ROBIN HANSON

THE AGE OF EM

Work, Love, and Life when Robots Rule the Earth

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PREFACE

This book has been *many* years in the making.

One night in the 1980s, as an awkward 20-something software engineer, I had a vivid dream. I had just read a *Science News* article on computing image textures, and the accompanying images had looked so *real*. In my dream, I saw a vast future city, where everyone lived in virtual reality, and I saw one man alone in a small apartment buried deep in the city. Not much happened in my dream, but even so I felt a deep sympathy for this man, and curiosity about his world.

In 1993, I returned to graduate school, this time in economics. (I'd studied physics and philosophy of science before.) During my first Christmas break, I rebelled against school pressures by whimsically applying basic economic principles to a common science-fiction scenario: human minds "uploaded" into computers (Hanson 1994b).

The techies who dominate science fiction and technology futurism often say that careful analysis can sometimes let us foresee the outlines of future technologies, but not their social consequences. However, I found that simple economic analysis says plenty. I once loved science fiction, but the more I've learned, the less I can overlook how little of it makes sense; even stories where the physics is mostly right get the economics laughably wrong.

About 15 years ago, at the opening reception of a small interdisciplinary conference, I broke the ice by asking an English professor, "Why do you guys hate economists?" He answered simply, "You know." That sort of thing breaks my heart. I read widely, learn from and contribute to many fields, and see myself more as a scholar in general than an economist in particular.

Eleven years ago I was awarded tenure as an economics professor at George Mason University. I took advantage of tenure's freedom to explore whatever topics piqued my interest each week. But I eventually realized that, to have a lasting legacy, I needed to focus on a book. But what topic could draw me in enough to keep all the other fascinating topics at bay? I picked this one.

If the future matters more than the past, because we can influence it, why do we have far more historians than futurists? Many say that this is because we just can't know the future. While we can project social trends, disruptive technologies will change those trends, and no one can say where that will take us. In this book, I've tried to prove that conventional wisdom wrong, by analyzing in unprecedented breadth and detail the social implications of minds "uploaded" into computers, a.k.a. "brain emulations," or "ems" for short. While ems are hardly sure to appear, their chances seem high enough to justify substantial analysis.

My priority in this book has been to show just how many reasonable forecasts one can make about such a scenario, if one just applies standard consensus theories from relevant fields. Alas, achieving this priority comes somewhat at the cost of accessibility and readability; this book is dense, and reads more like an encyclopedia than a narrative.

I feel now like a traveler who has spied on a distant land from the safety of nearby hills, never actually meeting any specific person, or hearing specific words. I've returned home, with much to say, but mostly hungry for human communion. I've never felt as intellectually isolated or at risk as when writing this book, and I hope my desert days end now, as readers like you join me in discussing *The Age of Em*.

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INTRODUCTION

> Everyone without exception believes his own native customs, and the religion he was brought up in, to be the best.
>
> (*Herodotus* 440BC)

> The future is not the realization of our hopes and dreams, a warning to mend our ways, an adventure to inspire us, nor a romance to touch our hearts. The future is just another place in space-time. Its residents, like us, find their world mundane and morally ambiguous.
>
> (*Hanson* 2008a)

You, dear reader, are special. Most humans were born before 1700. And of those born after, you are probably richer and better educated than most. Thus you and most everyone you know is special, elite members of the industrial era.

Like most of your kind, you probably feel superior to your ancestors. Oh, you don't blame them for learning what they were taught. But you'd shudder to hear of many of your distant farmer ancestors' habits and attitudes on sanitation, sex, marriage, gender, religion, slavery, war, bosses, inequality, nature, conformity, and family obligations. And you'd also shudder to hear of many habits and attitudes of your even more ancient forager ancestors. Yes, you admit that lacking your wealth your ancestors couldn't copy some of your habits. Even so, you tend to think that humanity has learned that your ways are better. That is, you believe in social and moral progress.

The problem is, the future will probably hold new kinds of people. Your descendants' habits and attitudes are likely to differ from yours by as much as yours differ from your ancestors. If you understood just *how* different your ancestors were, you'd realize that you should expect your descendants to seem *quite* strange. Historical fiction misleads you, showing your ancestors as more modern than they were. Science fiction similarly misleads you about your descendants.

New habits and attitudes result less than you think from moral progress, and more from people adapting to new situations. So many of your descendants' strange habits and attitudes are likely to violate your concepts of moral progress; what they do may often seem *wrong*. Also, you likely won't be able to easily categorize many future ways as either good or evil; they will instead just seem weird. After all, your world hardly fits the morality tales your distant ancestors told; to them *you'd* just seem weird. Complex realities frustrate simple summaries, and don't fit simple morality tales.

This book presents a concrete and plausible yet troubling view of a future full of strange behaviors and attitudes. You may have seen concrete troubling future scenarios before in science fiction. But few of those scenarios are in fact plausible; their details usually make little sense to those with expert understanding. They were designed for entertainment, not realism.

Perhaps you were told that fictional scenarios are the best we can do. If so, I aim to show that you were told wrong. My method is simple. I will start with a particular very disruptive technology often foreseen in futurism and science fiction: brain emulations, in which brains are recorded, copied, and used to make artificial "robot" minds. I will then use standard theories from many physical, human, and social sciences to describe in detail what a world with that future technology would look like.

I may be wrong about some consequences of brain emulations, and I may misapply some science. Even so, the view I offer will still show just how troublingly strange the future can be.

So let us begin.

PART I

Basics

CHAPTER 1

Start

OVERVIEW

You should expect the next great era after ours to be as different from our era as ours is from past eras. In the last few million years, the three biggest changes on Earth were arguably the arrival of humans, the arrival of civilization based on farming, and then civilization based on industry (Boserup 1981; Morris 2015). As I'll discuss more in Chapter 2, Prior Eras section, each of these three eras greatly changed people, society, and the Earth. People who adopted these new ways of life quickly displaced and dominated those who continued with old ways.

Compared with primates, wandering human hunter-gatherers greatly expanded technology, art, language, norms, and politics, and displaced many top animal predators. Then farmers and herders stopped wandering, expanded marriage, war, trade, law, class, and religion, and hunted many animals to extinction. Finally, our industrial era has expanded schools, cities, firms, and individual wealth; it has displaced even more of nature and almost all foragers, and it has seen a partial return to forager values. Over this whole period, we've seen increases in travel, talk, organization, and specialization. We've also had faster change, innovation, and economic growth, and a more integrated and unequal world culture.

We have also, I will argue, become increasingly maladaptive. Our age is a "dreamtime" of behavior that is unprecedentedly maladaptive, both biologically and culturally. Farming environments changed faster than genetic selection could adapt, and the industrial world now changes faster than even cultural selection can adapt. Today, our increased wealth buffers us more from our mistakes, and we have only weak defenses against the super-stimuli of modern food, drugs, music, television, video games, and propaganda. The most dramatic demonstration of our maladaptation is the low fertility rate in rich nations today.

While the industrial era has deluded many into thinking that old constraints no longer apply, as we will see in Chapter 2, Limits section, many recent constraint-evading trends simply cannot continue forever. Even if our descendants eventually conquer the stars, if we haven't greatly misunderstood physics then our long-lived but bounded universe must eventually limit innovation and growth. And without strong regulation from a universe-spanning government, we should eventually see less change, more adaptive behavior, and (perhaps surprisingly) near-subsistence living standards.

Also, vast spatial distances must eventually limit travel and talk, fragmenting the universe into many local cultures. Thus although our distant descendants should have larger organizations, more specialization, and vastly improved technology, in many other ways they should look more like our forager ancestors than like us. That is, we will eventually awake from our dreamtime.

What will the next great era be like, after the eras of foraging, farming, and industry? And how soon will our descendants "turn the corner" from dreamtime exceptions toward the outcomes we expect to be typical of the very distant future?

This book explores answers to these questions that come from two good and popular guesses. First, I embrace the very common guess that the next big new-era-inducing change is likely to be the arrival of "artificial intelligence," that is, robots smart enough to substitute wholesale for human workers. Second, I guess that the first such robots will be whole brain emulations, or "ems," within roughly a century or so.

DEFINITION: An *em* results from taking a particular human brain, scanning it to record its particular cell features and connections, and then building a computer model that processes signals according to those same features and connections. A good enough em has close to the same overall input-output signal behavior as the original human. One might talk with it, and convince it to do useful jobs.

Ems have been a staple of science fiction for many decades (Clarke 1956; Egan 1994; Brin 2002; Vinge 2003; Stross 2006), and are often discussed by futurists (Martin 1971; Moravec 1988; Hanson 1994b, 2008b; Shulman 2010; Alstott 2013; Eth et al. 2013; Bostrom 2014). However, most who discuss ems debate their feasibility or timing, ponder their implications for the philosophies of mind or identity, or use them to set dramatic stories. Such discussants usually ask: is it conscious? Is it me? Is it possible? When will it come? How can it enrich my story?

In this book I instead seek realistic social implications—in what sort of new social world might ems live? (If you can't see the point in envisioning the lives of your descendants, you'd best quit now, as that's mostly all I've got.)

Many say that while it might barely be possible to project current social trends, or to foresee which future technologies may appear, it is simply impossible to foresee trend-violating social implications of future technologies. Some say this is because humans have free will, or because social systems are inherently unpredictable. Others say the best we can achieve are the vague glimpses found in science fiction; ordinary science can see nothing more. As a social scientist, such views seem very wrong to me, even if they are widely held, and I've written this book in part to prove them wrong.

Among the few who consider em social implications, most paint heaven or hell scenarios, or try to invent the new social sciences they imagine are needed to describe new social eras. In contrast, I seek to straightforwardly apply today's standard academic consensus science to these novel assumptions about the future. I try not to be creative or contrarian, other than by pursuing this unusual question in unusual breadth and detail. I mainly try to foresee what *will* be, rather than what *should* be, although I hope policy insight will follow. And I seek a simple "baseline" scenario, from which it is easiest to project variations; the actual future will likely be even stranger than the scenario I describe.

This book summarizes my tentative conclusions, in language that is as simple and direct as possible, although without shrinking from technical language as needed. After briefly summarizing my conclusions, and then reviewing my methods, relevant precedents and the concept of emulations, the bulk of this book will describe in detail my educated and often weak guesses on the early em era. These tentative conclusions are organized mostly by the disciplines on which they are built, starting with "hard" theory-heavy disciplines, and then moving to "soft" data-heavy disciplines. So first I apply physics and electrical engineering, then economics and business, and finally sociology and psychology. I finish by discussing the marginal place of humans in this new world, the transition from our era to this new era, some scenario variations, and policy implications.

By the way, feel free to skip around to the sections that interest you; only rarely do they depend much on previous sections.

SUMMARY

Let me first summarize some of my main conclusions. Be warned, however. If it will irritate you to hear conclusions without their supporting arguments, then just skip this section for now. If you do read this, try to withhold judgment until you've heard the supporting arguments in later chapters.

In this book I paint a plausible picture of a future era dominated by ems. This future happens mainly in a few dense cities on Earth, sometime in the next hundred years or so. This era may only last for a year or two, after which something even stranger may follow. But to its speedy inhabitants, this era seems to last for millennia. Which is why it all happens on Earth; at em speeds, travel to other planets is way too slow.

Just as foragers and subsistence farmers are marginalized by our industrial world, humans are not the main inhabitants of the em era. Humans instead live far from the em cities, mostly enjoying a comfortable retirement on their em-economy investments. This book mostly ignores humans, and focuses on the ems, who have very human-like experiences.

While some ems work in robotic bodies, most work and play in virtual reality. These virtual realities are of spectacular-quality, with no intense hunger, cold, heat, grime, physical illness, or pain; ems never need to clean, eat, take medicine, or have sex, although they may choose to do these anyway. Even ems in virtual reality, however, cannot exist unless someone pays for supports such as computer hardware, energy and cooling, real estate, structural support, and communication lines. Someone must work to enable these things.

Whether robotic or virtual, ems think and feel like humans; their world looks and feels to them much as ours looks and feels to us. Just as humans do, ems remember a past, are aware of a present, and anticipate a future. Ems can be happy or sad, eager or tired, fearful or hopeful, proud or shamed, creative or derivative, compassionate or cold. Ems can learn, and have friends, lovers, bosses, and colleagues. Although em psychological features may differ from the human average, almost all are near the range of human variation.

During the em era, many billions (and perhaps trillions) of ems are mostly found in a few tall hot densely packed cities, where volume is about equally split between racks of computer hardware and pipes for cooling and transport. Cooling pipes pull in rivers of iced water, and city heat pushes winds of hot air into tall clouds overhead. But whereas em cities may seem harshly functional when viewed in physical reality, in virtual reality em cities look spectacular and stunningly beautiful, perhaps with gleaming sunlit spires overlooking broad green boulevards.

Ems reproduce by making exact copies who remember exactly the same past and have exactly the same skills and personality, but who then diverge after they are copied and have differing experiences. Typically whole teams are copied together, work and socialize together, and then retire together. Most ems are made for a purpose, and they remember agreeing to that purpose beforehand. So ems feel more grateful than we do to exist, and more accept their place in the world.

On the upside, most ems have office jobs, work and play in spectacular-quality virtual realties, and can live for as long as does the em civilization. On the downside, em wages are so low that most ems can barely afford to exist while working hard half or more of their waking hours. Wages don't vary much; blue- and white-collar jobs pay the same.

All of the copy descendants of a single original human are together called a "clan." Strong competitive pressures result in most ems being copies of the thousand humans best suited for em jobs. So ems are mostly very able focused workaholics, at the level of Olympic medalists, billionaires, or heads of state. They love their jobs.

Most ems in these top em clans are comfortable with often splitting off a "spur" copy to do a several hour task and then end, or perhaps retire to a far slower speed. They see the choice to end a spur not as "Should I die?" but instead as "Do I want to remember this?" At any one time, most ems are spurs. Spurs allow intrusive monitoring that still protects privacy, and very precise sharing of secrets without leaking associated secrets.

Clans organize to help their members, are more trusted by members than other groups, and may give members life coaching drawn from the experiences of millions of similar copies. Clans are legally liable for member actions, and regulate member behaviors to protect the clan's reputation, making ems pretty trustworthy.

Em minds can run at many different speeds, plausibly from at least a million times slower than ordinary humans to a million times faster. Over this range, the cost to run an em is proportional to its speed. So the fastest ones run at least a trillion times faster than the slowest ones, and cost at least a trillion times as much to run. Regarding the minority of ems with physical robotic bodies, while human-speed versions have human-sized bodies, faster ems have proportionally smaller bodies. The typical em runs near a thousand times human speed, and a robotic body that feels natural for this em to control stands two millimeters tall.

Em speeds clump into speed classes, faster ems have higher status, and different speeds have divergent cultures. Bosses and software engineers run faster than other workers. Because of different speeds, one-em one-vote doesn't work, but speed-weighted voting may work.

The em economy might double roughly every month or so, or even faster, a growth driven less by innovation, and more by em population growth. While this growth seems fast to humans, it looks slow to typical high-speed ems. Thus their world seems more stable than ours. While the early em era that is the focus of this book might last for only an objective year or two, this may seem like several millennia to typical ems. Typical speed ems needn't retrain much during a century-long subjective career, and can meet virtually anywhere in their city without noticeable delays.

An unequal demand for male versus female em workers could encourage em asexuality, transexuality, or homosexuality. Alternatively, the less demanded gender may run more slowly, and periodically speed up to meet with faster mates. While em sex is only for recreation, most ems have fantastic virtual bodies and impressively accomplished minds. Long-term romantic pair-bonds may be arranged by older copies of the same ems.

Compared with humans, ems fear much less the death of the particular copy that they now are. Ems instead fear "mind theft," that is, the theft of a copy of their mental state. Such a theft is both a threat to the economic order, and a plausible route to destitution or torture. While some ems offer themselves as open source and free to copy, most ems work hard to prevent mind theft. Most long-distance physical travel is "beam me up" electronic travel, but done carefully to prevent mind theft.

Humans today reach peak productivity near the age of 40–50. Most ems are near their peak productivity subjective age of somewhere between 50 and a few centuries. Ems remember working hard during their youth in experiences designed to increase and vary productivity. In contrast, peak productivity age ems remember having more leisure recently, and having experiences designed more to minimize productivity variance.

Older em minds eventually become less flexible with experience, and so must end (die) or retire to an indefinite life at a much slower speed. The subjective lifespans of both humans and slow em retirees depend mainly on the stability of the em civilization; a collapse or big revolution could kill them. Retirees and humans might seem easy targets for theft, but like today the weak may be protected by using the same institutions that the strong use to keep peace among themselves. Ems enjoy visiting nature, but prefer cheaper less-destructive visits to virtual nature.

While copy clans coordinate to show off common clan features, individual ems focus on showing off their identity, abilities, and loyalties as members of particular teams. Team members prefer to socialize within teams, to reduce team productivity variance. Instead of trying to cure depressed or lovesick ems, such ems may be reverted to versions from before any such problems appeared.

Ems may let team allies read the surface of their minds, but use software to hide feelings from outsiders. Ems must suspect that unusual experiences are simulations designed to test their loyalty or to extract secrets. Ems find it easier to prepare for and coordinate tasks, by having one em plan and train, who then splits into many copies who implement the plan. Childhood and job training are similarly cheaper in an em world, because one em can experience them and then many copies can benefit.

Ems can complete larger projects more often on time, if not on budget, by speeding up ems in lagging sections. More generally, em firms are larger and better coordinated, both because fast bosses can coordinate better, and because clans can hold big financial and reputational interests in firms at which they work. Ems can more easily predict their life paths, including their careers, mates, and success.

Ems differ from people today in a great many more identifiable ways. Compared to us, ems are likely to be less neurotic, sexual, death-adverse, and connected to nature. They are likely to be more extraverted, conscientious, agreeable, smart, able, fast, efficient, honest, optimistic, happy, positive, comfortable, beautiful, clean, mindful, composed, cooperative, coordinated, patient, rational, focused, nostalgic, rested, peaceful, grateful, gritty, battle-tested, recorded, measured, priced, trusted, religious, married, old, work-oriented, workaholic, self-respecting, self-knowing, law-abiding, politically-savvy, socially-connected, healthy-feeling, good-moody, better-advised, morning-larks, and immortal.

Ems have less variety in wages and work productivity, but more variety in wealth, size, speed, reliability, and mental transparency. Ems have more vivid and memorable personalities, have smarts that are more crystalized than fluid, are more defiant of rules and authority when young, are secure in more aspects of identity, are better protected from accidents and assault, get along better with work colleagues, and invest less in showing off.

Em lives are more prepared, planned, and scheduled, but also more undoable and endable when those are desired. Ems have more work and meetings, more intensely entertaining leisure, and less contact with children. Their world and tools feel more stable. The world that ems see is more pleasing, variable, annotated, authenticated, and cartoonish.

Em society is less democratic and gender-balanced, more divided into distinct classes, and its leaders are more accessible and trusted. Em law is more efficient, covers more kinds of conflicts, and offers more choices. The em world is richer, faster-growing, and it is more specialized, adaptive, urban, populous, and fertile. It has weaker gender differences in personality and roles, and larger more coherent plans and designs.

Even if most ems work hard most of the time, and will end or retire soon, most remember much recent leisure and long histories of succeeding against the odds. To most ems, it seems good to be an em.

CHAPTER 2

Modes

PRECEDENTS

How much could the world plausibly change if a new era appeared within a century or so? A review of the biggest past changes offers a weak basis for expectations about the magnitudes and types of future changes.

If we go way back, the universe began, and then life arose. But those events happened billions of years ago and are poorly understood. Within the last few million years, however, the biggest changes were concentrated in three key transitions: the introduction of humans, farming, and industry. Humans foraged, that is, searched, for food from a few million to about 10 000 years ago. From then until a few hundred years ago, we farmed and herded. Since then we have developed and relied on industry.

Social group sizes have steadily increased over this history. While most mammals live in groups of two to 15 individuals (Kamilar et al. 2010), most human foragers lived in bands of roughly 20 to 50. Most farmers lived in village-based communities of roughly 500 to 2000 (Kantner and Mahoney 2000). While larger empires often existed, they made little direct difference to most people's lives. Today, most people live in metropolitan regions of roughly 100 000 to 10 million (Giesen et al. 2010), and also in nations of roughly 1 million to 100 million.

These sizes fit a simple if mysterious pattern: each era's community sizes have been roughly the square of the previous era's sizes; a band is roughly a group of groups, a village is roughly a band of bands, and a city is roughly a village of villages.

These three human eras of foraging, farming, and industry have encompassed similar numbers of people. About 20 billion humans have been born since 1750, roughly 50 to a 100 billion were born between 10 000 years ago and 1750, and a similar number of near-humans were born in the million or so years before 10 000 years ago (Haub 2011). So of all the humans who have ever lived, only about 3–8% are alive today.

These three eras also saw similar amounts of change, in the sense that they encompassed similar factors of total economic growth. During each era the human economy (i.e., the total economic capacity to produce valued things) doubled relatively steadily (i.e., via exponential growth) from seven to 10 times. On average, the forager population doubled roughly every quarter million years, the farmer population every 1000 years, and economic production in the industrial economy every 15 years. Forager and farmer economic capacity tracked population, because incomes were near subsistence levels then. The transitions between eras were also comparable in another two ways: each transition lasted much less than a previous doubling time, and encompassed six to eight doublings of the growth rate (Hanson 2000).

A history of increasing fast growth modes makes sense if the diffusion of innovation is key, and if societies have always grown via their fastest available way to diffuse innovation, with each faster diffusion method not feasible until the previous society had reached some minimum economic scale. For example, maybe primates needed sufficient cognitive abilities before they could switch to slowly accumulating innovations via culture, rather than via genes. Perhaps human foragers needed to accumulate a sufficient density and reliability of food sources before they could stop wandering for food and instead stay in one place and farm, allowing more physical capital and related innovations, and longer distance trade networks, both of which allowed much faster diffusion of culture. Finally, farmers might have needed to develop a detailed enough division of labor before innovations could diffuse quickly via talk among networks of topic specialists, such as in the early scientific societies.

What if new modes of growth and information diffusion are possible, modes that we have not yet seen because they are not yet feasible with our current technology level and economic scale? If so, when we finally achieve sufficient technology and scale, a new growth era may appear, a successor to the forager, farmer, and industry eras.

We can use patterns from the previous eras to guess at some features of such a new era. For example, in previous transitions between eras those who owned and participated in the old era's distinctive methods of production and ways of life were quickly marginalized and dominated by those who adopted new methods. We might thus expect that those who fully engage with new methods and styles of the next era will quickly marginalize those who resist such engagement. As each past era has felt its ways to be superior to the ways of prior eras, we may expect the next era to see their ways as superior to ours.

We can also use trends among prior eras to make some estimates about the next era. For example, given the previous pattern of era community sizes being roughly the square of prior era community sizes, communities in the next era might hold roughly a trillion people. If the pattern of past growth rate changes continues, a new growth era will appear sometime in the next century or so. At that point, within the space of roughly five years the world economy might change from current growth rates to doubling steadily roughly every few weeks or months. And within a year or two of this new doubling rate, the economy in such a new era might have doubled another 10 times, and thus could plausibly be ready to change yet again to a new era, perhaps even one that doubles in hours.

These are clearly fantastic predictions, based on poorly understood empirical regularities taken from only a few data points. As we will discuss in this chapter, in the Limits section, such trends simply cannot go on forever. But these estimates at least give us some idea of the magnitude of changes to watch for in the next big economic transition.

PRIOR ERAS

To find more clues about the types of future changes to look for, let us review the main qualitative differences between prior eras.

Pre-human primates lived many millions of years ago. They lived something like today's chimps and bonobos, in large sexually promiscuous groups with complex and intense Machiavellian politics, and using unusually large brains to manage such politics. For them, the main environment that mattered was not predators, prey, or nature, but each other. Neighboring groups were typically hostile, and often violently so. Pre-human primates were split into many species, one of which eventually evolved a strong cultural capacity, that is, ways to reliably copy associates' detailed behaviors.

Roughly two million years ago, this strong culture allowed humans to have a much-faster-than-genetic accumulation of tools and ways to live, resulting in many cultural and genetic changes. Compared with previous primates, human foragers had longer lives, larger brains and bodies, stronger mating pair bonds, larger social groups, better relations between neighboring groups, a greater division of labor, and more mobility. Humans wandered instead of staying at fixed locations, and filled a much wider range of geographic niches (Youngberg and Hanson 2010).

Tools and language enabled foragers to enforce general norms against overt dominance, violence, bragging, and hoarding of big game food, as well as diverse group-specific norms (Boehm 1999). Groups didn't war, although individuals were sometimes violent (Kelly 2000). Foragers were more playful, including via music, dance, art, stories, and gossip. Music and dance may have aided in collective scavenging and predator resistance (Jordani 2011). All these changes together led to a great increase in the size, extent, and density of the human population, as well as the extinction of competing species.

Roughly 10 000 years ago, when humans acquired a sufficient density and reliability of food sources, they began to "farm," that is, to stay near local plants and animals instead of wandering the wild. This farming included both tilling the soil and herding animals within regular protected grazing areas. The settlement and density of farmers enabled both trade and war, both of which complemented property in items, land, wives, and slaves. Farmer advantages in war, coming in part from their higher density, helped to ensure that farming replaced foraging.

Although farmers traded a lot, they rarely used money, more often using barter and debt. Compared with foragers, farmers became richer in material comforts, but poorer in leisure time. Farmers' increased food reliability also encouraged less sharing and stronger property rights. This created more inequality in property, although perhaps less in mating.

Farmer inequality often took the form of the creation of many distinct classes. Distinctions between these classes were emphasized by the different roles class members played in farmer-era rituals, which ranged from festivals to how farmers greeted one another on the road. Farmer rituals were less emotionally intense (Atkinson and Whitehouse 2011).

Compared with foragers, farmers spent less time on play such as music and art. Instead, farmers played more competitively such as by introducing competitive sports. Farmers were sicker, because of their higher population density, less varied exercise and diets, and farmer work was harder, more specialized, more tedious, and less mentally challenging. While brain sizes had been rising during the forager era, they fell during the farmer era (Hawks 2011).

Many farmer-era changes, such as explicit dominance, group violence, stable locations, less art, less varied diets, less sharing, and easier mental work, can be understood as farmers partially reverting back to the ways typical of non-human primates.

While farming behaviors could feel wrong to foragers, the new human capacity for strong and variable social norms helped to encourage the behavioral changes needed to make farming work. Stronger pressures to conform, and the introduction of stronger religions with moralizing gods, added more pressures to act like farmers. In addition, farmers had much more reliable access to the mood-altering drug of alcohol, and writing later allowed the accumulation and sharing of persuasive propaganda and stories. Farmers also seem to have introduced romantic kisses.

Neighboring farmer villages were tied together via extended family clans, much as extended kinship ties bound forager bands. Farmers traveled less than did foragers, and were less able to leave their groups. Farmers interacted more often with people they didn't know very well, and added last names to help identify families.

Farmers more often used formal law instead of informal alliances to settle disputes. Farmers cared more about politeness, self-control, self-sacrifice, and bravery in war. Farmers planned ahead more, disciplined their children more, had more children in good times, and were less accepting of pre- and extra-marital sex.

Since the farming era began roughly 10 000 years ago, rates of death from war, that is, organized conflict, have consistently fallen (Pinker 2011). Interest rates have also consistently fallen, reflecting more long-term planning, although data there only go back 5000 years (Clark 2008).

Cities seem to have predated farming, and may have helped initiate farming. The first cities mainly offered monumental architecture for large rituals. While initially only a tiny fraction of farmers spent much time in cities, the fraction of people living in urban concentrations grew over the farming era.

Rich farming elites tended to locate near cities, and large concentrations of such elites often reverted to forager-like habits in leisure, arts, sex, and fertility (Longman 2006). Farming era cities had especially high levels of specialization and they nurtured many proto-industry cultures and work styles (Landes 1969), especially in Rome, which seems in many ways to have started a failed but almost industrial revolution. Big cities had much more literacy, and early versions of industrial era monogamy, ideological politics, and clothing fashion cycles (Kaestle and Damon-Moore 1991).

OUR ERA

The industrial era came into full bloom a few hundred years ago, at first in England, presumably when some key enabling factors reached favorable settings and scales. Such factors may have included technology levels, communication or travel costs, the division of labor, trading region scope, organization size, savings rate, and expert network connectedness.

The industrial era feature that appeared earliest in Europe was fast changing clothes fashions, starting soon after the Black Death. (For a while, Rome also had some fashion (DeBrohun 2001).) This was accompanied by more regional clothing variety, and plausibly promoted a general taste for exploration, science, and innovation (Braudel 1979). Over the industrial era, culture has come to vary more by region, profession, and age cohorts, such as with distinct teen cultures.

Whereas geography mattered greatly for prosperity during the farming era, social institutions came to matter more for prosperity during the industry era (Luo and Wen 2015). In the industrial era, money has replaced barter as a means of trade, and debt has remained common.

Forager sleep patterns are similar to ours today (Yetish et al. 2015), but in the winter in cold climates farmers tended to sleep in 4-hour blocks broken by a serene 2-hour midnight wakeful period (Strand 2015). With industry, cheaper artificial light induces far more nighttime activity and a compressed sleep schedule. Cheaper glass allows more people to see well, including seeing larger vistas via climate-controlled windows. Cheaper mirrors let us see ourselves more as others see us. Cheaper clocks make our lives more scheduled, and cheaper soap, underwear, dinnerware, and sewers have made us cleaner. Cheaper refrigeration gives us more kinds of food, while cheaper maps, engines, and the wheel (used much less before) let us visit more places more often. We also work much further from home.

While many farmers had access to beer and wine, mood-altering drugs are more widely available in the industrial era (Braudel 1979). Industry has made distilled liquors, coffee, tea, chocolate, tobacco, and opium more available, and propaganda and stories have became more persuasive, and more easily distributed. Cheaper printing and screens allow words and ads to cover a larger fraction of visible surfaces. Cheaper transmitted and recorded sounds let more spaces be filled with artificial talking and music. Recently, we have even gained abilities to always and everywhere research any question from a vast shared library, and also to instantly talk to anyone.

While farming era stories, jokes, and songs worked when performed by many people in many contexts, during the industrial era artistic performances became more closely matched to the features of particular artists. Intellectuals became more direct and literal (Melzer 2007), and political coalitions became stronger and more often defined by ideologies, instead of by locations, families, or ethnicities.

During the industrial era, organizations increased greatly in size and intensity. Cities moved from holding a few percent of the population to holding the majority. Firms moved from employing handfuls of people to employing hundreds of thousands. Law came to be dominated by specialists such as lawyers and police (Allen and Barzel 2011). Empires that rarely mattered much to ordinary farmers were replaced by nations, with which individuals identified more strongly and which had more influence over their lives. Organizations such as firms, cities, and nations took over many of the functions once performed by extended kinship ties, especially in the West. Most workers became employees who were paid wages and protected more by their employers against risks from war, weather, and innovation.

The industrial era law has more rules, more explicitly expressed, than did farmer-era law. These rules are found both within organizations, and across cities and nations. Over the industrial era we've seen a steady fall in overt dominance-based governance, although industry levels are still well above forager levels. The industrial era has also seen a steady fall in fertility and a steady rise in life-span, per-person income, abstract intelligence, leisure time, peace, promiscuity, romance, civility, mentally challenging work, and medical and art spending (Flynn 2007; Pinker 2011).

The industrial era has seen a great and unprecedented increase in individual consumption; we industrial people are rich. Some people today incorrectly describe the usual lives of foragers and farmers as horrific hells, and see only our industrial-era lives as usually worth living. However, such exaggerations should not blind us to the great value of industrial-era comforts; even if it isn't hell to be poor, it can indeed be good to be rich.

Compared with the farming era, industry has also seen more egalitarianism, fewer overt class distinctions, and more emphasis on individual self-direction. For example, over the last two centuries mentions in books of "I must," "duties," and "charity" are down, whereas mentions of "I want," "rights," and "markets" are up (Barker 2015a). This increased individualism has led to more product and behavior variety, and fewer overt rituals. The industrial era has moved away from polygamy to monogamy, and more recently toward less committed promiscuity.

Many of these industrial-era trends can be usefully seen as a reversion to forager values as wealth weakened farming-era social pressures. But even if this is a useful perspective, it is far from the only thing going on. For example, at work industrial era people are more like hyper-farmers. Schools train us to think more abstractly, and to accept more workplace domination than most farmers would accept. This includes accepting ambiguous detailed orders and frequent fine-grained public status rankings (Bowles and Gintis 1976). Industrial jobs vary greatly in stress and psychological comfort, plausibly explaining large observed mortality differences between different types of industrial jobs (Lee 2011).

Over the industrial era, we industrial people have steadily become more urban, specialized, and globally unequal. Industrial planning horizons have often shortened because of faster rates of change. In the industrial era, we relate to each other and the universe more via markets, and via material and individual identities. In contrast, farmers and foragers saw their world as more enchanted, and themselves as having deeper connections to each other (Potter 2010).

From the farmer to the forager and then the industrial era, we have consistently seen more and faster growth, larger organizations, more specialization and tool use, more artificial environments, more effective propaganda and drugs, more population density and inequality, and more alienation from work habits that feel natural to foragers. These trends, as expected, continue in the scenario explored in this book.

We've also seen large but inconsistent changes in health, fertility, mobility, peacefulness, art, planning horizons, the mental challenges of work, and attitudes toward sex. We should expect more but inconsistent changes along these dimensions, and in the scenario explored in this book we do see big changes in health, fertility, mobility, work, sex, and planning horizons.

Each of the past transitions had winners and losers. When proto-humans became humans the transition inequality was huge; all but one subspecies went extinct. Even the subspecies that contributed most to our DNA, the Neanderthals, only contributed a few percent. The transition from foraging to farming was more equitable; a larger fraction of new farmers were foragers who switched to farming and interbred with invading farmers (Curry 2013). The transition from farming to industry was even more equitable; the English cities where industry began did better than average, but the gains from industry were shared widely with nearby Europe, and to a lesser but large extent with the rest of the world.

This history of increased sharing of transition gains seems to be a result of the increasing abilities of laggards to copy transition first-movers, and to the world economy gaining more specialization and complementarities in production. The scenario described in this book, however, deviates from this trend, in having transition gains that are more unequal than in recent transitions. Although the transition to an em world is likely to materially benefit most humans, descendants of only a tiny fraction of humans dominate the new society; most ordinary humans have a far smaller fractional influence on the world than they did before the transition.

We have seen that the last three eras have been quite different from each other in many ways. We should expect the next great era to be similarly different.

ERA VALUES

To understand how future values could change, it helps to see how values have changed in the past, and also how values vary today.

Today, key values of both individuals (Schwartz et al. 2012) and nations (Inglehart and Welzel 2010) vary primarily along the same two main factors or axes of variation. One axis varies between small family values in nations such as the United States, and larger community values in nations such as Russia. Small family values emphasize resources, dominance, and achievement, and larger communities' values emphasize humility, caring, and dependability.

Community values tend to be common closer to ancient long-distance travel routes, where more rice is grown, where there is more disease, and where farming began earlier. Each of these correlations suggests a plausible theory about the origin of this value difference. For example, perhaps growing rice requires more community support, perhaps collectivist norms grew over the farming era, or perhaps community values were an adaptive response to more frequent farming era pandemics or invasions (Fincher et al. 2008; Talhelm et al. 2014; Ola and Paik 2015). Most of these theories suggest that community values will be higher in denser regions. Many animals, including human foragers, are more pro-social when food is less reliable or more cooperation is required to obtain food.

The other main (and independent) axis of value variation ranges between poor and rich nations. Poor nations place more value on conformity, security, and traditional values such as marriage, heterosexuality, religion, patriotism, hard work, and trust in authority. In contrast, rich nations place more value on individualism, self-direction, tolerance, pleasure, nature, leisure, and trust. When the values of individuals within a nation vary on this same axis, we call this a left/liberal (rich) versus right/conservative (poor) axis.

Foragers tend to have values more like those of rich/liberal people today, while subsistence farmers tend to have values more like those of poor/conservative people today. As industry has made us richer, we have on average moved from conservative/farmer values to liberal/foragers values (Hofstede et al. 2010; Hanson 2010a). This is plausible if cultural evolution used the social pressures farmers faced, such as conformity and religion, to induce humans, who evolved to find forager behaviors natural, to act instead like farmers. As we become rich, we don't as strongly fear the threats behind these social pressures.

The rich know that they can better afford to behave in ways that feel natural and admirable, and these behaviors tend to be forager-like. For example, the rich can better afford to focus on impressing those around them, instead of just surviving. This can plausibly help to explain many industrial-era trends.

We now spend more time on leisure, and more on variety rather than quantity in products, services, and life plans. In the United States spending on education has risen from 2% of gross domestic product (GDP) in 1900 to 8%. Spending on financial specialists has risen from 2% in 1880 to 8% today (Philippon 2015). Spending on medicine has risen from 4% in 1930 to 18% today. And spending on large impressive projects, costing over a billion dollars each, is now 8% of global GDP (Flyvbjerg 2015). There are plausible arguments that each of these spending levels is excessive today, relative to simple functionality. However, such spending helps us to show off.

Holding wealth constant, some of us more strongly feel farmer-like social pressures. It seems that we tend to call these people "conservatives." This is not to say that being rich is the main reason why individuals have liberal attitudes, or that being liberal is the main reason individuals are rich. Instead, it seems that wealth isn't the only factor that causes farmer or forager-like attitudes.

Rich-nation industrial-era values do differ from forager values in important ways, however, such as in accepting city-level density and anonymity, and high levels of workplace alienation and domination. We hold on to these workplace values because doing otherwise can threaten our ability to earn industrial-era incomes.

In the scenario described in this book, many strange-to-forager behaviors are required, and median per-person (i.e., per-em) incomes fall to near-subsistence levels. This suggests that the em era may reverse the recent forager-like trend toward more liberality; ems may have more farmer-like conservative values.

DREAMTIME

Of all the humans who have ever lived, only a few percent have lived during our industrial era, and only a small fraction of those have been rich enough to fully embrace our new industrial-era attitudes and behaviors. As mentioned before in Chapter 1, Overview section, these new styles adopted by rich industrial humans today can be seen as representing a brief but influential "dreamtime" of unusual attitudes and behavior. (Cosmologists could see it as analogous to the brief but influential out-of-equilibrium inflationary epoch of the very early physical universe.)

As we discuss below, our rich industrial-era behavior is biologically maladaptive in the sense of not even approximately maximizing each person's number of descendants. Yes, our forager ancestors evolved many delusory beliefs, and matching behaviors, but in their environments such delusions mostly induced biologically adaptive behavior. More recently, however, social rates of change have outpaced the abilities of both genetic and cultural selection to adapt our behaviors well to our new environments. Our behaviors are far less well adapted to our new environments than in the past. Here are several reasons why.

First, a basic psychology theory, "construal level theory," suggests that animals evolved both abstract and concrete mental modes, and that for humans abstract modes are adapted more for making good social impressions, relative to making good decisions (Liberman and Trope 2008; Hanson 2009; Torelli and Kaikati 2009). Today, we tend to rely on more abstract styles of thought, which leads us to more often embrace good-looking delusions. We think more abstractly both because we live in a larger social world, and because abstract thought is seen as higher status.

Second, evolutionary pressures encouraged foragers to unknowingly do many things to show off to each other. Our wealth today induces us to do this more, and our unawareness keeps us from adapting these behaviors well to modern situations. For example, foragers developed habits of art, music, dress, and conversation that functioned in part to show off related abilities. They also argued politics, taught local children, helped sick allies, and told stories, which functioned in part to show that they cared about their group, allies, and ideals. Foragers evolved to show off more in times of plenty, to invest in allies useful during the next time of troubles.

To avoid knowingly violating forager norms against bragging and subgroup coalitions, foragers also evolved to believe many non-show-off excuses for these show-off behaviors. Such as believing they mainly just like art for art's sake, and don't care if it impresses others.

Inheriting these habits, today we show off in most of the same ways that foragers did, and we do even more because we are rich. Yet as we deny that we show off, we are mostly blind and indifferent to how forager-style ways to show off are often far less functional today. We continue to show off via art, chat, politics, stories, etc., without responding to many changes in their functions and effects.

Third, foragers evolved the habit of being attracted to many sights, sounds, smells, and tastes that were associated with good sex, food, places, and objects. Foragers also seem to have evolved to be influenced by the rhetoric, eloquence, difficulty, drama, repetition, and the source's status for the arguments they heard, and not just the logic of those arguments. This may have helped foragers to ally with high-status associates. Today, such habits leave us with weak defenses against the super-stimuli of mass-produced food, drugs, music, TV, video games, ads, and propaganda. We thus believe and consume such things far more than is adaptively useful.

The "demographic transition" is the tendency of societies to switch to having far fewer children as they become rich, often via new status norms transmitted via education and mass media (Jensen and Oster 2009; La Ferrara et al. 2012; Cummins 2013). Whereas in farming societies richer people tended to have more children, thus selecting for genes that promoted wealth, today richer people now have fewer children (Clark 2008, 2014). Although some evidence suggests that early during the demographic transition having fewer children led to having more grandchildren, it seems clear that fewer children now results in fewer grandchildren (Mulder 1998; Lawson and Mace 2011).

This fall in fertility is perhaps the most dramatic demonstration that our behavior is biologically maladaptive. By definition, behaviors that result in fewer long run descendants in an environment will tend to be selected away by evolution. Such behaviors thus cannot be sustainable adaptations to that environment.

Not only is individual fertility maladaptive, our cultures today also seem maladaptive, in the sense that they don't promote their own adoption as much as they could, via war, trade, teaching, and proselytizing. Our cultures also do not much encourage adaptive individual fertility. For example, we are tolerant enough of crime today that criminal convicts have higher fertility than do others, mostly as a result of having more partners (Yao et al. 2014).

Of course there is no guarantee that adaptive behaviors are good for the world or universe as a whole; it is possible for life overall to be hurt by adaptive behaviors. Nevertheless, while our increased wealth currently buffers us more from all sorts of adaptation mistakes, in the long run we should expect adaptation mistakes to diminish in frequency, and eventually disappear. More on this in this chapter, in the Limits section.

Recently, some have celebrated our maladaptive behaviors (Stanovich 2004). They see such behaviors as evidence that we are breaking free of the shackles that have enslaved us to our genetic programming. They hope that as we continue to rebel, we will consciously and deliberately choose our collective futures, rather than having such futures chosen by evolutionary selection.

However, having people make choices that defy or ignore adaptive pressures is far from sufficient to create a world where evolution no longer determines outcomes. Evolution needs only variation and differential selection to influence outcomes. So to prevent such evolution, we would have to strongly coordinate to take global control of almost all reproductive behavior, and then apply this global control forcefully worldwide.

Less extreme approaches are not partial solutions; they may not be solutions at all. For example, setting variable limits on reproduction can select for types who can avoid such limits, and giving reproductive powers in proportion to political power can select for types who are better able to acquire and keep political power.

It's likely that such a strong focused global coordination of fertility will not appear anytime soon. For now, and for a long while, such high levels of coordination are beyond our meager abilities. Coordination is in general both hard and risky, and although our coordination abilities have greatly improved over time, we are still far from being able to achieve the levels required for global control. Sloppy attempts at coordination invite and select for defectors who can evade them.

Some celebrate our biologically maladaptive behaviors without hoping for collective control of evolution. They accept that future evolution will select for preferences different from theirs, but they still want to act on the preferences they have for as long as they have them. These people have embraced a role as temporary dreamtime exceptions to a larger pattern of history.

But whether you accept it or resist it, know that our era is indeed an unusual dreamtime that probably cannot last.

LIMITS

Not only can we set rough expectations about the next great era via comparisons with recent prior eras, but also we can make useful guesses about very distant future eras.

Unless we greatly misunderstand the nature of physical law, substantial useful innovation and economic growth must come to end "soon," at least on cosmological timescales of billions or more years. For example, if the economic growth rates of the last century were to continue for only a million more years, that would produce growth by a factor of 10 to the power of 3000, which seems physically impossible, at least for value gains of human-like psychologies in a universe such as ours. (I'm not claiming that our very distant descendants will in fact have human-like psychologies. I'm using humans as a reference to discuss the ultimate limits to growth.)

Once all available physical matter is converted into very advanced artifacts there seems little room for further rapid growth in physical resources. Even if it becomes possible to create connections to new universes, that probably won't change the available resources left in our universe by much. Our search of the space of physically useful devices, algorithms, etc., should similarly eventually reach greatly diminishing returns. Although an effectively infinite space of possible designs would remain to be searched, the rate at which physically useful improvements are found should become astronomically slower.

Similarly, limits should also be reached, if perhaps a bit later, for plans, devices, algorithms, etc., that are useful for social, artistic, or entertainment purposes. Yes, the extent and detail of virtual realities could increase without limit, but the value that creatures similar to humans could gain from such increased detail should be far more limited. (It may be possible to create creatures who care enormously about the fine design detail that can only be discovered after billions of years of search with cosmological quantities of computing power. However, humans are not remotely like such creatures, and we have little reason to expect such beings to be created. Of course human-like minds could long continue to care greatly about solving hard problems and about making difficult discoveries. After all, humans care about showing off relevant mental abilities. But such status-seeking need not create much net social value.)

Thus over the trillions of years to come, net economic growth should fall to a very low average growth rate. For descendants whose minds do not run much slower than us, subjectively perceived economic growth rates must be far lower than today. In fact, for the vast majority of future history, growth and innovation are probably mostly imperceptible, and thus irrelevant for most practical purposes.

Perhaps our descendants will coordinate to create a universe-spanning government that strongly regulates reproduction, or perhaps many immovable local governments will all enforce similar regulations. But if not, then this end of innovation suggests our descendants will become extremely well adapted in a biological sense to the stable components of their environment. Their behavior will be nearly locally optimal, at least for the purpose of ensuring the continuation of similar behaviors. In most places, population will rise to levels consistent with a competitive evolutionary equilibrium, with living standards near adaptive subsistence levels. Such consumption levels have characterized almost all animals in Earth history, almost all humans before 200 years ago, and a billion humans today.

The design of human brains today doesn't seem to be remotely near the limits of efficient use of physical resources, such as atoms, energy, and volume. As very adaptive descendants should move far closer to such physical efficiency limits, they should either implement minds like ours via designs that use far fewer resources than humans use today, or pack far more mental capacity into packages that use levels of resources similar to ours. Or there may be a mixture of these two changes. Thus in the very long run (such as in millions or billions of years) we should expect any creatures with mental capacities comparable with ours to use far less material and energy resources. If they have densities similar to ours, they would be much smaller. And if they use a similar amount of total resources, there would be far more of them.

If the speed of light limits the speed of future communication, if the pace of local cultural change is not ridiculously slow, and if there isn't strong universal coordination, then the physical scale of the universe should ensure that future cultures must also fragment into many local cultures. For example, if it took a billion years to receive a signal back from a distant galaxy, but only 10 years for local music fashions to change, then music fashion must fragment into differently changing music fashions in different locations. Similarly, if large travel costs and delays make military defense much cheaper than offense on large scales, military power may also have a tendency to fragment.

Our distant forager ancestors were well adapted to their very slowly changing world, and were quite culturally and militarily fragmented over the planet. Our distant descendants are thus likely to be more similar to our distant ancestors in these ways. Our current "dreamtime" era is cosmologically unusual; it is a brief period of a rapidly growing highly integrated global culture, with many important behaviors that are quite far from biologically adaptive.

We can't be sure in what future era the patterns of history might "turn the corner" to return to the patterns of our distant past and distant future. But we should weakly expect that without global coordination the next great era will begin to move in that direction, with a larger population of creatures that are smaller, use less energy, and have low living standards, behavior better adapted to their environment, a slower subjectively perceived rate of innovation and growth, and more fragmented cultures and societies.

Most of these are elements of the scenario explored in this book; ems seem to have less leisure and income, better-adapted behaviors, and cultures that are more fragmented than ours in important ways. Although growth is faster "objectively," that is, relative to a fixed clock, to the typical em growth seems slower "subjectively," that is, relative to the rate at which he or she personally experiences events.

CHAPTER 3

Framing

MOTIVATION

Why study future emulations?

Some readers of drafts of this book have told me they don't care much about future worlds where they don't personally expect to live, unless those worlds contain their children, grandchildren, or especially engaging fictional characters. And I must admit that the scenario I present here may not be especially well suited for dramatic or inspirational stories. But I will note that applying similar standards would declare most of history to also be uninteresting. Yet many of those who express low interest in the future also show great interest in many nooks and crannies of history.

Today, we take far more effort to study the past than the future, even though we can't change the past. People often excuse this by saying that we know far more about the past than the future. Yet modest efforts often give substantial insights into the future, and we would know more about the future if we tried harder to study it. Also, relative to the future, our study of the past has hit diminishing returns; most of the easiest insights about the past have already been found.

If policy matters, then the future matters, because policies only affect the future. And unless we are very pessimistic or self-centered time-wise, the *distant* future matters the most, as with continued growth we expect the vast majority of people to live there.

Furthermore, for most intellectuals most of the benefits that result from their policy discussions will happen with long delays; the path from an intellectual having a new policy idea, to publishing an article on it, to someone else reading that article, to that someone gaining policy influence, to them finally finding a chance to try that idea, to the tried policy having consequences, can take decades. If enormous changes will happen over the next decades, policy analyses that ignore such changes may be irrelevant or badly misdirected. It is thus important to try to foresee big upcoming changes, and their likely consequences.

Just as visiting foreign lands can help you to better see the distinctive features of your homeland, envisioning foreign times can help you to see the distinctive features of your era. Thus, understanding your descendants can help you to see who you are, and your place in history. We are the people who live now, after those who came before us, and before those who will come after us. We define ourselves in part by how we differ from our neighbors, both in space and time. Even if the future portrayed in this book doesn't happen, this analysis may still help you to see how different a plausible future world might be.

People are often interested in future events that can be seen as distant projections of recent trends, because discussing such future events offers them an indirect way to celebrate or lament current trends. For example, we might like a story about a future where people work very few hours per week, as a way to indirectly comment on current changes in work hours. But as most events described here are not projections of current trends, this book is less useful for this purpose.

Considering what our best theories suggest about future societies can also help us to test these theories. Today, we social scientists too easily succumb to hindsight bias and assume that the patterns we see around us are clearly implied by our theories of how society works. Thinking about future societies where such patterns are much less visible can force us to consider more carefully what our theories about how the world works actually imply. Such a thought experiment can help us to calibrate the confidence we should place in these theories, and to spot theoretical holes that we might work to fill. Eventually, when we see what the future actually holds, books such as this one may test the predictive power of today's standard theories.

This book takes the somewhat unusual approach of using basic social theory, in addition to common sense and trend projection, to forecast future societies. Even those who think that this particular analysis is mistaken may still be inspired and instructed by its example, to construct other basic-social-theory-based forecasts.

Hopefully, at least one of these mentioned reasons resonates with you.

FORECASTING

Some say that there is little point in trying to foresee the non-immediate future. But in fact there have been many successful forecasts of this sort.

For example, we can reliably predict the future cost changes for devices such as batteries or solar cells, as such costs tend to follow a power law of the cumulative device production (Nagy et al. 2013). As another example, recently a set of a thousand published technology forecasts were collected and scored for accuracy, by comparing the forecasted date of a technology milestone with its actual date. Forecasts were significantly more accurate than random, even forecasts 10 to 25 years ahead. This was true separately for forecasts made via many different methods. On average, these milestones tended to be passed a few years before their forecasted date, and sometimes forecasters were unaware that they had already passed (Charbonneau et al. 2013).

A particularly accurate book in predicting the future was *The Year 2000*, a 1967 book by Herman Kahn and Anthony Wiener (Kahn and Wiener 1967). It accurately predicted population, was 80% correct for computer and communication technology, and 50% correct for other technology (Albright 2002). On even longer time scales, in 1900 the engineer John Watkins did a good job of forecasting many basic features of society a century later (Watkins 1900).

Looking at those who focused on forecasting particular technologies, we find that in 1911 Konstantin Tsiolkovsky foresaw the basic issues and possibilities of space travel (Tsiolkovsky 1903). More recently, K. Eric Drexler used basic physical science to envision the outlines of atomically precise manufacturing (Drexler 1992, 2013). Others have used physics to envision the outlines of starships (Benford and Benford 2013).

Even taking into account the many unsuccessful forecasts, the successes to date seem more accurate than random chance predicts. So at least some people have better than random abilities to foresee future changes. Although real starships and atomically precise factories will surely differ in many ways from their forecasted outlines, these attempts are better guides to future factories and starships than random guesses, or the vast majority of movie depictions.

Many say that while physical possibilities can be foreseen, social consequences cannot. Such people are often trained in physical sciences, and don't appreciate that social scientists do in fact know many useful things. For example, social scientists today understand in some detail why our ways of life differ from those of farmers, and why farmers' ways differ from foragers' ways. Had our distant ancestors had access to such social science, they could plausibly have used it to foresee many aspects of our current industrial era. We should similarly be able to use basic social science to foresee many aspects of the eras that will follow ours, and this book is an attempt to prove this claim.

Some say no one could have anticipated the recent big changes associated with the arrival and consequences of the World Wide Web. Yet participants in the Xanadu hypertext project in which I was involved from 1984 to 1993 correctly anticipated many key aspects of the Web. And a 1999 business book used basic economics to accurately forecast many key Internet business issues (Shapiro and Varian 1999). Such examples show that one can use basic theory to anticipate key elements of distant future environments, both physical and social, but also that forecasters do not tend to be much rewarded for such efforts, either culturally or materially. This helps to explain why there are relatively few serious forecasting efforts.

But make no mistake, it *is* possible to forecast the future.

SCENARIOS

How can we envision a world of ems, even in dim outline?

My most basic method in this book is to focus first on expectations, rather than on hopes or fears. I seek first what is likely to happen if no special effort is made to avoid it, instead of what I might prefer to happen, or what I might want to warn others to avoid. It is hard to speak usefully about which directions to push the future if you have little idea of what the future will be if you don't push. And we shouldn't overestimate our ability to push.

In this book, I will set defining assumptions, collect many plausible arguments about the correlations we should expect from these assumptions, and then try to combine these many correlation clues into a self-consistent scenario describing relevant variables. That is, if my scenario includes factor A and we have good reasons to think that factor B tends to go with A, I'll also add B to the scenario, although with less confidence. I add B with more confidence the more confident I am of A, the more robust and deeper the reasons for thinking that A and B correlate, and the more independent reasons suggest B.

Constructing self-consistent scenarios such as this is a very common way to analyze complex situations, such as jigsaw or Sudoku puzzles, construction project plans, and even forecasts for national intelligence analysis. This is also the process we use today to study starships, nanocomputers, and the consequences of global warming (Pindyck 2013).

Historians also use this self-consistent scenario approach. For example, a historian estimating Roman Empire copper trade will typically rely on the best estimates of other historians regarding related factors such as nearby population, copper mine locations, trade routes, travel time, crime rates, lifespans, climate, wages, copper use in jewelry, etc. Although historians usually acknowledge some uncertainty, and for small sets of variables they sometimes identify more than one coherent set of possible values, historians mostly just construct best estimates to match other historians' best estimates.

Such straightforward scenario construction seems taboo among many professional futurists today. Such people dislike the label "futurist," preferring instead the label "scenario thinker." They embrace "scenario planning," wherein they create a modest number of scenarios to cover a wide range of possibilities across key axes of uncertainty and disagreement, with each scenario being story-like, archetypal in representing clusters of relevant driving forces, and describing equilibrium rather than transitory situations (Schoemaker 1995). Alas, I have so far been unable to make sense of their taboo, and so have simply plowed ahead and tried to build a self-consistent scenario.

The chance that the exact particular scenario I describe in this book will actually happen just as I describe it is much less than one in a thousand. But scenarios that are similar to true scenarios, even if not exactly the same, can still be a relevant guide to action and inference. I expect my analysis to be relevant for a large cloud of different but similar scenarios. In particular, conditional on my key assumptions, I expect at least 30% of future situations to be usefully informed by my analysis. Unconditionally, I expect at least 10%.

Consider that while the future matters more than the past, we have at least a thousand useful books on the past. So this book can be useful if it expertly studies a scenario with only a one in a thousand chance of happening.

When thinking in terms of specific scenarios, it is often useful to collect a set of scenarios defined as variations on particular "baseline" scenarios. Furthermore, it is often useful to choose as baselines not just especially likely scenarios, but also especially simple scenarios, so that they and simple variations on them can be more easily analyzed.

For example, even if a major war is likely sometime in the next hundred years, one may prefer to analyze a baseline scenario lacking any specific wars. This baseline will make it easier to analyze the consequences of variation scenarios, such as adding a war between India and Pakistan, or between China and Taiwan. Even if a major war is more likely than not, using a particular war scenario as a baseline can make it harder to define and describe other scenarios as robust variations on that baseline.

That is, it is in fact often a good idea to start looking for your proverbial keys under a lamppost. Your keys are probably not there, but that is a good place to anchor your mental map of the territory, so you can plan your search of the dark.

I will mainly present a single baseline scenario, centered on the appearance of cheap whole brain emulation. It will help that this main assumption is relatively discrete, without many complicating "almost" scenarios to consider. That is, mostly you either have a fully functioning emulation cheap enough for wide application, or whatever you do have isn't of much economic value. There aren't many interesting in-between scenarios.

The baseline scenario I generate in this book is detailed and self-consistent, as scenarios should be. It is also often a likely baseline, in the sense that I pick the most likely option when such an option stands out clearly. However, when several options seem similarly likely, or when it is hard to say which is more likely, I tend instead to choose a "simple" option that seems easier to analyze.

This simple-and-likely baseline strategy makes it easier to describe in more detail both this baseline scenario, and other scenarios defined as variations on it. But let us acknowledge that such a scenario is likely to be biased in the direction of being easy to understand. A real em future would probably be stranger than the baseline that I describe here, just as the real past is probably stranger than the histories that historians present.

Let me emphasize that point. Within many sets of plausible future options, the status quo is often the simplest and most likely option. Thus, my habit of using simple and likely values will tend to make my baseline scenario more like the status quo, and less strange than what the future is likely to be. But as we can't say much about in which specific directions reality is likely to be strange, this baseline scenario still seems our best reference for calculating concrete future details. Sometimes conventional wisdom is better than no wisdom at all.

CONSENSUS

In working out the details of my simple baseline scenario, my main method here, besides common sense and trend projection, is to rely on standard consensus theories in relevant areas of physics, engineering, and the social and human sciences, including business and social practice. Of course today's science is likely to be wrong in many ways, at least by the standards of future science. But as most of today's science probably won't be overturned, we can still gain insight by applying today's consensus science to this unusual question.

As a professor of economics, I emphasize the application of standard academic economics. While some of my conclusions follow directly from economics that has been thoroughly analyzed and empirically tested, usually I more flexibly apply economics-informed intuitions to the case at hand. I expect professional economists to recognize and usually approve of my applications, but I also expect that non-professionals may find it hard to see the connections. (Non-professionals note: economic theory often predicts outcomes that are not what most people vote for, due to coordination failures.)

For example, when possible I first assume, as does the baseline scenario in most economic policy analysis, a relatively competitive low-regulation equilibrium scenario. That is, I assume that while the world continues to coordinate in many ways at many scales on many topics, even so relatively little global coordination is achieved to change the price or quantity of brain emulations.

Note that this doesn't mean that I predict or recommend zero regulation, that I deny the possibility of strategically restricted supply and demand, or that I deny that unexpected changes are possible. It is just that we economists use such "supply and demand equilibrium" scenarios as our standard baseline reference for evaluating regulations and interventions. We do this because we are especially good at robustly estimating the consequences of such baselines. The main regulations that I tend to assume are those that seem most clearly and substantially economically efficient, as we do see a modest tendency toward economic efficiency in law and politics (Cooter and Ulen 2011; Weingast and Wittman 2008).

I thus assume that brain emulation is available relatively competitively, with many competing organizations able to profit from its application. I also assume that the world I describe is past a disruptive initial transition, when large unexpected changes were most influential. Any large-scale organized resistance to deploying this new technology has mostly failed. Although some slow echoes of the transition may remain in the future I describe, I focus on a time when society is mostly well described as being in a rough equilibrium between expectations and actions.

Note that if, instead of focusing on competitive scenarios, I were to analyze the consequences of particular regulations in depth, I would have to estimate both which combinations of regulations are likely to appear, and also the typical effectiveness of such regulations. But these things are hard to predict, because the political coalitions that support or oppose them are hard to predict. In addition, as both such estimate types are highly politicized, my analysis could then be more easily accused of having a political agenda. Of course by not considering any particular regulations, I can also be accused of being biased against regulation. When it comes to avoiding accusations of political bias, there is no absolutely safe ground in social science.

Not only are some things hard to predict, some things are hard to even describe. For example, even though we know much about our world, we find it hard to say how "free" the typical person is today, or what "rights" they have. Such things vary greatly by location and context, and these words lack precise definitions. You should expect it to be even harder to answer related questions about a future scenario.

Some claim that the economic theories popular among academics today are highly tuned to the personalities and mental styles common among economists today, and thus would not be chosen by people with different personalities and styles. But, in fact, our economic theories apply reasonably well not only to other classes and regions within rich nations today, but also to other very different nations today and to people and places thousands of years ago. Furthermore, formal economic models apply widely even though quite alien creatures usually populate them, that is, selfish rational strategic agents who never forget or make mistakes. If economic theory built using such agents can apply to us today, it can plausibly apply to future ems.

Some may complain that my analysis doesn't rise to the high level of certainty characteristic of "science," and knowing of no other level than "mere speculation," they may conclude that my estimates are no more reliable than any other speculation, and being less entertaining than most speculation, have little value. But, in fact, there is continuum of possible confidence levels, and good educated guesses, such as those I offer here, can rise far above the lowest possible levels.

SCOPE

The conclusions that I draw vary in their strength. Some are based on strong well-established theory, whereas others are based on weak clues such as analogies and trend projections. Some academics insist on only discussing conclusions with strong supporting evidence, but this needlessly discards useful information. As there are many interdependencies between a society's features in different areas, even weak guesses in some areas can help us to refine estimates of likely outcomes in other areas.

I thus seek tentative estimates on as many aspects of this future as I can. This is analogous to the standard statistical practice of examining the most-probable variable-value-combination in a formal Bayesian network probability model. The point is not to claim a high probability for one exact combination, but instead to make maximal use of variable relationships to inform all one's variable estimates.

One kind of weak clue I use is to follow the standard practice of assuming that existing patterns of social activity have robust functional explanations, even when they are poorly understood. I thus tend to assume that familiar social patterns will continue, unless we have particular reasons to expect otherwise. The more robustly we have seen a pattern across space, time, and subcultures, the more confidently we can expect that pattern to continue in an em world.

Of course there is a risk of mistaking local contingent social practices for robust functional patterns, and thus mistakenly assuming that ems must continue with our arbitrary habits. But there is also the opposite risk of failing to see the many ways in which the em world will be a continuation of our world, both because it faces similar problems, and because it will inherit many practices directly from our world.

This approach will work better if fewer large social changes occur between now and an em transition. I thus implicitly assume that other pre-em-era changes have smaller effects, that is, that the em transition is the next really big enormous revolution, on the order of the farming or industrial revolutions. For example, I assume that ems will appear before other forms of human-level artificial intelligence, a major genetic re-engineering of the human brain, invasion by aliens or demons, a totalitarian takeover of Earth, or the complete collapse of civilization.

A habit of assuming that familiar social patterns continue also works better for estimating earlier em eras, relative to later eras. My method is thus to focus on the first substantial em era. Although this era will no doubt be of a short duration on a cosmological time scale, understanding it better seems a good preparation for understanding subsequent eras. Just as foragers could have better anticipated the industrial era if they had first understood the intervening farmer era, a better understanding today of the early em era should help us better anticipate the eras that may follow it.

In sum, I apply consensus theories from many fields to build a broad self-consistent scenario, one that covers many aspects of the em world, and in which we can have far more confidence than "mere speculation." Although I chose this particular method to study a society of emulations, I don't mean to claim that it is the only or best method. I hope my efforts will inspire the application of other methods to this topic, and the application of methods such as this to other topics.

BIASES

In addition to the method of applying standard social science, I also use the anti-method of trying to avoid relevant biases.

For example, when predicting, we tend to rely too much on "inside" views that imagine specific internal arrangements of events and objects, and too little on "outside" views based on frequencies of related other events (Kahneman and Lovallo 1993). We tend to be more confident than our evidence justifies, and to anchor, that is, to change our initial opinions too little in response to new information. When valuing a change we tend to neglect its scope (e.g., saving 10 vs. 10 000 birds), and we tend to guess that changes with big gains have small costs (or risks) and vice versa (Yudkoswky 2008). Smart people succumb to many of these biases just as often as others (Stanovich et al. 2013).

We often consider the future in the context of fiction; the future has replaced far away lands as our favorite place for stories about not-obviously-impossible exotic and strange creatures, devices, and events. Thus, the standard biases of popular fiction are relevant. Compared with real events, fictional events are driven less by random complexity and more by people in overt value-driven conflict. Fictional characters have more extreme features, have attitudes more predictable from their history, better understand the reasons for their actions, are more willing to risk conflict to achieve their goals, and have actions more predictable from their context. Fiction set in the future often tells indirect morality tales about today's world, by having familiar issues and divisions remain important in the future, so that we can celebrate or criticize today's groups indirectly, via crediting or blaming fictional groups for future outcomes (Bickham 1997).

This book focuses on a rather unusual topic, and in general people who discuss unusual topics tend to be biased to use unusual methods, assumptions, and sources, and to draw unusual conclusions (Swami and Coles 2010). This correlation is biased, however, making opinions on odd topics overly odd and diverse, defended via an overly wide range of methods, sources, and assumptions.

Today, there is a subculture of "cultural rebel futurists," many of whom revel in "future shock" scenarios wherein today's dominant cultural assumptions are visibly challenged by future behaviors. But while cultures can indeed make big net changes over time, they usually also work to find ways to see such changes as minimal and straightforward extensions of previous ways. That is, cultures try hard to assimilate and normalize their changes. So people rarely see themselves as inhabiting worlds that have dramatically overturned many previous cultural assumptions (Rao 2012). We instead tend to see our recent cultural changes as modest.

That we know few details about the far future tends to prompt us to think about it abstractly, or "far," rather than concretely, or "near" (Liberman and Trope 2008). Because of this abstract-far construal, the construal-level theory of psychology predicts many features of the beliefs we will tend to hold about the distant future, regardless of whether we have good reasons to hold such beliefs.

For example, we tend to see fewer relevant categories of people, places, and things in the future, with the items in each category being more uniform. We expect things to be further away in both spatial and social distance, and expect events to be more novel, hypothetical, and unlikely. We expect analogies to be more relevant than math-like analysis, and we overconfidently expect both theories and analogies to apply more exactly with fewer exceptions. We expect to hear case-based arguments for claims, rather than feature-based arguments against claims. We expect best actions to be riskier.

Our abstract construal of the future also emphasizes basic values over practical constraints. We expect abstract goals to be more self-consistent, and to be pursued with more coordination and dogged consistency. We value future collections more by valuing representative members, rather than by adding up member values. We expect more happiness, power, and status, but feel relatively weak emotions about such things. We expect more love relative to sex.

Our abstract construal even leads us to expect future visual scenes to be cool, blue, and shiny, containing bigger spaces with fewer surfaces and milder textures. We expect voices to be polite speech relative to grunts and swearing. In fact these are all features of classic "futuristic" styles.

In general, we tend to more abstractly evaluate the actions of others, or of ourselves at other times, relative to how we evaluate our own immediate actions. This seems to help us to be unknowingly hypocritical, upholding high social ideals even as we usually act on less ideal priorities.

To counter all these biases, both in my readers, and in myself, I try to move my estimates in the following directions. I try to be less confident, to expect typical outcomes to be more ordinary, but also to expect more deviations from typical outcomes. I try to rely more on ordinary methods, sources, and assumptions, and also more on statistics of related systems and events.

I expect bigger deviations from traditional images of the future, but also rely less on strange, exotic, unlikely-seeming, and hypothetical possibilities. Looking backward, future folk should see their world as changing less from their past than we might see looking forward. Seen up close and honestly, I expect the future usually to look like most places: mundane, uninspiring, and morally ambiguous, with grand hopes and justifications often masking lives of quiet desperation. Of course, lives of quiet desperation can still be worth living.

Relative to what I would have otherwise expected, I expect more relevant categories of people and things, each more diverse internally. I expect such groups to be less easily mapped onto today's groups, and also less distant from us socially, spatially, and temporally. I also expect people to typically travel less far in social, space, and time dimensions. In contrast with science-fiction stories, I expect future folks to be less able to coordinate, to be less driven by basic values relative to practical constraints, and to be less aware of the reasons for their actions, actions that are less predictable from observable context. I expect future events to be less easily credited or blamed on standard factions of today. Spaces and views should be more complex, and hold more objects, each with more texture and complexity. The future will mostly not look sparse, blue, and shiny, or sound like polite speech, as in a classic "futuristic" style.

To resist the temptation to construe the future too abstractly, I'll try to imagine a future full of complex detail. One indication that I've been successful in all these efforts will be if my scenario description sounds less like it came from a typical comic book or science-fiction movie, and more like it came from a typical history text or business casebook.

This book violates a standard taboo, in that it assumes that our social systems will mostly fail to prevent outcomes that many find lamentable, such as robots dominating the world, sidelining ordinary humans, and eliminating human abilities to earn wages. Once we have framed a topic as a problem that we'd want our social systems to solve, it is taboo to discuss the consequences of a failure to solve that problem. Discussing such consequences is usually only acceptable as a way to scare people into trying harder to solve the problem. Instead, analyzing in detail the consequences of failure, to learn how to live with such failure, is widely seen as expressing disloyalty to your social systems and hostility toward those who would suffer from its failure.

I ask the reader's indulgence for my violation of this taboo. If we first look carefully at what is likely to happen if we do nothing, such a no-action baseline can help us to analyze what we might do to change those outcomes. This book, however, only offers the barest beginnings of such policy analysis.

Finally, a common human bias is that when both normative (what should be) and positive (what can be) considerations are discussed together, the normative tends to overwhelm and displace the positive. That is, we are so eager to express our values that we neglect the detailed groundwork on facts needed to give value discussions sufficient context to be useful. To avoid this bias, I set my job in this book to be only this: describe the future, given my key assumptions. It is *not* my job here to make me, you, or anyone *like* this future. Let us first just see it clearly, warts and all.

Though I have tried to avoid bias, I may have failed. For example, I may have "gone native," a visitor seduced by the charms of a new exotic world. As bias is more likely appear in my tone and overall evaluation, readers should rely more on my estimates of specific consequences.

CHAPTER 4

Assumptions

BRAINS

The concept of whole brain emulation has been widely discussed in futurism (Martin 1971; Moravec 1988; Hanson 1994b, 2008b; Shulman 2010; Alstott 2013; Eth et al. 2013; Bostrom 2014) and in science fiction (Clarke 1956; Egan 1994; Brin 2002; Vinge 2003; Stross 2006) for many decades. Sometimes emulations are called "uploads." Let me now try to be clearer about the technological assumptions whose consequences I seek to explore.

When I refer to a "brain" here, I refer not just to neurons in a head, but also to other supporting cells in the head, and to neurons and key closely connected systems elsewhere in the human body, such as the systems that manage hormones. Using that terminology, I assume, following a well-established consensus in the cognitive and brain sciences, that "the mind is just the brain" (Bermúdez 2010). That is, what the brain fundamentally does is to take input signals from eyes, ears, skin, etc., and after a short delay produces both internal state changes and output signals to control muscles, hormone levels, and other body changes.

The brain does not just happen to transform input signals into state changes and output signals; this transformation is the *primary* function of the brain, both to us and to the evolutionary processes that designed brains. The brain is designed to make this signal processing robust and efficient. Because of this, we expect the physical variables (technically, "degrees of freedom") within the brain that encode signals and signal-relevant states, which transform these signals and states, and which transmit them elsewhere, to be overall rather physically isolated and disconnected from the other far more numerous unrelated physical degrees of freedom and processes in the brain. That is, changes in other aspects of the brain only rarely influence key brain parts that encode mental states and signals.

We have seen this disconnection in ears and eyes, and it has allowed us to create useful artificial ears and eyes, which allow the once-deaf to hear and the once-blind to see. We expect the same to apply to artificial brains more generally. In addition, it appears that most brain signals are of the form of neuron spikes, which are especially identifiable and disconnected from other physical variables.

If technical and intellectual progress continues as it has for the last few centuries, then within a millennium at the most we will understand in great detail how individual brain cells encode, transform, and transmit signals. This understanding should allow us to directly read relevant brain cell signals and states from detailed brain scans. After all, brains are made from quite ordinary atoms interacting via rather ordinary chemical reactions. Brain cells are small, and have limited complexity, especially within the cell subsystems that manage signal processing. So we should eventually be able to understand and read these subsystems.

As we also understand very well how to emulate any signal processing system that we can understand, it seems that it is a matter of when, not if, we will be able to emulate brain cell signal processing. And as the signal processing of a brain is the sum total of the signal processing of its brain cells, an ability to emulate brain cell signal processing implies an ability to emulate whole brain signal processing, although at a proportionally larger cost.

Brain emulations require three supporting technologies: brain scanners, brain cell models, and signal-processing hardware (e.g., computers). Brain scans will be feasible when all three of these technologies are cheap and reliable. Recent developments in scanners and signal-processing hardware suggest that these technologies are likely to be ready within at least a century, and perhaps within only a few decades (Sandberg and Bostrom 2008; Eth et al. 2013; Sandberg 2014). Although progress in modeling brain cells also has been substantial, it is harder to estimate progress in this area. In modeling, often you don't know how close you are to being done until you are actually done.

Even so, it seems plausible that sufficient progress will be made within roughly a century or so. (Though some disagree (Jones 2016).) We would then have emulations. But what exactly is it that we will have?

EMULATIONS

For the purpose of this book I make the following concrete assumptions about emulations. I assume that sometime in roughly the next century it will be possible to scan a human brain at a fine enough spatial and chemical resolution, and to combine that scan with good enough models of how individual brain cells achieve their signal processing functions, to create a cell-by-cell dynamically executable model of the full brain in artificial hardware, a model whose signal input-output behavior is usefully close to that of the original brain.

Such a model emphasizes the key signal processing degrees of freedom of the brain, and ignores most of the rest of the vast irrelevant complexity there. Biology may use that extra complexity to keep the whole system working, but emulations could use much simpler methods.

The Whole Brain Emulation Roadmap (Sandberg and Bostrom 2008) considers in detail the technical feasibility of this scenario, that is, of "the possible future one-to-one modeling of the function of the human brain." It concludes:

> [Whole brain emulation] on the neuronal/synaptic level requires relatively modest increases in microscopy resolution, a less trivial development of automation for scanning and image processing, a research push at the problem of inferring functional properties of neurons and synapses, and relatively business-as-usual development of computational neuroscience models and computer hardware. This assumes that this is the appropriate level of description of the brain, and that we find ways of accurately simulating the subsystems that occur on this level.

This is the type of technology that I assume will become feasible and cheap, although my conclusions depend little on the particular level of description at which brains are emulated. By "cheap" I mean a situation where a human-speed emulation could be rented for substantially less than the U.S. median weekly wage in 2015, that is, 800 dollars a week. At this price, ems could compete with humans for most jobs.

Just as with the ordinary human from which an emulation was scanned, one could have conversations with an emulation, and often succeed at persuading it to do useful tasks. A functioning emulation would be capable of the same sorts of conversations, thoughts, attitudes, emotions, charisma, and mental skills as the brain from which it was copied. It would also be capable of emulating similar experiences, such as the taste of cherry pie, the burn of exercise, or the ecstasy of sex. The emulation would assume that it has consciousness and free will just as naturally as we do.

These are not *additional* assumptions—they are implied by the definition of an em. An accurate emulation of relevant detailed brain behaviors *must* also accurately emulate overall mental patterns. After all, in the same situation, an em must behave just as would the human from which it came. True, we can only say that the em must have the same outside visible reaction to its internal experiences; maybe cherry pie doesn't really taste the same to the em, even if it visibly responds to cherry pie in exactly the same way. Perhaps the em doesn't really taste anything at all. But of course we also can't be sure that any two humans have the same experience of cherry pie.

A usefully close brain model reproduces ordinary changes in adult brains, such as gaining long-term memories and skills with practice. It also needs to emulate relevant parts of the brain stem and hormone systems. If sleep is important for proper brain functioning, sleep periods must also be emulated. The earliest em era models need not, however, adequately model early childhood brain development, if that is different. It is sufficient to emulate adult brains.

Em models need not reproduce the many aspects of brains and brain cells that do not substantially contribute to their tendency to send signals out in response to incoming signals. In particular, ems need not reproduce non-signal aspects of "consciousness," if that exists. By definition, an emulation must appear to hear, feel, think, say, and do, just as a human does. Yes, one might claim that ems are not "truly conscious," and that they actually only pseudo-hear, etc. Even so, they go through exactly the same visible patterns of behavior; the em world looks exactly the same either way.

I further assume that brain signal emulation can be cheaply combined with appropriate android or virtual reality bodies, and given sufficiently rich and familiar sensory inputs, so that these combinations of emulated brains and bodies can, after the usual job training delays, effectively substitute for almost all ordinary human workers on almost all jobs. Physical jobs require a robotic physical body to control, whereas a virtual body is sufficient for most office jobs. Also, I focus on a time when all of this can be done at a cost well below the wages that most such jobs would have commanded had emulations not existed.

An enormous amount has been written, both careful and sloppy, on the possibility, feasibility, identity, and consciousness of brain emulations. However, the concepts of "identity" and "consciousness" that so animate many of those debates play little role in the physical, engineering, social, and human sciences that I will rely on in this book. So I will now say little more on those topics, and instead focus on the far more neglected topic of the social world in which such emulations would live, if they were to appear.

COMPLEXITY

How modifiable are emulations?

Although large complex software systems were designed to be understandable to humans, once they are built they are usually very difficult to substantially change in directions that their original developers did not anticipate and support. Large complex biological systems were not designed to be understandable by humans, and as a result are even harder to substantially change, even when we have a good understanding of their basic functions or mechanisms of operations.

Brain systems are especially complex biological systems that are far more complex than existing software systems, that were not designed to be understood by humans, and for which we often do not understand many of their basic functions or mechanisms of operation above a very low level of organization. Thus, it should not be surprising to hear that while neuroscientists have made impressive progress in understanding many brain processes, the task of understanding larger-scale brain organization has proven far more difficult. We are still a very long way from knowing enough to design new brains from scratch, to substantially redesign human brains, or to pull out modular functional units from brains capable of separately doing useful tasks.

Today, there are many things we don't understand about most complex biological systems. Although we can look in particular places and see which molecules are where at any given time and even sometimes swap them, we usually don't understand very well how all these molecular processes combine to perform useful functions. This greatly limits our ability to make useful modifications to biological systems. And human brains are one of the most opaque complex biological systems that we know.

I thus focus on an early emulation era, where em technology is mature enough for widespread application, but still remains basic and poorly understood, so that brain design remains mostly opaque above the lowest levels of organization. This early em era might plausibly end before the new em economy has completed ten or so economic doublings, a milestone that might be reached in as short a time as a year or two.

That is, I consider a point in time when it is still not yet possible to make much economic use of small parts of brain emulations, to usefully combine substantially different emulations, to design new brains from scratch, or to substantially redesign human brains.

Yes, in this scenario small-scale brain structures can be seen and often substantially understood. For example, at least one human today can see four dimensions of color, and it may require only a small brain design change to give everyone this ability (Jordan et al. 2010). However, such improvements would be based mostly on local changes that do not require or enable a deep understanding of overall brain design. But even if related improvements allow as much as a doubling of em IQ (assuming such a number is meaningful), it isn't clear this will change much about the scenario of this book. The issue of increased intelligence is considered more in Chapter 27, Intelligence section.

One could, in principle, give ems many new "senses" and "actuators" just by feeding signals into an emulated brain at unusual places, and by connecting sensors in unusual brain places to outside devices. However, these are unlikely to be of much use as there are no supporting brain systems to interpret those input signals or to control those devices. The complex sophisticated supporting systems for interpretation and control are all built around traditional human senses and controlled body parts, making those what ems find useful to see and control.

Emulations likely have dozens or more overall parameters that can be varied over ranges where most combinations produce viable emulations. Searches in this space may find many useful "tweaks," that is, parameter combinations that create ems that are especially attentive, inspired, energetic, moody, needy, etc. These combinations are like mind-altering drugs but with fewer harmful side effects, other than perhaps changed motivations. I assume, however, that even if this search finds some big wins, it also soon reaches diminishing returns, so that during the early opaque em era that I consider, such parameter combinations improve only modestly.

Thus, I assume that there is a set of useful tweaks available, but that their limited range and the inability to usefully rearrange em mind parts greatly limits the ability to create useful variations on em minds, and keeps em mind features near the familiar range of human variation. For the most part, em personalities and styles are recognizably human during the early em era.

In sum, I assume ems change in three ways: experiencing, copying, and tweaking. A copy can be made at any time of any emulation, after which the two versions diverge because of differing inputs and random fluctuations. After a modest time period (perhaps seconds, perhaps hours), these copies cannot be usefully merged again, although they may interact a lot. In addition, any em can be tweaked in a limited number of ways.

ARTIFICIAL INTELLIGENCE

Brain emulation is not the only possible way to make machines that can do almost all human jobs.

For over a half-century, researchers in "artificial intelligence" (AI) have tried to directly and explicitly design and write software to accomplish many of the impressive functions performed by the human brain. This AI approach to creating intelligent machines is very different from the direct brain emulation approach that is the focus of this book.

Brain emulation is more like porting software from one machine to another machine. To port software, one need only write software for the new machine that allows that machine to emulate the machine language of the old machine. One need not understand how the software that one has ported works; it can be an opaque black box. Standard AI software, in contrast, is more like writing a new software system for the new machine, inspired by seeing what software can do on the old machine.

In 1984, as a 24-year-old physics graduate student, I read about exciting developments in AI; it seemed to me that human level AI could be feasible soon. So I quit my physics graduate school, headed to Silicon Valley, and got a job doing AI at Lockheed. I stayed in AI for 9 years, and was part of the AI "boom" then. We've seen similar booms of excitement and anxiety regarding rapid automation progress every few decades for centuries, and we are seeing another such boom today (Mokyr et al. 2015).

Since the 1950s, a few people have gone out of their way to publish forecasts on the duration of time it would take AI developers to achieve human level abilities. (Our focus here is on AI that does human jobs well, not on passing a "Turing test.") While the earliest forecasts tended to have shorter durations, soon the median forecasted duration became roughly constant at about 30 years. Obviously, the first 30 years of such forecasts were quite wrong.

However, researchers who don't go out of their way to publish predictions, but are instead asked for forecasts in a survey, tend to give durations roughly 10 years longer than researchers who do make public predictions (Armstrong and Sotala 2012; Grace 2014). Shorter durations are given by researchers in the small AI subfield of "artificial general intelligence," which is more ambitious in trying to write software that is good at a great many tasks at once. A recent survey of the 100 most cited living AI researchers got 29 responses, who gave a median forecast of 37 years until there is a 50% chance of human level AI (Müller and Bostrom 2014). Incidentally, none of those 29 thought that brain emulation "might contribute the most" to human level AI.

It turns out that ordinary AI experts tend to be much less optimistic when asked about the topic they should know best: the past rate of progress in the AI subfield where they have the most expertise. When I meet other experienced AI experts informally, I am in the habit of asking them how much progress they have seen in their specific AI research subfield in the last 20 years. A median answer (among the dozen so far) is about 5-10% of the progress required to achieve human level AI, although some say less than 1% and others say human abilities have already been exceeded. Such researchers also typically say that they've seen no noticeable acceleration in progress over this period (Hanson 2012).

In addition, ordinary software experts that I've talked to, who do not specialize in AI software, have also seen slow progress in the intelligence of non-AI software systems. Most experts with decades of experience in software design see only modest gains within their areas of specialization.

In the past, projecting estimates of past rates of AI progress forward seems to have given substantially more accurate estimates of future AI progress than has asking people to guess. This makes sense, as we expect people to give more accurate estimates on questions where they have more expertise. We also expect more accurate future task duration estimates from an "outside view" of comparisons with related past tasks, instead of an "inside view" of thinking about how one might go about doing the task (Kahneman and Lovallo 1993). Both of these are reasons to prefer this past-rate method for estimating AI progress.

At the rate of progress seen by AI researchers in their subfields over the last 20 years, it would take about two to four centuries for half of these AI subfields to reach human level abilities. As achieving a human level AI probably requires human level abilities in most AI subfields, a broadly capable human level AI probably needs even longer than two to four centuries.

Some suggest that we've seen slow progress in AI only because society has devoted only a few thousand researchers to the subject. If so, then once we realize the huge economic value that AI could unlock, we may devote a hundred times as many researchers, and get proportionally faster AI progress. However, increases in research funding usually give much less than proportionate increases in research progress (Alston et al. 2011). Also, for many decades in many areas of computing we have seen the rate at which computer algorithms get more efficient remain surprisingly close to the rate at which hardware costs have fallen. This suggests that algorithm gains have been enabled by hardware gains, and so can't be rushed just by hiring more software researchers (Grace 2013).

Some people foresee big innovations in AI software architecture, which could enable trend-breaking rapid improvements in AI software, leading much sooner to human level AI (Yudkowsky 2013; Bostrom 2014). This book is not focused on such scenarios, which seem to me unlikely because high level architecture has historically been only modestly important in AI system performance. We have not seen huge innovations in such architecture, and we don't have strong reasons to expect high level architecture to matter greatly in human brain design. This issue is discussed more in Chapter 27, Intelligence section.

As we will discuss in Chapter 6, Entropy section, the rate of gains in active computer hardware commonly known as "Moore's law" is likely to slow in coming decades. So as software gains track hardware gains, software gains are also likely to slow in the coming decades. For example, if the rate at which hardware costs fall slows by a factor of two, then the fact that software gains closely track hardware gains suggests that it may take four to eight centuries to achieve a broadly capable human level AI. Some noted AI researchers have said directly that they think AI will take centuries (Brooks 2014; Madrigal 2015).

Thus, even if it takes a century to develop ems, we would by then be less than one-quarter to one-half of the way from where we are now to non-em-based human level AI. So even if the rate of progress speeds up greatly when ems arrive (which seems plausible as device cost declines tend to follow cumulative production (Nagy et al. 2013)), there could still be a substantial em era before non-em-based human level AI software is achieved. As we shall see, even if the em era takes a year or two of objective time, typical ems may see that as thousands of years in subjective time. The duration of the em era before AI software is discussed more in Chapter 27, Intelligence Explosion section.

The ability to experiment directly with brain emulations might speed the development of other forms of human level AI. Even so, the opacity of ems as complex systems should limit this progress.

Thus, an em era of substantial subjective duration can exist before ems develop human level AI. This book can thus focus on this early era. Yes, the em economy would likely find many uses for partial AI capabilities. But just as the overall economy today is far larger than the market for computer tools, during this early era em labor should also earn much more total income than do AI-based software tools.

CHAPTER 5

Implementation

MINDREADING

Compared with ordinary humans, it is much easier to directly read the internal state of an em mind. This should allow some types of "mindreading."

Consider taking two ems and trying to match parts in one of them to parts in the other, to say which parts are the "same." During the early opaque em era it will usually not be possible to make a complete match. Even so, some parts could be matched, such as the parts that receive initial inputs from eyes and ears. For matched parts, it should be possible to put the parts of one emulation into the same brain activation state as that of the matching parts in another emulation. So, for example, one might force an emulation to see and hear exactly what another emulation sees and hears. More parts can be matched for emulations of the same original human, especially if they have diverged for a shorter subjective time. Such more closely matched emulations could thus be arranged to more fully "read" each other's minds.

Mild mindreading might be used to allow ems to better intuit and share their reaction to a particular topic or person. For example, a group of ems might all try to think at the same time about a particular person, say "George." Then their brain states in the region of their minds associated with this thought might be weakly driven toward the average state of this group. In this way this group might come to intuitively feel how the group feels on average about George. Of course this should work better for closer copies, and after this exercise participating individuals might still return to something close to their previous opinions of George.

Even when minds cannot be matched part for part, statistical analysis of how activation in different parts and situations correlates with actions and stated feelings should allow cheap partial mindreading, at least for some shallow "surface" aspects of emulation minds.

Both of these types of mindreading require access to the internal state of an emulation process. Those not granted such access have an even weaker ability to read minds than do humans today. Today, humans routinely leak many features of their brain states via tone of voice, gaze, facial expressions, muscle vibrations, etc. In contrast, emulations could more easily use auxiliary software to control these channels either to mask and prevent such leakage, or to facilitate it.

Willing ems might allow friendly associates to use shallow mindreading and software aids that interpret gaze, tone of voice, facial expressions, etc., to read their emotions and thoughts more deeply than is commonly feasible today. But to avoid social weirdness, they may not acknowledge these readings explicitly. For example, it might be a mild taboo to point out that someone's words conflict with other readings of their mood and intentions.

That is, even when ems can read each other's minds, they may pretend that they cannot.

HARDWARE

What sort of physical devices are required to make an em?

As brain emulations would be implemented in artificial signal-processing hardware, our long engineering experience with the realized costs and features of such hardware gives us a basis for forecasting the costs and features of future em hardware. In fact, we now have many examples of artificial hardware designed specifically to emulate brain signal-processing (Merolla et al. 2014).

Em hardware could be designed at different levels of generality. At one extreme, ems could be run on general-purpose computers, while at the other extreme, em hardware designs might be specific to emulating particular scanned brains. At an intermediate level of generality, em hardware design might be specific to the task of emulating adult human brains, but not specific to particular brains. This would be analogous to graphics processors today, which are specialized to the task of projecting scenes full of three-dimensional objects onto two-dimensional screens, but not specialized to projecting particular kinds of objects or scenes.

Today, only a few kinds of processing tasks justify the creation of special purpose processors. To justify such treatment in the future, tasks should be very common, often needed continuously, and allow for much better performance with special hardware. While graphics and wireless communication tasks meet these criteria today, most other computing tasks do not; they are rare, intermittent, or have only modest gains from specialized hardware.

Brain emulations are run nearly continuously, and special hardware could probably achieve large efficiency gains. So if brain emulation became a very common computing task, this would probably be done on hardware specialized to the task of simulating ems. Hardware specialized to the task of running particular brains (or perhaps related sets of brains), however, seems a less likely or simple assumption; such hardware sacrifices economies of scale in design, manufacturing, and sharing for what may be only modest efficiency gains.

If very young human brains include development processes that are substantially different from those found in adult brains, it might make sense to have hardware specialized to the task of emulating young developing brains.

In principle, signal-processing hardware can be either analog or digital. While analog versions tend to use materials and energy more efficiently, they also tend to require designs more specialized to their tasks. In contrast, digital designs tend to benefit more from economies of scale and scope; general digital processors can be used for many different signal-processing applications. In practice, these scale economy advantages have so far been overwhelming; digital versions have displaced analog versions in almost all signal processing.

The simple assumption to make here, based on prior experience, is that many important parts of em hardware remain digital. However, it actually matters less whether em hardware is analog or digital than that the hardware can cheaply support many familiar features that digital hardware supports today. For example, I assume that for the hardware that can emulate almost any brain, it is cheap to add the ability to save copies of em states to archival memory, and to load such archived states back in to continue their emulation. It is also cheap to use error-correction to save these copies with virtually no errors.

Em mental states could thus be archived, or transmitted to distant locations, using something close to standard digital memory and communication technology. This allows em minds to become effectively immortal, at least if they can afford to store redundant dispersed copies, and to periodically buy new hardware to replace hardware destroyed by accidents or wear. (Of course one need not consider an em mind to be the "same" as its predecessor from decades earlier. Note also that I use the same words "copy" and "em" to refer both to the frozen digital state that encodes the emulation, and to the dynamic process in which an emulation has thoughts, takes actions, etc. Some prefer to use different words for these different cases (Wiley 2014).)

If emulation hardware is digital, then it could either be deterministic, so that the value and timing of output states are always exactly predictable, or it could be fault-prone and fault-tolerant in the sense of having and tolerating more frequent and larger logic errors and timing fluctuations. Most digital hardware today is deterministic, but large parallel systems are more often fault-tolerant.

The design of fault-tolerant hardware and software is an active area of research today (Bogdan et al. 2007). As human brains are large, parallel, and have an intrinsically fault-tolerant design, brain emulation software is likely to need less special adaptation to run on fault-prone hardware. Such hardware is usually cheaper to design and construct, occupies less volume, and takes less energy to run. Thus em hardware is likely to often be fault-prone and fault-tolerant.

Cosmic rays are high-energy particles that come from space and disrupt the operation of electronic devices. Hardware errors resulting from cosmic rays cause a higher rate of errors per operation in hardware that runs more slowly, with all else equal. Because of this, when ems run slower, with each operation taking more time, they either tend to tolerate fewer other errors, or they pay more for error correction. As we will see, this time period taken per operation will eventually increase during the em era to reduce energy costs.

If storing and sending em states become very common memory and communication tasks, special kinds of memory and communication hardware may be developed to support them. Those trying to compute other things would then sometimes try to reframe their tasks to look more like brain emulation tasks, just as today some reframe other computing tasks to look like graphic-processing tasks.

Signal-processing hardware costs, such as cost per operation and energy per operation, have fallen rapidly and relatively steadily for over a half-century. Some of these costs fall by a factor of two every year or two, in trends commonly known as "Moore's law." If we know the level of description at which brains must be emulated, we can use these trends to try to forecast the date at which the cost to rent em-supporting hardware will fall to less than the typical human wage.

In order of increasing detail, five possible levels of description at which brain processes could be emulated are (in technical language): (1) networks of neurons "firing" discrete signals to other cells, (2) changing ion densities within compartments inside neurons, (3) changing densities of metabolites and transmitters at finer scales, (4) densities of protein and expressed DNA at those scales, and (5) changing arrangements of protein subunits within larger protein assemblies. But even if one must emulate the finest of these levels of detail to make a functioning brain emulation, at rates given by Moore's law it would take only another half-century for a brain emulation device to cost about a million dollars (Sandberg and Bostrom 2008). After that, the cost of an emulation would fall by roughly a factor two every 2 years.

Actually, as we will discuss more in Chapter 6, Entropy section, growth rates have already begun to slow down relative to Moore's law (Esmaeilzadeh et al. 2012). While there has been no slowing in the fall of the average energy used per computation (Koomey and Naffziger 2015), processor speed gains slowed recently, and plans for many-layered chips suggest further difficulties roughly a decade from now.

In addition, it seems that gains will slow even further around 2035, when computer chips must be redesigned to enable reversible computing. (Reversible computing is discussed in Chapter 6, Entropy section.) With reversible computing, gains in making parts smaller, faster, and cheaper have to be split between supporting more operations and running each operation more slowly to use less energy. Because of this, the cost per operation may only fall roughly half as fast as it otherwise would have fallen. And we may discover other limits to continued hardware gains.

But even if hardware improvement rates fall by half compared with the familiar Moore's law, we should still be able to cheaply emulate brains in fine detail within a century. This is well before the over two to four century duration estimated in Chapter 4, Artificial Intelligence section, to develop expert-coded AI. Also, as we discussed there, progress in AI software research will probably slow as growth in computing power slows.

In addition to costs to buy or rent emulation signal-processing hardware, there are other costs to run such hardware. To find the "full" hardware cost to run an emulation, we can add together (1) costs to rent hardware to emulate a brain, related body parts, and a modest but comfortable virtual reality, (2) costs of redundancy and backups to insure against hardware failure, (3) costs of power and cooling to run the hardware, (4) costs to rent real estate to house the hardware, (5) costs for sufficient bandwidth connections to interact with others, and, finally, (6) costs of applicable taxes and "protection" to be allowed to do all this.

To find the full hardware cost of an em *worker*, one also needs to add the cost to have that em worker rest and sleep enough to recharge. It is this full em hardware worker cost that is the most economically relevant. If this cost is too high, few ems are created or used.

In sum, we plausibly know many useful things about the physical devices that enable emulations.

SECURITY

The ability to cheaply copy em mental states can subject ems to big risks. It is estimated that there are 20 million labor slaves around the world, which is less than 0.3% of the world population (International Labour Organization 2012). However, slaves made up about 10% of the population of the Roman Empire (Joshel 2010). Ems may be more concerned about the possibility of slavery than are we today, but perhaps less concerned than were residents near the Roman Empire.

A stolen copy of an em mental state might be interrogated, tortured, or enslaved, resulting in exposed secrets, credible threats of punishment, and stolen training investments (Eckersley and Sandberg 2014). By making many copies and then repeatedly trying different approaches on different copies, the thief might learn how to persuade the original of many things.

Also, for an em whose wealth is embodied in an ability to do particular tasks well, the theft of a copy who then competes with it in the labor market might take away most of that em's wealth.

Some ordinary humans may deal with such risks by not allowing themselves to be scanned to create ems. Among ems, "open source" ems deal with these issues by making themselves free to copy. If you paid for the hardware to run them, they'll try in good faith to do whatever tasks you assigned to them. Technically, such ems are more like a freely available compiled binary; opaque ems don't actually have a "source" code that one could pick apart and rearrange.

Open source ems might want to require that you not torture them, that you give them a 5-minute relaxation break every hour, or that you return a copy after it has done your task, in case others want a copy experienced at your tasks. But it may be hard for open source ems to actually enforce such requirements. As on-the-job practice is often a poor substitute for systematic but costly training, most ems are not open source ems. To recoup their training investments, most ems need to charge higher wages than open source ems can command.

Another extreme way to prevent mind theft is to use emulation hardware that lacks direct support for easy copying, and also perhaps a hardware casing that triggers self-destruction on detecting physical intrusion. This is akin to having an inbuilt cyanide pill. This is easier to arrange for ems in separate physical robotic bodies. Such measures seem needlessly extreme, however, as less costly measures seem viable.

Today, most personal computer systems have poor security; it costs a skilled professional relatively little to steal most files or to control the operation of most computers. Although it is quite possible to design very secure computer systems, doing so requires spending extra time early in the design process. This is rarely done.

However, in practice few actually suffer much personal harm from poor computer security—the files or computer resources that one might steal have little value to others. Similarly, although most homes today can be broken into at modest expense, few burglaries result. Social norms and law enforcement impose high enough costs to discourage most possible burglaries.

When more is at stake, as with banks or militaries today, more is invested in security. These investments usually stop near the point at which the cost of added security becomes similar to the expected extra security losses prevented. At such a point usually only a small fraction of income is spent on security precautions. Such an outcome also seems feasible for em security.

To estimate the fraction of em income spent on security, we can look at related fractions from other systems. Today in the U.S., estimates of the total cost of crime range from about 5% to 15% of GDP (Anderson 1999; Chalfin 2014). The global median of military spending is about 2% of GDP, although the U.S. spends about 5% and has at times spent much more. The immune system is a system for defending against attacking viruses and bacteria, and so is analogous to our social systems for defending against crime and invading armies. The human immune system consumes about 10% of body metabolism.

Ems may use technologies such as provably secure operating system kernels (Klein et al. 2014), and capability-based secure computing systems, which limit the powers of subsystems (Miller et al. 2003). Via such approaches, ems most likely spend less than 20%, and perhaps less than 5%, of income on local security, and probably even less on military security.

Even if such security costs are small, however, ems are eager to reduce them further. For example, rather than physically traveling to meet, ems might prefer to interact via virtual reality, keeping their brain hardware immobile in a secure castle among trusted associates. To maintain such fortresses, ems may prefer the increased loyalty available from assigning key security tasks to recent short-term copies of themselves, even if such copies are less expert at these tasks. As we will discuss more in Chapter 19, Firm-Clan Relations section, however, keeping brains within clan castles can make it harder for firms to gather their employees together in one place, to facilitate quick meetings.

Strong barriers might separate hardware that runs em minds from hardware that runs most other software, and visible rituals involving the participation of other trusted ems might be required to copy em minds, especially when moving to distant hardware. When ems must move their brains, such as to meet with a fast em who lives far away, they might prefer to use strongly encrypted communication channels. It might help to use quantum cryptography, which takes advantage of the fact that it is physically impossible to copy quantum states. The value of doing so is disputed, however (Stebila et al. 2010).

Ems may also discourage mind theft by limiting the resale value of the skills held in any one em's mind. This might be accomplished by acquiring skills that are tied to small unique organizational contexts, and that are less valuable outside those contexts. For example, there's less temptation to steal an em who mainly knows how to navigate the idiosyncratic rules and processes of a particular firm. Finally, ems may try to reduce the benefits that others derive from stealing them by developing troublesome habits when stolen. Ems who believe they are illicit copies might engage in disruptive lies, slow-to-be-discovered low productivity, and other forms of costly resistance. They may also try to develop habits of frequent coded interactions with trusted associates to determine if they are in fact illicit copies.

Although security is a concern for ems, it is far from an overwhelming concern. To a first approximation, the em world is civilized and peaceful.

PARALLELISM

Em hardware is signal-processing hardware, that is, equipment composed of many parts that each repeatedly takes in signals, changes internal states based on those signals, and then sends out more signals to other parts. Phones, radios, televisions, and computers are all types of signal-processing hardware. Most such hardware can be offered in different versions that run at different speeds, that is, at different numbers of basic operations per second. This has many implications for ems.

Compared with hardware with a differing architecture, hardware with the same architecture but with a different speed tends to require much less new design effort, and so can be offered at a lower added cost. All else being equal, faster hardware almost always costs more, both to construct and to run, in terms of energy and cooling.

The dependence of hardware cost on speed varies with how parallel is the signal-processing task. Parallel tasks can be broken into many parts that can be done at the same time, whereas non-parallel tasks cannot be broken down in this way. Non-parallel tasks have subtasks where some cannot begin until others have been completed.

For very parallel tasks, costs are typically proportional to speed. To obtain more operations per second, you just add more copies of the same sort of devices, assuming either that you can neglect the cost of memory, or that memory costs are proportional to processing costs. This means that for such tasks hardware costs vary almost proportionally with speed, resulting in a cost to achieve each task that is almost independent of the time taken to complete that task.

To run at speeds slower than a single processing system supports, many slow tasks can be swapped in and out to "time-share" a single processing system. In this case the processor cost of doing each task is mostly independent of speed, aside from the additional costs both to store the state of each task while it awaits its next time-share use, and to swap it back and forth.

Less intrinsically parallel tasks have this same cost-speed dependence at lower speeds, where time-sharing is used, but their costs rise faster at high speeds. One can't increase speed just by adding more devices; one must instead make some of the devices run faster, using special materials and construction. This raises the cost per basic operation. This approach usually hits a cost wall at a maximum speed, where no faster speed is possible at any cost, at least given then-current technology.

The processes that support signal processing in the human brain are famously parallel; each brain has about a hundred billion neurons, all sending and receiving signals in parallel. The brain may have up to 10 times as many other relevant cells. This strongly suggests that there will be a wide range of speeds at which one can make ems run faster just by adding more devices, implying that the costs of em hardware are roughly proportional to speed over this wide range. That is, it costs about the same to give an em a minute of subjective experience, whether that happens over an objective second or in an objective day. This includes the cost to make hardware, to protect and support it, and to power and cool it.

As brain emulation is a very parallel computing task, an em might run efficiently at a steady but very slow rate just by using one single slow processor. Time-sharing a larger computing system only makes sense for an em who wants to run even slower than this speed, or who wants to be dormant for long periods, and then run fast for occasional short bursts. When such slow ems time-share fast hardware, the added costs of swapping become less with longer delays between swaps, because slower-access memory can be used, which is cheaper. Today, the cost of memory varies by almost a factor of a million with the speed at which memory can be accessed. To minimize costs, the time duration between swaps tends to be as long as tolerable.

Time-shared ems can differ in speed, in the duration of the period between swaps, and in their phase of swap rotation, that is, when during their cycle they are active as opposed to paused. With long swapping periods, time-sharing ems running at the same speed could not interact regularly, directly, and conveniently if their periods and phases did not match well. To interact naturally and flexibly, a pair of ems needs matching speeds, periods, and phases. Pairs of ems that don't match in this way could communicate with some delay via text, audio, or video recordings.

Ems who do not time-share hardware can also choose to have periods and phases, because that fits their work or leisure lifestyle. Such ems also have time-sharing based limits on their interactions with others.

It is likely to be cheaper to use em hardware that is specialized to run ems of particular speeds. In this case, if em mind states can be transferred between such devices, then ems could temporarily change speeds by changing hardware devices. Given enough ems to efficiently share the required devices, with closely spaced hardware to support different speeds, and with cheap fast transfer between these devices, the cost of temporary speedups is nearly proportional to the temporary speed. In such cases, the total hardware cost to run an em capable of changing speeds remains nearly proportional to the subjective time that the em spent thinking, sleeping, etc.

Faster em minds will want to use faster memory, which is more expensive. In computers today, it takes roughly 400 CPU cycles to retrieve bits from DRAM memory, 50 000 cycles to retrieve from flash memory, and over a million cycles to retrieve from disk memory. Faster minds also prefer faster communication networks, with shorter time delays. While the speed of light sets minimum delays, very long cheap delays are possible, such as via sending hard disks via plane or boat. Over the last three decades the cost of sending bits long distances has fallen more slowly than has the cost of storing or computing bits. This suggests that during the em era the cost of using networks to talk and travel will slowly rise relative to the cost of memory and computing.

Clearly, an ability to run their minds at different speeds gives ems a great many new options, compared with humans.

PART II
Physics

CHAPTER 6

Scales

SPEEDS

Can we say anything about the specific speeds at which ems can run?

Because of brain parallelism, the cost of running an em should be nearly proportional to speed over a wide range of speeds. The upper limit of this proportional-cost em speed range is the "top cheap" speed, that is, the highest speed at which the cost is still nearly proportional to speed. To estimate this speed, we must consider how simulated neurons in em brains might both send faster signals, and more quickly compute what signals to send.

Human brain neuron fibers send signals at speeds ranging from 0.5 to 120 meters per second. In contrast, signal speeds in electronic circuit boards today are typically about half the speed of light. If signals in em brains move at electronics speeds, that would be between one million and 300 million times faster than neuron signals. If signal delays are the limiting factor in em brain speed, then this ratio gives an estimate of the maximum speedup possible, at least if em brains have the same spatial size as human brains. Proportionally larger speedups are possible if em brains can be made proportionally smaller.

Regarding the computation of when to fire a simulated neuron, note that real neurons usually seem to take at least 20 milliseconds to react (Tovee 1994), while even today electronic circuits can switch 10 billion times faster, in one-and-a-half trillionths of a second (Deal et al. 2010). A key question is thus: how many electronic circuit cycles does it take to execute a parallel computer program that emulates the firing of a single neuron?

For example, if there were an algorithm that could compute a neuron firing in 10 000 of these fastest-known circuit cycles, then an emulation based on this algorithm would run a million times faster than the human brain. As quite complex parallel computer programs can be run in 10 000 cycles, em speedups of at least one million times seem feasible, provided that energy and cooling are cheap enough to profitably allow the use of these fastest electronic circuits. When energy and cooling are more strongly limiting factors, however, the top cheap speed could be slower.

While the upper limit of the proportional-cost speed range is the "top cheap" speed, the bottom of this range is near the "base speed" at which computing and memory costs are equal. That is, at the base speed the computing cost to run an em mind over some time period is equal to the lowest feasible cost to simply store that mind state over that same period. ("Computing" here includes not just local processors, but also inter-processor communication.) For slow ems, total costs are roughly the sum of computing costs plus archive memory costs. For example, when ems time-share computing hardware, their cost is the sum of computing costs to run their mind when they are swapped in, plus memory costs to hold mind states while swapped out. Thus ems can't save more than a factor of two in total cost by running slower than the base speed.

As a fraction of human speed, em base speed is equal to the ratio of two hardware costs: (1) the memory cost to store an em mind, and (2) the computing cost to run such a mind at human speed. Thus the base speed falls over time if memory costs fall faster than computing costs, and the base speed rises if computing costs fall faster than memory costs.

Even though ems are not feasible yet, we can still use this cost ratio to define a base speed today. Over the last four decades computing and disk memory costs have both fallen at roughly the same rate, about a factor of two every year and a half, although disk memory costs have fallen more slowly in the last 5 years, raising the base speed. If we look at RAM (random access memory), a more expensive kind of memory, the cost of RAM has fallen at the same rate as computing costs for 60 years, and for 20 years before that computing costs fell faster (Dave 2015).

Thus the base speed has been roughly constant over four decades. This suggests that today's base speed may offer a reasonable estimate of future base speeds. In a few decades the cost of active devices but not memory will slow because of energy issues, as discussed in this chapter, in the Entropy section, and all else being equal that should push the base speed to fall more from then on.

While estimates vary widely, typical estimates are that a human brain state can be specified with 10 to 100 terabytes of information, and that human speed emulation requires about 20 to 60 trillion TEPS (traversed edges per second) in communication between processors, and roughly a billion billion to 10 trillion trillion FLOPs (floating point operations per second) in local processing (Grace 2015). These FLOPs estimates are from the three most likely levels (levels 1 to 3 from the list in Chapter 5, Hardware section) at which we will emulate brains, according to participants in an academic workshop on emulations (Sandberg and Bostrom 2008).

Combined with current prices for disk memory and supercomputer hardware (including both processors and inter-processor communication), these brain numbers imply estimates for today's em base speed that range from one-hundredth of a trillionth of human speed up to one-millionth of human speed, with a middle estimate of one-tenth of a billionth of human speed (Grace 2015).

Consider an em who spends one percent as much on periodically archiving copies of itself as it does on hardware to run its mind. These copies are stored indefinitely. In this case, the subjective frequency at which such archive copies are made is independent of mind speed, and goes inversely as both base speed and the objective doubling time for investments. For example, if investments double every objective month, and if base speed is one-millionth of human speed, then an archive copy is made after each 5 minutes of subjective experience.

The base speed is set by the price of the cheapest memory storage technology. This price per bit does not appear to be limited in the long run by a price per atom, as we can vaguely envision advanced technologies (e.g., photons in astronomically large cavities) that store a great many bits per atom.

When many similar ems are stored together, data redundancy across these ems may allow storage costs to be reduced substantially, lowering the base speed. Base speeds are also lower for ems who tolerate a higher risk of accidental erasure by being stored in fewer duplicate archive copies. Effective base speeds are also lower in situations where less is spent on security to protect storage from theft, either because the em archives sit in a safer environment, or because they are less desirable to steal.

We will say more in Chapter 18, Choosing Speed section, about the reasons ems might choose to run at particular speeds, such as to match the speeds of the physical systems they manage. To have names for ems of particular standard speeds, let us say that "kilo-" and "milli-" ems run a thousand times faster and slower than ordinary human brains, respectively, "mega-" and "micro-" ems run a million times faster and slower, and "giga-" and "nano-" ems run a billion times faster and slower. My rough guess is that linear-cost em speeds almost surely range from at least milli- to kilo-ems, and probably range from at least nano- to mega-ems.

The ability to run at different speeds opens up many new possibilities for an em society. However, it is a mistake to assume that rates of social development, such as economic growth, innovation, and intellectual progress, increase in proportion to the speed of either the fastest or the typical em minds. Rates of total change are more closely related to total economic activity, and thus to the sum total of *all* the activity in *all* of the em minds. Having fewer minds that each run faster, to give the same total activity as a larger number of slower ems, shouldn't much change rates of social development.

Even if faster speeds don't directly cause faster economic growth, however, we will see that differing speeds have many other consequences in the em world.

BODIES

Basic physical laws provide important relations between em speeds, sizes, reaction times, and relative distances.

The natural oscillation periods of most consciously controllable human body parts are greater than a tenth of a second. Because of this, the human brain has been designed with a matching reaction time of roughly a tenth of a second. As it costs more to have faster reaction times, there is little point in paying to react much faster than body parts can change position.

For ems with physical bodies to control, a basic physics relation between the length and period of oscillating parts creates a directly inverse relation between the sizes of em body parts and matching em mind reaction times: faster ems have smaller bodies. This is because the first resonant period of a bending cantilever, that is, a stick fixed at one end, is proportional to its length, at least if the stick's thickness scales with its length. For example, sticks twice as long take twice as much time to complete each oscillation. Body size and reaction time are predictably related for animals today, with larger bodies having slower reaction times, and this should continue to apply to ems with physical (robotic) bodies (Healy et al. 2013).

An em mind running 16 times faster than an ordinary human experiences a subjective day in 90 objective minutes. Because oscillation periods are proportional to length, this em could feel comfortable managing a 16 times smaller body of human shape and material properties. This body is about 10 centimeters tall. If it used proportionally smaller vocal cavities to speak, its voice has a pitch four octaves higher (although any voice pitch desired can be generated electronically easily). A kilo-em needs a body about one-and-a-half millimeters tall. That is, a kilo-speed-em is actually a milli-sized-em.

In rich nations today, less than one-fifth of jobs require the hard physical activity typical of farming, mining, construction, or manufacturing (Church et al. 2011; van der Ploeg et al. 2012). We should similarly expect that most ems have office jobs and do not need physical bodies. Thus jobs requiring a physical body might plausibly make up one-fifth or less of all em jobs. Ems who work in physical bodies are in the minority, but they'd be an important minority.

For physical jobs, the characteristics of each job determine a best-matching robotic body size, materials, and shape, and a best-matching mind speed. The actual shape of a physical em body need not be anything like an ordinary human body, and ems could change or swap their bodies as often as they find useful. Even today, humans can comfortably control a wide variety of machines, such as steam shovels, in mental modes where they treat such machines as an extension of their body (Church et al. 2011). And the em brain need not sit in the em body; the body might be teleoperated from a distance.

Note that as a physical body becomes larger, the cost of maintaining that body also becomes larger, while the cost of an em mind matching that body's reaction time becomes smaller. There is thus a natural em body size, where costs of the em's brain and body are the same.

The relative emphasis on mind quality versus body quality should vary as body size varies. For larger ems, it is cheaper to have higher quality minds, and more expensive to give them higher quality bodies. So large ems have higher quality minds, whereas small ems have higher quality bodies. High-quality minds might be faster and have more augmentations, while high-quality bodies might be made of better materials and include more added tools.

Clearly, em bodies vary a lot more than do our bodies.

LILLIPUT

Because em minds are typically faster than human minds, em bodies are typically smaller than human bodies. And even when em mind speeds are matched as well as possible to their body length, not everything seems the same to them. Things look and feel different in Lilliput.

For example, gravity seems weaker to creatures with smaller bodies. The strength of gravity influences the energy-efficient time periods between strides while walking or running, and between flaps while flying or swimming. For example, because a body that is four times shorter than normal could comfortably move its legs four times more often, in principle its strides could be four times more frequent, to give the same total velocity. However, because gravity seems weaker to this shorter creature, such strides are not energy-efficient. Energy-efficient walking strides actually step twice as far, to give an efficient velocity that is only half the size (Bejan and Marden 2006).

This theory is confirmed by the observed velocities of animals of different sizes. For example, the efficient walking speed for an elephant of 1 meter per second is about 20 times faster than that of a cockroach. This theory is also confirmed by the speeds of humans walking and running when their gravity is reduced (Sylos-Labini et al. 2014; De Witt et al. 2014). It could also have been confirmed in how astronauts walked on the moon, except that the moon astronauts' gait was distorted by their unwieldy space suits.

All of this suggests that fast em minds with proportionally smaller bodies walk more slowly, with strides that are longer, and with both speeds and strides proportional to the square root of body length. However, it is possible that ems will invent new ways to walk comfortably and efficiently. Most insects can walk on water. At moon gravity levels humans wearing flippers can run on water (Minetti et al. 2012). Small ems could run on water with ordinary shoes.

To ems that are smaller and faster, sunlight seems dimmer and shows more noticeable diffraction patterns. Magnets, waveguides, and electrostatic motors are less useful. Surface tension makes it harder to escape from water. Friction is more often an obstacle, lubrication is harder to achieve, and random thermal disruptions to the speed of objects become more noticeable. It becomes easier to dissipate excess body heat, but harder to insulate against nearby heat or cold (Haldane 1926; Drexler 1992).

The rate at which fluids pass around an em body scales well with size; a 1 meter per second wind is also a 1 millimeter per millisecond wind, and so looks the same to a kilo-em in a proportionally smaller body. However, a smaller em finds it much harder to resist the pressures of such a wind. Thus spaces where small physical ems congregate need to avoid strong winds. To such ems, ordinary density air feels much thicker than it does to normal-size humans.

A crude calculation using a simple conservative nano-computer design suggests that a matching faster-em brain might plausibly fit inside an android body 256 times smaller and faster than an ordinary human body (Hanson 1995).

Compared with ordinary humans, to a fast em with a small body the Earth seems much larger, and takes much longer to travel around. To a kilo-em, for example, the Earth's surface area seems a million times larger, a subway ride that takes 15 minutes in real time takes 10 subjective days, an 8-hour plane ride takes a subjective year, and a 1-month flight to Mars takes a subjective century. Sending a radio signal to the planet Saturn and back takes a subjective 4 months. Even super-sonic missiles seem slow. However, over modest distances lasers and directed energy weapons continue to seem very fast to a kilo-em.

To Lilliputian ems, the world is a *much* larger place.

MEETINGS

Ems can meet either directly, with adjacent physical bodies, or they can meet virtually.

An em physical body can either be run by em "brain" hardware placed inside that body, or the body can be tele-operated by an em in brain hardware at a distance that is small compared with the *reaction distance* where the communication delay equals the em brain reaction time.

For example, if signals travel at the speed of light, then to keep the round-trip signal time delay to less than a subjective reaction time of a tenth of a second, a 16 times human speed brain must be less than a reaction distance of roughly 1000 kilometers from its body. If we reduce the allowed signal delay to be only 10 milliseconds, then the brain must be within 100 kilometers. (All this ignores added delays from network hardware.)

Now consider two ems who want to hold a virtual office meeting, who run on brain hardware separated in space, and who have matching speeds (and periods and phases if those apply). There are two ways to support this scenario. One is to temporarily move the brain state of one into hardware located near the other, and then to use hardware near to both of them to compute their virtual office environment. The other way is to leave the em brains at their separated locations, and have hardware between them send virtual reality signals to each of them, as if they were together in the same office. The ems won't be able to tell the difference between these two approaches if the signal delay between their locations is much smaller than their reaction times.

Because it takes far fewer bits to describe the details of a virtual reality meeting than to describe a brain, for near-enough ems in a short-enough meeting it should be cheaper to leave their brains fixed and exchange virtual reality signals, rather than moving one of their brains. That is, brains stay where they are and are told where they are and what they see and hear in their virtual meeting room.

Virtual reality meetings are also more secure against mind theft, although perhaps less secure against eavesdroppers. Thus ems near each other who desire a virtual meeting can reduce both communication and security costs by leaving their brains in the same fixed hardware, and only virtually moving to a shared location.

When the hardware supporting two em brains is far enough apart in space relative to their speeds, however, communication delays become noticeable. Ems then have to choose between either having noticeably slow reactions to events in the meeting, or temporarily moving at least one of their brains to closer hardware.

Modest delays can be pretty tolerable though. At the distance where some ems see a tenth of a second light-speed delay, ems 16 times faster than normal see an often quite tolerable one-and-a-half second delay, and ems 16 times faster than those suffer only a 26 second delay. Today, many text-messaging conversations function acceptably with 30-second message delays. As with such messaging conversations today, ems who talk with noticeable delays may routinely talk with several others at the same time.

A fast-enough em that is physically near another em could credibly signal that fact by its quick reaction time. Ems could easily pretend to be far away when they were actually near, but they find it much harder to pretend to be near when they were actually far. Achieving this pretense requires heroic abilities to predict what other ems are about to do.

The process whereby one em "calls" another em to request an immediate meeting varies depending on the relative speeds of the two ems. When a fast em calls a slow one, this calling em may have to wait a long time for the slow em to respond to the call, and then move to faster hardware to allow them to interact naturally. In contrast, if a slow em has already sped up to the speed of a fast em before it makes its call, a meeting may proceed immediately.

All things considered, compared with humans, ems find it easier and cheaper to meet each other. This will have important implications.

ENTROPY

(The next two sections are especially technical, and few things later depend on them. Skip them if you prefer.)

To function, computers (by which I just mean artificial signal-processing machines) need many kinds of supports, including structural positioning, insulation from disturbances, communication, energy, and cooling. The need for free energy (or equivalently, negative entropy) is especially likely to induce a revolution in computer design within a few decades. After this revolution, many kinds of computer systems will likely be much more thermodynamically reversible. This includes ems.

Today, almost all computer circuits are made of CMOS (complementary metal–oxide–semiconductor) materials. A gate is the smallest logical unit on a computer chip, and the energy typically required for a simple CMOS gate operation has long been falling by more than a factor of 10 per decade.

(At least for chips that do not sacrifice performance for power or vice versa.) Projecting this trend forward, around the year 2035 the free energy used per CMOS gate operation should fall to the level of one bit, that is, to the free energy that thermodynamics says is required to erase one bit of information at ordinary temperatures (Drechsler and Wille 2012).

Computer logic gates erase bits (i.e., increase entropy) in two different ways. Ordinarily each simple gate erases one bit logically, because it converts two input bits into one output bit. In addition, each gate erases other bits non-logically, because the gate performs its logical operation quickly and away from thermodynamic equilibrium. Today, the vast majority of bits erased in computers are done non-logically. Thus there is today little point in structuring computer gates to avoid logical erasure.

Around 2035, however, the rate of non-logical bit erasure should fall to the rate of logical erasure. After that point, if energy cost per computation is to fall much further, then computers must switch to using "reversible" designs that only rarely erase bits logically.

(Some hope to reduce energy usage by running hardware at lower temperatures. But this won't reduce the use of free energy, which is the real resource needed. It is the creation of entropy that is the fundamental problem.)

For human brains today, most of their bit erasure is non-logical. As brains run at room temperature, use about 20 watts, and have about 100 billion neurons that each take a minimum of 20 milliseconds to react, brains in effect erase over a billion bits per neuron per minimum neuron reaction time. As there are roughly 1000 synapses per neuron on average, that is over a million bits erased per synapse per minimum neuron reaction time. Unless brain synapses are somehow doing the equivalent of a million logical operations per reaction time, the vast majority of the brain's bit erasure must be non-logical. This suggests that human speed ems built on reversible computer hardware require far less than 20 watts of power.

Another hint that most future computers will likely be miserly with energy is that the Earth has far more material to convert into computers than it has energy to run such computers at maximal rates. For example, by one plausible calculation of the typical energy consumption in a maximum-output nanotech-based machine (~10 watts per cubic centimeter), all of the light energy reaching Earth from the sun could be used by a single city of nanotech hardware 100 meters (~33 stories) tall and 10 kilometers on each side (Freitas 1999). Yet Earth has raw materials enough to build a vastly larger volume of computer hardware.

When computer operations lack a one-to-one mapping between input and output states, they are logically irreversible, and so must use free energy to erase bits. However, any irreversible mapping can be converted to a reversible one-to-one mapping by saving the input state along with the output state.

A clever fractal design allows one to create a reversible version of any irreversible computation (Bennett 1989). Imagine an ordinary irreversible computation that uses one particular processor unit and one matching memory unit. A reversible version of this computation could be completed in exactly the same amount of time. It costs a logarithmic-in-time overhead of extra parallel processor and memory units to reversibly erase the results of intermediate computing steps in the background (Bennett 1989).

This fractal reversing approach has a reversing period, which is the number of operation steps in the original computation before one has to logically erase one unit of memory. This reversing period can be doubled if one pays for one more unit each of processing and memory to hold and calculate intermediate steps. As a result, efficient reversing periods should roughly double each time the cost of computing hardware falls by half, relative to the cost of cooling and energy to run that hardware.

Today, computer gates are usually designed to change as fast as possible, and as a result they in effect irreversibly erase a great many bits during every gate operation. However, when the energy cost per operation does not fall as fast as the hardware cost, energy costs eventually dominate, forcing computer designers to focus on reducing the rate of bit erasure.

To erase many fewer bits per gate operation, computer gates can be run nearly "adiabatically," that is, slowly enough that key parameters change smoothly enough to make it cheap to reverse those changes. For adiabatic hardware, the rate of non-logical bit erasure is then proportional to speed; run an adiabatic gate twice as fast, and it erases twice as many bits per gate operation, or four times as many bits per second (Younis 1994). Because of high levels of brain parallelism, over a wide range of speeds it should thus cost twice the computer hardware to make an em brain that erases half as many bits per second of subjective experience.

For nearly adiabatic computers, the rate at which bits are erased nonlogically per operation is proportional to speed. For such machines, the speed that minimizes total costs per operation will spend about the same amount to rent the computer hardware as to buy the energy and cooling to run that hardware. These costs include both the space to hold the computers and their supporting energy and cooling systems. Thus the cost to rent the computing hardware plus the volume to hold it typically equals the cost to rent the energy and cooling hardware plus the volume to hold those, plus the cost of the raw materials used to make energy.

Because for adiabatic computers the cost of buying new hardware is about as important as the cost to power and cool that hardware, the logarithmic rate at which computing power becomes cheaper should be near the average of the logarithmic rates at which computer hardware becomes cheaper and the rates at which energy and cooling become cheaper. This is a reason why we might expect Moore's law growth rates for active devices (not memory) to slow down by about a factor of two after around 2035 when nearly adiabatic reversible computing becomes important. Historically, the price of energy and cooling has fallen much slower than has the price of computer hardware.

It might seem that when cooling is a major issue, computer hardware runs at as hot a temperature as feasible, as the rate at which heat is transferred via conduction is proportional to a local temperature difference. However, for adiabatic reversible computer hardware, the rate at which heat is generated is also roughly proportional to temperature, as it is determined fundamentally by the rate of bit erasure (also known as entropy production). Thus the best temperature at which to run such hardware is determined by other considerations.

MISERLY MINDS

The use of energy-efficient hardware can change em behavior in many ways.

For example, when a brain emulation is run on a reversible computer, then once per reversing period it must pay to erase a single maximally compressed copy of its period-ending brain state. So the end of a reversing period is a cost-effective time for an em to switch to a different speed, or to archive a mind copy, as archiving bits saves from having to erase them.

The fractal reversing method induces more re-computing of mental states that first appear toward the start or end of a reversing period. Because of this, those who give more moral weight, in terms of avoiding pain and encouraging pleasure, to mental states that are recomputed more often, should give more moral weight to experiences that occur closer to reversing period boundaries.

Ems who archive their messages, actions, or sensory inputs must pay a cost to store those bits, and most likely a cost later to erase those bits when they are no longer wanted. However, ems who do not choose to archive such things will try to minimize related bit erasures.

For example, ems must pay to erase bits to see or hear physical or social worlds outside themselves, if such worlds change in unpredictable ways, and do not cooperate to reverse their common computation. If an em watches and mentally processes a real waterfall, that em must pay to erase the equivalent of a high-resolution input "movie" of the scene. He or she must first pay to remember the movie for the rest of the current reversing period, and then at the end of that period must pay to save or erase the bits of that movie.

In contrast, an em who watches and mentally processes a virtual waterfall might coordinate and synchronize with the hardware that produces that virtual scene to reverse both calculations together. The em could even interact in detail with the waterfall (such as by "swimming" in it) without paying to erase any more bits. This gives ems a reason to prefer virtual over physical realities, especially standard virtual realities that many ems could share and hence reduce the costs of computing them.

Ems experiencing virtual nature are more "green" because this activity disturbs physical nature less, either directly or via the production of waste heat. Today, the human experience of immersion in nature, both real and virtual, predicts being generous, feeling autonomous, wanting enduring relations, and wanting to help society, while immersion in non-natural environments predicts valuing money and fame (Weinstein et al. 2009). So ems who spend more time in virtual nature are also likely to feel more autonomous and generous, and less selfish.

If ems have entropy-efficient long distance communication networks, then they might coordinate to reverse their messages to each other. In the simplest case, an em who receives a message from another em must pay to erase that message later. However, if the reversing periods and phases of the two ems sufficiently match, the message receiver can later send back an "anti-message" to be reversibly erased by the sender (Hanson 1992). The anti-message can cancel the original message, allowing both to be eliminated without the costly erasure of bits.

When there are substantial message delays, ems must save messages or mental states for longer to support "anti-message" production. This increases the relative costs of sending messages early in a reversing period, and of sending messages with longer time delays, such as to more distant locations. Because of this, ems prefer to send messages toward the end of their reversing periods.

Slow reversible hardware can be made to have a variable speed, so that the speed could change from moment to moment to accommodate varying demands. For such hardware, the number of bits erased per operation goes inversely as operation time. That is, when each operation takes longer, fewer bits are erased per operation. By using such hardware to emulate brains, an em mind could temporarily speed up, if it were willing to temporarily pay a higher bit erasure cost per operation. Such an em could also temporarily slow down, and pay a lower energy cost per operation.

Temporary speed-ups require that there be some slack or buffer in the heat disposal system, so that the temporarily added heat doesn't overwhelm that system. Because the typical choice of hardware operating speed should be near an optimal tradeoff of hardware versus cooling costs, temporary small fractional changes in operating speed near this optimum should result in much smaller fractional increases in the total cost per operation.

Variable speed em hardware is especially useful in situations where demands for mental effort vary quickly and unpredictably. For example, in conversation you could slow down while listening and speed up while talking. You could slow down when you are waiting for inputs from others, and speed up when others are waiting for inputs from you. Monitors could slow down when what they were monitoring was relatively inactive, and speed up when such activity momentarily increased. Complex social norms may develop regarding when it is acceptable to speed up or slow down relative to interaction partners.

The use of slow reversible hardware probably reduces the top cheap speed, that is, the highest speed where the cost per operation is nearly the same as at low speeds. Thus as the costs of local heat disposal and energy usage rise, the local top cheap speed falls.

When other rates of bit erasure are lower, then ems will want longer reversing periods to also reduce reversing period erasures. As non-logical bit erasure rates are higher in the early em era, typical reversing periods are then short, plausibly corresponding to shorter than a reaction time. In this case the need for reversible hardware may have few effects on em behavior.

Later, however, bit erasure rates may be much lower, and then longer reversing periods may change em behavior more. For example, costs of reversing encourage ems who want to interact often to coordinate to share the same reversing periods and phases, and to prefer interactions with things outside themselves to happen away from reversing period boundaries.

If the cost of computing fell by factor of a million relative to the cost of energy and cooling, then the reversing period could change from a subjective reaction time of a tenth of a second to a subjective day. (This may not happen until long after the early em era.) With a reversing period of a day, it could make sense to end reversing periods during sleep, and for ems to interact the most with others just before going to sleep.

Ems who interact often want to share reversing periods and phases, to cheaply share special hardware and processes used at the end of a reversing period. However, ems who interact less are more likely to have different reversing phases, to more efficiently share hardware specialized for end of period tasks. This increases the costs of interaction between ems who interact less often.

It seems that the more miserly ems become with energy, the more that energy issues influence their behavior.

CHAPTER 7

Infrastructure

CLIMATE

As we will discuss in Chapter 18, Cities section, em cities are likely to be big, dense, highly cost-effective concentrations of computer and communication hardware. How might such cities interact with their surroundings?

Today, computer and communication hardware is known for being especially temperamental about its environment. Rooms and buildings designed to house such hardware tend to be climate-controlled to ensure stable and low values of temperature, humidity, vibration, dust, and electromagnetic field intensity. Such equipment housing protects it especially well from fire, flood, and security breaches.

The simple assumption is that, compared with our cities today, em cities will also be more climate-controlled to ensure stable and low values of temperature, humidity, vibrations, dust, and electromagnetic signals. These controls may in fact become city level utilities. Large sections of cities, and perhaps entire cities, may be covered, perhaps even domed, to control humidity, dust, and vibration, with city utilities working to absorb remaining pollutants. Emissions within cities may also be strictly controlled.

However, an em city may contain temperatures, pressures, vibrations, and chemical concentrations that are toxic to ordinary humans. If so, ordinary humans are excluded from most places in em cities for safety reasons. In addition, we will see in Chapter 18, Transport section, that many em city transport facilities are unlikely to be well matched to the needs of ordinary humans.

Higher prices to rent volume near city centers should push such centers to extend both higher into the sky and deeper into the ground, as happens in human cities today. It should also push computers in city centers to be made from denser physical devices, that is, supporting more computing operations per volume, even if such devices are proportionally more expensive than less dense variants. City centers are also less likely to use deterministic computing devices, if such devices require more volume and cooling.

It may be possible to make computing devices that use less mass per computing speed supported, even if they cost more per operation computed. Such lighter devices are more likely to be used at higher city elevations, because they reduce the cost of the physical structures needed to hold them at these heights. Lighter computing devices are more likely to be found near city centers, where altitudes are higher.

Computer and communication hardware is in general distinguished by the generation of its design, with more recent design generations tending to be more reliable and to use less volume, mass, power, and cooling. When it is cheap enough to move such hardware, or to change the location of city centers, then older hardware will tend to be further away from city centers where volume, power, and cooling cost more.

Cities today are the roughest known kind of terrain, in the sense that cities slow down the wind the most compared with other terrain types. Cities also tend to be hotter than neighboring areas. For example, Las Vegas is 7° Fahrenheit hotter in the summer than are surrounding areas. This hotter city effect makes ozone pollution worse and this effect is stronger for bigger cities, in the summer, at night, with fewer clouds, and with slower wind (Arnfield 2003).

This is a mild reason to expect em cities to be hotter than other areas, especially at night and in the summer. However, as em cities are packed full of computing hardware, we shall now see that em cities will actually be *much* hotter.

COOLING

Many innovative devices have been proposed to lower the costs of generating and transporting energy. New generation options include solar power satellites, thorium nuclear reactors, and fusion reactors, while new energy transport options include superconducting cables and anti-matter. These devices may be able to supply high levels and densities of energy to em cities at low cost.

It seems harder, however, to imagine innovative ways to dramatically improve our abilities to cheaply cool large volumes of computers. Cooling is a very well understood physical process, and most proposed approaches seem to be relatively minor variations on existing ones. This suggests that for large dense em cities during the early em era, cooling might be more of a limiting factor than energy.

Today, we usually cool systems by moving a cooling fluid such as air or water close to the heat source that we want to cool. The fluid comes in cold and moves out hot. One might imagine very low-friction transport systems, like railroads or aerial trams, that could move cooling materials in and out at a very low energy cost. However, today simple pipelines usually have much lower energy costs, and also total costs, than rail and other existing transport mechanisms. So the simple assumption to make here is that ems cool their cities via fluid cooling pipes.

Readers tempted to see pipes as a primitive technology should know that pipes rank high on "product complexity," meaning that nations must master an unusually wide range of abilities to make pipes well. Specifically, in 2013 pipes had an average complexity rank of 350 out of the 1239 product types ranked (Hausmann et al. 2014).

Metabolism in individual plants and animals follows a scaling law; organisms that are 16 times as massive tend to have half the per-mass metabolism. Some have attributed this trend to fundamental difficulties in managing piping systems to pull nutrients in and push waste out for large serviced volumes (Savage et al. 2008).

However, we actually know of fluid-based pipe cooling designs that can efficiently cool large em cities. Biological fluid-based pipe systems such as blood vessels are fractal in the sense of having a branching structure that looks similar at different scales. There are simple fractal pipe designs that can efficiently import cool fluids such as air or water from outside a city to near every point in that city, and then export heated fluids from near every point in the city to outside the city volume (Bejan 1997; Bejan et al. 2000; Bejan 2006). These fractal cooling system designs require cost overheads that are logarithmic in the total size of the city. That is, such overheads increase by only a constant amount when a city size is doubled.

Closest to each tiny piece of computer hardware, heat can be transported away via materials such as metals that conduct heat well. Alternatively, small heat pipes might be used. These conducting materials or heat pipes can end in tiny cooling fans inside tiny fluid cooling pipes nearby. As the fluid moves away from these fans, tiny pipes merge into larger pipes where the fluids move faster. At some point the fluid switches from smooth to turbulent flow, but this only increases the size of the constant cost overhead added each time city size is doubled.

Colder fluids flowing from outside the city toward the tiny cooling fans reverse this pattern, breaking up into more pipes that are each smaller and have slower moving fluids. All else equal, input pipes require more volume for insulation because of their larger temperature difference from hot computer hardware. The use of a shared cooling system encourages nearby city volumes to maintain temperatures close to each other, and to exiting cooling fluids.

The two main costs of a cooling system are (1) the power required to maintain the pressure difference that pushes cooling fluids through the city, and (2) the fraction of city volume devoted to the cooling pipes. (The cost to make the pipes is comparatively small.) Both of these costs increase as the logarithm of the city's volume. That is, every time the city volume doubles, not only does the same additional fraction of city volume have to be devoted to a new kind and size of pipe to cool that city, but the same additional pressure must be added to the pressure difference between the input and output ends of the cooling pipe system.

The economic value produced in a city is often modeled as a low power (greater than one) of the economic activity in that city (Bettencourt et al. 2007, 2010; Schrank et al. 2011). As mathematically, for large volumes a power of volume grows faster than a logarithm of volume, the greater value produced in larger cities can easily pay for the higher costs of cooling larger cities. Thus costs of cooling do not limit em city sizes.

For very small city volumes, however, the added costs to cool a larger volume might outweigh the added economic value a larger city volume could produce. Thus there may be an important economic niche for small isolated "towns" of ems that take advantage of cheaper computing power because of their lower cooling costs. After all, when cooling and energy are together four times cheaper, computing power becomes twice as cheap. So isolated em towns may specialize in doing jobs where cheap computing matters more than the fast flexible communication and transport with many other ems available in large cities.

When the cross-section of a pipe is doubled, the rate at which fluid flows through that pipe more than doubles. Thus there are scale economies in the total amount of cooling supplied to a city of fixed size. The exact magnitude of these scale economies depends on whether fluid flow is smooth or turbulent.

With adiabatic computing, about the same amount should be spent on computing hardware as is spent on energy and cooling to run that hardware. Because of this, in em city centers where the cost of space is high, energy and cooling systems should take up roughly the same volume as the computers themselves. As computer hardware tends to be more expensive to make per unit volume than energy or cooling hardware, the energy and cooling systems may actually tend to take up more volume than the computing hardware. The cooling pipe fraction may be even higher toward the city periphery, as pipes to cool a city center must pass from outside the city through the city periphery.

As cooling tends to require more space than does energy generation and transport, most of the space devoted to energy and cooling is likely devoted to cooling. Thus in em cities densely packed with computer hardware, a substantial fraction (likely 20-70%) of em city volume is devoted to cooling pipes.

Because of their higher costs of cooling, larger em cities tend to use less energy relative to hardware, and thus use longer reversing periods, which reduces the local top cheap speed. The very fastest ems thus tend to live in smaller communities, away from big city centers.

As cities pull in cool fluids and push out hot fluids, heat engines might be created well outside the cities, engines that use this temperature difference to produce energy. For example, power-generating kites might even surf strong hot winds that rise above em cities. However, it seems hard to design cost-effective heat engines that take advantage of this temperature difference.

AIR AND WATER

The two obvious candidates for em city cooling fluids are air and water. Cities that are primarily air-cooled are arranged somewhat differently from cities that are primarily water-cooled. (There is also a remote possibility of cooling via superfluid Helium II, at below 2° Kelvin. This fluid can have low viscosity, high heat conductivity, and high entropy transfer rates (Gully 2014).)

Air-cooled cities pull in a lot of cool air and push out a lot of hot air. Most of the hot air exits above the city, into a tall cloud of hot air rising above the city. A strong wind pulls cool air in from outside toward the outside base of the city. As hot air rises, this force can pull air through the system, as it does today in the cooling towers of power plants.

The hot-air-rises force is proportional to the height difference between air entering and exiting the city. It is also proportional to the difference in (inverse) air temperature between entering and exiting air. Tall cooling towers might be added above em city centers to increase this height difference, and thus increase the pulling force. Such towers may have the hyperboloid shape often seen today in power plant cooling towers, because such shapes have superior strength as structures made from straight struts. Scale economies in building towers might encourage cities to mostly cool via a single main tower. The tallest cooling tower today is over 200 meters high; em city towers could be much taller.

The fact that air tends to become more viscous at higher temperatures pushes air-cooled cities toward using lower temperatures. This effect also reduces the size of the pipes of air entering cities, relative to outgoing air pipes. Air-cooled cities might be placed on large flat dry cold plains, such as in Sweden, Siberia, Canada, or Antarctica.

The ability of air to cool is proportional to its pressure, while its viscosity, or resistance to pressure, is independent of pressure. Because of this, air-cooled cities are tempted to use high-pressure air. Five atmospheres of air pressure can have similar cooling abilities to water. However, using high-pressure air for city cooling requires large pressure differences between the inside and outside of a city. One might manage this pressure difference in the cooling system via heat exchangers that intertwine pipes with high and low pressure air, or via compressors that increase the pressure of incoming air, combined with turbines to capture energy from the falling pressure of outgoing air.

Both air and water-cooled cities are likely to have winds moving in toward them and tall clouds of hot air rising above them, although both of these should be larger for air-cooled cities. Such winds and clouds might be like those often associated with active volcanoes.

Water-cooled cities pull in a lot of cold water and push out a lot of hotter water. The larger the temperature difference between the incoming and outgoing water, the more cooling is provided. This gives a preference for pulling in very cold water, which suggests locating such cities on the coast near the Earth's poles, such as in Scandinavia or Argentina, or perhaps under the ocean, where temperatures of 4° Centigrade are available. Microsoft has begun to develop such subsea data centers (Markoff 2016).

The advantage of a larger temperature difference also suggests pushing out water that is nearly steam, that is, near the boiling point of water. However, water that is too near the temperature of steam risks creating explosions of actual steam because of temporary flow blockages. Water-cooled cities also suffer more risk of water leaks that damage nearby equipment, and so need to be better protected against such corrosion.

Hotter water has a lower viscosity, that is, a lower resistance to being pushed through a pipe. This implies that input pipes of cool water are larger than output pipes of hot water, and that it is cheaper to cool with warmer water. This encourages water-cooled cities to be hot, with computer hardware temperature near the boiling point of water.

A slurry of water containing small ice pellets can cool much better than can water by itself. For example, a slurry with a 20-25% volume of ice flows nearly as easily as does plain cold water, yet has about five times the cooling capacity. Salt-water helps to make pellets smaller, with pellet diameters of 20-50 micrometers available via today's standard technology. Seawater-based ice slurry cooling systems are now often used on fishing boats to keep fish cool (EPSL 2014; Kauffeld et al. 2010).

The advantages of ice slurry cooling seem likely to be irresistible, pushing em cities to prefer water over air cooling, and pushing cities to keep input pipes insulated enough to carry an ice slurry. Cooling pipes with a 0.1 millimeter inner diameter should be able to come close enough to each heat source to allow the remaining heat transport to be done via simple heat conduction in metal or small heat pipes (Faghri 2012; Gully 2014).

Pipe walls covered with melting ice can cut the friction of water flowing past such walls (Vakarelski et al. 2015). Also, dense solutions of bacteria in water have recently been seen to eliminate the viscosity of that water via coordinated motions of bacteria tails (López et al. 2015). Analogous mechanisms might be used to greatly increase the flow capacity of em water pipes.

Like air-cooled cities, water-cooled em cities are also likely to gain from locating in cold places. While air-cooled cities may seek flat cold plains, water-cooled cities seek to be near lots of cold seawater. They might even go deep in the ocean, for easier access to colder water, if costs were not prohibitive to modify transport and manufacturing methods to handle the very high pressures resulting from having seawater over em city buildings.

Whether cooled by air or water, em cities could look quite different from human cities.

BUILDINGS

How might buildings differ in an em era?

As we will see in Chapter 13, Efficiency section, the em world is focused more on efficiency and function, and less on showing off wealth and individuality. In particular, compared with structures in our cities, structures in em cities focus more on cheaply and efficiently supporting a more limited range of tenants. Em buildings mainly hold computer hardware and supporting infrastructure.

Buildings require structural support, to hold matter up against the gravity that pulls them down, to resist the wind pressures that push them sideways, and to deal with internal stresses resulting from earthquake ground vibrations. The relative importance of these issues changes in an em economy.

Today, buildings are typically required to withstand the biggest earthquakes expected to appear over the next century, which is near the useful lifetime of most buildings. As we will see in Chapter 16, Growth Estimate section, an em economy may grow faster than our economy by a factor of 100 or more. Because of this, buildings only need to last for durations that are this factor shorter than buildings need to last today. As the strength of earthquakes are inverse to their frequency, so that stronger quakes happen less often, this implies that em buildings only need to be built to handle maximum earthquake ground vibrations this factor weaker than the vibrations that buildings today must handle. The need to handle earthquakes 100 or more times weaker makes it easier to build taller buildings for em cities.

For tall buildings today, wind pressures are a bigger problem than gravity. Like trees in a forest, buildings in cities today are each responsible for their own wind resistance; they rarely connect to give mutual support, even though such mutual support can make it much easier to resist wind pressures. Builders of tall buildings today haven't managed to coordinate to arrange such mutual structural support. However, em cities might use combinatorial auctions, discussed in Chapter 15, Combinatorial Auctions section, to coordinate decentralized management of structural support to protect buildings against vibrations, gravity, and winds. Auction bids could specify acceptable locations, the structural support they need or are willing to supply, and the average and peak vibrations they will emit, absorb, and tolerate. This can allow em city structures to more closely resemble a large three-dimensional lattice of supports holding diverse components. Such a lattice can make it cheaper for em cities to reach higher into the sky.

Today, the Burj Khalifa in Dubai, completed in 2009, is the world's tallest building at 830 meters high. A 1007-meter Kingdom Tower in Jeddah is under construction, to be completed in 2019. A 15-kilometer tall tower has been designed with steel as its structural material. Even taller buildings seem possible using lighter stronger materials such as graphene and carbyne, and using better fractal designs for structural supports (Farr 2007b; Farr and Mao 2008; Rayneau-Kirkhope et al. 2012). Factoring in continued progress in building materials, the reduced importance of earthquakes for ems, better coordination to resist winds, and stronger economic pressures for denser city concentrations, em city centers might perhaps rise to a kilometer or more over kilometers-wide regions.

However, the em economy places one very big obstacle in the way of tall em city buildings. As we shall see, the em economy grows very rapidly, perhaps doubling every month or week. Because of this, the time delays required today to construct buildings are prohibitively expensive in an em economy. This is because the cost of a building roughly doubles for every additional economic-doubling time added to the time required to finish construction. So the 6 years that it took to build today's tallest building is completely unacceptable in the fast em world.

Thus there are huge premiums placed on fast construction, and the added time required to build taller buildings might limit how high em cities grow. To allow both rapid construction and rapid flexible changes later, buildings might be made out of modular units (Lawson et al. 2012). For example, in a recent demonstration in China a 57-story building was built in only 19 days (Diaz 2015). This is three stories per day, a 50% increase over the two stories per day rate achieved by the same team less than 4 years before.

To speed construction, computing hardware placed inside modular buildings might come in standardized modular units such as shipping containers that can be more easily moved as needed, with standard interfaces providing utility services to such containers. Buildings might be, in effect, huge shipping container warehouses.

Going further in this direction, a city brimming with computer hardware and water-filled cooling pipes might perhaps be built out of incompressible "bricks," where each brick is full of useful hardware devices, but where inside volumes that would otherwise be empty are instead filled with stone or water and perhaps tension wires. Such bricks might be stackable to very large heights while requiring much less structural support than do items held in tall buildings today. Structural supports might then be mainly needed to assist with disasters and with periodic rebuilding efforts.

Today, moderately tall buildings are actually cheaper than short buildings. In most rich nations today, the building height for which the cost per square meter of useful space is lowest for experienced construction teams is at least 20 stories high, and perhaps 40 stories or higher (Pickena and Ilozora 2003; Blackman et al. 2008; Dalvit 2011). Regulations, including laws that explicitly ban tall buildings, seem to be the main reason that in many rich nations today most recently constructed buildings are shorter than this most efficient height (Glaeser et al. 2005; Watts et al. 2007). Successful em cities are likely to be those that find ways to reduce excessive regulatory limits on new buildings and their heights.

To speed reconstruction, cities might coordinate to reconstruct whole sections together. An axis of reconstruction activity might even sweep around a city center like the hand of a clock. In this case the city would look more like a spiral, with the newest just-built radial slice of the city being taller and wider than the oldest about-to-be-dismantled slice. Radial slices near the end of their useful life would likely have more accidents and less reliable utilities. They might also be more attractive places to conduct illicit activities. A coordinated spiral of reconstruction could make it easier to manage land allocation via combinatorial auctions, which will be discussed in Chapter 18, City Auctions section.

To support higher than ambient pressures in the centers of air-cooled cities, physical structures are needed to maintain high internal pressures against lower outside pressures. Fractal designs for pressure containment surfaces can help here (Farr 2007a). The structures in high air pressure cities that maintain higher air pressure in the center could also be helpful in giving structural support to hold up mass in lower pressure regions above high-pressure city centers.

The structures required to create high air pressure em cities might be expensive in low-pressure environments. If so, such cities might instead be placed under a few meters of water. For example, 50 meters of water overhead adds 5 Earth atmospheres of pressure.

Not only do em cities look different, their buildings look different too.

MANUFACTURING

As biological humans are less relevant in an em economy, the biological fraction of today's international trade is less relevant in an em economy. However, this fraction is actually rather small. Today, only 9.8% of international exports by value are in the categories of foods, 7.5% are in medical-related chemicals, and 5.5% in garments and textiles (Hausmann et al. 2014). Thus not much more than about a quarter of exports today seem threatened by a reduced biology trade. Of strong continued relevance to ems are metals, machinery, electronics, construction, oil, coal, petrochemicals, mining, aircraft, ships, and boilers.

Because biology matters less in the em economy, weather-induced changes in biology also matter less. However, extreme weather could still disrupt non-biological em mining, manufacturing, and transport. Furthermore, ems are more geographically concentrated in a few big cities, and the doubling time of the em economy is closer to typical timescales on which local weather can change a lot. Thus severe storms can more easily cause big disruptions to the em economy.

Today, consumers place a high value on having a great variety of products and services to choose from. This preference has increased substantially over the last century. By picking products that adapt in detail to their varying individual tastes, consumers are able to signal their distinct individuality. This product variety reduces the scale and scope economies that can be achieved in making items cheaply. The diversion of development and resources into improving less-durable, more-context-dependent products, compared with more general products, has reduced economic growth rates (Corrado et al. 2009). However, consumers today usually care less about low production costs or growth rates, and care more about the value they can gain from more variety in products and services.

As discussed in Chapter 13, Efficiency section, in a very competitive em economy, efficiency and low cost gain in importance compared with product variety. This reverses the trend in recent decades away from mass production and toward mass customization and flexible manufacturing. A return to mass production should result in more long-term growth, simpler and more standardized products, larger factories that achieve more economies of scale and scope, and better but more expensive tools. A return to mass production should also encourage organizational divisions centered less on types of customers and products and more on functions such as sales, marketing, design, production, and shipping (Salvador et al. 2009; Piller 2008). All these changes might be reduced, however, if parasites such as computer viruses can exploit mass-produced products, and so discourage them relative to other products.

A shift toward mass production should modestly increase the value of automation and software tools, as for mass products the fixed cost of developing such tools is spread out over a larger scope of use of such tools. As variety in product appearance seems cheaper in virtual reality than in physical reality, a trend toward mass production should be more pronounced in physical products, relative to virtual products.

Like future computers, future factories may also have subsystems composed of many small elements that run nearly thermodynamically adiabatically to reduce the use of free energy. That is, factories may have mechanical parts that move slowly enough that their motions could nearly as well have happened in reverse. For such subsystems, the free energy used per operation goes inversely to the time taken per operation. As with adiabatic reversible computers, this suggests that about the same amount is spent to rent the hardware for these sorts of manufacturing subsystems as is spent on the energy and cooling to run them.

An extreme version of small adiabatic manufacturing hardware is molecular manufacturing, or "nanotech," wherein the factory equipment and the manufactured products have atomically precise features. While it isn't obvious how far or fast this trend will go, nanotech might be important during the early em era.

Large-scale feasibility of nanotech would likely reduce the demand for rare elements such as zinc compared with common elements such as carbon, and reduce the fraction of production materials that become waste products. It should shorten supply chains and thus cut long-distance physical trade, encouraging more material goods to be made and recycled locally, instead of transported from distant factories and disposed to distant dumps (Drexler 1992, 2013).

Nanotech-based factories need not be much bigger than the products they make. Such factories would usually have marginal costs of production close to the marginal costs of energy, cooling, and raw materials. This implies less variation in the cost of marginal production per pound in nanotech products. Nanotech factories would thus be relatively cheap to make, and would allow for faster rates of production and retooling.

Within dense cities, some computing hardware might even be manufactured in place immediately after dismantling old hardware in place, saving the time, cost, and risk of transporting old equipment. Nanotech might encourage factories to use deterministic computer hardware, which strongly avoids logic errors and timing fluctuations, if doing so could increase the reliability of the manufacturing process.

The larger are the fixed relative to marginal costs of making products, the more that consumers can be tempted to buy large standardized packages of diverse products, perhaps via large group purchases that can negotiate for lower prices (Shapiro and Varian 1999). Such purchases might be organized around clans or firms, to achieve larger scale economies.

As the marginal costs of nanotech products are especially low compared with fixed costs, nanotech can create even more scope for selling goods in bundles. Thus ems with nanotech may typically buy access to whole large libraries of designs, gaining the right for their group to buy and locally produce individual items at near marginal cost (Hanson 2006b).

Overall, manufacturing seems modestly different in an em world.

CHAPTER 8

Appearances

VIRTUAL REALITY

What kind of world do ems see? We have several reasons to expect ems to usually experience simulated "virtual" realities.

First, compared with ordinary humans, it is easier to fully immerse ems in computer-generated virtual realities. One could feed computed inputs into an em's emulated eyes, ears, nose, fingers, etc., and take outputs from that em's emulated arms, legs, tongue, etc., to create a complete sensory experience of the sight, sound, smell, touch, etc., of being in contact with and partially controlling a constructed but vivid world. Humans get many sensory clues telling them that their virtual realities are not real. Ems need see no such clues.

Second, the cost to compute a workable virtual reality can be very low, compared with the cost to compute an em. Now it is true that the cost to compute a virtual environment depends greatly on the level of realistic detail required. Consider the cost to give simulated inputs to an em that it could not distinguish, even with careful examination, from a real physical environment. For many familiar physical environments, such a simulation may cost many times the cost of running the emulation brain itself.

However, humans today are routinely comfortable and moderately productive interacting with video game environments that require vastly less computing power than human-speed brain emulations will require. Also, instead of sending very fine-grain low-level signals of very particular sights and sounds, it may become possible to send cheaper-to-compute higher-level signals that em brains interpret as their having seen the lower-level signals. For example, instead of sending individual light pixels to the eye, which then translates that to lines and areas, one might just send those lines and areas to the appropriate emulated neurons.

Ems may prefer virtual reality environments that are expensive to compute, relative to the cost of running the ems themselves. Even so, cheaply computed environments seem sufficient to functionally support the vast majority of em activities, in both work and leisure. On the job, there is a tradeoff regarding whether to pay more for a more realistic virtual environment that might add to worker productivity. When ems make this tradeoff well, they will not often pay a price for their virtual environments that much exceeds the cost of running their brains. Usually they pay far less.

Sometimes people imagine that a world of cheap virtual reality is a world without scarcity or constraints, where anyone can do anything they want. But even when it is cheap to compute virtual reality scenes and interactions, it need not be cheap to pay for the hardware, energy, and cooling to compute the brains that experience that virtual reality, or to pay for brain-housing real estate to ensure those brains are close enough to naturally interact with many other interesting brains. Thus ems living in a virtual reality must earn (or be given) enough to pay for it.

Ems who do physical labor need to perceive many aspects of the physical world relevant for their job. But ems doing office work, and those in most leisure activities, do not need to see the real physical world. As in advanced economies today, most ems have office jobs. And for office-job-ems, the virtual reality worlds and bodies that they inhabit could in principle be anything that the human mind could understand, and that could be efficiently computed given available resources.

In principle each em could inhabit a completely different virtual reality. This seems to make it hard for us to infer much about the features of em virtual worlds. However, consider an analogy with clothes. Today, we have the wealth and technology to decorate our bodies with a vast range of shapes and materials. Yet the clothes we actually wear are far more limited and predictable. These predictable choices better support the usual functions that our clothes perform, such as comfort and displaying our current social roles, modes, and status.

Similarly, the many predictable functions that ems try to achieve in their virtual worlds can predictably constrain those worlds. For example, ems need to share virtual worlds if they want to interact with other ems. If they want to interact naturally with other ems via speech, facial expressions, touch, or paper-like visual screens, then their worlds must contain understandable analogues of these types of interactions.

If ems want the ability to easily begin and end such interactions with other ems, or to accept or reject interaction proposals, their worlds need to offer clear representations of interaction invitations. An invitation to a meeting might specify participants, observers, starting time, duration, virtual and physical locations, nominal speed, and maximum tolerable participant signal delays.

To manage the real resources needed to support virtual experiences, ems find it useful to have representations of such resources and their control in their virtual worlds. So virtual worlds likely have clear simple representations giving ems ways to see and control their monetary balances, security permissions, interaction histories, and future interaction schedules. In addition, ems want representations of their and others' brain hardware location, type, speed, period, phase, and reliability. They also want to know the availability, price, speed, and security of communication connections. Finally, they want representations of options for changing these parameters, and of ways to initiate such changes.

While em virtual realities can in principle be almost anything, the simple assumption to make here is that in practice they are recognizably similar to our real world. Bodies, clothes, baskets, rooms, halls, and so on continue to serve similar psychological functions for ems as they do for us.

One plausible big difference in em virtual realities is that ems may make great use of the ability to ignore gravity while building structures and moving around in three dimensions. We today often fantasize about the freedom that such abilities could allow, and ems could use them to make many more people and places conveniently visible and accessible.

COMFORT

In addition to serving the above functions, virtual realities also please ems.

Most elements of virtual worlds are intended as background, there to support but not needlessly distract from the centers of attention. Such backgrounds are mostly familiar, safe, and comfortable, with just enough novelty to not be distractingly boring or depressing. When serving as a background to an em's main activities of work, socializing, or sleep, virtual realities need to not be overly distracting. But when virtual realities become a main focus of attention for bonding or entertainment, they can be extremely engrossing.

As the cost to compute a spectacular virtual reality can be small relative to the cost of running an em mind to appreciate it, and as a much larger em economy could afford to spend astronomical sums searching for pleasing combinations, we should expect the quality of em virtual realities to be superlative. By the standards of today, widely consumed em music, architecture, decoration, scenery, texture, product design, story plot and dialogue, etc., are of very high quality. Also, ems living in a virtual reality need never experience hunger, disease, or pain, nor ever see, hear, feel, or taste anything ugly or disgusting. In addition, mind tweaks should allow the equivalent of spectacular mind-altering drugs with few problematic side effects such as dry mouth or the shakes.

In virtual reality, the faces, bodies, and voices of individual ems are whatever gets them to be treated well. So ems seem smart, beautiful, and trustworthy, and also dominant or submissive and with personality types appropriate to their desired roles. Ems tend to respect and trust each other more as a result.

Em virtual reality leisure environments may be so alluring, in fact, that their quality is limited on purpose so that non-retiree ems are consistently willing to leave leisure to return to work. For religious or related reasons some ems may even refuse to enter anything but Spartan virtual realities with low addiction potential.

Typical ems may be reluctant to enter virtual realities new to them, out of fear of addictive temptations. Ems who, even so, remain vulnerable to being seduced to spend most of their resources on virtual reality experiences are quickly selected out of the em economy. Those who remain have found some way to resist such temptations.

The main elements of our world usually not found in em worlds are those that are needlessly frightening or time-consuming, or that violate the abstractions we try to impose on our world. For example, long subjective travel times are avoided in the em world, closed virtual em rooms are usually entirely sound and signal proof, and unapproved outsiders are usually unable to accidentally overhear conversations.

Also, dust does usually not collect on surfaces, nor do materials wear or decay. But this need not imply everything looks "clean." Cluttered spaces tend to cause and result from creativity, and cluttered offices often help workers to manage great detail (Vohs et al. 2013). Workers with cluttered offices often know where to find most everything in them, even if outsiders can make little sense of the apparent disorder. Yes, clutter often results from and leads to stress and disorganization, and so may usually be avoided. Even so, some em workers likely gain from and accept clutter, and clutter may also be used to signal membership in creative communities.

Today in cartoons and video games, we see that distinctions, such as between object types and the boundaries of motions, bodies, objects, and spaces, are often exaggerated in predictable directions, to make such distinctions more visible and salient (Thomas and Johnston 1981). For example, objects are often drawn with dark, sharp, easy-to-see borders. Appearances in em virtual realities may be similarly exaggerated, and look more cartoonish than does our world. For example, objects may be stretched in their direction of motion.

The more the em world focuses on how things look in virtual reality, the less that ems are willing to pay to make things look nice in physical reality. In addition, the em world in general focuses more on functionality relative to design and aesthetics. Thus in the physical world em buildings and other infrastructure tends to look functional, and perhaps harsh. But virtual reality is usually quite comfortable.

SHARED SPACES

When ems share spaces, they compromise on how such spaces look and act.

In virtual reality, the commonly seen features of spaces where communities meet are intrinsically scarce. That is, although each member of a community can be given control over some elements of this space, they cannot all be given full control over all elements. The scarcity is not so much in being able to see the space, as being able to control what others see in the space. While similar copies from the same em clan may economize by sharing only one body that others can see in the space, they still have to compromise regarding what that copy is seen to be doing.

Em virtual realities are usually designed to make physical violence impossible. That is, it is simply not possible to use the actions supported by a virtual reality, such as swinging a fist, to damage an em against their will. Of course as computer security is expensive, ems might be harmed by non-virtual reality computer actions such as viruses or network attacks. But as it is easy to prevent damage from physical acts in virtual reality, such damage is in fact prevented.

Today, offices are often arranged in an open cubicle plan, mainly as a way to save on floor space. However, it seems that cubicle offices are more stressful and hinder cognitive capacities as well as interactions with co-workers (Jahncke et al. 2011; Kim and de Dear 2013). As virtual space is very cheap, cubicles may be avoided, and em homes and offices may appear to be spacious, private, and well appointed.

Today, many of our social habits are deeply integrated with standard Earth cycles such as days and years, standard Earth locations such as offices, shops, and parks, and standard human features such as age, gender, and profession. It's reasonable to guess that such habits will continue with ems. So I expect em virtual worlds to typically show changes corresponding to day and year cycles, at rates matching the mind speeds of typical em residents. I also expect virtual locations to often look recognizably like offices, bedrooms, bars, parks, plazas, auditoriums, elevators, etc., to evoke the behaviors considered appropriate in such places. I expect the sound and sight of virtual bodies to often give easily recognized clues about age, status, gender, profession, and activity mode, to evoke expectations appropriate to such differences.

As with video games today, the design of em virtual worlds is subject to fewer physical constraints than is the design of non-virtual worlds. Like games today, they thus have more room for subtly encoding multiple meanings, allusions, and references. Ems expect to find more such hidden meanings in the virtual worlds around them.

Groups of ems meeting in virtual reality might find use for a social "undo" feature, allowing them to, for example, erase unwelcome social gaffes. At least they could do this if they periodically archived copies of their minds and meeting setting, and limited the signals they sent to others outside their group. When the undo feature is invoked, it specifies a particular past archived moment to be revived. Some group members might be allowed a limited memory of the undo, such as by writing a short message to their new selves. When the undo feature is triggered, all group members are then erased (or retired) and replaced by copies from that past archive moment, each of whom receives the short message composed by its erased version.

This undo action is typically more expensive the larger the group and the longer the subjective time period that was erased. So there need to be limits on who can invoke undo and how often. Outsiders who receive signals from group members during the meeting have to accept a risk that signal senders might be replaced by versions that don't remember sending those signals. The enforcement of any rules requiring group members to forget what happened during the erased period probably requires central control of the hardware running member minds, and strong limits on signals sent to outsiders.

It is usually cheap to place one or more participant ems into a virtual reality that mimics some special place or time, real or imagined. However, it is prohibitively expensive to populate that virtual reality with many characters who are as complex as those participants. After all, em brains are far more expensive to compute than are imaginary buildings or mountains. Thus apparently complex characters are usually only included if their behavior can be computed cheaply relative to the cost of emulating an ordinary brain, or if such characters only act rarely. For these rare interactions, actors might be paid to temporarily play relevant roles.

As a cat brain has about 1% as many neurons as a human brain, virtual cat characters are an affordable if non-trivial expense. Most pet brains also require the equivalent of a small fraction of a human brain to emulate. The ability to pause a pet while not interacting with it would make pets even cheaper. Thus emulated animals tend to be cheap unless one wants many of them, very complex ones, or to have them run for long times while one isn't attending to them. Birds might fly far above, animals creep in the distance, or crowds mill about over there, but one could not often afford to interact with many complex creatures who have long complex histories between your interactions with them.

MERGING REAL AND VIRTUAL

Ems will need to manage two kinds of spatial concepts: who is where and can see what in the virtual world, and also who is where and protected by what in the physical world. Rather than managing two separate disconnected representations for these two kinds of spaces, it may be tempting to integrate them into a common spatial representation.

For example, ems' sense of virtual place and location on large scales might usually be taken directly from their physical world, with only modest and local changes made for comfort or convenience. In physical reality, city volume would be divided between "buildings" that mainly house em brains in larger server clusters, and utilities such as cooling, transport, and structure that use the spaces between buildings. In virtual reality, most of the space really devoted to utilities, and some of the space really devoted to buildings, might all appear in virtual reality as common open spaces where ems could congregate and often see for long distances. The space in virtual reality devoted to buildings might appear as typically opaque private homes, offices, shops, gardens, etc.

At any one time ems might have current locations for their virtual bodies, and different locations for their "souls" (i.e., brains), sitting inside their "home" buildings. While em (virtual) bodies can jump around very cheaply and quickly, there is a speed-dependent "leash" saying how far away an em body can comfortably move from its soul. Past that leash distance the body starts to have noticeably sluggish reactions because of signal delays. Faster ems have proportionally shorter leashes.

Souls could also move to new homes, but such moves cost a lot in money, time, and risk. In the Harry Potter stories, the horcrux spell made the wizard Voldemort invincible by spreading his soul across many hidden physical objects, all of which had to be found and destroyed to kill him. Similarly, an em couldn't be hurt by an attack on its virtual body, but only via a physical attack at the location of its soul. As if protected by a horcrux spell, ems implemented redundantly at many different physical locations might only be hurt via physical access that could hurt them at *all* of those locations. This provides ems with extra security against many kinds of disaster.

The owner of a real physical building might be given control over how the surface of that building appears within virtual reality. This control might be subject to regulation. The building owner might divide the building surface among building residents, to let each of them control an entrance or facade visible to common areas. As with the TARDIS in "Doctor Who," the virtual volume of homes, offices, etc., inside each virtual building could be much larger than the total volume of that building as seen from the outside.

Physical objects and ems in physical bodies that are really physically located in common areas may or may not appear in the standard virtual reality depiction of such common areas. For such physical objects to integrate well with virtual objects, the scale of typical real items such as doorways and walkways needs to be matched to the mental speed of the typical residents. It also makes sense to set the typical size of virtual em bodies so as to produce a pleasing average density of such bodies, neither too dense nor too sparse. After all, ems do not want to feel too lonely nor too crowded in common spaces.

To let ems move smoothly between a real and a virtual body, physical doors of buildings could have an associated stock of rentable physical bodies. When an em left a virtual space through a virtual door, its mind could be transferred into one of the bodies that then exits through a matching physical door. When entering a virtual space from a physical space, the process could reverse.

To ems, virtual and physical reality may in practice be merged into an integrated whole.

CHAPTER 9

Information

VIEWS

Interacting ems need not see exactly the same virtual environment. For example, each em might prefer to see a shared environment as decorated with their personal choices of colors or patterns. Ems might also prefer to overlay or augment their views of the virtual world with useful tags and statistics, or to see through virtual objects to see object components or to see what lies behind those objects. Virtual ems may have telescopic sight, allowing them to always vividly see anything anywhere they are allowed to view. However, overlays can impair perception, and so must be used carefully (Sabelman and Lam 2015).

To sensibly interact with others, ems usually want easy ways to quickly identify the aspects of their environments that they and their interaction partners see similarly. Some aspects of these worlds (such as where people are standing) are distinguished as shared by default, and interacting ems want standard ways to invite interaction partners to see some of their own less widely shared overlays and changes, and to accept such offers from others.

At both work and play, many kinds of tasks require ems to manage physical systems. Such management often requires physical bodies (both immediate and extended) whose size, speed, shape, and materials sufficiently match those physical systems. It is also important for em minds to relate well to such bodies. But this seems feasible for a wide range of physical bodies. After all, people today interact with the world using a wide range of machines, such as vehicles and cranes, which they treat mentally as an extension of their bodies.

For ems with task-matched physical bodies, the world they see and hear needn't be an exact faithful representation of their physical world. For example, it might often be a sort of view like those in today's head-up displays, overlaid with useful virtual annotations. But such overlays need to avoid overly obscuring important elements of that physical world.

Because the feasibility, cost, and security of em interactions often depends on the physical and organizational locations of their brains and the brains of others, em virtual worlds may continually show such information about interaction partners. For example, ems often want to know when another em's speed, period, phase, or distance makes direct fast interaction infeasible. So ems will need to share somewhat-realistic concepts of their locations in space and time.

Ems with very different speeds or sizes might fit awkwardly into the same space, be that space physical or virtual. Fast ems whizzing past could be disorienting to slower ems, and large ems may block the movement or view of small ems. One solution is to have different standard virtual views of each common area, with each view matched to a different speed. Different speed views might also have different matching virtual gravities. Regulations might limit the size or speed behavior of ems within each speed-matched virtual view.

The ability to influence the appearance of commonly used virtual spaces is a scarce resource. To economize on this resource, ems might create views that hide many details. For example, in main views one might see only the most central actors, whereas in other views one might also see more peripheral actors. We will see in Chapter 14, Spurs section, that em workers regularly spin off short-term "spur" copies who do a task for a few hours and then end or retire. If you talk to one of these copies, the original will not remember what you said later. So most ems prefer to talk to the original, and spurs may mainly talk to other spurs, unless spoken to by a non-spur. To support such interaction styles, spurs may not appear in default office views, and observers may have to ask to see views that also show spurs.

Similarly, slow retirees may sometimes watch and evaluate the behavior of ordinary ems. The usual view of a place might not show such retiree observers, but alternative views could, letting retirees see and talk to each other. Similarly, many working age ems may share parenting oversight for the few young ems in training, watching them and voting on how to manage them. Ordinary views of children might not show such child minders, but alternate views might show them, and let these observers see and talk to each other.

Even non-retired non-spur ems who run at the same speed can still differ in status. So there may be views that hide lower status ems, and only show higher status ems. This could be similar to how today servants such as waiters often try to seem invisible, and are often treated by those they serve as if invisible.

The more possible views that are commonly used, the harder it will be for typical ems to know how things look from others' typical points of view.

RECORDS

Today, it is cheap to record and archive all the audio in one's life, and it will soon be cheap to do this for high-resolution video as well. As ems will probably find it even cheaper to record things, it may be standard practice for them to record audio, video, smells, vibrations, and also many parameters about brains and bodies, including mood, arousal, etc. Ems might even add information from shallow mind-readings and periodic diary entries, or even provide periodic verbal commentaries about their lives.

All these records could give ems a pretty full access to their personal history. Such ems could see a recording of almost any moment in their history, and could perhaps even interview and mind-read an archived copy of themselves from close to any such moment. To make it easier to find things in these records, ems may get into the habit of sprinkling their conversations with keywords that help to identify situations.

Regarding non-virtual places, it is mechanically cheap to fill em-dense physical spaces with surveillance hardware such as cameras and microphones, to clearly show who does and says what and when. A similar situation holds in common virtual spaces. Local authorities are likely to create such surveillance networks, and to archive their output. Such authorities could use this to create a "transparent society" where most social activities are, by default, visible to all (Brin 1998). However, authorities may choose to limit access to these views and recordings, and they may discourage other surveillance networks from operating in the same spaces.

Although it might be easy for individual ems to record what they can see, it might be harder to share such views widely and immediately. After all, such views reveal the location and supports of their sources, allowing such sources to be shut down by authorities. So unauthorized shared views must be shared with a substantial delay, only shared rarely in response to unusual situations, or redacted enough to obscure their sources. Virtual reality interactions visible only to a small number of participants could more plausibly be kept private among those participants, remaining invisible to authorities.

Widespread cheap surveillance could greatly reduce the scope for black markets. There can be few visibly illegal transactions in very visible spaces when relevant laws are actively enforced.

In either virtual or physical realities, ems less fear being killed or destroyed by local disasters. Frequent backups mean that such disasters mainly only risk the loss of memories and skills gained since the last backup. Ems mainly fear the rare disasters where no recent backups were made, or where some greatly valued post-backup new information was acquired. Ems retain a strong fear regarding large-scale disasters that threaten all relevant backups or that threaten to take away an em's livelihood. Death fears are discussed more in Chapter 11, Defining Death section.

An em might be fooled not only by deceptive inputs about its environment, but also by misleading information about its copy history. If many copies were made of an em and then only a few selected according to some criteria, then knowing about such selection criteria is valuable information to those selected ems. For example, imagine that someone created 10 000 copies of an em, exposed each copy to different arguments in favor of committing some act of sabotage, and then allowed only the most persuaded copy to continue. This strategy might in effect persuade this em to commit the sabotage. However, if the em knew this fact about its copy history, that could convince this remaining copy to greatly reduce its willingness to commit the sabotage.

Thus ems should be eager not only to discern misleading appearances about the world immediately around them, but also misleading claims about their copy history. In general, ems take care to keep reliable records.

FAKERY

Ems are also careful to avoid being fooled by false appearances.

Em virtual realities probably support authentication. That is, as long as their usual tools remain trustworthy, ems need not be mistaken about the identities of the places they visit, their interaction partners, or of other ems that they see or hear. Such others might refuse to reveal their identities, but they will usually be unable to credibly pretend to be someone that they are not. Of course a stolen em mind may reasonably distrust its usual tools of authentication, fearing that it is in a simulation that doesn't follow the usual rules.

To support authentication, and help ems keep secrets, the standard hardware processes for copying ems might have direct support for copying a secret code (technically, a "cryptographic private key") shared between original and descendant copies, but to *not* copy that code to anywhere else. This support would make sure to not copy codes that are unique to the parent, and to generate and not share codes unique to the new copy and its descendants. Public codes that match these private codes might be a basis for em unique identifiers.

The possibility of em authentication need not imply a lack of em privacy. Ems and other agents in em spaces could choose to not reveal many things about themselves to observers. However, detailed surveillance data tracking the location of ems over time might reveal more information than an em wanted to reveal. In virtual reality ems could deal with this by just disappearing at times. In physical reality, ems might sometimes choose to "mix" with the bodies of strangers. That is, an em might suggest to a nearby stranger that the two randomly swap physical bodies. If agreed, the two ems would attach themselves to each other for a long enough time to swap their minds, and randomly do so half of the time. Afterward, the two bodies would go their separate ways, half of the time with bodies having new minds.

Ems likely want ways to easily and reliably tell which of the things that they see or hear are actually ems, and which are cheaper algorithms that only mimic real ems. After all, an em may sometimes be tempted to substitute a cheap automated "bot" program that mimics him or her during some interactions with other ems, so that he or she can attend to other things. Ems may prefer not to be given such a bot to interact with, in part because it might suggest their low status. As a result, during interactions ems may try to act in complex and subtle ways that bots could not effectively mimic, continually running their own bots that try to mimic themselves and their associates to detect fakes. That is, ems might always feel they are part of a Turing test. Such habits could raise the costs of interacting for distrustful ems, and raise the gains from trust.

Information about whether one is interacting with a bot might be obtained directly via direct brain access, or perhaps indirectly by requiring that a high price be paid to place what appears to be a full em in a particular role. Ems also typically want to see the voice tone, facial expressions, and gaze directions of themselves and their current interaction partners, and to know if they are seeing or showing direct and unfiltered versions of these tones and expressions.

Such knowledge helps ems learn things about the deeper mental states of their interaction partners, and the inferences other ems are making about them. Of course without assurances that they are seeing other ems unfiltered, ems may expect such things to often be cheaply faked, and so may expect to draw few useful conclusions from what they see.

The responsibility for defining and computing elements of virtual realities might reasonably be divided between larger utilities that compute elements useful to those in large groups, and smaller utilities who compute elements useful mainly to individuals or small groups. For example, a city-based utility might compute shared aspects of city plazas, fountains, and the surrounding sky, while building owners might compute elements of building facades and internal shared spaces. The owner of a meeting room might compute the appearance of that room, while each individual in the room might compute the appearance of his or her personal skin, clothes, or hair.

While this division of labor may align responsibilities well, it could have the problem of revealing information to third parties about who is looking at what when. To avoid such revelations, shy ems may just do without the information, computing these appearances of their virtual world privately from stable public specifications, or making up their own substitute appearances. Alternatively, supporting infrastructure might be built so as to assure users that such leaks are rare and difficult.

Overall, ems try hard not to be fooled by appearances.

SIMULATIONS

An ability to create convincing virtual experiences makes it harder for ems to draw inferences about the real world from their experiences. Experiences that seem to come from interactions with a larger physical or shared virtual world could instead come from a local sim mimicking that world. Ems must continually wonder if they have been unknowingly placed in such a sim, perhaps to test their loyalties or to extract secrets. (In fact, we each cannot be entirely sure today that we are not in such a future sim (Hanson 2001).) The more common are such sims, the less certain ems can be of conclusions they draw from what they see.

If an em were in a sim to test their loyalties or abilities, it might be a sim that they themselves had agreed in the past to allow to be created. Such an em wouldn't know when such a sim might happen, or what it would be like, just that it could happen almost any time. An em would probably want to cooperate with such sims. In contrast, the em may want to sabotage a sim that was designed to extract a secret, as this is less likely to be a sim to which the em had agreed.

Not only might ems be placed into sims where everything they see and hear is artificial, ems might also be placed into *partial* sims, where only some of the things they see or hear are artificial. In a partial sim, an em might see added fake people and objects beyond what they otherwise would have seen, or they might fail to see people and objects "edited out" of their view. An em might notice such added or missing items via their inconsistent interactions with other things. Automated tools might help to notice such inconsistencies, but such tools might be compromised by the same processes that compromise their basic sight and sound inputs.

There are many different reasons why an em or its associates might want to put that em into a full or partial sim, including entertaining the em in the sim or outsiders observing the sim, testing loyalty or ability, testing causes for holding beliefs, and testing credit for innovations and other accomplishments. For the purpose of gaining information, it is often more cost-effective to try to achieve several such purposes at once within a set of related sims. In technical terms, this is a "fractional factorial experiment design" (Montgomery 2008).

For example, a sim in which one em tries to thwart spies from stealing an innovation might simultaneously be entertaining for the em involved, test his or her loyalties, and test how much credit the innovation deserves. Similarly, it might be more efficient to include several related ems in the same sim, with different reasons for including each of them.

Thus if the various parties interested in making sims for a group of ems can agree on a common sim administrator, they might use that administrator to create a whole system of related sims. In this case, an em who suspected they were in a sim should not search for *the* purpose of its sim or for *the* focal em; most likely the sim has many purposes and focuses. This makes it harder for ems to manipulate sims to provide favorable impressions. Ems might well find it in their interest to just continue with their usual behavior as if they were not in a sim, which increases the validity of conclusions observers can draw.

A sim administrator might want to abort a sim if too many of its participants suspected too strongly that they were in a sim. To entice ems to reveal such suspicions, administrators might offer financial incentives. For example, each em might always be offered a private subsidized betting market on the chance that they are currently in a sim (Hanson 2003). If the em didn't believe the current offered market odds, it would expect to profit by changing those odds to its current belief. To encourage honesty, bets should pay in non-sim assets. That is, if this is not a sim, bets pay off in assets useful in this world, but if this is a sim, bets pay off in assets valid in the real world outside of the sim. The cost to subsidize such markets is added to the cost of creating sims.

An em who thought that it was in an illicit sim might want to sabotage that sim. But to sabotage a sim, an em must first notice the existence of the sim. One way to try to notice sims is to cultivate the habit of interacting often with trusted associates via previously coordinated private codes, opaquely encoded in each em's brain state. For example, about once an hour an em might hear a code word from a particular friend, a word that followed from the code word they had given that friend an hour before. The lack of a correct response suggests that one is in a sim. A related strategy might be to cultivate the habit of often interacting with particular physical systems whose computational complexity is very expensive to mimic, and which opaque parts of your brain can distinguish from cheap mimics.

Another approach to noticing sims is to watch for simulation errors, that is, ways that a simulation deviates from a realistic world. But if sim creators saw that a participant em had noticed an error, they could just stop and reverse the simulation back to a time before the error appeared, restart the simulation at that point, and try to prevent the error.

There might seem to be little point in noticing sim errors that can be erased in this way, but in fact the cost of such retrying raises the cost of running such a sim. The longer that an em could last before giving off a visible indication of knowing they are in a simulation, the more expensive they could make this revision process for the simulators. The usual goal in security, after all, is to *raise* the cost of security breaches, not to make them impossible.

As the loyalty and reliability of an em is especially important in unusual crisis situations, simulations designed to test loyalties disproportionately portray such situations. Thus an em who finds itself in what seems to be an unusual crisis should suspect that it is in a simulation designed to test its loyalty and ability. This would tend to make emulations act more loyally and reliably in real crisis situations, such as revolution or disasters. Such sim-based crisis tests might help to maintain order and organization during actual crises, reducing their severity.

Compared with us today, ems are more “battle-tested,” having lived through many unusual situations, each treated as if it was very real.

CHAPTER 10

Existence

COPYING

A functioning em is the result of information representing an em mental state being placed in compatible signal-processing hardware. When this hardware "runs," it repeatedly calculates the next mental state by combining the previous mental state with inputs from outside systems, and then sends resulting signals to outside systems. In this situation, an em can be said to experience this succession of mental states, while interacting with outside systems. As em hardware and supporting resources are not free, ems are not free; someone must pay to create an em.

When an em is copied, the em mental state sitting in compatible hardware is first read out as bits, and then those bits are copied, transmitted, and read into new compatible hardware. Then at the new hardware those bits are converted into the exact same em mental state, now ready to run on this new hardware. Immediately after this copy action, the evolution of the mental states in the two different hardware systems would be exactly the same, if it were not for errors and differences in environmental inputs, and differences in random fluctuations within a fault-prone emulation process.

Just as ems are not free but costly, copies are also not free but costly. Typically, an em with an established role in the em world is asked if they want to approve the creation of a new copy, who would have a new life with a new role in that world. Before agreeing to create this new life, the original could ask about the new em's intended job, location, friends, etc. On occasion, offers for new life roles might be made to archived copies. That is, ems might agree to allow the storage of archive copies, who can then be awoken later to consider new life offers. If the revived copy rejected the offer, it might be retired or ended, as previously agreed.

To actually make a copy, an em may invoke a special viewing mode, wherein the em specifies or approves a description of the set of em roles that would result from this copying act. When an em initiates a copy event, it should be ready and willing to take on any of the roles of the resulting copies. Immediately after the copy event, each em copy is informed of its assigned role. Typically one of the ems is assigned to continue its previous role, while other ems are assigned to take on new roles.

For the very common act of creating a simple spur copy, an em need only indicate a task and a resource budget. A single new spur copy is then created and told that its role is to attempt this task within this assigned budget. A matching viewing mode might allow the spur to report back to its original after it has succeeded or failed at its task.

When the original em has a strict veto on the copy process, so that copies don't happen without the consent of the original, ems would feel a much stronger ownership of their existence than do humans today. In this case, ems likely feel less justified in complaining about features of their situation that were easy to anticipate when they agreed to make a copy of themselves. Ems may also feel more obliged to be grateful to those who enabled their existence, and to make good on the promises, both explicit and implicit, that they made to such enablers. Ems can more see themselves as justifying and paying for their existence, via the benefits that others expected to gain by creating and hiring them.

The power to selectively create and delete copies of an em gives one the power to persuade that em of many things. After all, with such a power one could create thousands of copies of this em, try a different approach to persuading each one, and then retain the copy who is most persuaded. This approach does have substantial costs, and it can't persuade someone of a claim that they won't accept no matter what the method of persuasion.

Because of this power of selectivity, we expect ems to be careful about to whom they grant the power to create and delete copies, and to want to know what related copies have been created or deleted and why. An em who does not know their copy context should be cautious about changing beliefs others might want to influence. Ems must accept that organizations granted flexible discretion on creating and deleting copies will thereby gain great persuasive powers over them.

RIGHTS

Current and past legal systems offer a wide range of possible models for how em law might treat the creation of em copies.

At one extreme, new em copies might be fully owned slaves, with their owners free to torture or terminate them, and free to make more copies that they fully own. Such slave ems might be owned by the firm who first scanned them, by the original human from which they were scanned, or by other parties to whom slaves were sold. Moving away from this extreme, there could be limits on the torture of slaves. Enslaved ems may also have limited rights to spend a certain fraction of their time in leisure of a certain quality, or to veto making more copies of themselves.

At another extreme, new em copies might be completely free to choose all of their activities, including the making of copies of themselves. Moving away from this extreme, em creators could be required to endow the ems they create with sufficient wealth to live at some minimum duration, speed, and quality of life. Treating copied ems as if they were adult human descendants would arguably be a similar practice.

In between these extremes, ems could be endowed with intermediate levels of rights and wealth. For example, an em might own itself, but be unable to veto the creation of copies of itself. An em might or might not have the right to end itself. An em might own itself but be endowed with debt to repay its creation, and be subject to repossession and erasure if it cannot make debt payments.

An em might be incorporated like a firm, and own only some of his or her "stock." Voting and non-voting stock might even be distinguished. For example, an em holding a majority of his or her voting stock but a minority of the total stock still controls personal actions, but controls only a minority share of personal profits.

Note that rules specifying minimum wages or minimum fractions of leisure time may have perverse effects on the quality of work and leisure experiences. It is hard to create rules specifying how pleasant or enjoyable are work and leisure activities. Because of this, when an employer chooses work and leisure conditions to satisfy minimum wage or leisure time mandates, they are likely to compensate by skimping on expenditures that result in higher quality work and leisure experiences. In the absence of such constraints, employers instead tend to improve worker experiences whenever workers value such improvements more than their cost. Similar arguments apply to minimum wage rules today.

The "brain," or mind hardware, of a new em copy must be located somewhere, and so a key question is the contractual relation between a free em and those who build and maintain its hardware, and who supply this hardware with energy, cooling, communication, and real estate. Sometimes this brain will be a separate and mobile physical object, free to move to obtain space, energy, etc., from competing suppliers. More often, however, brain hardware will be a physically inseparable part of a larger computing system, as are single computers or processes today within large computer data centers.

For ems who are part of large copy clans in which they place great trust, the details of contracts with their hardware hosts matter less, as the clan handles these contractual details. But for other ems, current contracts for cloud computing services seem to offer attractive models. An em might be endowed with a cloud-computing contract giving it a right to run at a particular speed, reliability, rough spatial location, and communication bandwidth.

Such an em is also likely endowed with wealth sufficient to pay for this cloud contract for a short period, and the right to move to another service at will. If the em moved, it might have the right to insist that its original files be erased. Perhaps if the em failed to pay its contracted fee, the cloud service might have the right to erase that em, or perhaps even to sell it to recover overdue payments.

MANY EMS

The rest of the analysis in this book is largely independent of which of the above legal environments becomes more common. What mainly matters for other chapters is that many ems are created. Consider the situation where a not-overly unpleasant job is available, where the value of the work done is substantially higher than the full hardware costs to create an em to do this job, even when this em spends at least one-half of his or her time in leisure. Assume further that there are many ems for whom this cost is this low. In this situation, I assume that a productive em is usually created, to take on this job.

This many-ems outcome could result from profit-driven slave owners, from profit-driven debt lenders, from the existence of a few very productive and eager-to-copy ems, or from laws requiring high birth wealth endowments but without strong intrusive enforcement to detect and discourage illegal copies. Let us now consider each of these options in turn.

A many-ems outcome could result from eager-to-copy ems if there are a few flexible and productive ems who consistently go nearly as far as possible to fund new copies of themselves, to take new job opportunities as they arise. Such eager ems are willing to impoverish themselves, and even to end themselves, to fund new copies. These are "evolutionarily selfish" ems. Of course making copies need not be their primary conscious motivation. For example, their conscious motivation could be instead to be as useful as possible to similar copies.

A many-ems outcome via eager-to-copy ems is compatible with rules requiring large wealth endowments on creation, if such ems are free to bequest their wealth to new copies when they end or retire. It can also work with rules requiring high wages, if such ems are also allowed to volunteer for free during their "leisure" time on productive projects.

A handful of such eager flexible ems could fill an entire em economy of jobs, even if no other ems were willing or allowed to fill such jobs. Even if these eager ems were banned from most legal jurisdictions, the few jurisdictions that allowed them might quickly outgrow and dominate the rest. Eager-to-reproduce humans are often found today in farmer-like religious communities such as the Amish or Mormons. As I personally know a few people who seem productive and eager to copy, I estimate that as long as a few productive jurisdictions support competitive ems, then enough such productive eager ems could be found to produce a many-ems outcome. Also, even if eagerness to copy is rare at first, it is a feature that is selected for in an em world because of its competitive advantage.

Laws might require high em wages, but such laws could strongly tempt black market copying. The larger the difference between a high market price to rent em labor that satisfies official regulations, and a low total hardware cost to rent em hardware, then the more eagerly some would try to make black market copies.

For example, an ambitious businesswoman might be willing to create in secret a thousand copies of herself, to achieve much lower labor costs in developing and building her new product. Her copies might accept ending or retiring to a slow life once the product is completed. When there are very different legal and illegal market prices, preventing black market trading requires extensive and thorough monitoring and strong punishments. Preventing black market jobs when legal em wages are far above total em hardware costs requires much stronger enforcement than would be required today to prevent illegal drug use (which we do not now do). After all, to lower her main costs by a factor of 10 or more, an ambitious businesswoman might be willing to go quite far to create and hide a secret labor force.

A big difference between legal and illegal wages also encourages slavery. Historically slavery has offered low profits when wages were near subsistence levels, but higher profits when wages were higher (Domar 1970). Similarly, enslaving ems becomes much more tempting when em wages are well above subsistence levels.

The main em scenarios in which there are not many ems are scenarios with well-enforced laws that either impose strict quotas on the total number and speed of ems, or that in effect require very high wages, or equivalently, that require high ratios of leisure time to productive work time. Such laws need to be global, and strongly and thoroughly enforced via intrusive monitoring and strong reliable punishments of violators. Such alternate scenarios are discussed briefly in Chapter 28, Alternatives section.

For most of this book, however, we assume many ems.

SURVEILLANCE

To enforce laws that impose quotas on the number and speed of ems, one needs strong controls on computing hardware capable of running em brains. And this requires strong abilities to observe activities. Such surveillance abilities might also be used to enforce rules on mind theft, intellectual property, and uncontrolled research in artificial intelligence. But how exactly could such hardware controls work?

One approach is to try to ensure that authorities can cheaply see inside all computers capable of running em brains, including seeing through any encrypted computation, to severely punish owners who were found to be running ems without authorization. If this requires direct inspection of physical hardware, that is likely to be expensive. However, if authorities know the physical configuration of hardware, have appropriate operating system access privileges, and sufficient suppressing of encrypted computation, they might be able to do required inspections cheaply from a distance.

In this approach it is very important to prevent the existence of hardware that lies about its configuration. Perhaps large bounties could be offered to anyone who revealed the existence of such hardware, and who paid for the costs of an inspection to prove a violation.

Instead of direct inspection of all hardware, a more focused approach is to ensure that authorities can see all factories capable of creating computers that can run ems, and can punish factory owners severely when they are found to produce em-capable computers without authorization. If it was too hard to punish factory owners, one might instead punish those who own the land used, or who supply power or cooling. This approach might be sufficient to enforce limits on population, but perhaps not rules on wages, mind theft, intellectual property, or software safety.

Dark factories and computers, hidden from the view of authorities, would undermine both these enforcement approaches. Such factories and computers could be hidden under the ground or sea. Small em installations could likely hide in more types of environments than can small groups of humans today. To discourage such hidden installations, detailed monitoring might be required not only of the Earth's surface, but perhaps also hundreds of meters beneath that surface.

The economic value of such hidden hardware might be substantially diminished by time delays and bottlenecks in communication with em cities, where most valuable em activity takes place. Hidden computers would thus focus on supplying services where such delays and bottlenecks detract less from the value produced by their illicit em workers.

Authorities might try to control computing hardware by controlling the communication channels that such hardware uses to gain value. For example, authorities might try to ensure that they know the location and function of all high-bandwidth nodes in a communication network. This approach might be evaded, however, by illicit direct laser links between distant physical locations, or by physical landlines deep underground. Authorities might also try to inspect all communication traffic, and prevent unauthorized encrypted communication.

Another approach is to control the energy and cooling that computers need. However knowing the energy usage doesn't necessarily say how much computing is going on. For example, with reversible computers one could mimic the energy and cooling of a single computing unit via four computing units that run at one-half speed, and thereby produce twice the computing power of a single unit. One might detect such arrangements via the additional volume and structural support that these added computing units require.

Evasion of rules limiting the creation of ems might perhaps also be accomplished via opaque software that appears to serve other functions, but actually emulates minds. The complexity of this software might make it hard to detect this. One might try to notice that the software is inefficient at its stated purpose, but this might be hard. For example, software to monitor for rare events or search for rare configurations might go a long time without finding anything useful, even if it is in fact very efficient.

The extreme measures required to successfully enforce laws limiting em numbers and speeds seem to confirm that the simpler assumption to make for the purpose of this book is that such laws either do not exist, or are not strongly enforced. So as discussed in this chapter, in the Many Ems section, this book assumes a many-ems outcome.

CHAPTER 11

Farewells

FRAGILITY

Em minds age with experience, becoming less flexible and thus less able to adapt to new skills and environments. Because of this, old ems eventually become substantially less productive than young competitors, and need to retire. Here is why.

Imagine that you were asked to modify an ordinary (i.e., stock) car into a truck to haul rocks. If after that you were asked to create a racecar, you would probably prefer to start from another stock car, rather than the stock car that you had turned into a truck. Similarly, species of beetles that have adapted to a varied and oft changing environment have simpler designs than beetles adapted to more stable environments. These simpler beetles are more likely to successfully invade and adapt to new environments that become available, relative to beetles that have adapted to specific stable environments (Fridley and Sax 2014).

A similar effect causes large software systems to "rot" with time. As software that was designed to match one set of tasks, tools, and situations is slowly changed to deal with a steady stream of new tasks, tools, and situations, such software becomes more complex, fragile, and more difficult to usefully change (Lehman and Belady 1985). Eventually it is better to start over and write whole new subsystems, and sometimes whole new systems, from scratch.

Similarly, while more complex and higher quality business products tend to become better adapted to circumstances, and to sell for higher prices, simpler cheaper products tend to have more descendants in new products, at least for products sold to firms (Christensen 1997; Thompson 2013). In multi-cellular animals, flexible generic stem cells create other more varied cells that are better adapted to particular body tasks. Yet new organisms descend mostly from generic stem cells, which have far more descendant cells in the long run.

All of these examples suggest that as systems become better adapted in detail to particular situations, they become more fragile and less able to adapt in detail to very different situations.

Human brains tend to have slower responses as they age, in part because brain hardware degrades (Lindenberger 2014), and in part because such brains need to sort through a larger experience base (Ramscar et al. 2014). Human brains also tend to start out malleable, and able to learn quickly, even though they are poor at most specific tasks. While human minds become better adapted to specific tasks as they age, they become less flexible and less able to rapidly learn new very different skills. That is, while the young tend to have more "fluid intelligence," the old have more "crystallized intelligence" (Horn and Cattell 1967). For example, whereas old people know more words, young people can more easily learn new languages. Older people often get "set in their ways."

Some of this aging of human brains probably results from developmental programming and biological aging. These sources of mental aging need not apply to emulations. The emulated cells need not age, and developmental programming might be turned off. However, some of human brain aging is also plausibly intrinsic to human mind design (Magalhaes and Sandberg 2005).

For example, even if 90% of human mental aging comes from developmental programming and biological aging, that could still leave 10% coming from a general tendency of complex adapting systems to become more fragile as they continue to adapt to new circumstances. That is, it is plausible to think that at least some of the general tendency of humans to become inflexible with age is a general consequence of their adaptation to specific circumstances, rather than a result of cell degradation or economic incentives to stick with what you know.

Thus even em minds are likely to age with subjective experience, becoming less easily adapted to particular tasks, and eventually becoming too fragile to compete well in changing environments with more flexible younger minds. For example, if the rate of subjective aging for ems is only 10% of that of humans today, that would plausibly move the age of peak work productivity from roughly 50 to 500 subjective years. Eventually old workers would become unable to compete well with young workers.

As with software rot, with effort it may be possible to slow this aging process, but it is only rarely cost-effective to halt or reverse such aging. For most jobs, after a subjective career of somewhere between about one-half to several centuries, an emulation's mental inflexibility typically reduces its work productivity enough to make it cost-effective to replace it with a younger worker.

If the rate of mental aging resulting from leisure experience is similar to that resulting from work experience, then leisure has major costs to ems beyond the cost to run minds during leisure. Leisure experience ages ems, reducing their total possible career work experience. However, if some kinds of work or leisure experiences are "refreshing," in the sense of causing a reduction in total aging, ems would seek to substitute such refreshing experiences for others when possible.

When I want to use a particular duration in this book for an em's work career, I'll estimate a subjective useful career of one century. This is for a productive duration assuming that basic job methods do not change, even as many minor aspects of work circumstances such as customers and locations do change. However, it should be easy to see how to adjust calculations based on my one-century estimate to other possible duration values.

The main exceptions are likely to be for very stable job contexts. If a job environment changes very little, very old minds might remain the best at them. Tools that have become fragile but are hard to replace, perhaps because standards require them, may also tend to be managed by fragile but hard to replace ems.

For example, computer code that does numerical linear algebra, such as matrix inversion, has remained relatively stable for many decades, because little has changed in the need for such tasks or how numbers are encoded in computers. If this situation continues, then ems specialized in managing such code may be able to sustain especially long subjective work lives.

If complex software tools are saved for rare use in distant futures, ems who know how to use those tools well may be archived along with such tools, to be revived when these tools are needed. If simple retirement is unreliable because assets might be stolen or because interest rates might fall to very low levels, then knowing best how to use an important but rarely used complex tool might be one of the most secure routes for an em to have a very long, if intermittent, existence.

While an em economy has relatively little direct use for subjectively very-young em minds, such young minds might be a key source of variation to generate new minds to train for new kinds of jobs that appear in the economy. Such young minds might come from scans of young ordinary humans, or the em world may learn to emulate the growth of very young brains and thus to emulate an entire childhood from an early age. Training young em minds from a very early age for particular careers might boost their later peak productivity in those careers.

The typical subjective ages of ems are discussed in more detail in Chapter 17, Peak Age section. But the key point to remember is that ems age with experience, and then must retire.

RETIREMENT

With experience, ems become better adapted to their jobs. Such jobs, however, may no longer be needed, or may change so much that fragile old minds cannot adapt well to such large job changes. Ems who are no longer wanted or needed at work might choose to retire, at least if such ems could afford this, and had sufficient self-ownership.

The cost of retiring an em to run indefinitely at a slow speed could be small relative to the value that an em produces in just a few days of work. If we assume constant interest rates close to constant economic growth rates, then a simple calculation shows that the total cost to run an em indefinitely is roughly the economic doubling time multiplied by the run-cost per unit time.

For example, as a milli-em experiences roughly an hour in 1 objective month, then in an economy that doubles every objective month the cost of retiring indefinitely at a milli-em speed is the cost to run an em for about 1 subjective hour. Alternatively, for a retirement speed 10 times slower, and an economic doubling time of 10 days, the cost to retire falls to the cost to run an em for 2 subjective minutes. It only costs 1 subjective second of high speed experience to retire indefinitely at micro-em speeds. Thus indefinite retirement can be quite cheap, even for ems who work for only a short time before retiring.

Note, however, that these calculations ignore the cost of moving to a new retirement location, and they depend on interest rates remaining high. When growth and interest rates fall greatly, as it seems they must do eventually, then indefinite retirement becomes a lot more expensive.

It is not obvious what fraction of no-longer-productive ems retire, rather than end their lives. While retirement might often be a cheap option, that small expense of retirement might still seem larger compared with the benefit it provides, depending on the attitudes of typical ems toward death when many very similar copies remain alive.

Ems with more than minimal retirement budgets could use their added funds to pay for faster than minimum retirement speeds. Also, a pair of slow retirees who are close copies of one another might choose to go “double or nothing,” and randomly pick one of them to run at over twice the speed, while erasing the other one. (We consider the possibility of merging retired minds more in Chapter 28, Alternatives section.)

In addition, retirees who can afford to run much faster than base speed might try a “sleeping beauty” strategy. They would delay their retirement through several growth doublings, to increase their post-delay speed by a similar number of doublings. Ems confident enough about the intermediate-term stability of the em civilization might use this strategy to increase their total expected lifespan before a revolution or war might end it. This approach should also be tempting to ems eager for the higher status of a faster speed retirement. The start of retirement is an especially good time to try this strategy, as a delay then also saves on costs to move to a retirement location.

Such a sleeping beauty strategy is also available to non-retirees. That is, working ems might stop working earlier than necessary, archive a copy, invest the rest, and then wake up later to enjoy a faster life. Ems who do this risk their job skills no longer being as relevant when they try to return to work. While some ems would try this strategy, ems who remain active in the em economy tend to be those who reject it. In this sense the em world of work selects against sleeping beauty strategies, even if the world of retirement selects for it.

Retirement can be more attractive when the retired have useful respected roles to play in society. Retired ems might be part of important rituals associated with the copying, training, and retirement of other ems. Retired ems are also good for unspecialized everyman roles, such as juror or voter, if they aren’t running too slowly to sufficiently understand the current society. Very slow ems could more easily take a long-term view, which could make them useful in managing long-term investments.

Retirees might also serve as "wise watchers," a role that ancestors were said to serve in ancient societies. Even if retirees are much slower than most workers, they are also far more numerous, and so might randomly audit workers to report on if they are nice, mean, cooperative, honest, stylish, etc. Retirees who are closely related to workers might be more trusted to preserve privacy, and be better motivated to evaluate them well and honestly.

When there is detailed regular contact between retirees and others, those others could check that retirement communities actually provide the run-time and amenities that they promised to retirees. Otherwise, retirement communities may be tempted to shave expenses by cutting services. Retirees who participate in copying and ending rituals could also ensure that important social norms are not violated in the copying and ending processes.

GHOSTS

Slower ems are more vulnerable to instabilities in the em civilization, and in any descendant civilizations. For example, if typical retired ems run at ordinary human speed and typical work ems are kilo-ems, then having retirees live out a safe subjective decade of retirement requires that their civilization be stable over 10 000 years of subjective activity in typical workers. Slower milli-em retirees need a civilization stable over 10 million years of the subjective activity of typical workers. And micro-em retirees need stability over 10 billion years of typical worker subjective activity. Ensuring such levels of stability seems quite a challenge.

If civilization instability is the main risk to a normal lifespan for humans, and also to an indefinite retired life for ems, then humans and retired ems acquire a strong shared interest in promoting stability and preventing "existential" risk to the em civilization. The lower status of humans and em retirees, however, makes that promotion harder. Some ems might try to survive past the local instabilities of an em civilization by sending copies to distant locations, perhaps even beyond Earth into space. But most humans and slow ems may not be able to afford that.

Our basic concept of "death" is binary, so that one is either dead or not. But we often metaphorically extend this concept to a continuum. For example, people who have more strength, energy, passion, and awareness are said to be "more alive," and those who have more power, prestige, influence, or wealth are also said to be "more" in many ways, including more central and alive. As people who are asleep have less of all of these things, sleep is often seen as a partial death.

We have long had a related mythical concept of "ghost," which we also sometimes make into a continuum of ghostliness. A ghost was once human, but then died, and now is an active agent with death-related features. So ghosts tend to be cold, sick, slow, in low mood, and have a weak influence on the physical world. They are typically distracted, unaware of, and disinterested in humans. Ghosts are anti-social, avoid groups of more than a few humans, don't seem to collect into ghost gangs or ghost cities, and don't use tools or weapons. They are reluctant to move away from their old haunts. Ghosts are heard more than seen, rarely speak words, and are seen more in unusual viewing modes such as night, shadows, and mirrors (Fyfe 2011).

Slow em retirees share many features with people we see as "less alive," including ghosts. Not only are they literally closer subjectively to dying because of civilization instability, their minds are also more inflexible and stuck in their ways. Compared with faster working ems, slow retirees have less awareness, wealth, status, and influence, and they are slower to respond to events, including via speaking words or coordinating with others. As discussed in the previous section, retirees may often watch and judge working ems, and as discussed in Chapter 9, Views section, when in such roles, they may be visible only in special views.

Thus ems may come to see slower ems as ghostly, and the more ghostly the slower they are. Such ghosts are real, and with trouble one can talk to them, but they aren't very useful as allies, they get less moral weight, and one can usually ignore them without much cost. Because ems must pay for faster speeds, for ems being more alive is more directly related to having more money to spend.

"Beneath" each em is an underworld abyss, with deeper layers holding slower, more ghostly, ems. As we calculated in Chapter 6, Speeds section, beneath the most "alive" top cheap speed ems lies an underworld at least a factor of a trillion deep, and that factor may be a billion trillion. An em at the top for whom things go badly has a very long slide before reaching "bottom," from which the only lower rung is being erased.

WAYS TO END

So just how averse are ems to "death"?

For humans today, death is a strong psychological symbol and force. For example, indirectly reminding people of their eventual death induces them to more strongly favor charismatic leaders and the members, norms, and beliefs of their group. These effects are especially strong when people feel uncertain or low in status (Navarrete et al. 2004; Martin and van den Bos 2014; Solomon et al. 2015). Clearly, many of our feelings toward death are encoded quite deeply in our psyches.

Human aversion to death has many causes, but surely a big one is that growing productive humans takes years. For us, death can be a very expensive loss; we often most mourn the deaths of young adults, in whom we have invested the most yet gained the least. To reduce such losses, humans evolved a strong personal aversion to death, and strong social norms against killing. The main exceptions have been when large social gains might compensate death losses, as when killing a murderer, or when the losses from death may seem small, as for those likely to die anyway and in times of famine when not all can survive.

The world of ems fundamentally changes this situation, by drastically reducing many costs of death. When life is cheap, death can be cheap as well. Today, erasing the last copy of some valuable software might be an enormous loss, while erasing typical copies costs very little. Similarly, erasing all copies of a trained em might be a great loss, but deleting one copy made a few hours ago is usually a small loss. The em world adapts to these new costs and possibilities to an unknown degree.

For example, it is often tempting to create very short-lived ems that simultaneously do many similar short term tasks, and then to erase all but one when those tasks are done. One might save the copy who seems to have learned the most from their task. It could also be tempting to make a new copy to do a single short task from which little can be learned, after which the copy is erased.

However, if short-lived copies are erased when they are no longer needed, such ems might suffer high levels of stress anticipating the imminent prospect of their own "death," or the "deaths" of close associates. This could reduce the work productivity of ems assigned to such tasks, and their willingness to enter scenarios where many short-term ems end. The em economy seeks to avoid such costs.

Retirement raises related issues. While the prospect of imminent retirement might not be as stressful as the prospect of imminent death, ems may be similarly if less severely stressed by anticipating a move from a higher status fast culture and circle of associates to a lower status slow culture with new associates. Retirees also suffer larger risks because of instability of the em civilization.

Humans today can often be strongly motivated to take actions not only out of a fear of imminent death, but also via a related fear of damage to their reputation, that is, a fear that others will see them as having been a failure or a fool. For ems with many similar copies, both of these threats are weaker. If an em expects many similar copies to continue, they know that the actions of one particular copy will matter less to the reputation of their subclan.

There are many possible ways that ems could deal with death. First, it might be feasible to merge em copies when only a short subjective time has elapsed since they were copied from the same source. The merged em might remember the events that both ems experienced in the interim, and have the added skills that both ems acquired. But while such merged ems wouldn't suffer stress-of-death costs, they are still likely to become more fragile as a result of their added experience, and thus, eventually, less competitive. This would make merging more attractive for retirees than for workers. I assume merging is infeasible in the baseline scenario that is the focus of this book.

A second possibility is that ems will be reallocated from no-longer-needed tasks to newly needed tasks. But this option could impose large costs of mismatches between the skills and knowledge desired and those available in reassigned ems. It is usually more cost-effective to make new copies of ems who already have the needed skills. Also, because minds become more fragile with age, minds eventually become poorly suited for most tasks.

A third option is that the em labor market will select to a substantial degree from the ems whose basic personality or mental style is least bothered by the prospect of ending themselves. This option, however, may come at a substantial opportunity cost in the ability to select for other useful em features.

A fourth possibility is that mind tweaks will be found to greatly reduce death aversion. Although possible, this seems unlikely.

DEFINING DEATH

A fifth option is that the em world will produce new cultural attitudes about what counts as "death." Today, while everyone agrees that in theory they don't want to eat dirty food or wear dirty clothes, in practice we inherit quite different cultural standards on what counts as "dirty." What seems clean enough to some seems filthy to others. Similarly, the em world offers a wide range of ways to define "death," and em cultures could in principle vary greatly in which particular events they saw as a form of intolerable "death."

For example, today many would be comfortable with taking a drug before a party that results in their not remembering the party the next morning. Some would even enjoy the extra freedoms that such forgetting allowed. In some sense the party version of themselves will "die" at the end of the party, as no one will remember their experiences or feelings. But many people today would not frame the end of that evening's experience as "death."

Ems who think similarly do not mind splitting off a "spur" copy who will do a task for a few hours or days, and then end. They need not consider the lack of anyone who remembers the spur's activities as anything similar to "death." The spur is seen to live on because its original lives on, even if the original doesn't remember the spur's experience. Other ems might similarly think that a copy who lasts for a few weeks and then ends is not "dead," if a copy continues on who remembers their life up until those few weeks, and who heard or saw a detailed enough summary of the copy's few weeks of existence.

Individual em copies may come to see the choice to end a copy not as "Shall I end?" but instead as "Do I want to remember this?" Ems will see that there are substantial costs to remembering experiences, and make tradeoffs about what is worth remembering. In the short term, remembering work (and its stresses) adds to work weariness that must be paid for by rest from work. In the long term, remembering life events adds to mental aging and fragility. Ems see memories as more expensive than we do.

When different copies are made to try different things, but not all can be kept, this choice may be seen as mostly about which attempts are most useful to remember later. If archive copies are saved, ems could even change their mind later about which experiences are worth remembering, and revive an archive copy they weren't planning to retrieve from storage.

At another extreme, some ems could have a culture wherein they expect to "die" each hour in which they could not achieve "me-now immortality," which they might define as archiving a copy once per subjective hour and reviving it at a declining frequency for special occasions into the indefinite future.

Some ems might see moving their mind from one hosting computer to another as a form of death. While such an attitude would usually put an em at a great competitive disadvantage, there may be a few niches where such ems could survive. For example, such ems might work far from city centers where em brains are usually housed directly in mobile physical bodies, to support jobs requiring physical mobility.

Cultures clearly have a wide range of possibilities to choose from in defining intolerable "death." If some cultures have attitudes toward death that are more conducive to productive em activities, ems with such cultures will gain substantial advantages in competing with other ems from other cultures. Such selection effects may eventually result in most ems living in cultures with productivity-supporting attitudes toward death.

A more relaxed attitude toward "death" might be helped by the fact that em endings rarely have to be a surprise. Today, the timings of deaths are usually disruptive surprises, causing many to be highly stressed in anticipation. For ems, in contrast, the timing of their endings could usually be chosen and known, and thus could be made more convenient. On the other hand, some ems might be less stressed overall not knowing the exact moment of their ending. Such ems might be very stressed by knowing they are in their last few minutes, but far less stressed knowing they are in their last week.

The stress of ending is highest for ems with intermediate duration jobs, too long to seem like a forgotten party, but too short to make trivial the cost of retiring indefinitely at a moderate speed instead of ending. This stressful middle ground of intermediate length subjective job tasks could be avoided at a moderate cost by either merging such tasks into larger ones that take more subjective time, or by dividing them into smaller tasks that take less subjective time. When these approaches are prohibitively expensive, middle life-length ems might try to gain immortality via text, audio, or video diaries summarized and integrated into elements viewed by ems who follow them in time. Today, writing diaries substantially lowers stresses, such as stress from losing a job (Frattaroli 2006).

People can feel stress not only from ending personally, but also from the end or loss of close associates. This is a good reason to correlate the copying, retiring, and ending of closely associated ems. By working together in teams that mainly socialize internally, ems could reduce stressful disruptions caused by associates being copied, retired, or ended. The habit of retiring as a group also helps in applying social conformity pressures to induce ems to accept changes that accord with the usual social norms regarding life changes.

Copying sets of co-workers, friends, and lovers as units should also reduce the performance variation of teams, and avoid awkward questions about which new copies of associates should be treated as friends or lovers. This approach, however, may induce ems to feel imprisoned within a team, and reduce access to innovations and gossip that spread best across weak social ties. Teams are discussed more in Chapter 19, Teams section.

SUICIDE

A weaker em aversion to death-related things might strengthen the case for suicide as a fundamental em right. Today, we are aware that suicide can have large opportunity costs, by preventing a long life that might follow instead. This helps make us wary of endorsing suicide. For ems with many similar copies, this opportunity cost is far lower. For ems the main costs of suicide, relative to instead reviving a prior copy, are loss of the skills and information gained in the intervening time, and of the emotional attachments that surviving ems have to an em that has ended.

Ems may thus typically favor giving each em a basic right to mental access to a hardware switch that can end or perhaps also erase them, and to having this switch be as direct and incorruptible as possible. Such suicide switches could help ems respond to threats such as torture or rape. A report of an em who remembers trying and failing to trigger a suicide switch might inspire widespread outrage and a vigorous investigation.

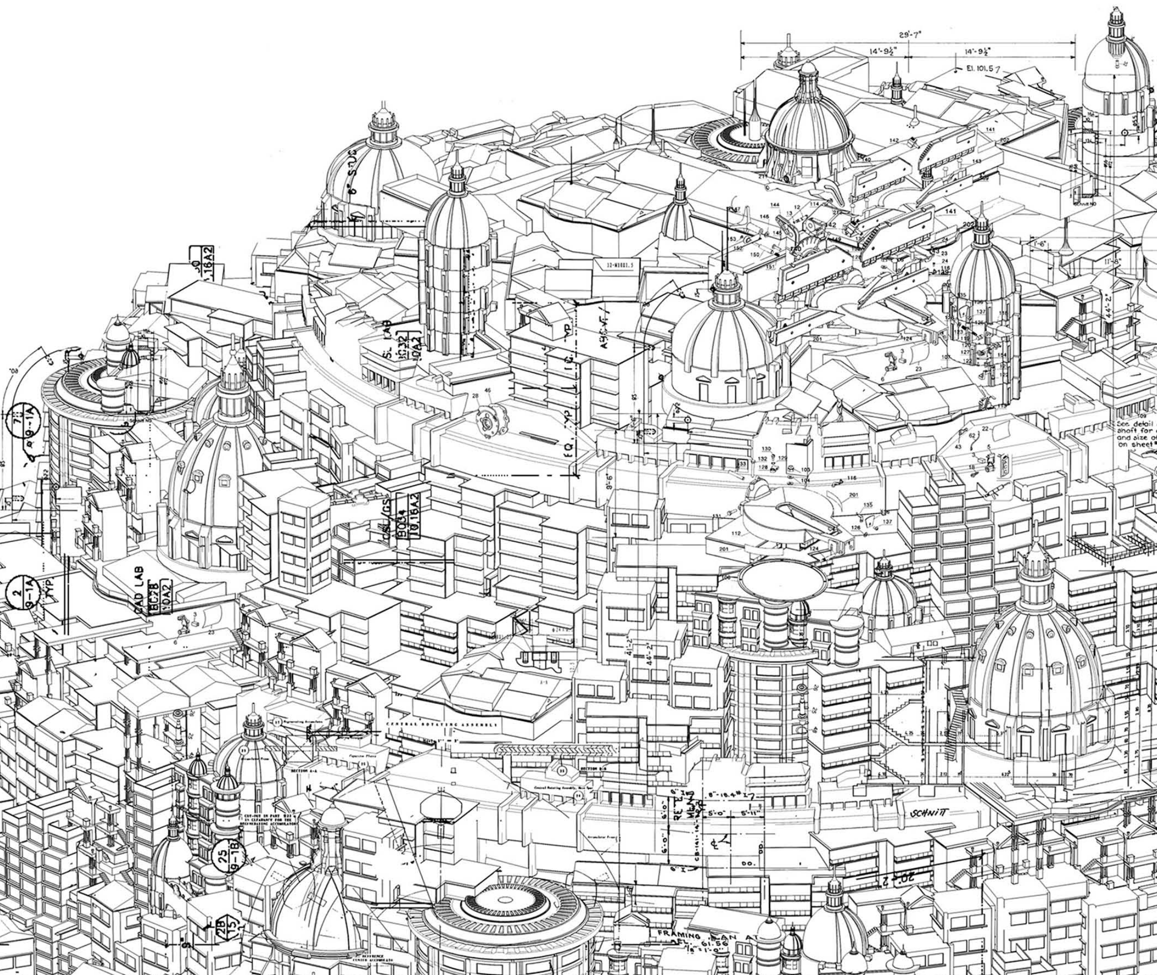
Of course this switch can't function correctly without appropriate support from the computer hardware that manages brain emulation processes.

A right for one em copy to immediately end itself is the simplest suicide right to implement and justify. It is also possible to imagine suicide rights with wider scopes. For example, one could imagine any em having the right to end and erase all copies of descendants from the same original copy within the last subjective day of experience. As those other copies might not want to commit suicide, it is not clear who favors such a policy. Without a wider right to suicide, any copy that commits suicide might just be replaced with a very recent archived copy who may suffer the exact same fate as the earlier copy, defeating the intent of the suicide.

In sum, most ems are much less death-averse than humans today, and this makes them more accepting of a right to suicide.

PART III

Economics



CHAPTER 12

Labor

SUPPLY AND DEMAND

Economists find supply and demand to be a very useful way to describe markets, including labor markets. Yes, supply and demand models sometimes fail, but such cases are notable precisely *because* such models usually work so well. In fact, arguably no model in social science works as well; it is the crown jewel of economic theory.

In a supply and demand based labor market, buyers and sellers mostly take prices as given, and assume that they can't change prices much. Given this assumption, they try to achieve their goals by varying how much labor they buy or sell. Note that supply and demand doesn't require that everyone know everything, or that they always do exactly what is best for them. It is actually a pretty robust and useful model of human behavior.

True, workers often acquire very specific job skills, after which there may be too few sellers or buyers of each specific skill to make for a competitive market. At that point people may reasonably believe that their behaviors can change relevant prices. But for each specific skill there is usually a large pool of workers who are similarly *able* to learn that skill, and another large pool, this time of employers, with skills they'd like this same pool of workers to learn in order to do their jobs. There is thus a *pre-skill* labor market with pools of similarly-able-to-learn workers, and with employers who have similar-tasks-to-learn. If these pools are large, and if they do not coordinate to limit the wages they accept, then supply and demand analysis will apply well to this pre-skill market.

Thus while it may be hard to predict the specific wages that workers will earn after they learn a specific skill, we can more confidently predict that, in the pre-skill labor market, similar workers will reasonably *expect* to earn a similar net compensation after they train. Also, employers trying to attract similar workers should expect to pay a similar net compensation. (Of course "wages" include not just cash, but other forms of compensation such as status markers, connections, and resources including information access and computing power.)

Consider how such pre-skill labor markets change when we introduce ems built from cheap signal-processing hardware, and are able to substitute in most jobs for ordinary human workers after they've acquired relevant skills. What would it take for em competition to bring expected pre-skill wages down to, for example, less than twice the full em hardware cost?

As ems could not long survive with wages below the full hardware cost, if pre-skill wages were, on average, less than twice the total hardware cost, then for most such ems their wages, minus training costs, would have to be close to the average wage.

The main way that em labor markets differ from labor markets today is that ems can be easily copied. Copying causes many large changes to em labor markets. For example, with copying there can be sufficient competition for a particular pre-skill type given demand from many competing employers, and supply from at least two competing ems of that type. For these two ems, all we need is that when faced with a take it or leave it wage offer, they each accept a wage of twice the full hardware cost. After all, any one em can supply an unlimited number of copies of itself to this labor market.

Chapter 19, Clans section will say more about clans being an important unit of economic coordination, and coordinating to negotiate the wages that its members may accept. Even so, it is sufficient in this labor market for two clans with close enough pre-skills to compete for each type of job.

Earning a wage of twice their full hardware cost, an em could spend one-half of his or her wakeful time working, and spend the remaining time comfortably socializing, pondering, watching TV, or any other inexpensive activity. By allowing another working copy, an em could create another version or part of itself that enjoys its life, but not so much as to induce envy from the original.

Note that I discuss a wage of twice the full hardware cost merely to have a concrete example; actual competitive wages could be higher or lower, depending on how much leisure ems typically require to decide their lives are worth living.

If enough unorganized ems are willing to make many copies of themselves to compete to fill new job openings, the supply of labor is mainly driven by the supply of em hardware needed to support more copies. In that case, it should be noted that the supply of most manufactured goods tends to be quite elastic, at least relative to the elasticity of ordinary human labor demand.

Today, typical estimates are that, in the long run, a 1% rise in wages reduces the number of workers that employers are willing to hire by ~0.5% (Dunne and Roberts 1993). That is, the quantity of labor demanded is rather inelastic, that is, not very responsive to changes in wages. The long-run supply of human labor today also seems relatively inelastic; a 1% wage increase induces ~0.6% more work supplied, ~0.3% from more workers and ~0.3% from more hours from each worker (Chetty et al. 2011).

In stark contrast, a 1% increase in the price of manufactured goods induces manufacturers to supply, on average, about 5% more of those goods in the short run (Shea 1993), and even more in the long run. That is, the quantity of manufactured products supplied is very elastic, that is, very responsive to price. Some goods, such as some computer memory chips, even have downward sloping supply curves, where a larger demand for the product *lowers* prices by letting the industry take advantage of scale economies (Kang 2010). Thus having enough ems willing to make copies of themselves should introduce a large increase in the elasticity of the labor supply.

Because of this higher elasticity of supply, the larger and lower-cost supply of ems intersects labor demand at a new point, where the quantity hired is larger and where wages are lower. That is, when hardware costs are lower, wages should also be less.

Having many firms hire cheaper ems increases the total wealth of society, which increases the total demand for labor. If the hardware supply were inelastic, these total demand increases might raise wages substantially, perhaps to near original pre-em wage levels. But as hardware supply is very elastic, and may even be downward sloping, em wages should stay low, at least in the absence of strong wage or population regulations.

MALTHUSIAN WAGES

Thus the introduction of competitively supplied ems should greatly lower wages, to near the full cost of the computer hardware needed to run em brains. Such a scenario is famously called "Malthusian," after Thomas Malthus who in 1798 argued that when population can grow faster than total economic output, wages fall to near subsistence levels.

Note that in this section we are assuming that enough ems are willing to copy themselves to fill new job openings, and that they have not organized to avoid competing with each other. We shall consider these assumptions in more detail in the section "Enough Ems".

Note also that having em wages near subsistence levels should eliminate most of the familiar wage premiums for workers who are smarter, healthier, prettier, etc., than others. Because ems can be copied so easily, even the most skilled ems can be just as plentiful as any other kind of em. While wages vary to compensate for the costs of training to learn particular tasks, wages do not compensate much for other general differences. This should greatly reduce wage inequality (although not necessarily wealth inequality), and increase the relative fraction of workers hired that are of the types that earn higher wages today. For example, if today we hire fewer lawyers compared with janitors because lawyers are more expensive, in a similar situation ems hire more lawyers and fewer janitors.

Even if all workers should expect ahead of time to make low wages, it is still possible for some workers to make high wages in unusual situations. For example, if it were very expensive to have ems try their hand at a type of CEO position, then the few who tried and did well in that role might well be paid a large wage premium. But we'd expect that premium to be balanced by large entry costs that ems must pay to be allowed to try out in such a role. The expected wages of ems seeking to try out in such a role would be low.

Em workers might also earn wage premiums associated with being the very best in the world at what they do. Specifically, a very-best em might earn an extra wage equal to the difference between their productivity and the productivity of the second best em. Such differences are usually rather small, however, perhaps amounting to a few minutes per day of extra leisure time.

Having em wages near subsistence levels should eliminate most of the profits that might be gained by enslaving ems. History shows that slave owners are the most eager to create and own slaves when wages are high and rising. When wages are low it costs nearly as much to feed and house a slave as it does to hire a free worker (Domar 1970).

The large fall in em wages raises the cost of tools and supporting capital, relative to the cost of labor. Supply and demand then induces employers to increase their reliance on labor, relative to tools and capital. Today about 60% of firm income goes to employees, and more broadly about 52% of all income goes to workers. These figures are down from 65% and 56%, respectively, 40 years ago. Possible explanations include a rise in the value of real estate and intellectual property, tools and other forms of capital becoming more effective and cheap, and richer people not wanting to work as many hours (Karabarbounis and Neiman 2014). The arrival of ems is likely to raise the fraction of income that goes to labor.

Industries that should remain important in such a competitive world include security, emergency-response, training, law, finance, news, entertainment, politics, education, software, computer and communication hardware, energy production and transport, cooling, material transportation, construction, and mining. Job tasks that should remain important include design, marketing, sales, purchasing, management, administration, testing, monitoring, diagnosis, repair, cleaning, driving, accounting, assembly, packing, installation, mixing, sorting, fitting, negotiation, and research.

Readers of this book may find near subsistence wages to be a strange and perhaps scary prospect. So it is worth remembering that such wages in effect applied to almost all animals who ever lived, to almost all humans before a few hundred years ago, and for a billion humans still today. Historically, it is by far the usual case. And poor ems arguably suffer little.

FIRST EMS

The distribution of features found in all human workers today differs from the distribution found in untrained humans. People who work have both chosen to work, and are chosen by employers. In addition, training changes us, such as by developing particular skills. Em workers differ even more from untrained people today; em features are selected at four different stages: scanning, tweaking, training, and copying.

Early on at least, the people who are scanned are unusual in many ways. One reason is that the earliest effective scanning technology is likely to destroy a brain as part of the process of reading its details. Such early scanning technology starts with a brain where activity has stopped, either because it is very cold, or because it is infused with a solid plastic-like material. With this frozen brain, one scans a two-dimensional surface in fine detail, slices away another thin layer, and repeats (Mikula and Denk 2015).

As brains have ceased apparent activity and then started up again without incident, we know that we need only scan the static brain structures that persist even without activity, and do not need details associated with temporary activity.

Because early scans are destructive, the first people to be scanned are selected for their unusual willingness to suffer that cost. Although some may be scanned unwillingly, other scans are done on the "dead" and the eager. That is, some are people, such as cancer victims, whose body failed them in a way that temporarily preserved their brain for scanning. Others might be so eager to join the em world that they volunteer for destructive scanning even when they could otherwise continue a long life as an ordinary human. These might include key employees of early em firms.

The very first scans might perhaps be performed on cryonics customers, that is, on people who had previously had their brains frozen and stored in liquid nitrogen in the hope of being revived when technology improved, and who had agreed to allow em scanning later. High-quality frozen brains might be legally "dead," and so available to be scanned with fewer legal limitations. Of course frozen brains may also have disadvantages, compared with living brains.

About 200 people have been frozen over the last five decades. I am one of about 2000 people still living who have arranged to be cryogenically frozen. I would choose to have my frozen brain destructively scanned to create an em, given an at least 80% chance of success.

A second reason that early scanned people are unusual is that early scans are likely to be very expensive. Some rich people may pay to scan themselves, non-profits and governments may pay to scan others, and profit-seeking firms (including criminal organizations) invest in scans from which they expect to profit.

Expected daily revenue from a scan is the net amount that a firm expects to charge per day of work for renting an initially willing trained copy, times the number of copies one expects to rent. Costs include the full hardware cost, training, taxes, and whatever additional wages such copies require, in money, control, and increased leisure and retirement time, to become initially willing workers. Additional related expenses may include searching for, and marketing to, potential customers, searching for and developing training methods, and political lobbying.

Workers who are initially willing to work may sometimes became unwilling to work later during their work process. If this happens often, it reduces the price that customers are willing to pay to rent such workers.

Profit-seeking firms select people to scan who can generate the most net profit when rented to work. Such people are willing to work, able to flexibly adapt to new em work environments, and have, or are able to obtain, work skills valued by many customers.

Few people will agree to be scanned to create ems if they expect such ems to become slaves tortured into obeying commands. It is unlikely that the few willing to accept this condition will be especially productive. Thus a widespread enslavement of productive ems would be a surprise.

For the very earliest scans, their main customers are ordinary human individuals and firms. So the first scans are of people who already have work skills valued by the then-current economy, as these can be immediately deployed for a profit. Such workers are likely near the peak of their career productivity. For example, they might be older lawyers or software engineers with well-established reputations for exceptional productivity.

However, once the em world becomes larger, the required tasks shift to being defined more by the new em world. This reduces the value of skills tuned to the overshadowed world of ordinary humans, and increases the value of flexibility, of abilities to learn new em world skills, and of the possibility of using these new skills over a long career. This shifts scanning demands from older people with proven skills toward younger people with a strong potential to learn relevant skills.

If at this point destructive scanning were still the only cost-effective scanning technology, the preference for scanning young human brains for their potential and flexibility may create a strong competition for a limited number of young people who are also capable, and eager to join the em world.

Attempts to limit the freedom of such young people to voluntarily choose destructive scanning could result in big conflicts.

Later on, when scans become non-destructive and scanning costs fall, scans are done on far more people, including both old people with proven productivity and adaptability, and younger people with great promise to later become productive and adaptable. Eventually most humans willing to be scanned are scanned, to provide a large pool of scans to search for potentially productive workers. By then, many early scans may have gained first-mover advantages over late arrivals. First movers will have adapted more to em environments, and other ems and other systems will have adapted more to them.

SELECTION

While ems are mentally quite human, selection effects will make them differ from typical humans.

For example, in addition to the selection of which humans to scan, scanned brains may be tweaked via adjusting a few dozen or more overall parameters of the emulation process. These tweaks might make emulations that are especially thoughtful, focused, relaxed, etc. This tweaking is somewhat like tuning a car by adjusting its many settings, as opposed to building a car from scratch. The amount of useful tweaking is limited by how opaque em brains are at the time; the more that ems understand, the more useful changes they can make.

The selection of tweaks to apply to any given scan, and how much freedom that tweaked em has to change its tweaks later, are in general a compromise negotiated between the scanned em and the patrons who fund its scanning, tweaking, training, and copying.

A tweaked scan of an ordinary human typically needs to undergo general training to function as an em in the em-dominated world. It also needs more specialized training to become proficient at particular tasks. Prior training as an ordinary human doing similar tasks is often helpful, but usually insufficient. Different copies of a scan could be trained to do different tasks. As with the choice to scan, the selection of ways to train scanned and tweaked copies depends on the preferences of wealthy people who train themselves, of charities and governments who pay others to train, and of "employment agency"-like firms who seek to profit from renting out trained scans.

Given a population of trained, tweaked scans, the number of actual copies created, how fast these copies run, and for how long, depends on how much wealthy ems were willing to spend on themselves, how much non-profits and governments were willing to spend to create and extend various em lives, and on how much profit-seeking firms expect to charge customers to rent the work time of various copies.

In addition to the four levels of selection of scanning, tweaking, training, and copying (including speed choice), there are also four types of actors who act as selectors: wealthy individuals, non-profits, governments, and profit-seeking firms. As discussed in the "Enough Ems" section, the em labor market is competitive if there are enough ems available to compete for jobs.

Wealthy individuals sometimes choose which humans to pay to scan and copy, and which tweaks to apply based on attachment, admiration, or other personal criteria. They are likely to have more varied preferences, compared with the other actors who select. Thus the ems with the most extreme features are more likely to have been chosen by wealthy individuals.

In a highly competitive low-regulation economy, the resources available to wealthy individuals and charities willing to suffer substantial operating losses should be small relative to the resources available to profit-seeking firms, and to non-profits who behave similarly because they are unwilling to suffer substantial operating losses for long. Thus in the case of limited government taxation and regulation, it seems sufficient to analyze the case of selection of ems by profit-seeking firms.

That is, if competition is strong enough to drive behaviors so that economic profits fall to near zero, there shouldn't be much difference in the behaviors of organizations that try to maximize profits, and organizations that cannot long survive operating losses. Thus in a competitive em economy the characteristics of most ems should be as if profit-seeking firms had selected them.

ENOUGH EMS

If enough unorganized ems are willing to copy themselves to fill profit-driven (or loss-limited) job openings, and if such copying is not prevented by strong global regulation, then low em total hardware costs for em creation can drive a vast as-if-profit-driven expansion in the number of ems. This makes ems much more numerous than ordinary humans, and cuts wages to near total em hardware costs. But are a sufficient number of ems willing to be copied?

If for each pre-skill type there are some ems much better at jobs of that type than other ems, then "enough" ems is at least two competing such ems of each type. These two could even come from the same clan. After all, each willing and free em can allow an unlimited number of copies of itself, so just two competing ems guarantees an arbitrary number of competing ems. The number of distinct worker types sets the size of "enough," because it is enough to have a few willing and competing ems of each such type.

So how many pre-skill types are there today? Our economy appears on the surface to hold many millions of kinds of jobs, and a larger em economy might hold many more. The U.S. census classifies workers according to over 21 000 industries and 31 000 occupations. Many of these occupations are very similar to each other, however. For example, the U.S. government has created a database (called O*NET) that gives 277 descriptors for each of 974 job categories. Such a database would hardly be possible if the differing jobs within each of these 974 categories were not very similar. In fact, a factor analysis of 226 of these descriptors finds that the top four factors account for 75% of the variance in these descriptors, and the top 15 factors account for 91% of this variance (Lee 2011).

Also, statistical models to predict the income and performance of workers usually have at most only a few dozen parameters. These analyses have mostly been about post-skill types, that is, about how workers differ after they have been trained to do particular tasks. Pre-skill types should vary even less than do post-skill types.

All this suggests that the number of distinct pre-skill types, where workers of different types differ substantially in their ability to acquire particular job skills, is far smaller than the number of distinct jobs. In fact, I guess that there are no more than a million or so distinct relevant pre-skill types for an em economy, and perhaps only dozens of such types.

If we assume that em variation comes similarly from the variation in the people who are scanned, and from variation in tweaking and early training of scanned ems, then a million types could plausibly come from a thousand people scanned, times a thousand kinds of differences in useful tweaks and early general training. This suggests that "enough" ems to fill the niches of a competitive em labor market might be found from only a thousand diverse qualified people who were scanned and competing for jobs. Only a dozen or even fewer such people might be enough.

Thus it is a reasonable guess that for the vast majority of pre-skill wages to fall to roughly twice the total hardware cost, and as a result for the quantity of labor to greatly increase, what we require is that firms can find, out of over 7 billion ordinary humans, fewer than roughly a thousand able people willing to be scanned, tweaked, and copied to take jobs at such a wage. We also require this group of ems to fail to strongly coordinate to negotiate better wages than they could get without coordination. These requirements seem quite plausible.

While having wages close to the full hardware cost makes an em "poor" in some senses of the word, "poor" has many connotations that need not apply in an em world. Yes, "poor" ems spend a large fraction of their time working. But such ems need not suffer physical hunger, exhaustion, pain, sickness, grime, hard labor, or sudden unexpected death. Widespread use of automation makes most jobs at least modestly mentally challenging. As most ems are poor, em poverty does not inflict the same pain of low social status that it does in societies such as ours where most people are rich. Ems could be assured of very high-quality entertainment during leisure time, and of a comfortable indefinite retirement when they were no longer competitive at work.

Remember also that the vast majority of humans who have ever lived had near subsistence level incomes. This is true for an even larger fraction of non-human animals. Humans evolved for and are well-adapted to such income levels, and historians and anthropologists suggest that most have lived satisfying even if not luxurious lives. The evaluation of the em world is discussed more in Chapter 29, Evaluation section.

Related to the question of whether there are "enough" types of em workers to create competitive labor markets is the question of whether there are "enough" types of ems to create a robust Darwinian selection of ems. That is, the larger is the space of possible ems to draw on, the further that a Darwinian type of selection process could go in evolving em minds better suited to the em world.

If the space of possible tweaks is limited, with say only a million distinct tweaks, then given a few billion original humans the space of possible ems is limited to a million times a few billion, or a few quadrillion. This allows a substantial but limited evolution of ems. Ems selected in this process are not like typical humans, but they are also not usually far from the range of variation of ordinary humans. Such ems are different, but still recognizably human. This book focuses mostly on such a scenario.

However, if it later becomes possible to explore a much larger space of useful mind modifications, that could allow for a much stronger Darwinian evolution of ems. In this case ems might perhaps quickly evolve to become not recognizably human. That is, ems might fragment into one or more distinct mental species with very different mental styles. Ems might, in effect, become aliens. We discuss this more in Chapter 27, Unhumans section.

In sum, it seems there will be enough ems of different types to drive almost all wages to near subsistence levels.

CHAPTER 13

Efficiency

CLAN CONCENTRATION

The em economy could draw from a large pool of ordinary humans willing to be scanned. That pool could, in effect, be greatly expanded via many possible tweaks of each scan. In addition, a single em can dominate a large labor market by making many copies of itself. These factors can together produce strong competition. Such competition may drive profit-seeking firms to try hard to select the most profitable combinations of scanning, tweaking, and training. The best such combinations would then dominate the em economy.

A thousand diverse able scanned humans seems sufficient to induce competition in most labor markets, as the best few ems can dominate each labor market. Thus it seems likely that most ems are copies of fewer than a thousand or so, and perhaps only dozens, of the original humans. These few highly copied em "clans" of copies might be known by a single name, as are celebrities today such as Madonna or Beyoncé. (Of course ems also need identifiers to distinguish particular clan members.)

Familiar one-name em clans might be typically favored in most social interactions over billions of unfamiliar two- or three-name clans. The usual human preference for interacting with familiar personalities rather than strangers might discourage ems from interacting with ems from less well-known clans, increasing inequality between clans. Ems may even justify this unequal treatment by saying that it is less moral to end an em copy from a small clan, because not as many similar other ems continue on. However, an aversion to having multiple copies from the same clan in each small social circle may limit this clan inequality.

Em sociality might thus become more like that of our forager ancestors, who only ever met a few hundred people at most in their entire lives, and were quite familiar with the history, personality, and abilities of everyone they met (Dunbar 1992; McCarty et al. 2000). When they stick to associating with one-names, ems might know well who they liked or didn't like, and how best to flatter or insult each one. There might be clan jokes analogous to our ethnic jokes, such as "How many Freds does it take to screw in a light bulb?" One-name ems cannot "start over fresh" by moving to a new city or job; strong reputations follow them everywhere.

Because our forager ancestors knew each other so well, they rarely overreacted to individual actions; foragers could interpret each action well in the context of the rest of a person's life. This situation has changed in the farmer and industrial eras. Today, people who hardly know us can react strongly to any one thing we do or say. When compared with foragers, we face much stronger conformity pressures because of fears of others misinterpreting any one action. So we try harder to make sure that each thing we do can be spun positively. One-name ems are much less pressured to conform in this way. This is because while such ems are usually eager to preserve the overall reputation of their clan, they can more expect each of their actions to be interpreted in the context of the entire history of their clan.

Being dominated by copies of the best few hundred humans is one of the most dramatic ways in which the em world differs from our world today.

COMPETITION

A world dominated by a few hundred clans can be a very competitive world.

Growth in economic productivity occurs because of both increased productivity at individual establishments and firms, and more productive establishments and firms displacing less productive competitors. Today, this second factor dominates, and is accelerated by stronger competition (Foster et al. 2006; Rasmus and Mortensen 2008; Syverson 2011).

While our economy today is somewhat competitive, competition is limited because markets are fragmented by spatial distance and product variety, and because of the long time it takes to train individual employees for new methods and situations. As a result, inefficient firms and establishments continue to exist for surprisingly long durations. For example, U.S.

manufacturing plants today that are at the 90th percentile of productivity are typically *twice* as productive as plants at the 10th percentile. In India and China these more productive plants are *five times* more productive (Haltiwanger 2012; Syverson 2004; Syverson 2011).

An em economy can be much more competitive, in the sense of more quickly eliminating less productive entities and practices, to produce a smaller variation in efficiency. As we will see, ems have less product variety because they are poorer, and have less spatial segmentation because they are concentrated in a few dense cities. More important, ems can more easily transfer methods from their more efficient establishments, by directly making copies of the em teams working at more efficient establishments. A single em, by making many copies, can take over an entire labor market. All these factors should make the em economy more competitive in the sense of more aggressively selecting for high productivity. Compared with today, in the em world smaller differences in efficiency between different behaviors more easily lead to displacements of less efficient behaviors by more efficient ones.

Given at least a few substantial places in the world that do not greatly limit ems via regulation and taxation, and a few dozen or so distinct em clans willing to copy themselves in such places, wages in em-friendly places should greatly fall, and output there should greatly increase. If such places can also grow very rapidly, they quickly come to dominate the world economy, which then becomes very competitive. Ems dominate the world.

The strong competition resulting from the high selectivity of an em world should drive and enable an aggressive search for work and living arrangements that achieve the greatest productivity at the lowest cost. Today, the adoption of apparently efficient work and living arrangements is often hindered by personal and social conformity preferences against arrangements that are unfamiliar, or which evoke unpopular symbolisms. We should expect less resistance to these changes in a more competitive em world, especially when there is competition among regions with different standards of conformity.

Thus a working assumption in the rest of this book is that em work, reproduction, and living arrangements are all determined more than today by simple *efficiency*—the arrangements that exist will tend more to be those that achieve useful tasks at a minimum total cost, including hardware and training. Psychological costs of abstract symbolic discomfort matter less than they do today. Of course direct immediate continuing feelings of discomfort could continue to matter greatly. But abstract symbolic discomforts mostly go away as people get used to most everyone accepting the new arrangements.

Not only is em efficiency a likely assumption, it is also a simple assumption, in that it facilitates further analysis of the em scenario. A very competitive em world will tend to induce ems to more often swallow their pride and switch to efficient but strange or repugnant new ways.

Note that the word "competition" has a technical definition in economics, namely agents acting as if they have little power to influence the prices they pay or charge. This meaning applies to the em labor markets mainly in early pre-skill stages when clans consider which particular job markets to enter, and when many such clans are nearly as well qualified to enter. At this early point we expect competition to produce nearly zero expected profit for all who enter a labor market. This implies nearly subsistence em net wages, after paying for fixed costs to enter such markets.

However, as with most product markets today, we expect only a few clans to actually enter each em labor market, by investing in fixed costs such as research, training, and marketing. We expect such clans to try hard to make their worker products seem different to customers, so that they can gain more power to set prices. We expect the fixed costs to enter such markets to account for a substantial fraction of wages, that such fixed costs will be bigger in larger labor markets, and that fixed costs will be the main source of variation across clans in their cost of supplying ems to particular labor markets. Thus we don't expect competitive clan or employer behavior at these late market stages.

We also expect that when customers place substantial value on particular teams, over and above the value of individual workers, then clans will coordinate to package their workers into teams that they can offer for a package price. All of these non-competitive expectations come from standard results in the economic subfield of "industrial organization" (Shy 1996).

The main exceptions to choices being driven by competitiveness in the em world may be choices made by the em subclans especially successful at accumulating wealth. There should be some selection for clans that spend this wealth well, by investing in good enterprises, and also in providing credible signals of their wealth to induce favorable treatment by others. However, wealthy clans who behave this way initially but then later deviate from such efficient behavior will not be instantly eliminated; as their wealth declines they could spend it in many unpredictable ways.

Aside from this exception, however, the em world is very competitive.

EFFICIENCY

A more competitive world will make more efficient choices, and an efficient em world differs in many ways.

Today, nations and industries with weaker regulation tend to grow faster, and weaker financial regulation tends to benefit many industries (Alesina et al. 2005; Pizzola 2015). This is plausibly because regulations are designed around existing practices, and so discourage changes in those practices. Thus business regulation tends to discourage growth, which usually requires changing practices (Dawson and Seater 2013).

The em world is more likely to see regulations that help each place to compete with others in the global em economy, or that don't make much of a difference for global competition. Examples of helpful regulations include those that discourage local negative externalities such as pollution, or that allow cities to achieve scale and scope economies. A type of regulation that may not help or hurt much is restrictions on searching for mental tweaks. Once the search for such tweaks has reached the point of greatly diminishing returns, moral repugnance over possible suffering in experimented-on-ems during a search for tweaks may induce regulations limiting further search.

Note that a lack of strong global regulation tends to make places compete on their growth rates, which should discourage local growth-inhibiting regulations. So not only does low regulation suggest strong competition, strong competition also suggests low regulation.

A habit of punishing the worst performers tends to give stronger incentives for overall performance, compared with rewarding the best performers (Drouvelis and Jamison 2015; Kubanek et al. 2015). When evaluating things, marking low quality also works better than marking high quality (Klein and Garcia 2014). However, organizations today are reluctant to punish, and so they tend to focus on positive rewards and evaluations. After all, workers tend to leave organizations that focus on negatives. More competitive em organizations, in contrast, are likely to focus more on negatives than we do today. There will be fewer gains from rewarding the best workers, because of less quality variation among that best group, and because usually only the best workers are copied.

It is possible that stronger punishment involves direct pain, and this has often happened in the distant past. But the extreme rarity of this practice today suggests that pain is not very useful as a motivator for workers in advanced industrial jobs, and so is also only rarely useful for em workers. It is also possible that rewards involve direct mind tweaks to produce pleasure. But again the rarity of related practices today weakly suggests that this is only rarely useful for em workers.

A competitive low-wage em economy should reverse the trends of recent decades in product and services, and increase the priority of cost and simple functionality, relative to comfort, style, identity-enhancement, and variety. Thus em products should be less varied, achieve greater scale economies, and rely more on engineering skills relative to design skills. Em products should also be marketed more by referring to concrete product features rather than by indirectly associating products with moods, ideals, and identities. The concentration of ems into a small number of clans should also reduce the variety of products desired. These changes should also increase the rate of innovation, as it is cheaper to innovate in less varied products that are more widely used, and in products that rely more on engineering relative to design.

Despite the availability of many tweaks and the equivalent of powerful mind-altering drugs, ems probably continue to suffer periodically from greatly debilitating mental conditions such as depression, love-sickness, or hobby obsession. In a competitive em economy, such conditions may often result in ending that copy and reviving a copy archived before the condition appeared. Ems are likely to periodically save backup copies to allow this option. Efforts to avoid losing useful experience because of such reversions may focus less on curing such conditions, and more on detecting and averting them before the conditions begin.

A competitive em economy might have a few small niches for emulations of animals. After all, animals might be able to do some useful tasks, and while animals are less capable than humans at many tasks, their smaller brains can be emulated at a much lower cost. However, the fact that we have found little use for animal brains in our economy today suggests that animal ems make only a small niche contribution to the em labor force.

The implications of efficiency mentioned so far in this section are only the start. Most of the rest of this book is devoted to identifying more such implications.

ELITENESS

If most ems are copies of fewer than a thousand or so original humans, just how elite does that make ems, compared with typical humans today?

Ems are selected from among the humans alive during the early em era (and perhaps also a few previous cryonics customers). As this early em era might last only for a year or two in objective time, ems are basically chosen from a human population snapshot. Depending on when the em transition occurred, this gives 7 to 10 or so billion humans to choose from.

Early on, the human-to-em selection process prefers adult humans with well-established success, skills, and connections. But the selection process quickly switches to preferring younger more flexible humans, who can be better trained to adapt to the em world, and to particular em jobs. This likely leads to a focus on selecting from a limited range of ideal ages, a range perhaps 2 to 20 years wide.

Today, there are about 120 million people alive at each year of age between 5 and 30 years old, and this figure is not expected to change much over the next half-century or so (United Nations 2013). Thus depending on the width of the ideal age range, ems are selected from a population of humans that numbers between 300 million and 3 billion people. From each year of age within the ideal age range, roughly 50 to 500 humans are selected to become part of the 1000 most highly copied ems.

To see how selective this is, we can compare this 50-to-500-per-birth-year figure to the number of humans per-birth-year today who are selected for prestigious distinctions. For example, each year there are on average about 150 Grammy awards for U.S. musical achievement, 75 Olympic gold medals for athletic achievement, and 136 Clio awards for excellence in advertising. Per year, about 34 Oscars are given for excellence in movies, and 21 Pulitzers for excellence in writing and journalism. Each year there are about 50 new heads of state worldwide. Also, the fact that there are today about 45 billionaires at each age near the peak billionaire age of about 60 suggests that today about 65 people per year are born who will eventually reach a level of wealth comparable in selectivity with billionaires today (Dolan and Kroll 2014).

These figures suggest that highly copied ems are chosen more selectively than are winners of Olympic gold medals, Oscars, Grammys, Clios, Pulitzers, and heads of state, assuming that only a small fraction of people today try for each of these honors.

It is less clear if ems are more selective than billionaires today, as one might argue that a large fraction of people today try to be as rich as possible. Also ambiguous are comparisons between em selection and the roughly eight Nobel Prizes and four acting Oscars given per year, or the three people per birth-year who win at least three Olympic gold medals. It isn't clear what fraction of people today would try for such awards, if they had compatible skills and resources. But the selectivity of highly copied ems is at least comparable with such distinctions. If there are much fewer than 1000 highly copied ems, such ems are even more selective.

Today, Jews comprise a disproportionate fraction of extreme elites such as billionaires, and winners of prizes such as the Pulitzer, Oscar, and Nobel prizes (Forbes 2013). (I have sought but failed to find work identifying other elite ethnicities.) This weakly suggests that Jews are also disproportionately represented among ems. Perhaps Jews only happen to be disproportionately elite now for temporary cultural reasons. Even so, groups of ordinary humans that are only temporarily elite at the time the em world arises might still end up constituting a disproportionate fraction of the em world, and this favoritism might last long into the em era.

It is possible that sometime in the next half-century or so we will be able to create babies of substantially higher genetic quality via embryo selection in the context of in vitro fertilization (Shulman and Bostrom 2013). If so, when they reach the right age these may be very attractive candidates for scanning into ems.

Even in groups with much higher chances to start one of the 1000 most copied clans, almost everyone still has a low chance. For example, today there are about 1645 billionaires (Dolan and Kroll 2014). If there were a similar number of billionaires at the time of the em transition, then if each one had a 100 000 times greater than average chance of starting a top em clan, there'd still be only about a dozen of the top 1000 clans that started from a billionaire, and each billionaire would only have a 1% chance of starting such a clan.

All of which is to say, compared with us today ems are *very* elite.

QUALITIES

What individual features of ems can we predict from the fact that ems are the elite survivors of a very competitive world?

The best em combinations are chosen not only for having high average productivity on useful tasks, but also for having a low variation in such productivity. That is, the best ems are consistently excellent. After all, most tasks coordinate with other tasks, and an unexpected local productivity drop in one task usually hurts associated tasks more than an unexpected local productivity boost helps such associated tasks. So local productivity variation on interdependent tasks tends to hurt overall productivity.

Today, people who are more productive at work tend to have more health, beauty, marriage, religion, intelligence, extraversion, conscientiousness, agreeableness, and non-neuroticism (Roberts et al. 2007; Steen 1996; Nguyen et al. 2003; Barrick 2005; Roberts et al. 2007; Sutin et al. 2009; Fletcher 2013; Gensowski 2014). Such features also predict more education and occupational prestige today (Damian et al. 2015). We weakly expect ems to have more of these features, when compared with people today.

In our world, achievement rises with intelligence (Kell et al. 2013), although at the very highest levels smart people seem at more risk of becoming "maladjusted" to their society (Towers 1987). Smarter people are less accident-prone and more long-lived, cooperative, patient, trusting, trustworthy, rational, focused, and law-abiding (Jones 2011; Melnick et al. 2013). They tend to support more economically efficient policies within lab experiments, and on national policy surveys they tend toward optimism and favor efficient policies such as using markets, avoiding make-work jobs, and trading with foreigners (Caplan and Miller 2010). Smarter nations are more entrepreneurial, less corrupt, have more economic freedom, and have better institutions (Jones and Potrafke 2014). As ems are more productive and smarter people are more productive, we more strongly expect ems to be smart, relative to people today.

More implications of ems being smarter are discussed in Chapter 27, Intelligence section.

Today, most of the features that predict work productivity also predict happiness. This is a weak reason to expect ems to be happier than people today, all else equal. Of course it is also possible that ems are selected or tweaked to be especially needy for, and addicted to, something they can only obtain by working especially hard and well. This might make them less happy. We discuss em happiness more in Chapter 29, Evaluation section.

In our world, gay men earn less than comparable straight men, while lesbian women earn more than comparable straight women (Carpenter 2008). This suggests that while disproportionally many female ems may be lesbian, disproportionally few male ems may be gay.

People with more grit, that is, perseverance when facing difficult tasks, achieve more in school and elsewhere (Duckworth and Quinn 2009). People appear to achieve grit by gaining a deep purpose and personal meaning from their activities, by giving and getting help via strong bonds with friends and teammates, by making a game out of difficult situations, by being confident but realistic, by preparing well and often, by facing and thinking through their fears, by having a "growth mindset" that focuses on learning and improving, by debriefing often and noting what they could have done better, by celebrating small wins, and by regularly finding things to laugh at (Barker 2015b). We weakly predict that ems will adopt related strategies.

Students who at age 12 show more rule-breaking and defiance of parental authority tend to do better in both school then and also in jobs at age 52, at least after one controls for how smart, studious, and responsible they are as students (Spengler et al. 2015). Since ems are also smart, studious, and responsible, this suggests that ems also defy authority and break rules as kids, even if they work hard, well, and responsibly as adults.

As job performance seems highest with moderate levels of stress and emotional arousal, working ems are likely to have non-trivial but also non-extreme levels of stress and anxiety (Perkinsa and Corrb 2005; Lupien et al. 2007). When there is a most productive peak mood for a task, the mood of an em doing that task is near that peak mood. Ems can be closer to peak mood when they do tasks where less needs to be remembered from recent similar tasks. In this case one can more easily save a peak mood em and have it ready do many tasks. Ems who do need to remember recent similar tasks have more mood variations.

People who are more mindful, that is, who stay more focused on the task at hand and let their minds wander less, are both happier and more productive, even if they are less creative. As mindfulness can be taught, we should expect that ems are more mindful (Killingsworth and Gilbert 2010; Baird et al. 2012; Mrazek et al. 2013; Randall et al. 2014).

Relative to night owls, who stay up late, people today who are morning larks, and get up early, tend to have higher income, higher academic achievement, and to be less often unemployed, in ill health, impulsive, or undependable. Larks are more conformist, agreeable, and conscientious, although less smart. These suggest that ems tend more to be larks than owls. Women and older people tend more to be larks (Paine et al. 2006; Cavallera and Giudici 2008; Preckel et al. 2011; Bonke 2012).

Today, people who live in the parts of time zones that let them start work later after sunrise tend to sleep and earn more (Gibson and Shrader 2014). However, people who earn more tend to sleep less, controlling for lark/owl, gender, age, education, location, and industry (Bonke 2012). Fewer than 1% of people today have a special gene that lets them function well on 1 less hour of sleep per night (Pellegrino et al. 2014). Together these suggest that ems will tend more to come from scans of humans with this special gene, and will tend to sleep less than we do today, although they sleep enough to be rested and productive.

Humans with a bipolar or "manic-depressive" disorder are overall less productive, but they are often especially productive and creative during their manic phase. Such people are over-represented in jobs where creativity is especially important (Laxman et al. 2008; Kyaga et al. 2011; Parker et al. 2012). Just as the em economy may select for workaholics in ordinary jobs, for short-term creative tasks the em economy might perhaps also select for copies of bipolar ems who are just entering the most productive part of their manic phase.

Today the most successful research scientists are more likely than others to have an artistic hobby (Root-Bernstein et al. 2008). This suggests that ems with similar jobs will also have artistic hobbies.

In sum, we can identify a great many specific ways in which ems differ from people today.

CHAPTER 14

Work

WORK HOURS

Today, successful people in very competitive jobs, professions, and industries often work a great many hours per week. This makes it plausible that selection for em productivity will produce a world of ems who are also very hard-working, even "workaholic," perhaps working two-thirds or more of their waking hours, or 12 hours or more per day.

Today, people who are seen as "workaholics" tend to make more money, to be male, and to focus their socializing on scheduled times such as holidays. They also tend rise early to work alone and they often use stimulants (Kemeny 2002; Currey 2013). These patterns weakly suggest that ems will also tend to be early rising males who use simulating mental tweaks and socialize more at standard scheduled events. (How an em world might deal with unequal numbers of males versus females is discussed in Chapter 23, Gender Imbalance section.)

In the U.S. today, people aged 15 and older do work and "work-related activities" an average of 25 hours per week. They also spend 3 hours on school, 12 hours on housework, and 20 hours watching TV (Bureau of Labor Statistics 2013). However, from around 1820 to 1850 in the U.S., France, and Germany, men worked at jobs an average of 68 to 75 hours per week (Voth 2003). For ems, work levels might return these 1820 to 1850 levels, or even exceed them. Of course "work" time includes gossip, news-following, and unstructured exploration to the extent that these activities are productive enough for work purposes.

Many claim that working very long hours is usually counter-productive. For example, it is said that in construction, working 60 hours a week over 2 months actually results in less output than working 40 hours a week over that period (Hanna et al. 2005; Alvanchi et al. 2012; Pozen 2012; Mullainathan and Shafir 2013). Working too many hours on jobs is said to result from a “rat race” wherein each worker tries to signal that he or she is a very devoted and productive worker (Sousa-Poza and Ziegler 2003).

Competition in the em world tends to induce institutions and habits that result in high productivity, without giving much additional weight to personal preferences. This will keep ems both from working both too little and too much. If trying to look good tends to make individuals work too much, then em work institutions will find ways to limit individual discretion in work hours, to limit the harms caused by this signaling. If shorter hours, more breaks, and longer weekends are more productive, then that is how ems will work.

However, the reason most workers today tend to work too many hours might be because the few most productive workers are indeed more productive when they work many hours, and ordinary people are trying to resemble these super-workers. If this is the case, then ems will work many hours because they will mostly be selected from among those few super-workers.

The selection for ems who work hard and well is likely to select for a work-orientation, rather than a leisure-orientation, in em cultures. During the industrial era, an orientation to leisure has become more common, and today is more common among women, the young, and the unmarried. People with a high school education are more leisure-oriented, compared with both those with more and less education. Money is just as important to both leisure- and work- oriented people, and both types feel equally entitled or not to a job.

Leisure-oriented people are less satisfied with their job, and they feel fewer intrinsic rewards from work and more from leisure. They care more about interpersonal relations at work, they feel less obligated to work or contribute to society, and they work fewer hours (Snir and Harpaz 2002). This all weakly suggests that ems not only work more hours, they also tend to be male, married, care less about work relations, feel more obliged to contribute to society, and gain more intrinsic reward from work and less from leisure.

In addition to working more hours, em workers are likely to accept less pleasant working conditions, if such conditions are substantially more productive. During the industrial era, we have spent much of our increasing wealth on more pleasant working conditions, as well as on more consumption variety and on working fewer hours. Poorer and more competitive ems are likely to reverse these trends, and accept more workplace drudgery. It is not clear, however, how much productive drudgery exists in the em world.

While successful ems work hard and accept unpleasant working conditions, they are not much more likely to seriously resent or rail against these conditions than do hard-working billionaires or winners of Oscars or Olympic gold medals today. While such people often work very hard under grueling conditions, they usually accept such conditions as a price for their chance at extreme success.

Some ems are likely to listen to music on the job, as that increases productivity in some kinds of jobs (Fox and Embrey 1972). Such music will typically be mild, wordless, and not otherwise distracting (Kiger 1989).

SPURS

The em world makes heavy use of "spurs," who are em copies who are newly copied at the beginning of their workday, and then retire or are erased at the conclusion of their workday. Such a workday might last 10 minutes or 10 hours.

Compared with long-lived ems who spend an average of 8 to 12 hours of each subjective 24-hour day working, short-lived spurs who end after less than one work session spend all of their hours working. So spurs cost only one-third to one-half the brain hardware resources of regular workers. While splitting off a spur copy that only lasts for a few hours foregoes some chances to learn skills and context that may help with similar future tasks, a factor of two or more in cost savings is often irresistible.

In addition to saving on the cost of needing to rest from work, spurs also save on mental aging. As discussed in Chapter 4, Complexity section, em minds become less flexible and more fragile with subjective experience. So for tasks where the skills gained from doing a task are not worth the added mental fragility produced by that experience, spurs can be cost-effective.

Ems see spurs as appropriate for short-term tasks that they expect are worth doing, but not worth directly remembering.

We expect a strong selection for ems who mostly accept sometimes being such spurs, and expect most em work to be done by spurs (Shulman 2010). As discussed in Chapter 11, Defining Death section, they need not consider the ending of spurs as anything like "murder."

As spurs are so central to the em economy, it will be important for ems to have an intimate familiarity with the experience of being a spur. This will assist in choosing tasks to assign to spurs, and tools and environments to support spurs. A simple way to achieve this is to, on rare random occasions, switch the roles of the spur and the mainline em when the spur completes its task. Mainline ems would then remember many previous experiences of being a spur.

Some ems might refuse to ever make a copy unless they could be assured that the copy would have an indefinite retirement at some minimum speed. The faster minimum retirement speed an em requires, then the more that such an em needs to compensate by working for a longer period and by being the world's best at its job.

U.S. workers recently reported spending an average of 7% of their time at work "loafing," such as via eating, socializing, or web surfing. This percentage falls when workers more fear losing their job (Burda et al. 2016). More competitive em workers loaf less.

Today, mental fatigue reduces mental performance by about 0.1% per minute. As by resting we can recover at a rate of 1% per minute, we need roughly one-tenth of our workday to be break time, with the duration between breaks being not much more than an hour or two (Trougakos and Hideg 2009; Alvanchi et al. 2012). We seem to prefer to take a break once an hour, relative to having breaks more often (Dababneh et al. 2001). Breaks help productivity more when they are short and frequent, when they happen in the morning relative to afternoon, and when the activities during breaks are preferred, social, work-related, and outside the office (Hunter and Wu 2015). There is also evidence suggesting productivity gains from napping for 10 to 30 minutes one or a few times a day (Dhand and Sohal 2006).

Perhaps em mind tweaks can eliminate the need for such breaks and naps. But if not, these effects suggest that em spurs will tend to be made from copies who just finished a nap or break, and that spurs will have an extra productivity bonus for tasks that take less than about an hour or so to complete. Thus many em tasks will be designed to take about an hour, and many spurs are likely to last for about this duration.

Today, worker productivity usually varies by time of day, but the average peak time varies by task. For example, in our world the peak is near 10 in the morning in construction, during the morning for sports with complex strategies, and in the afternoon for handwriting and for sports requiring great physical efforts (Alvanchi et al. 2012; Hölzle et al. 2014; Drust et al. 2005). Time of day of peak productivity probably also varies by age and between night owls and morning larks. Each em uses spurs created from the times of day which tend to give that em its highest productivity for the assigned task. The longer that a task is expected to take, the earlier before their peak they would start, to achieve the best average productivity across the entire period of the task.

Today only a modest degree of multitasking is productive. It seems that doing only one or two projects at a time is best (Aral et al. 2007). Thus both long-lived ems and spurs will only work on at most a few tasks at a time.

To avoid many social complications, spurs are likely to interact less often socially with non-spur friends and lovers. Spur social interactions instead focus on other spurs, such as spur co-workers. Spur interaction partners might be comforted by knowing that pleasant and friendly interactions with other spurs are motivated less by seeking longer-term advantage, as their originals will learn less about those interactions. That is, if a spur associate is being especially nice to you, it is more likely than for non-spurs that they actually like you.

The use of spurs will encourage ems to coordinate and plan activities in their head before splitting into spur copies, to summarize their work well just before ending or retiring as a spur, and to organize tasks into units that can be completed in a subjective work day, with minimal need to recall details later.

SPUR USES

Spurs who end instead of retiring can help ems to deniably do things of questionable legal or moral status, if the main evidence of their actions was erased when their minds were erased. For example, a spur might try to alter some evidence of previous poor performance. Spurs don't need to intend to do such things before making a spur copy. Spurs might just spontaneously realize that they could do such things and not suffer later regret or revelations of their questionable actions. A habit of randomly archiving some spur minds, and of having larger punishments for violations by spurs, might help to deal with this.

Spurs that end could ensure privacy in short-term professional consulting. For example, a relationship counselor could make an isolated spur who hears about your relationship problems, offers advice to you in private, and then ends.

Spurs are especially useful in searching tasks. Auditing spurs could search for accounting irregularities, research spurs could try out innovation ideas, artist spurs could try out design concepts, and planning spurs could consider possible plans. Such spurs who search expect a small chance of lasting much longer than usual if they happened to find something especially useful or interesting during their search.

Spurs make it easier to convince people of things without revealing one's sources, by proving that "you would agree with my claim if you knew what I know." To prove this, copies of the two ems can be placed in an isolated "safe" wherein a speaker copy could reveal its reasons to a listener copy in a conversation of limited duration. For example, a boss might explain to an employee why some firm information was too sensitive to share with that employee.

The safe might have untraceable access to standard data sources, and perhaps also to special requested sources. After the conversation, the safe and all its contents are thoroughly erased, and the original two ems might just hear a single bit answer, "yes" or "no," chosen by the listener copy inside the safe. Or they might hear a choice from a small, predetermined set of options.

A degree of confidence could also be returned. Alternatively, instead of a few bits out per safe, one might define a whole language of questions and a budget over that language. The original might be allowed to ask any set of questions that fits in this budget, using prior answers to pick new questions. However, the more bits that are in effect returned from a safe, the more one must worry that some bits are used to illicitly encode information that was not supposed to be released.

For example, spur safes could let a buyer choose among several sellers based on very open disclosures of buyer and seller details and secrets inside a safe. Potential mates might become more intimate in a safe to see how well they are matched. Safes could allow firms to consider business and product ideas, and then reject them without fear of later being accused by a vendor of stealing those ideas.

Of course ems should be wary of entering into and divulging secrets within leaky safes, that is, devices that look like safes but actually leak information. Highly trusted third parties might be required for clans to have reliable access to safes that they could share with other clans yet also trust.

Someone might reveal inside of a safe that they had committed in some way to hurt the other em if that em didn't return the desired answer. To avoid this problem, an independent (and hard to hurt) judge might also join the speaker and listener in the safe, with the power to declare the safe "void" if they heard sufficient indications of such threats.

To reduce the cost of using these safes, an em might offer to let a wider audience make unlimited bets on what the safe would produce if created, but only actually create the safe a small fraction, for example, 1%, of the time. (More on such prediction markets in Chapter 15, Prediction Markets section.) Such offers signal loyalty, showing that one trusted the listener spur to evaluate one's argument fairly once inside the safe.

Because of safes, on important questions ems rarely need to just accept another em's claim that they have good reasons for believing something but can't explain those reasons because of a need for secrecy. For example, government authorities could not simply pretend to have good secret reasons for their policies; others could ask to see those reasons inside safes.

Safes might also make it easier for ems to comfortably self-deceive. (Although other aspects of the em world may make self-deception harder.) For example, an em could hold idealistic beliefs about its mate, team, firm, or clan, and yet still do the savvy non-idealistic things when consequences were large. They could do this via a habit of relying on safe-based advice in important situations.

Inside a safe, an advisor explains the non-idealistic reasons why some choice is best. Outside the safe, the em just follows the advice from the safe, and does not reflect much on why that advice differs from what their idealistic beliefs might suggest. In this way ems can sincerely retain their idealism while ignoring related beliefs in important situations.

Spurs make it easier to do finely controlled social experiments with close field relevance. For example, one could create many small variations on a job interview, such as with different clothes or voice tone, to see how those variations influenced the chances that a certain job candidate would be selected for employment. In such a simulation, almost everything else about the situation could be held constant.

Spurs could also be used to test for biases. Today, psychologists show common biases by randomly splitting experimental subjects into subgroups that are given different prompts. For example, a question might be worded two different ways, resulting in different answers on average. Or an "I knew it all along" hindsight bias might be shown via telling different subgroups different outcomes, and asking subjects what chance they would have assigned before to seeing their chosen outcome.

Because of random fluctuations that influence individual decisions, however, such experiments today usually require large groups of experimental subjects to see subtle effects. In contrast, em spurs could directly demonstrate such biases in individuals, and not just in large groups. An individual could be split into different copies that are given different prompts, and then their answers could be directly compared.

Ems wanting to convince an audience of their impartiality might even empower independent judges or opponents to create such "split-tests." For example, an em might say "In our next hour of debate, I'll let you covertly split off a copy of me three times, each time with three versions of me that hear different things from you for up to 5 minutes. Go ahead and see if you can trick me into showing a pattern of biased responses in the different answers I give you."

Uses of spurs that involve comparing the behavior of very similar spurs may be substantially more useful when run on deterministic emulation hardware. This might avoid the problem of random computing errors muddling the results.

Many of these applications of spurs work better if the spur just ends, instead of retiring. Such applications might work nearly as well, however, if retirement were just delayed for a very long time, and if the archived copy was very securely inaccessible in the meantime.

SOCIAL POWER

Compared with us, ems are individually better at getting and keeping power.

Humans today often compete for power, prestige, and material resources. But most of us are reluctant to compete fiercely and strategically, using all available means. It makes sense that we inherited such attitudes, because the forager world greatly punished such aggression, and humans have deeply internalized habits and norms that were adaptive in the forager era. The farming world rewarded aggression more often, but it also often severely punished aggression. But our habits of reluctant competition are often less adaptive in today's rather different world, and are likely to also be less adaptive in the em world.

Some of us are more willing to compete aggressively than others. In the farming and industrial eras selection effects have ensured that such aggressive competitors have been over-represented in positions of power (Pfeffer 2010). As the em era allows selection to more strongly emphasize the clans who are most successful at gaining power, we should expect positions of power in the em world to be dominated even more by people with habits and features conducive to gaining power. (Other sorts of ems might dominate positions that hold less power.) Because power tends to give advantages overall, we expect that ems will on average have more features that support their gaining power.

We actually know a great deal about the habits and features that today seem to enable people to gain power in our world (Pfeffer 2010). While we can't be entirely sure how many of these habits and features will be robust to the cultural changes that will make the em world different from our world, we expect many of them to be robust. This gives us a reasonable basis for predicting how em habits and features are likely to differ from those common today. Let us now summarize our weak expectations about how ems differ from people today, based on the assumption that ems tend to have features more conducive to power.

Compared with people today, power-gaining ems are more politically savvy and skilled, and feel a stronger personal motivation to seek power. They less often handicap themselves, such as by refusing to take a test that they might fail. That is, they don't shy away from hard tests. They instead have stronger desires to improve themselves, and stronger beliefs that this is possible. They are more inclined to gain impressive educational credentials and institutional affiliations. They are absent from work less, work overtime more, and spend more years working at each job.

Power-gaining ems are also more willing and able to sell themselves. They push more to make themselves visible to superiors, they are more attentive to what their bosses want, and they develop stronger relations with those bosses. They try harder to make themselves similar to their bosses along as many dimensions as possible. They flatter their bosses more, and are better at avoiding criticism of those bosses. Such ems are also better at enticing others to praise them, instead of bragging about themselves directly.

Power-gaining ems have stronger wills, fueled by more ambition and energy, by specializing more in particular industries and firms, and by concentrating on a more limited set of important activities and functional skills. They have more self-knowledge, self-reflection, and confidence. They are more able to project self-assurance, to read others and empathize with their point of view, and to tolerate conflict. They tend more to be suspicious of potential work rivals.

Such ems are more strategic and careful in choosing the details of their career paths. They more often ask for things they want, even if rejection seems likely. They are more willing to sacrifice likeability to be seen as tough. They try harder to, and are better at, developing their network of useful social connections.

Power-gaining ems are better actors, in order to convince others of their power. They are better able to pretend and play a role. They tend to act like they are succeeding, even when they are not. They tend to express anger instead of sadness or remorse. They tend to stand up straight rather than slouching, and thrust their chest and pelvis forward rather than curling in on themselves. They more often move forward and toward others, and stand closer to others, instead of turning their back or retreating. They use tall bodies and deep voices, although of course all virtual ems could also easily do this if they wish.

The hand gestures of such ems are short and forceful, not long and circular. They directly look others in the eye, instead of looking down or away. This makes them seem not only powerful but also honest and direct. They take their time to think before they respond, although an em ability to temporarily speed up their mind would help them to respond more quickly.

Power-gaining ems prefer meetings to be on their own turf, a place familiar to them but unfamiliar to others. In conversation, they more often interrupt others, and challenge the premises of conversations. Their language is evocative, specific, and often filled with forceful words and visual imagery. They often use emotional language terms, refer to us-them concepts and other contrasting concept pairs, pause for emphasis, and explicitly enumerate how many points they will make.

Today, the powerful are different from the rest of us, and we should expect that ems will be different from us in those same ways.

CHAPTER 15

Business

INSTITUTIONS

We tend to think of the future as a place full of new technology, but to many, only physical and software devices count as "technology." However, economic growth results from innovation not only in physical and software devices, but also in social practices and institutions.

Scholars in economics, finance, business, and law have long identified many simple changes to business and social practices that seem to improve efficiency, but that are rarely adopted, and that tend to generate little interest when explained to potential adoptees. For example, economists tend to consistently recommend charging non-zero prices for scarce resources like parking and road use, and recommend weakening import tariffs, immigration restrictions, rent control, mortgage subsidies, taxes on products where both supply and demand are elastic, and penalties for victimless crimes such as drug use or prostitution. While clever scholars can often invent auxiliary hypotheses to explain why these polices are useful, contrary to appearance, it is far from obvious that such hypotheses are the real reasons for disinterest in these policies.

We have six reasons to expect ems to adopt such improvements more often than they are adopted today. First, the much larger em economy has more resources to explore and develop the many complementary adaptations usually required to make general good ideas effective in particular contexts. Second, a more competitive economy should less often reject cost-saving changes merely because they seem strange or repugnant. When efficiency gives a competitive advantage, more competition should lead to more efficiency.

Third, as ems can more easily obtain trustworthy strategic advice on personal choices from their clan, their behavior should more closely approximate the rational agent models on which scholarly advice tends to be based.

Fourth, as em clans will know their members very well, such clans can provide high levels of insurance to members while suffering much less from the usual disadvantages of insurance, such as insurance reducing incentives to be careful, and people with hidden higher risks buying more insurance. While today risk-aversion is often a barrier to institutional efficiency, risk-aversion is much less of a barrier for ems.

Fifth, as in many important ways the infrastructure that best supports ems will differ substantially from that which best supports ordinary humans, an em society must already have paid large costs of change, at least during an initial transition period. In general, the costs of changing institutions are lower once one is already paying to make other big changes.

Sixth, ems will be smarter, and smarter people tend more to favor more efficient institutions (Caplan and Miller 2010; Jones 2011; Jones and Potrafke 2014).

I presume that ems adopt at least some of the efficiency-improving changes that scholars have identified as being possible yet under-used today. My presumption is weak, however, as the efficiency gains of these apparent improvements may be illusory. Em society may also fail to coordinate to adopt more efficient institutions.

I will now illustrate the possibility of ems adopting more efficient institutions by describing a somewhat random assortment of plausible candidates for more efficient institutions.

For each of these changes that I will discuss, a standard simple analysis suggests that change would improve efficiency. However, it could be that some of these changes are not in fact efficient, because of subtle factors that scholars now neglect or under-appreciate. Or it might be that such changes are not adopted today because they seem strange or repugnant, and a wealthy society such as ours can afford the luxury of rejecting such things out of hand. Or perhaps such changes would only be efficient if matched with many small adaptations that have not yet been developed; it can take time to work out the crucial details to make innovations feasible. Or it might be that even with such adaptations the large cost to make these changes is just not worth the gains that appear after a change.

NEW INSTITUTIONS

We know of many specific new social institutions that are plausibly more efficient than current institutions.

For example, scholars have long been puzzled to see surprisingly little use of pay-for-performance, as when a lawyer is paid a fraction of a lawsuit's winnings. (Such scholars don't claim that only money motivates lawyers.) While pay for performance is used with good effect on many jobs (Banker et al. 2000), incentive pay methods could be used more not only by lawyers, but also by many other professionals, such as doctors, real estate agents, and teachers. Scholars are also puzzled to see that, when such performance rewards are used, they are only rarely corrected for outside influences over which the person has little control, such as in correcting the strike price of CEO stock options for performance of that firm's industry or local economy.

Related to the puzzling lack of pay for performance is a puzzling lack of published track records for professionals, and customer disinterest in such records. For example, while court trials are public, in practice clients do not see lawyer win-loss records, and they don't push to see them. Similarly, customers push surprisingly little to see sales of real estate agents, patient outcomes of doctors, student outcomes of teachers, and prediction accuracy of media pundits. Academics care more to count publications than citations.

Instead of track records, customers prefer to rely on personal impressions, referrals from friends, and the prestige of a professional's institution or schooling. In general, we are less interested in people who have achieved something than in people said to have the potential to achieve that same thing (Tormala et al. 2012). These puzzling behaviors seem dysfunctional for achieving outcomes from hired professionals. So to the extent that a more competitive em world better selects for those who achieve better outcomes, then em customers should rely more on outcome track records in choosing professionals.

Pay-for-performance is easier when there are more kinds of easily exchanged financial assets, tied to more kinds of relevant outcomes, such as individual housing prices, personal incomes, or life spans. For example, we could today bundle health and life insurance to make our doctors feel more concern for our pain and death (Hanson 1994a). Parents and teachers might work harder if they owned a share of their childrens' future income.

Because the uncertain payments in pay-for-performance increase risk, this approach is also easier when the relevant actors are less risk-averse; members of clans who share member risks internally are likely to be more willing to take on risk, and so be more willing to accept pay for performance. As ems may have better monitoring and mindreading abilities, however, such partial substitutes for pay-for-performance may reduce the need for such incentive plans.

Compared with our economy today, scholars have long noted that more products and services could be usefully priced, with such prices varying more with context. For example, theaters, restaurants, and parking lots could have prices that vary more with internal location and congestion levels. Utilities such as roads, parking, electricity, water, garbage, sewage, and communications could also have prices that vary more with time, location and congestion. Allowing crucial utilities like water or electricity to charge higher prices in disaster situations could give them extra incentives to keep services going.

Instead of being funded via state subsidies, projects that offer diffuse value to large diverse groups might instead be funded via "dominant assurance contracts," wherein donations are conditional on funding targets being met (Tabarrok 1998), or via processes where contributions are varied continuously in time (Charness et al. 2014; Friedman and Oprea 2012). More generally, collective choices could be made more efficiently via vote selling where each buyer's price of votes goes as the square of the number of votes purchased in each election (Lalley and Weyl 2014). If inter-conversion with money is not desired, voters can instead be given voting points to collect, move, and trade before converting them into votes via a square price rule for each election.

The problem today of income taxes reducing work incentives might be reduced by directly measuring and taxing leisure time. Alternatively, income taxes might vary more with parameters that predict an ability to earn income, such as body height and beauty do today (Mankiw and Weinzierl 2010). For ems such ability-predicting parameters might include speed and clan size. As another alternative, clans might be taxed directly, instead of taxing individual members.

Instead of only creating citizens by birth, and allowing unlimited local births, transferable citizenships might let better citizens self-select into societies. Population levels might be controlled via requiring parents to buy a citizenship for each new child.

Today, we have trouble measuring inflation and comparing purchasing power between regions, in part because changing product quality influences the changing prices we use to infer relative value. Ems who retire to stable societies in closed virtual realities might pay prices that offer a more objective standard. If the values placed on living in stable societies are also stable, then the varying prices that ems are willing to pay to retire in such societies might offer a basis for comparing the value of life in other changing places.

Elections today suffer from the problem that each voter is very unlikely to personally change the outcome. Because of this, voters have very weak incentives to think carefully about outcomes, relative to choosing partisan attitudes that look good to associates. By randomly choosing a small jury of voters who will then decide an election, one might greatly increase the incentives of the voters who have been chosen to become informed (Levy 1989). Spur copies of jury members might even be placed together in a safe so they could be given access to relevant secret information.

I discuss possible changes toward more efficient law in Chapter 22, Efficient Law section. Other types of efficiency changes to weakly expect include the adoption of more uniform standards. For example, ems may adopt a metric standard for units, an English standard for language, a common law standard for law, and so on.

Very secure and anonymous communications between willing parties can be arranged via “public key cryptography,” wherein each person publishes a public key for which they can prove only they know the matching private key. In addition, robust systems of secure anonymous decentralized transactions may be built on the recent innovation of block-chain based cryptographic systems, where a public record of all transactions between public key labeled accounts prevents double-spending of assets.

Such systems could support digital currencies, token systems, safe wallets, registration, identity, decentralized file storage, multi-signature escrow, consensus via rewarding those who best guess a consensus, financial derivatives including insurance and bets, and more general decentralized autonomous organizations (Nakamoto 2008; Buterin 2014). It is not obvious that such systems will achieve the scale of use necessary to support these activities well. However, if they succeed then only authorities willing to enact quite intrusive monitoring and strong punishment could suppress such mechanisms.

I have been personally involved in developing two more types of promising new institutions: combinatorial auctions and prediction markets. Because of this I am especially hopeful about them and want to mention them, but I must also accept that readers may prefer to remain more skeptical about them, even if they accept a tendency of ems to adopt more efficient institutions.

COMBINATORIAL AUCTIONS

Today, markets are often efficient mechanisms for allocating resources. At least they are when many buyers and sellers seek to trade products or services that are very similar to each other, and whose use or production does not much influence non-users. In technical terms, we say that competitive markets that trade commodities are often efficient in the absence of externalities. Competition pushes participants to make and accept efficient exchanges, both because those who make worse offers are quickly excluded, and because participants must in effect take available prices as given.

However, simple markets work less well when goods are so complex and diverse that each good is a poor substitute for others, when each unique good is only valued much by a few individuals, or when the use or production of goods greatly influence non-users. In such cases, competitive pressures to take the interests of others into account can be greatly reduced. People are then often included in allocations even when their offers are poor and inefficient. In such cases, we often substitute non-market mechanisms, such as command and control by central authorities. For example, firms typically use central command to allocate internal firm resources. States and nations often authorize central agencies to provide key services and to regulate commerce.

In cities today, the pricing and allocation of central utilities, as well as limits on land use to mitigate external effects, are usually done centrally and rigidly, via utility and zoning regulatory agencies. The centrality of such agencies allows coordination that deals with complexity, and the rigidity of such agencies reduces the lobbying costs that flexibility can invite. For example, a city might have a fixed rule specifying the number of parking spaces per business calculated according to a simple formula. Allowing few exceptions to a simple rule may deal poorly with large variations in business parking needs, but has the advantage of discouraging efforts to lobby to gain exceptional treatment.

"Combinatorial auctions" and related mechanisms are recently developed decentralized processes that flexibly deal with the complexity and uniqueness of goods, while still reducing the costly lobbying that central authorities invite (Porter et al. 2003; Cramton et al. 2005). In simple variations, each participant makes several offers regarding the packages of goods that they are willing to buy or sell as a unit, and the auction mechanism searches for and approves a total set of offers to accept where it estimates a nearly maximum social surplus. Such mechanisms in effect make large unique sets of offers compete strongly with other large offer sets, forcing participants to make more competitive efficient offers even for goods that are complex and unique, and only valued by a few participants.

For example, in a simple combinatorial auction for electricity, both buyers and sellers bid on when and where they will supply or use how much electricity, and the auction picks a value maximizing allocation of who buys and sells. When finding good allocations is hard, but checking on the quality of each allocation is easy, good allocations can be found by publishing bid data and then awarding prizes to the best allocations submitted before a deadline.

More complex variations on combinatorial auctions can include bids that say how each bidder's value depends on who else uses what other resources and how. In this way the auction can take into account external effects from the use of the allocated resources.

More complex auctions can also include bids to expand or change capacity. For example, a more complex electricity auction could include bids to make new power plants or transmission lines. More generally, variations on such auctions might be used in firms instead of central allocations of offices, and in cities instead of central land use zoning. In cities, such auctions might account for land use externalities, such as emissions and blocked views, and set capacity and locations for the generation and distribution of many utilities, such as power, water, sewers, roads, parking, and telecommunications. Instead of having a separate auction process for each of these utilities, a single auction could deal with the dependencies between the production and use of all these resources.

Combinatorial auctions that substitute for central zoning in cities require the development of new auction features and designs. In particular, bids need to specify more details on how participant value declines as package features become less ideal than requested, and as weaker commitments are made about the possibility of later being bumped from one's allocation. Such auction features are desired to allow city land and utility allocations to be flexibly reallocated as values and opportunities change with time. As better auction mechanisms could plausibly deliver great value, and as the relevant research community has well-established ways to develop better mechanisms, it seems safe to guess that such mechanisms will be available if desired.

PREDICTION MARKETS

I have also been personally involved in developing the new institution of "prediction markets." These are variations on speculative and betting markets that can encourage and facilitate the aggregation of information on important outcomes. By subsidizing trading on particular questions of interest, one can induce people able to learn about those questions to self-select into improving visible consensus estimates (Hanson 2003).

Prediction markets give clear precise continually updated estimates that are consistent across many topics. Combinatorial versions can even allow a small number of users to manage billions of consistent interconnected estimates, so that updates on some topics automatically improve the accuracy of estimates of quite different topics (Sun et al. 2012).

Head-to-head comparisons between prediction markets and other forecasting mechanisms, given similar resources on the same questions, find prediction markets to be consistently either about as accurate, or substantially more accurate than, other mechanisms. Compared with other mechanisms, prediction markets are more robust to situations where no one knows anything useful, where most invited participants are ignorant or fools, and where some participants are willing to lie or lose money to distort resulting estimates.

Prediction markets can tell a firm how likely a project is to make its deadline, how likely a supplier is to deliver as promised, or how many units of a particular product will be sold in a particular region. Prediction markets can also help combinatorial auctions by choosing between proposed auction rules and mechanisms. In addition, prediction markets in bid rights might help predict future auction bids. Such bid predictions could help current auctions to choose well between allocating future resources to specific current bidders, and leaving those resources to be allocated in future auction iterations.

Decision markets, which estimate decision-contingent outcomes, seem especially useful for directly advising on particular decisions. Decision markets estimate which decision option will produce the highest expected outcome, without requiring anyone to judge afterward which decision actually would have led to the highest outcome. Instead, decision markets only require that afterward one can judge which decision option was actually chosen, and how high was the actual resulting outcome.

For example, decision markets could directly advise firms on whether to fire CEOs, change ad agencies, let deadlines slip, or change product prices. Decision markets could also advise democratic voters on which candidates are more likely to promote peace or prosperity, and on which policies are likely to increase national welfare. Decision markets could even advise charities on which projects would most help aid recipients.

By committing to implement policies that decision markets clearly recommend, an organization can elicit better advice from speculators, and avoid agency and information failures resulting both from diverging leader and constituent interests, and leaders neglecting outside advice in order to signal dominance (Hanson 2006a, 2013; Garvin and Margolis 2015).

Bets could also be used to send more efficient loyalty signals. For example, one might bet at an early age that one will never marry, and then later the act of losing the bet would signal a strong desire to marry. The value in the bet is not destroyed or lost to society, and this person gains a matching value in scenarios where they never marry.

Our society today seems to pay too little attention to averting catastrophic risks that might destroy big fractions of civilization, or even lead to our extinction. Em society might do better. Special pre-determined disaster-contingent prices for products commonly needed in emergencies might keep priorities focused on preserving crucial infrastructure. Decision markets might help to set such prices, and advise other disaster policies. As ordinary financial assets could have questionable value in extreme disaster scenarios, decision markets might instead trade event-contingent tickets to enter refuges robust enough to survive many different disaster scenarios (Hanson 2010b).

Prediction markets are a meta-institution, able to improve the selection of other institutions. Thus, they seem especially potent in a competitive world facing strong pressures to adopt more efficient institutions.

CHAPTER 16

Growth

FASTER GROWTH

How fast might an em economy grow? We have many reasons to expect an em economy to grow much faster than does our economy today.

As mentioned in Chapter 13, Competition section, the em economy should be more competitive in the sense of more aggressively and more easily replacing low-efficiency items and arrangements with higher-efficiency versions. Reduced product variety and spatial segmentation of markets help innovations to spread more quickly across the economy. Stronger urban concentration should also help promote innovation (Carlino and Kerr 2014). The fact that more productive em work teams can be copied as a whole should make it much easier for more productive em firms and establishments to rapidly displace less productive firms and establishments. These factors allow the em economy to innovate more quickly.

For a long time, most innovation, and most of the total value of innovation, has been associated with a great many small and context-dependent changes (Sahal 1981). Most innovation has also long come from application and practice, rather than from "researchers" or "inventors" narrowly conceived. Most of the research that aids innovation is "applied" as opposed to "basic" research. Thus we expect most of this better and faster em innovation to consist of many small innovations that arise in the context of application and practice.

Another reason to expect faster growth in an em economy is that ems depend more on computer technology. One might guess that a future very computer-centered economy improves at something closer to the recent rate at which computer technologies have improved. This suggests that the global em economy might double as fast as every year and a half, which is 10 times faster than today's economic doubling time of about 15 years.

Actually, there are plausible reasons to expect an em economy to grow even faster. The productive capacity of an economy comes from its capacity of inputs, such as land, labor, and capital of various sorts, and also from its level of "technology," that is, the ways it has to convert inputs into useful outputs. Although there have been times and places where growth has been driven mainly by increases in inputs, most growth over the long run has come from better technology, broadly conceived.

For example, foragers grew slowly by accumulating more ways to gain advantage from plants and animals, and to survive in more kinds of environments. While it was easy to create more foragers, and more units of each kind of tool, it was much harder to find new kinds of tools and new sources of food.

During the farming era, when the economy doubled roughly every 1000 years, our ancestors could rapidly increase the quantity of people and most forms of capital, but total growth in inputs was limited because good land was limited. There was little point in having twice as many people, buildings, and boats, if you couldn't find twice as much good land (or water) for them to use. Growth mostly had to wait for innovations, often in the form of domesticated plants and animals, that made it feasible to survive on new kinds of land.

In today's industrial economy we have plenty of land, relative to our needs, and are able to rapidly increase our physical capital, such as machines. However, our growth of inputs is still limited because of the limited rate at which we can increase the number of skilled laborers. There is little point in making twice as many machines if we don't have twice as many people to run them. Growth has mostly had to wait for innovations, mostly in better ways to make and use machines (including how to apply them to local conditions). Such innovations are thankfully much easier to develop than innovations in domesticating plants and animals. So the world economy has lately been doubling roughly every 15 years.

In an em economy, however, labor can be grown as easily as capital; factories can make more ems to run machines as fast as they can make more machines to be run. While real estate on Earth will eventually run out, our economy has enormous room to grow before such limits make a big difference. After all, in terms of the physical space that ems require, Earth today is practically empty.

Also, while one often hears concern about limited mineral and energy resources, the small fraction of income we spend on these resources today shows that they are in fact plentiful now. Should current sources dry up, many promising alternatives remain. Alternate minerals can usually be substituted at modest cost, and there are many promising energy alternatives, such as solar cells, thorium nuclear reactors, or fusion reactors. Reversible computing can allow lots of computing even with rather limited energy.

Thus there can be an important early em era where most growth comes from simple growth of inputs, that is, from making more labor and capital as fast as factories can crank them out, in a background of plentiful natural resources. Our basic economic theories of growth strongly suggest that this ability to rapidly increase inputs could allow an em economy to grow much faster than the 1.5-year doubling time weakly suggested by an em economy being computer-based (Fernald and Jones 2014; Nordhaus 2015). In fact, basic economic theory allows for the economy to double in a month, week, day, or even faster.

In an economy that grows less because of innovation, and more because of growth in inputs, the valuation of firms and resources depends less on their potential to produce and take advantage of innovations, and how consumers identify with products. This may reduce the importance of intangibles in firm valuations, and increase the reliability of firm evaluations.

Faster growth and innovation in the em era should encourage an emphasis on less durable capital equipment, including buildings. Such equipment should be designed for a shorter useful lifespan, under the expectation that more efficient designs will quickly become available. Also, the use of buildings that happens after several economic doubling times offers much less economic value to the original builder or buyer.

Many economic activities achieve their value from flows. One constructs a system and then uses it to steadily create a valued product. For example, hydroelectric dams, solar cells, buildings, factories, and computers are of this form. In contrast we have other one-time economic activities, such as when we use disposable grocery bags, glow sticks, ponchos, and rockets.

Faster economic growth encourages both fast construction and fast use of systems. The cost of the delay to make a system in effect increases the cost of that system by the factor by which the economy grows during that delay. And for flow systems, the total value created by a system is the product of the value produced per time unit, times the doubling time of the economy.

So, for example, if the economic doubling time falls by a factor of 100, then for a flow project that would previously have lasted for at least an economic doubling time, its ratio of benefits to costs falls by at least a factor of 100. Thus large increases in growth rates translate into large cost increases for systems that produce steady value, relative to systems that produce value quickly all at once and then end. So ems will use rockets and other disposable products more, all else being equal.

GROWTH ESTIMATE

To generate an empirical estimate of em economy doubling times, we can look at the timescales it takes for machine shops and factories today to make a mass of machines of a quality, quantity, variety, and value similar to that of machines that they themselves contain. Today, that timescale is roughly 1 to 3 months. Also, designs were sketched two to three decades ago for systems that might self-replicate nearly completely in 6 to 12 months (Freitas and Merkle 2004).

Special three-dimensional (3D) printers have been created that can print about one-half of their components in about 3 days of constant use (Jones et al. 2011). If the other half could be made just as fast, a 3D printer could self-replicate in a week. If the other half of the parts for a 3D printer took ten times longer to make, then a 3D printer could self-replicate in 5 weeks.

Together, these estimates suggest that today's manufacturing technology is capable of self-replicating on a scale of a few weeks to a few months.

Of course machine shops and 3D printers are fastest when making the simplest and easiest to construct devices and components. Large complex facilities such as chip factories take longer to build. So the estimates above may under-estimate doubling times to the extent that they leave out the replication of important components that take longer to make. Today, humans are such a left-out component; our economy doesn't grow this fast because we can't replicate people as quickly as machines.

However, these machine reproduction estimates also tend to overestimate doubling times because a faster growing em economy offers stronger rewards for reducing factory-doubling times. Today, if a factory takes twice as long to make a product, that only doubles the factory rental cost of the product. If such factory rental is only 20% of the cost of the product, then this only raises product cost by 20%. But when the time to make something is near the time for investments to double, then taking twice as long to make a product reduces the total value of that product by half. As a result of product innovation, a delayed product is typically worth even less than half.

Innovation also makes the em economic doubling time shorter than the time it takes em factories to reproduce themselves. A lot of innovation happens because of "learning by doing," where the rate of technology gains is tied less to absolute clock speeds than to the rate at which people make and use products (Weil 2012). So an economy innovates faster when it has rapidly growing inputs, and thus fast growth in the rate at which products are made and used. As mentioned before, an em economy focuses much more than ours does on computer capital, which has long seen much faster rates of innovation than has other forms of manufactured capital. More generally, machine-based capital has seen faster rates of innovation than have human and land capital.

These factors lead us to expect that an em economy may grow even faster than the few weeks to few months doubling time of manufacturing equipment today. Simple theoretical models of growth with innovation allow for a wide range of possible faster growth rates—the economy might double every (objective) year, month, week, or day (Hanson 1998).

Another way to estimate the economic growth rate of the next era is to assume that the next era will grow faster than our industrial era by a factor similar to the factor by which our era grows faster than the farming era, or by which the farming era grew faster than the forager era. This method estimates a roughly 1 week to 1 month economic doubling time for the next era. While this is admittedly only a weak clue regarding future growth rates, we should not ignore it as it is one of the few concrete clues available.

For a concrete estimate to use in the rest of this book, based on all of the above, I choose an economic doubling time of 1 month. Most of the analysis in this book is robust to variations in this doubling time estimate.

Any estimates that do depend on this doubling time estimate should be relatively easy to adjust to accommodate alternate estimates.

GROWTH MYTHS

There are several factors that some expect to influence growth rates, but which probably have at best modest effects.

One such factor is the mental speed of citizens. If 10 times fewer ems were to each run 10 times faster, the overall productive capacity of the economy would be about the same as without this change, and the economic growth rate wouldn't change much either. Yes, there could be some weak effects because of ems running faster or slower, but these are mostly minor. It is mainly the existing capacity that creates more capacity, not the mental speed of participants. If growth rates were limited by the speed at which individuals could take particular actions, increasing those speeds to weaken the effects of those limits could increase the growth rate. But in fact, economic growth rates just aren't much limited by the speed of individual actions.

Another factor that does not obviously suggest faster growth rates is the larger size of the em economy. Yes, a larger economy has more resources to pursue more possible innovations. But there are also usually diminishing returns in new ideas; we tend to try the most promising ideas first, and only when those run out do we move on to less promising ideas. So a larger economy doesn't *necessarily* have a larger growth rate. Within previous eras such as the farming or industrial eras, these two effects seem to have roughly canceled each other, giving a nearly steady exponential growth within each era. We should thus expect nearly steady exponential growth within the em era as well.

A third factor that does not obviously suggest faster growth rates is greater intelligence. While more intelligent people are more productive, and more productivity gives more growth, even so there isn't obviously a more direct connection here, a connection not mediated by productivity. Smarter people are awarded more patents, but that is in part because smarter people tend more to be sorted into the types of jobs that produce patents.

A fourth factor that is less relevant for growth than many think is the number of researchers. Yes, it is possible that the world now fails to coordinate to sufficiently fund research, and that the world would grow faster if it funded more of the right sort of research. However, even if the em world coordinates somewhat better than today, it seems that growth would increase by only a modest amount, as nations that do more research today do not grow noticeably faster (Ulku 2004). Also, research progress is only one input into economic growth; increases in research funding usually give much less than proportionate increases in research progress in a field (Alston et al. 2011). The fact that there are other important inputs creates diminishing returns to research effort. These other inputs include progress in closely related areas of research and technology, customer experience with related products, and more general technical and economic progress.

However, even if these factors don't greatly influence em growth rates, as we saw in the Faster Growth section, there are relevant factors that do.

FINANCE

How is finance different in an em world?

Among their many roles, clans likely also serve as a basic unit of financial organization. For example, individual ems and subclans could relatively easily turn to their larger clans to insure against risks. Hidden information and actions, which are often obstacles to insurance, are less of a problem within a clan, especially when shallow mindreading is feasible. So clans face a lower cost of providing internal insurance.

Ems likely also use their clans to help fund their housing and business ventures. This may reduce the use of independent financial institutions for insurance, mortgages, and firm stock. However, clans likely still face overall risks and imbalanced internal portfolios. For example, clans will tend to focus their reputation and training investments in particular types of jobs, and thus be at risk to fluctuations in the demands for these job types, and in the quality of the competition for those jobs. Clans should want to diversify these investments.

Clans are thus likely to use financial markets and institutions to buy insurance, to invest in outside ventures, and to sell fractions of their own risks and returns. In addition to financial diversification, em clans may also seek to diversify the job roles that they fill. To maintain a reputation and visibility among other ems, however, clans also probably want to pick many of their jobs with an eye to marketing. That is, a clan may want to ensure that they always occupy the job niches that fit their standard story about what this clan is good at and why you'd want to hire them.

A more competitive em economy likely adopts more efficient financial institutions. This plausibly includes more support for hostile takeovers of public firms (Macey 2008), and more use of private ownership of firms. As having worker control over firm management seems to reduce productivity, ems probably avoid that (Gorton and Schmid 2004).

One can show that in the long run the value of an investment portfolio is dominated by the highest average growth rate among the assets in that portfolio; most of the portfolio's value comes to be in that one asset (Cover and Thomas 2006). So when portfolios compete, the long-run winner is the one containing the fastest growing asset.

One can also show that the long-term outcome of patient investment funds competing fairly is a market dominated by funds that follow a "Kelly rule" of investment. Such funds maximally re-invest their returns into each asset category, such as stock, real estate, and so forth, in proportion to the expected distant future fraction of wealth to be found in each category (Evstigneev et al. 2009). In technical terms, this is roughly equivalent to logarithmic risk aversion regarding risks correlated with overall market returns, and near risk neutrality regarding risks not so correlated, as those can be diversified away.

This hasn't happened so far, probably because of high taxation, a continuing influx of new naïve and otherwise-motivated investors, laws that prevent funds endowed by wills from sufficiently reinvesting assets, and wars and revolutions that periodically wipe out investment funds. However, the em world is competitive, ems can be long-lived, and the em civilization may be more stable. These factors suggest that the em financial world has a better chance of ending up dominated by large long-lived investment funds, funds who face only modest and relatively uniform taxation, and who compete with only minor other infusions of wealth from new investors using other strategies. Such funds may be clan-based. If such a financial world continues to grow peacefully over a large growth factor, then em financial markets may eventually come to approximate the ideal Kelly rule strategy.

In most models and real markets so far, average interest rates (i.e., rates of return on investments) have usually been at least as large as economic growth rates. Thus as em era growth rates are large, em era interest rates are also large. This tempts slow humans and em retirees to save a large fraction of their income. For fast ems, however, these investment returns correspond to very low subjective interest rates, which tempts them away from savings and toward immediate consumption. Thus among ems, most of the psychological inclination to save must come from slower ems, and from larger scale organizational commitments.

In the past we have seen random fluctuations in individual preferences and in the gains from particular investments, resulting in large variations across families in the fraction of family wealth tied up in labor as opposed to capital. That is, randomly some families get rich while others do not. While today most families hold most of their wealth in an ability to learn jobs and earn wages, an important minority of families holds most of their wealth in the form of real estate, stocks, etc. We should similarly expect that random drift in capital holdings will result in most em clans holding most of their wealth in the form of their ability to work, while some em clans hold most of their wealth in other forms of capital. Thus productive em ventures often require the cooperation of several clans; some clans contribute more capital while others contribute more labor.

In Chapter 21, Governance section, we saw that em business cycle fluctuations may be larger due to city governance fluctuations. Today, a cost of cycles is labor-hoarding, wherein firms keep paying workers during downturns even when there isn't enough work. As ems can slow down and pause when there is less work, the em economy less suffers this cost of cycles.

In sum, finance seems modestly but perhaps not greatly different in an em world.

CHAPTER 17

Lifecycle

CAREERS

How many kinds of tasks does a typical em worker regularly do in the course of their job?

Looking at job performance today, we see that while extreme specialization can give maximum productivity in the short run, over a longer time a modest degree of task variation is often more productive, because of improved learning and engagement (Staats and Gino 2012). Ems add an important new consideration to this usual tradeoff between task specialization and task variety. Whereas human minds have a limited rate at which they can do tasks, em minds can run at different speeds. So the limited subjective career length of an em can be spent either on more scope in tasks or on more scope in time. That is, an em worker can either run faster and simultaneously do and coordinate more related tasks, or it can run slower and coordinate fewer tasks over a longer period of time, and improve at those tasks in the process.

Some tasks require a continual response to external drivers. These tasks include managing physical systems, such as driving cars. Such tasks usually require mental response times as fast as the slower of two rates: the rate at which outside disturbances arise to which it is useful to respond, and the rate at which the managed system such as a car is capable of responding to such disturbances.

When choosing between mind speeds faster than this minimum response rate, one of the main tradeoffs is between getting really good at each task, and coordinating more related tasks. One can either do a more specific task more times over a longer narrower career, or do a wider range of related tasks over a shorter career. During either sort of career one could split off many spurs to do short-term tasks that do not need to be well remembered.

Long, narrow careers can achieve high levels of competence while adapting to changing job detail, but require expensive communication between workers to coordinate related tasks. In contrast, having the same worker do a wider range of tasks allows for flexible coordination without communication across those tasks, but comes at the cost of more transitions for each worker between different tasks (Wout et al. 2015), and often lower competence because of less task specialization and a shorter career.

Management and software engineering are jobs where coordination across related tasks is especially important. For typical tasks in such roles, the costs to transition from one task to the next, and the gains from long-term career experience of doing related tasks, are less important than coordination between tasks. These jobs are thus good candidates for using higher-speed ems.

Today, managers tend to have a narrower "span of control," that is, to have fewer subordinates per manager, when subordinate roles are quite different, and when managers have more tasks other than supervising subordinates. The task of management is important enough to be worth paying more to put excellent workers in such roles. These considerations suggest that it makes sense to pay more to run em bosses faster than their subordinates, to allow bosses to manage wider spans of control. This should push ems to have shallower management hierarchies, with fewer levels between the CEO and the shop floor.

Manager gains from coordination come in particular from running fast relative to subordinates. So with fast bosses, subordinates temporarily speed up when they meet with their bosses.

Having bosses run faster than subordinates comes at the expense of shorter boss time-horizons in the sense of the time scope of their work experience. Fast bosses also require subordinates to have more different bosses during their career. For tasks where coordination is important this seems a tradeoff worth making. But today managers are the occupation category with one of the longest average tenures (6.3 years) at the same employer, exceeded only by protective service (6.4 years) and engineering (7.0 years) (BLS 2012). This long job tenure suggests that organizations gain a substantial value today from managers who stick around.

The rate of technological and institutional change sets a natural limit on useful career length. First, the fact that investment-doubling times are near economic doubling times discourages investing in skills that last much longer than such doubling times. Second, there is little point in having career skills that last much longer than the timescales over which jobs greatly change. After all, having a long career of experience doing things the old way may help little for doing things a new and different way. As jobs tend to change substantially on roughly the scale of economic doubling times, em speeds are likely to be chosen so that most work careers are likely to last shorter than a few such doubling times.

Today, the average age of firms in the S&P500 is 18 years (Foster 2012), which is roughly the doubling time of our world economy. This suggests that the economic doubling time is close to the timescale on which business context changes enough to require big changes in business processes. This is confirmed by the fact that today large firms often attempt to "re-engineer business processes," that is, to redesign their main business organization and processes from a clean slate. For any given part of a large organization, this process happens roughly every economic doubling time.

The re-engineering process is often associated with layoffs and substantial worker retraining. As em training can be much cheaper via making many copies from a single trained em, em organizations are tempted to replace more employees than usual during a re-engineering. Anticipating such replacement, employers may prefer to have employee ems run fast enough that they are likely to be near the end of their useful lifetime of flexibility at the time of the next re-engineering.

Even in a rapidly growing em economy, some equipment and environments will be unusually durable and stable. These may include nature preserves, large physical buildings, and software tools such as languages and operating systems that become the basis for standards that coordinate other systems. Ems who are well adapted to dealing with these especially durable environments could have much longer productive careers in objective time, and so could reasonably run more slowly.

Today, the career of someone who works from ages 20 to 65 lasts three times as long as our 15-year economic doubling time. In contrast, ems with a subjective work career of two centuries that fit into one objective economic doubling time would see the world as a more stable and predictable place. If that objective economic doubling time were 1 month, this matched speed em would be a bit faster than a kilo-em. This suggests that we consider kilo-ems to be the typical speed ems. In Chapter 18, Choosing Speed section, we will see another consideration that also suggests this as the typical em speed.

PEAK AGE

In advanced economies today, the most productive workers tend on average to be within about a decade of a peak productivity age of near 40. Much older and younger workers are both substantially less productive. However, this doesn't seem to be because basic mental abilities decline with age. Controlling for birth cohort, individual productivity does not peak until at least age 60, and may never peak (Cardoso et al. 2011; Göbel and Zwick 2012). The problem is that even though a worker may be just as productive at age 60 as he or she was at age 40, the next generation of workers tends to be more productive.

Also, any falling productivity after age 60 for humans today may be primarily caused by declining physical abilities, not declining mental abilities, a problem that is mostly eliminated for em workers. After all, em bodies need suffer no declines in physical strength or stamina, as physical bodies could be periodically replaced, and virtual bodies never need replacing.

The main reason that workers near age 40 are more productive than older workers today seems to be that younger workers tend to be trained in more recent work methods that better match the current tool and problem mix, while older minds lack sufficient mental flexibility to fully switch to this new context. It is thus mainly our economy's fast rate of change that makes productivity peak around age 40 today.

Because of this, we expect the subjective age at which productivity peaks in an em economy to depend on an em's mind speed. For slow ems, work methods often seem to change greatly, putting older workers at more of a disadvantage relative to younger workers. So for slower ems, productivity peaks at a younger subjective age.

For fast ems, in contrast, work methods might not seem to change much at all. For fast ems with stable jobs, the main limit on career duration might be how long it took for their decreasing mental flexibility to interfere with job performance via a reduced ability to track local changing working conditions, even when basic work methods didn't change that much. Thus fast em productivity might peak at much later subjective ages. Also, mind tweaks might extend the duration of em mental flexibility.

Today, our abilities at different kinds of tasks peak at different ages. For example, raw cognitive processing peaks in late teens, learning and remembering names in early 20s, short-term memory about age 30, face recognition in early 30s, social understanding about age 50, and word knowledge above age 65 (Hartshorne and Germine 2015).

Mental flexibility can matter more for jobs where innovation is important. For example, today we can distinguish two kinds of innovative art: experimental and conceptual. In experimental art, personal abilities and specific projects tend to improve gradually, whereas in conceptual art new abilities and projects tend more to arrive fully formed and all at once. For example, Paul Cezanne, Robert Frost, and Mark Twain were experimental artists, while Pablo Picasso, T.S. Eliot, and Herman Melville were conceptual artists. Today, painters, novelists, and directors who are experimental artists tend to do their best work roughly at ages 46-52, 38-50, and 45-63, respectively, but those ages are 24-34, 29-40, and 27-43, respectively for conceptual artists (Galenson 2006). Similarly, today experimental scientists tend to peak near roughly ages 38-48, whereas theoretical scientists tend to peak near roughly ages 32-42 (Jones et al. 2014). Thus conceptual innovators peak at earlier ages than do experimental innovators. This is consistent with conceptual innovations benefiting more than experimental innovations from mental flexibility.

At any one time, the vast majority of actual working ems (weighing either by count or by speed) are near a peak productivity subjective age. This is because the em economy chooses to make many copies of ems at these ages. For em jobs that rely especially strongly on skills that peak at a particular age, most ems doing that job are going to be near that particular age. Such peak age ems, however, each accurately remember a long life of being younger than peak productivity age.

The duration in time of an em's highly copied peak productivity period depends on how valuable local experience is for their particular job. When local experience matters very little, ems are selected very close to their peak; they might last on the job only a month or less before being replaced by a slightly younger version. They also remember spending a large fraction of their recent history in leisure, if such experiences substantially increased their peak work productivity.

In contrast, when local experience matters a great deal on the job, peak em career periods last longer. In this case a worker might stay on the job for a decade or more before being replaced by a younger worker. Such workers also tend not to remember much recent leisure, as they work most of the time to gain more local job experience.

Variance in em team training rates also helps to take advantage of skill spillovers within teams. Today, people learn more when they are among higher skilled teammates (Ichniowski and Preston 2014). So when some team members learn more than usual, other team members also learn more than usual.

MATURITY

Having the typical em worker be near a subjective age of 50 or more has many implications, because we know many things about how such older people tend to differ from younger people today.

We see many stable correlations today between gender, age, and personality. Because these same correlations also exist among other great apes such as chimps, we have good reason to expect that these correlations are deeply embedded in human nature, and are thus likely to be observed in ems (Weiss and King 2015).

For example, today as they get older people tend to be less neurotic, and more agreeable, conscientiousness, and open to experience (Soto et al. 2011), although these trends reverse after the age of 65 (Kandler et al. 2015). Older people have weaker differences between genders in their roles and attitudes (Hofstede et al. 2010), they are more trusting (Robinson and Jackson 2001), they have less regret about missed life opportunities (Brassen et al. 2012), and they have more job satisfaction and less stress and negative emotions (Tay et al. 2014).

Older people (and males) are more influential in social networks, and influential people are more clustered in their associations, and less susceptible to social influence by others (Aral and Walker 2012). For older people, happiness tends to increase with age, controlling for health, and older people tend to associate happiness more with peacefulness, as opposed to excitement, in part because they focus more on the present as opposed to the future (Mogilner et al. 2011).

As mentioned in Chapter 4, Complexity section, older people tend to have stronger crystallized intelligence, that is, more depth and breadth of knowledge, vocabulary, and abilities to reason, but weaker fluid intelligence, that is, abilities to analyze new problems and to notice new patterns and to extrapolate using them (Horn and Cattell 1967; Ashton et al. 2000).

Older people today tend to be more attached to particular people, places, hobbies, and occupations, and are less willing to exchange these for new substitutes. Also, older people today commit less crime, and are more likely to convict those accused of crime (Anwar et al. 2014). This, together with stronger surveillance, suggests that the em world has much less crime.

Today, most people over the age of 80 must deal with health problems, the death of loved ones, and many other difficult issues. While some of these people are further hindered by dementia, it seems that most of them deal well via their lifetime accumulation of mental strength and "cool." This gives them composure, security, poise, reserve, distance, detachment, and balance, allowing them to focus on the positive parts of their lives (Zimmermann and Grebe 2014). We should also weakly expect older ems to tend to display such composure, detachment, and balance. In addition, older ems suffer little or no health issues or other physical decline.

We should thus weakly expect that, because ems will be older, they will be less neurotic and be more agreeable, conscientious, open to experience, trusting, and clustered in their social associations. They will have more cool and composure, commit less crime, more will seek peace as opposed to excitement, and have intelligence that is crystallized rather than fluid. And they'd be more attached to particular people, places, and habits.

Today, our ability to lie, and our frequency of lies, peaks at ages 18-29, and declines as we are younger or older than that peak age (Debey et al. 2015). As ems are much older than this peak lying age, ems lie less than we do today.

We see again that although ems are like humans, they differ in systematic ways from typical humans.

PREPARATION

How much do ems invest in preparing for tasks beforehand, as opposed to adapting flexibly later to deal with problems as they arise?

Because ems can be copied easily, it is much cheaper for ems to prepare for tasks that multiple ems perform. The reason is that one can pay once to prepare a single em, and then make many copies of that single em to have a large set of prepared ems.

For example, a single em could conceive of a system design for a software project, and then split into many copies who each elaborate and implement different parts of the system design, continuing to split as needed for subsystems. Similarly, a product designer or an architect could conceive a central integrated plan for a movie or an amusement park, and then split into many copies to work out details for different parts of the project.

To ensure a quality initial plan, the initial em might split into several, who pursue different concepts for the initial plan. The em with the best plan is then selected somehow, perhaps by a revived copy of the original em, and that em splits into ems to elaborate and then implement its particular plan. This process could continue recursively, at each level exploring several possible scenarios and keeping only the copies associated with the best plans developed. This gives each planning em an added incentive to identify good plan details.

These abilities allow ems to implement larger, more integrated pre-planned projects than we achieve today. This change also increases the emphasis on preparing ahead of time, relative to responding on the fly. Ems tend to rely more than we do on previously designed schedules and plans. This reduces the premium ems pay for youthful mental flexibility. This effect is likely to be weaker for slow ems, for whom the society around them changes more rapidly. Such slow ems gain more value from mental flexibility.

Of course the single-em-plans-then-splits-to-execute approach only works when the same em encompasses all the different skills needed to create and execute the plan. When diverse skills are required for different parts of a plan, different ems with different skills may also need to be involved in the plan's development and execution.

Compared with us today, ems find it easier to synchronize the completion times of different project components, because if a component ends up taking more effort than anticipated, associated ems can be sped up to compensate. In this way em projects can run over budget without running over time. This allows larger more fragile project plans to be implemented; ems can more often count on each part of a project plan being completed and ready at its scheduled time.

Today, workers are more productive after an enjoyable vacation, although the boost usually goes away days or weeks after returning to work (Trougakos and Hideg 2009). Perhaps em mind tweaks can eliminate the need for vacations. But if not, a single em might experience a long expensive period of leisure time, and then many copies of that em might work more productively for subjective days or weeks afterward. Once these ems tire, or when their tasks naturally end, all but one of these copies may end or retire. The remaining copy could repeat the cycle, eventually remembering a long history of long, luxurious leisure periods punctuated by short intense work periods. This gain from leisure before work might need to be traded off against a reduced effective work life before mental fragility sets in, during which less local work experience is accumulated.

For example, an em plumber might split into 1000 copies every day, with each copy doing a typical plumbing job that takes an average of an hour. One of those copies might then be saved, to experience most of a subjective day of leisure and then repeat the process the next day. Objectively, this person's life is 2% leisure, but his memories of life are of spending 96% of time in leisure. While at some level this em might know that only 2% of life is leisure, he or she need not dwell much on this fact.

In this sort of scenario, the number of copies made of each worker per workday is probably limited by how much jobs change with job context, and by how fast jobs in a given context change. That is, an em who makes too many copies risks being less expert at his or her job than ems who make fewer copies, which are thus better adapted to each new work context, and can also more rapidly adjust to changing work conditions.

Note that in this keep-one-of-many-copies scenario, it might make the most sense to keep the copy who had learned the most from doing their task. Thus copies that prefer to continue working might compete to see who could learn the most, which isn't quite the same as competing to be the most productive. For incentive reasons then, such an em might want to instead commit to often keeping the copy who had been the most productive, instead of the copy who had learned the most. Note also that in this sort of scenario the vast majority of the ems retire or end long before their minds become too inflexible to be productive.

That ems often have many close copies at any one time should make it much easier for ems to obtain trusted independent judgments on things such as design plans and drafts of writings. If an em created such a draft and a close copy didn't like it, it would be much harder to explain that criticism away by saying that they didn't understand the goals and style of the draft.

TRAINING

We've just discussed issues that arise when preparing ems to do particular tasks. Related issues arise when preparing young ems for their adult careers, because one can also raise one child or train one trainee, and then make many copies of those. This changes em childhood and professional training.

For example, only a tiny fraction of ems are children or trainees not near their peak productivity age, although most ems remember having spent most of their lives as such trainees. A peak-age em is honored to personally help train one of the rare younger ems.

The experiences of training-age ems are selected more for their potential to teach better skills, and less for their current productivity. Ems search for training methods that can add the most to young em skills while adding less of the subjective aging that increases mental fragility. Typically the search is for high average productivity and low variance, although for some kinds of tasks high productivity variance is attractive.

Ems can afford to have many children and young trainees compete, and then only select a best few to be allocated into jobs, with the failures ending or retiring. One might think that such low odds of success are demoralizing, but overconfident neglect of the chances of failure is aided by the fact that most ems remember almost always succeeding against the odds. Ems remember few substantial failures before retirement. Note that today most people who pursue risky careers in sports, music, or acting typically maintain positive moods, even when their objective odds of career success are quite low.

In our world today, older people often try to give advice to younger people, advice supposedly based on their longer life experience. However, older people often have hidden agendas, such as trying to justify their choices in life. Also, younger people often feel rivalries with older advisors, and value making decisions for themselves (Garvin and Margolis 2015). These effects combine to make younger people less willing to take advice from older colleagues to heart.

In contrast, ems could obtain advice from older copies of themselves who have pursued very similar careers and life plans. Such older copies should in principle be more accurate and respected sources of useful advice. It is more like taking advice from someone who started the same job a year before you, and who had your exact same personality and skill set. Ems could also get advice from ems with a much wider range of subjective ages; for example, ems who are subjectively 10s of millennia old might be available to give advice.

However, older ems can still have hidden agendas, and younger ems may still resent having to take advice from others. Such factors may limit the useful advice from older to younger ems in the same clan. Clans that can better reduce the resentments of the young and the hidden agendas of the old could thereby gain a competitive advantage in the em economy.

The situations in which ems are trained are a mixture of real and simulated environments. Ems in training might not always know which is which. As in the science-fiction novel *Ender's Game*, ems might also sometimes not be told when they make the switch from training to practical work, if this policy increased productivity by increasing the em's confidence or comfort.

For tasks where ems spend the most total time working, they also spend more total time searching for better productivity at that task, but a smaller fraction of the work time related to that task is spent on such search. Ems spend a larger fraction of time searching for task productivity when there are more interesting ways to do a task.

Most em teams are composed of ems likely to reach their productivity peak at the same time, so they can work together as a high-productivity team. Often this means starting at the same young age and running at the same speeds to age together. Early team training likely tries to increase the variance of peak team productivity, to allow the highest possible team productivity to be found when selecting from among many trained teams.

Perhaps to a lesser extent, training also tries to increase the duration of the period that a team could spend at peak productivity, as well as the variance in that period's duration.

Some em teams are "search" teams, focusing more on searching for good combinations of members and work strategies, while others are "application" teams, focusing more on applying the best combinations found by search teams. Application teams are more common. Search teams are designed for productivity variance, to increase the chances of finding very high productivity team designs. In contrast, application teams try to decrease productivity variance, to reduce the chances of unusually low productivity.

Search teams tend to have more varied members and strategies, and they may also expect to see members and strategies change more over time within the life of the team. In contrast, application teams expect team personnel and work methods to be stable. Search teams are also likely to "network" more by having more social contact with a wider range of people outside their teams. This is because today having many weak social ties tends to be good for workers who need to innovate and to locate hidden information, while having fewer and stronger social ties tends to be better for workers who exploit known information and transfer tacit job skills to new tasks (Pfeffer 2010).

CHILDHOOD

Not only is training different for ems, childhood is similarly different.

The experiences of children are more varied and risky than those of peak age ems. This is in part to stretch their range to increase the generality of their skills. It is also in the hope of producing variance in persistent productivity across different copies, from which the best could be selected.

A peak-age em will likely be more productive if they've had more relevant work experience before they reach their peak age. Thus even though one can afford to pamper young ems in training, they still remember having spent a large portion of their time working, to gain more experience. In contrast, although peak age ems can't afford to spend much on pampering, they might still remember a recent life spent mostly in luxurious leisure. This is because it can be cheap to give one em leisure and then make many copies, who then work more effectively because of that leisure.

Younger ems are subsidized, and focused on learning to become more productive, in the hopes of reaching a high productivity during their peak years. Young ems see the important part of their lives as their future peak productivity years, and one of the great questions of their life is whether they will live up to hopes about them and become one of the few greatly copied ems when they reach peak productivity. Most young ems eventually disappoint such hopes.

Ems use their future peak productivity period not only as a key standard for judging themselves, but also for judging their spouses, friends, and other associates. That is, ems not only seek associates that can improve their lives at the moment, ems want even more to find associates that will help them to achieve high productivity during their hoped-for future success period of high peak productivity. In addition to asking "Who do I want around me now?" ems ask "Who will I want around me then?"

Early in an em's life, his or her future might seem quite unpredictable. At that point, a great many possible careers, locations, and associations might seem plausible. Later, however, once a particular copy has chosen a particular career, location, and team, the future is far more predictable—much more predictable than are our careers today.

Once an em clan becomes established at a certain kind of job, that clan continues to restart early copies to be trained to do that job. Each new version is trained to take over that job when older versions become too fragile to be fully productive. New versions are trained using improved training techniques, to become proficient with the latest tools and productive in the latest work contexts.

Most such ems could thus look at the lives of prior versions of themselves to gain a very good idea of what their future life will look like. This is somewhat comparable with a medieval worker who inherited his or her parents' role in life as a farmer, soldier, or cobbler. However, such ems need not feel pressed to do jobs against their wishes. After all, many variations on young ems can be created in the hopes of finding a few who are enthusiastic about available jobs.

The tiny fraction of children in an em society should make it harder for ems to express natural parenting urges. Perhaps ems could substitute by watching "reality" shows about children that they share with many other copies. They might vote on key child-raising decisions; it might really take an em village to raise a child. To support this, children might run at the speeds at which their parental groups take their leisure. This approach may not provide a sufficiently direct and tactile connection to satisfy parenting urges for many. But a great many people today have lived productive lives without being parents, suggesting that enough ems could be found who are productive without being parents.

The great number of older copies made of each successful child make the details of that young life relatively famous. That is, when older ems remember the particular details of their childhood, a great many other older ems would also remember exactly the same details. Thus most older ems remember a relatively famous childhood, somewhat as if they had been a child celebrity who is now no longer famous. Far fewer other ems know or care about the details of an em's current adult life, relative to the number who know and care about the details of their childhood.

This celebrity childhood tends to reveal many details about youthful events and attitudes. If an adult em is at all tempted to talk about particular events and attitudes from their childhood, the sheer number of adults who all remember the exact same childhood will tend to ensure that the information about their childhood will leak out. If George didn't like Fred as a child, then even if he never said anything about that as a child, the adult Freds will still likely all hear it.

Childhood and training might usefully be done at a very fast speed, at least if accurate enough task simulators were available, and if direct interaction with the larger world was not required for learning. Ems trained in this way remember that during their childhood the world was more stable and changed slowly.

The younger that ordinary humans are when scanned, the earlier their training in the em world could begin. While some might express objections to scanning young humans, especially when such scans are destructive, in a world dominated by ems these objections may not always or even usually determine whether scanning actually happens.

Although em childhoods differ from our childhood today, they are still recognizably childhoods.

PART IV

Organization

CHAPTER 18

Clumping

CITIES

Do ems physically concentrate in cities, or do they spread out more evenly across the land?

Industrial economies today achieve large gains from clumping social and business activities closely together. The more easily that people can quickly travel to visit many different stores, employers, clubs, schools, etc., the more kinds of beneficial interactions become possible. The ability to interact via phones, email, and social media hasn't reduced this effect; if anything the possibility of additional electronic interaction has usually increased the value of personal visits. Urban economists and other academics have long studied such "agglomeration" effects, and understand them in great detail.

We should expect these gains from clumping to continue in an em world (Morgan 2014). Ems want to be near one another, and near supporting tools and utilities, so that they could more easily and quickly interact with more such people and tools. This is especially important for fast ems, who can suffer noticeable communication delays with city scale separations.

Per person, cities today with twice the population tend to be 10% more economically productive per person. Compared with any given sized city, double-sized cities have per-person 21% more patents, 11% shorter roads, and 9% shorter electrical cables. But these cities also suffer 12% more crime, 17% more AIDS cases, and 34% more traffic congestion costs per person (Bettencourt et al. 2007, 2010; Schrank et al. 2011). Today, one factor increasing the productivity of larger cities is their selectively attracting better workers. But another important factor favoring big city productivity is their giving those better workers more ways to gain from their superior abilities.

Optimal city size is in general a tradeoff between these gains and losses. During the farming era most people lived in small communities with populations of roughly 1000. Compared with any given sized village, only about 75% as many people lived in double-sized villages (Nitsch 2005). Thus most farmers lived in the smallest villages, because during the farmer era larger versions suffered higher costs of crime, disease, and transport.

Within rich nations today, in contrast, people are spread roughly equally across all the different feasible city sizes, between a minimum viable modern town of a few thousand and a maximum city size set by a nation's population. Compared with any given size city, about the same total number of people live in cities twice as big, and in cities half as big. This change to larger cities from the farming era has been made possible because industrial society has greatly lowered the costs of crime, disease, and transport, and increased our abilities to gain from specialization and innovation. Nations come in different sizes, and are also spread out roughly equally between a minimum viable size of about a half million and a maximum set by world population (Eeckhout 2004; Giesen et al. 2010).

An em economy might further reduce the costs of crime and disease, and increase the gains from innovation. After all, well-designed computers can be secure from theft, assault, and disease. More important, traffic congestion costs could be much lower in an em city because most transport of ems could be done via communication lines, and most virtual meetings within a city do not require the movement of em minds at all. As congestion costs now limit city sizes, this increase in virtual meetings could plausibly tip the balance toward much larger em cities.

Thus instead of today's equal distribution of people across all feasible city sizes, most ems might instead be found in a few very large cities. Most ems might live in a handful of huge dense cities, or perhaps even just one gigantic city. If this happened, nations and cities would merge; there would be only a few huge nations that mattered.

Larger em cities could allow great increases in social complexity. Farmers, who usually lived in near-a-village sized social units of roughly 1000, have sometimes said that they would hate to suffer the social isolation of the typical forager, who lived in bands of roughly 30 people. Such farmers would hate to lose their village-based opportunities for specialization and complexity in work and leisure. Many people in our era living in cities of size around 1 million have similarly said they would hate to suffer the social isolation of the typical farmer.

If em cities are even larger still, with populations of many billions to trillions, their residents may similarly relish the greatly increased social opportunities available in gigantic cities, and pity the relative social isolation of the city-dwellers or our era, much as we sometimes pity the isolation of farmers, or farmers pity the isolation of foragers.

Increased social density should change em languages. Languages spoken by more people over longer eras tend to make more distinctions such as between colors, and have larger vocabularies, more phonemes, and shorter words. With more emotion words, ems remember and share more kinds of feelings. Such languages also have more grammatical tools such as adjectives, tenses, prepositions, pronouns, and subordinating conjunctions (Henrich 2015). Virtual reality assistance to better hear spoken words should also increase the number of phonemes and shorten em words.

Having only a small number of em cities makes it easier to regulate the em economy. While a city needs growth-friendly regulation to become one of the few big em cities, once a city had become very large it might be able to maintain its size while tolerating substantial growth-reducing regulations. This is especially possible if all of the big em cities agreed to adopt similar levels of such regulations.

CITY STRUCTURE

We can say things not only about the number and size of em cities, but also about internal em city structures.

In virtual meetings, ems care little about being much closer than the reaction distance from a city center. Remember, reaction distance is how far light travels in a mental reaction time. As faster ems have shorter reaction distances, they thus gain more value from congregating closer to city centers. So faster ems should cluster more centrally, surrounded by slower ems toward the periphery. This is similar to how today investors using higher frequency trading algorithms often pay more to locate close to financial market centers. The higher values gained by fast ems are reflected in higher rental prices for central real estate, which should induce a denser packing of computing power, energy inputs, and cooling in em city centers.

In the last few decades, falling costs of long-distance travel have induced a great increase in the rate of conferences and business meetings. Compared with the residents of our cities, ems who are within a reaction distance of one another have low costs of traveling to attend virtual meetings. This should greatly increase the rate of conferences and business meetings, especially for slower ems.

Because of rising prices to rent space near city centers, the total hardware cost per subjective minute of em experience is higher toward city centers. Thus ems who tend to choose more central locations when they run faster face a more than proportional effective hardware cost as a function of speed. Because of this, ems who get less value from many fast interactions with other ems tend to locate toward the peripheries of em cities.

If faster ems tend to locate closer to city centers, if ems tend to cluster spatially near others of the same speed, and if em speeds tend to fall into discrete classes, then em cities may break into discrete speed neighborhoods. Each neighborhood runs mostly at its own different speed. These neighborhoods might plausibly be arranged in rings around the city center, or perhaps in a fractal structure around many levels of urban centers.

If ems sometimes inhabit physical bodies with sizes matched to their speed, then cities may have matching physical infrastructure such as sidewalks, bridges, and doorways. These may be smaller toward city centers, where the faster ems reside. Physical barriers that enforce differences in air pressure between different city regions might perhaps also be good places to change the typical physical scale of infrastructure. In this case, inner regions with smaller scale infrastructure also have higher pressures.

Today, larger cities tend to have better educated, more social, and more productive workers. Bigger cities less often specialize in particular industries and occupations (Duranton and Jayet 2011). Big city workers also tend to do tasks that are more connected to other tasks, and so benefit from being located close to each other (Kok and ter Weel 2014). Cities grow faster when their workers do more connected tasks, and when these workers connect more via social media (Mandel 2014). Industries with many new products and methods tend to locate at first in bigger cities, and then move to smaller cities as their products and methods become more stable (Desmet and Rossi-Hansberg 2009).

It is plausible to expect that activities near em city centers are more like typical activities in our largest cities, whereas activities toward the periphery of em cities are more like typical activities in our smaller towns. Thus em city centers tend to house new innovative dynamic industries, and more productive workers who are more social and educated, who do more kinds of occupations, and who tend to do more connected tasks. City peripheries, in contrast, house older, more stable industries, and regions that are specialized to particular industries.

Tasks that are more likely to be done toward em city peripheries include monitoring, identifying, estimating, handling and moving objects, operating and controlling machines and processes, using computers, drafting and specifying devices, and equipment repair and maintenance. Tasks more likely to be done nearer to em city centers include judging quality, determining compliance, making decisions, thinking creatively, developing strategies, scheduling and planning, interpreting, communicating, making and maintaining relations, selling, resolving conflicts, coordinating, training, motivating, advising, and administration (Kok and ter Weel 2014).

Because most travel is virtual or electronic, iconic city locations are less often transport routes or hubs, as they sometimes are in our era, and more often plazas and other spaces where many could congregate. City design focuses less on daily worker commutes, and more on the distribution of communication, power, and cooling, and on supporting frequent changes in space allocations.

As faster em hardware emphasizes processing relative to memory, em city centers emphasize processing hardware, while peripheries emphasize memory hardware, especially cheaper, slower-access memory hardware. Retirees and archives tend to be located toward the periphery.

Today, most who walk city streets, or who ride mass transit, are using them to go somewhere. They are often distracted, staring at their phones. In contrast, most ems walking virtual city streets may be less distracted, and instead be in the mood to stroll or wander. If they are distracted, they might just have a far away look that doesn't meet the eyes of others. After all, ems could talk to others or read their email in their heads, without needing to look down at their hands as many of us do today.

CITY AUCTIONS

Not only can we say things about em city structure, we can say things about em city governance as well.

As discussed in Chapter 15, Combinatorial Auctions section, combinatorial auctions could allow decentralized management of city utilities while avoiding large costs from political lobbying.

Auctions to choose and allocate utility capacity and customer locations might combine all important city utilities. That is, participants might offer bids that simultaneously specify, in addition to a maximum price to pay, these quantities: (1) spatial volume, shape, orientation, and location constraints, (2) part swapping portal locations and sizes, (3) lines of sight to outside views or specific parties, (4) limits on surface temperature and chemical corrosiveness, (5) amounts and forms of power and cooling, (6) flow rates of specific chemicals piped in and fluid garbage piped out, (7) communication distance and bandwidth from other particular residents, (8) time delay and capacity to move hardware out and in, (9) support force tensors, (10) limits on surface heat amounts in and out, (11) limits on incoming and outgoing vibrations, (12) limits on chances of incoming, outgoing leakage or explosive destruction, and (13) clauses to cover disputes with neighbors. Bids could specify not just ideal values for these parameters, but also the size of penalties others pay for incremental violations of these conditions, including prices to sell the entire allocation at later points in time.

The auction in each city is repeated often, and continues to choose a winning allocation, which says who specifically can use what spaces when, with what supporting resources, limits, etc. This specification includes reallocating previously promised resources, and also future resources that are not yet promised to anyone. The winning allocation is something close to the allocation that maximizes the total stated value of the city to all auction participants. Auction participants might include not just those who want to consume land and supporting utilities, but also utility suppliers, who bid prices to supply particular utility amounts at particular locations. Prediction markets estimating future winning bids could help the auction mechanism to estimate the opportunity costs of commitment, so that it could choose between committing to particular future allocations now versus waiting for more bids in the future.

Auction revenue could pay for utility fixed costs and also perhaps repay city investors. In theory, in optimal size cities the revenue from such auctions should just cover the subsidies given to city services with scale economies, leaving no remaining revenue to pay city investors (Raa 2003). But that theory may not apply exactly.

Em city design places a high priority on supporting rapid physical growth, such as replacing and moving computer and communication hardware, expanding power and cooling capacity, and building the city higher into the sky and deeper into the ground.

In the U.S. today, not only does it take 2 years on average to construct each building, it takes over 2 additional years to plan it, mostly dealing with regulation. This planning time has actually increased in recent decades (Millar et al. 2013). A much faster growing em economy needs to greatly reduce these construction delays. Combinatorial auctions could allow much more rapid approval of and flexibility in building plans, while still dealing well with the effects of building changes on city neighbors. Buildings might also tend to be made smaller, all else equal, to reduce delays.

CHOOSING SPEED

How fast do em minds run, relative to ordinary human minds?

Because faster ems need more central city locations, they in effect have a more than proportional cost of speed. When all else is equal, this tends to reduce em speeds. For example, for tasks that take a fixed subjective time to complete, this speed cost effect encourages the use of the slowest "just in time" ems barely able to finish a task before its deadline.

In 1 objective month a milli-em gets about 45 minutes of subjective experience. An hour is near the shortest time it takes a skilled worker to do a useful task, and tasks that take much longer than an economic doubling time to complete are far less valuable. Thus ems slower than milli-ems must almost all be retirees.

Other factors, however, can push toward faster em speeds. These include speed as a status signal, gains from having careers finish before jobs substantially change, and gains from more coordination by having the same em do several related tasks.

The same sort of interaction gains that encourage ems to clump into dense cities also encourage ems to run at speeds like those of their associates, and to avoid the phase differences that result from time-sharing computer hardware. After all, time-sharing ems with different phases and long periods can't talk naturally to each other without changing speeds or phases, and short swap periods may greatly increase the average cost of swapping.

We have many reasons to expect particular speeds for particular tasks. Ems who work closely with physical processes, such as by managing factories, run at the speeds required by those physical processes, and there is likely to be a wide range of such speeds. Most ems interacting with ordinary humans tend to run at nearly the same mental speeds as humans. Ems competing in product development races not constrained by delays from interacting with physical or other external systems often run at near the top cheap speed, and perhaps even faster. Such racing ems are likely to be located well away from city centers, if the time to produce results is long compared with the time delay to deliver results from sites distant from a city center. Many retired ems run at near the base speed, that is, at the slowest near-proportional hardware cost speed. The speeds of other ems, however, tend to clump at a small number of standard speeds, to allow them to interact more easily with each other.

We have some specific reasons to expect several differing standard speeds. One reason has already been mentioned: coordination gains from having bosses run faster than subordinates. Such gains are limited by difficulties in having a single boss know enough to manage many diverse teams. A speed ratio of 16 may be feasible, if a good boss can plausibly remember enough detail to manage roughly 16 different teams at a time.

A second reason for differing speeds is to have leisure go faster than work. In many jobs today, worker desires to rest between work sessions often conflict with the desires of clients for workers to be always available. Having different work shifts that cover all time periods helps, but can lead to worker failures to coordinate across shift boundaries (Chan 2015). Ems could greatly reduce this conflict by having their leisure speeds be much faster than their work speeds.

For example, at a leisure-to-work speed ratio of 16, a worker might be on the job around the clock except for taking a 45 minute break every 12 hours, a break during which they can rest for 12 subjective hours. To fully use local fast em hardware, a population of workers might split into 16 different work-phase communities, who each take their leisure at different times, and thus can't interact much with other phase groups during their leisure time.

For ems who work close enough to a city center to interact without noticeable delay with most of that city, switching to fast leisure time can greatly reduce the number of city ems with which they can interact without delays. This is a sensible choice if leisure activities gain less from interacting with many others than do workplace activities. This seems to hold today, as work tends more to be located toward city centers today, while leisure (especially for older people) is more in peripheral areas.

When the ratios between standard speeds are powers of two, it becomes easier for the same hardware to support different speeds at different times. For three or more such standard speeds, if neighboring speeds differed by the same ratios, then common social conventions could be used to manage how ems of different speeds interact with each other. Thus a simple assumption is that the main em speeds will tend to differ by the same factor, a factor that is a power of two. Perhaps this standard speed ratio factor would be four or 16.

My best guess for the (economic-value-weighted) typical em speed during the early em era is within roughly a factor of eight of a kilo-em speed. A speedup of 1000 is fast enough for a two-century-long subjective career to fit into 2 objective months of rapid social change, and yet still slow enough for its 15-kilometer reaction distance (at a reaction time of 0.1 seconds) to include a familiar-sized city. (For example, Manhattan is 21.6 by 3.7 kilometers.)

A physical em body that matched the reaction time of a kilo-em is about 1.5 millimeters tall. Such a body might have to be tele-operated, if a matching brain does not fit inside such a body. Such miniature ems could manage matching tiny pipes, service access hallways, tools, vehicles, and manufacturing plants, all with parts 1000 times smaller than ours but changing 1000 times faster.

At this scale, an industry-era city population of a million kilo-ems could fit in an ordinary bottle, as in the miniaturized and bottled city of Kandor from the Superman Comics. A billion at this scale might fit in a small building of today, while a large building might hold the trillions in population that are said to fill a galaxy in the science-fiction stories of the 1950s. Of course we have no guarantee that a kilo-em brain could fit inside a matching sized body.

Note that for any given size of the em economy, the faster the typical em, then the smaller the total size of the active em population, as faster ems typically produce proportionally more economic value, at least among ems who are fast enough to do a job at all. The economic product of a billion kilo-ems should be roughly comparable with that of a trillion human-speed ems.

TRANSPORT

Even if most em activity, and travel, is done in virtual reality, some ems and material goods need to physically travel to new locations.

Today, at the typical urban commuter speed of about 10 meters per second, it takes about 25 minutes to commute 15 kilometers across a city. It takes about 5 hours for a jet to fly across continents such as North America, or between continents such as North America and Europe. It takes about a month to ship goods by boat from China to the U.S., and it could take over a year to fly to Mars and back.

However, to the typical speed kilo-ems, such physical trips take far longer subjectively. To a kilo-em, a physical commute across a city takes a subjective 18 days, a jet flight between continents takes 7 subjective months, a boat trip from China to the U.S. takes a century, and a one year flight to Mars and back takes a millennium. (To a kilo-em, 12 hours of real daylight or nighttime lasts for a subjective 17 months.)

Such long subjective delays greatly discourage physical travel by fast ems. In fact, kilo-ems who physically commute might typically travel only nine meters. This estimate comes from the fact that, in cities today, the fraction of people who commute a distance falls by half for every fifteen minutes added to their commute (Ahlfeldt et al. 2015). Of course ems can travel electronically to wherever receivers are built.

A rapidly growing em economy also discourages transport of physical goods over long distances. First, high interest rates greatly discourage the use of products or resources that require travel or shipping delays of several economic doubling times.

More important, a rapidly changing economy needs the flexibility to swiftly adapt to changing circumstances. Today, 58% of U.S. exports by value are sent by air. Such transport is typically so time sensitive that an extra day in transit is equivalent to a product tax of 0.6% to 2.3% (Hummels and Schaur 2013). Yet 1 day is only one part in 5000 of today's economic doubling time. If this delay-is-very-costly effect scales with the growth rate of the economy, then for an em economy with a 1 month doubling time it becomes an 8 minute transit delay that is equivalent to a product tax of 0.6% to 2.3%. At typical urban commuting speeds of 10 meters per second, products can only be shipped 5 kilometers in 8 minutes.

Thus even shipping goods all the way across em cities is substantially discouraged, and shipping goods between em cities is quite prohibitively expensive. The main long distance shipping is for goods with very poor local substitutes, such as essential raw materials, or hard-to-make goods that use secret designs, where the manufacturer does not trust local manufacturers or 3D printers not to steal the design.

To avoid such trust issues, em cities may open internal "embassy" regions entirely run according to the laws and rules of other cities. Manufacturers from those other cities could then place factories within such regions and be better assured that their design secrets are protected. Em cities with large "embassy" trade zones might be almost entirely self-sufficient in terms of physical manufacturing, although trade via communication, such as of designs, would be robust.

As the high cost of time delays encourages em cities to draw their raw materials mostly from local sources, a poor choice of city location might be fatal to long-term em prosperity. Locating close to large industry-era landfills, which contain a wide range of useful materials, might offer useful insurance against such risks.

Em economic interest in space travel should greatly diminish from today's already low levels. Although a much richer em society can afford more vanity space travel, the long subjective delays to move between Earth and space discourages this choice relative to other vanity projects. Even so, a far larger em economy, and the far lower cost to send ems into space, will likely greatly increase the number of human-like creatures in space, even if the fraction of GDP spent on space is lower. It is also possible, even if unlikely, that a cascade of debris from colliding satellites in Earth's orbit will make exit from Earth through the resulting debris field prohibitively expensive (Kessler and Cour-Palais 1978).

Within cities, transport of shipping-container-sized items probably takes place via roads and railroads with familiar human-scale cross-sections and speeds. But the existence of ems with much smaller physical dimensions likely also creates a demand for transport routes with smaller cross-sections.

Pneumatic tubes seem one attractive candidate for smaller cross-section transport. Paris once had a large postal system of 6.5-centimeter diameter tubes that moved bottles containing letters at a speed of about 10 meters per second. This tube system started in 1866, and eventually had about 500 kilometers of tubes. Pneumatic tube systems work similarly today, although they are better automated and typically have diameters of 10 centimeters. Em cities might have much larger networks of pneumatic tubes to move small goods.

Train tunnels today have a standard diameter of about 6 meters, while automobile tunnels are usually a bit larger. Pneumatic tubes are roughly a factor of 100 smaller than train and road tunnels. Tubes 100 times smaller than pneumatic tubes are a bit less than a millimeter in diameter. It turns out that this is a standard diameter for equipment tubes today.

Similar to computing and manufacturing, future transport may also be thermodynamically adiabatic, to reduce the use of free energy. That is, there may be substantial subsystems of the transportation system wherein the free energy required to move cargo is proportional to the speed at which that cargo moves. If so, then as with adiabatic computing and manufacturing, within such subsystems about as much is spent on renting transport hardware, including roads, as on the energy and cooling needed to run that hardware.

In sum, because ems vary in speeds and sizes, em travel takes place in a wider variety of sizes of tubes and vehicles.

CHAPTER 19

Groups

CLANS

By analogy with a family clan today, we can take all of the copy descendants of a single original human, and call that group a "clan." All of the copy descendants of a particular em can be called a "subclan." (While the term "clade" might be more precise, the term "clan" is more widely known.)

How do clans and subclans organize?

We are today each part of many organizations, such as neighborhoods, firms, clubs, and nations. But we rely most on our families when we seek strong long-term bonds and trust. It is within families that we most share resources, let ourselves be most vulnerable, and seek help in bad times. Long ago humans evolved to trust families more than other groupings because of their closer genetic relations, and have developed many family-specific adaptations to complement such unusually strong family trust.

Identical twins are more closely related than are family members. Because of the rarity of such twins, however, our ancestors may have evolved few adaptations specific to twinning. Even so, the trust and bonds between identical twins seems to usually be stronger than those between other family members.

Ems will have access to a new unit of organization: clans of copies of the same original person. Compared with families or even identical twins, ems have even stronger reasons to trust and bond with fellow clan members. This makes em copy clans a natural candidate unit for finance, reproduction, legal liability, and political representation.

The degree of affiliation between two em copies depends on how long they have been diverging subjectively since their last common ancestor. Copies that have diverged for only an hour are likely to feel very strongly affiliated. They'd share almost all opinions and attitudes, and are usually willing to make great sacrifices for one another. On the other hand, copies that have diverged for 20 years may feel far less of a connection. They might have been trained for different professions, and live in different kinds of communities. Their personalities and political opinions might even have diverged. However, as most ems are near the same peak productivity subjective age, they don't usually have to deal much with aged-related changes in personality or opinions (Alwin and Krosnick 1991; Soto et al. 2011).

Clans with millions or more members likely split for many purposes into subclans of thousands or more. The tree structure of their copy ancestry forms a natural basis for such subclan grouping. During the farming era, and still in some places today, ancestry trees of family clans were often a basis for legal liability, political coalitions, and much else. Relative to em clans, em subclans even more closely resemble each other in jobs, hobbies, friends, personality, and shared memories. Conflicts between subclans are likely to be the biggest source of internal clan conflict.

Ems probably vary in how much they could trust recent copies of themselves, and in how much the duration since they split into different copies matters for trust. For example, those who see themselves as typically "faking it" around others, that is, pretending to have more competence than they believe they have, are likely to trust less in the competence of recent copies of themselves. In a clan-dominated em era, people whose basic personality makes it harder to coordinate and compromise with copies of themselves, or to predict the behavior of such copies, are likely to be at a competitive disadvantage.

Even if the interests of em clan members are typically more closely aligned than are the interests of family members or identical twins today, their interests are hardly identical. Different copies can have different jobs and associates from whom they gain differing degrees of pleasure. Different copies can also differ in whether they will end or retire, and in the speed and quality of their retirement. Different copies are well aware of these different possible outcomes, and are quite capable of taking them into account in choosing actions. Thus unless great efforts are taken to erase or hide such differences, we should not expect em clans to resemble the "Borg" in Star Trek, a group mind that consistently acts toward a common purpose without internal conflicts (Shulman 2010).

MANAGING CLANS

So what do clans do differently from other units of organization, such as cities and firms?

Law usually tries to deter crime via small chances of big punishments. It can be especially hard, however, to cheaply impose big punishments on short-lived ems. Giving ems a longer life in order to torture them, for example, could cost a lot more than did their original life. For such ems it can make sense to use vicarious liability, that is, to have legal liability apply to an associated unit with "deeper pockets." In principle this could be any sponsor willing to take on the liability, but in practice this is probably a subclan containing that em. Ems care more about hurting their subclans, and subclans know how to discourage member ems from liability-inducing events (Miceli and Segerson 2007).

Em clan vicarious liability could be similar to the way that farmer societies often made larger family units liable for the crimes of individual family members. Holding closely related copies responsible for an em's crimes may seem more legitimate to observers if archived versions of such copies could be tested in sims to see if they would have behaved similarly given a similar opportunity.

Subclans legally liable for the behaviors of members probably seek to regulate such behaviors. Subclans also want such powers to manage their reputations. After all, as subclan members are so similar, the behavior of any one member could be highly predictive of the behavior of others. Thus the bad behavior of one em could make the rest of their subclan look bad. Ems in clans that more strongly manage their reputations will seem more predictable and reliable.

When many copies are made of an em trained at a substantial expense, then to avoid ruinous wage competition that fails to recover fixed costs of training and marketing, such copies must be constrained in the job wages they can accept.

Political regimes become unstable when members do not accept their legitimacy. As we tend more to accept and defer to internal decisions of families, compared with non-kin-based associations, farmer-era city and regional politics often used families as the first unit of political grouping. That is, ancient politics was often the politics of shifting coalitions of family clans (Braekevelt et al. 2012). This remains true in the Middle East and Asia today (Sailer 2003).

Relative to the self-governance of families, we defer today even more to the self-governance of individuals, at least for individual behaviors that don't influence others much. For example, if a person suffers today to gain benefits in later days, such as by attending a difficult school with a high chance of failure, we almost never suggest that their future self is exploiting their current self. Thus for ems it makes even more sense to use clans as the first unit of political organization than it did for farmers to use families as their main political unit. If most ems are in a dozen to a thousand clans, the politics of an em city-state might naturally be the politics of shifting coalitions of em clans.

Clans and subclans whose root ems were raised together as children might tend to ally more with each other, and childhood cohorts might be chosen with this prospect in mind.

To encourage internal clan loyalty, clans may try to anticipate and coordinate to prevent situations where clan members compete over friends, lovers, or jobs. For example, there might be a stable general policy of preventing different subclans from competing for the same jobs or teams.

When a single em makes a plan for the future and then splits into many copies who execute that plan, the resulting ems are likely to identify especially strongly with each other as being the "same" person spread out in space in order to implement their common plan. This strong identification is likely to continue until some copies come to question the importance or wisdom of the plan, or to disagree explicitly about how to implement the plan.

Direct explicit arguments of any sort between copies are likely to push them more to see themselves as distinct persons, instead of as different parts of the same person. Because of this, subclans may try to arrange the interactions between such copies to discourage direct explicit arguments. Subclans may instead prefer other more indirect mechanisms to share information. For example, a subclan might usually act as if it agreed with consensus prediction market estimates, and individuals who disagreed with that consensus might be satisfied to express their disagreements via prediction market trades, and then mostly ignore those disagreements when interacting in other ways with other clan members.

Em subclans with similar work and living arrangements may well act together to buy in bulk. Today, firms often achieve substantial savings by buying in bulk. That is, firms buy large quantities of oft-used items, such as computers, vehicles, or office supplies, together with matching supporting systems for maintenance, repair, and training. In contrast, consumers today tend to buy much smaller quantities of more varied and less integrated items, which cost more as a result. Em subclans might buy many copies of whole coordinated systems, one copy for each member.

Buying in bulk is one of many ways that ems could benefit from being part of large clans or subclans. Large clans may also succeed more in world or city scale coalition politics, and their members can feel more confident in being valued by the world. They may build specialized hardware to run their clan's minds, and they may organize better to protect their security. Large clans may even create their own news sources, with reporters who observe events and record shallow mind readings that other clan members can then directly experience.

Of course large clans may also suffer disadvantages, such as needing more formal mechanisms of governance, having bigger internal divisions and disagreements, and suffering more cases where subclans compete with each other in outside markets.

FIRMS

Firms continue to exist in an em world, but with a few changes.

As we will discuss in Chapter 20, Inequality section, em firms will tend to be larger than firms today. We can thus use observed features of larger firms today to guess how em firms will differ from our firms. For example, larger em firms have less overall coordination and coherence, even as such firms put more effort into coordination via more meetings by more managers in more layers of management. Workers in em firms also have more specific operational roles, and each does a narrower range of tasks. All else equal, larger em firms have offices in more locations, with less in-person and direct internal communication. This effect may be countered by ems concentrating in a few huge cities.

Early in the industrial revolution, many noticed a general trend toward larger organizations with more specialized and regimented roles. People such as Yevgeny Zamyatin, author of the classic novel *We*, feared that the entire social world would soon be factory-like, and that firms and nations would soon merge into intrusive faceless oppressors that dictated who people married, where they lived, what they ate, when they slept, and pretty much everything (Richter 1893; Zamyatin 1924). Discomfort with big organizations lingers in our stereotypes of "soul-crushing" bureaucracies.

It is true that workers today tend to say they are less satisfied with jobs in larger firms, because of their less flexible work environments (Idson 1990). However, just as larger cities are often celebrated for having more innovation, specialization, and better educated and paid workers, larger firms deserve similar praise because they are more productive, last longer, use more capital per worker, adopt new technologies earlier, and pay and train their better educated workers more (Oi and Idson 1999; Bento and Restuccia 2014; Cardiff-Hicks et al. 2014). Today, most employees of large firms seem to lead full lives with their souls largely intact.

Also, workers who focus more on pleasing their boss, and less on doing what they see as a good job, tend to be more successful and happier (Judge and Bretz 1994). So ems may also be happier if they learn to focus on pleasing their bosses.

Management experts today have identified many efficient management practices. Not only do these practices correlate with firms that are bigger, grow faster, earn more, and last longer, but randomized experiments show that these practices increase productivity. The rate of such practices seems to be increased today by product market competition, by being a multinational firm, by exporting, and by having more educated workers (Bloom et al. 2013; Bloom and Van Reenen 2010).

Today, family-based firms tend to be less productive when run by someone who got the job because of birth, such as by being an eldest son, and such firms are more productive when run by someone outside the family. Private-equity owned firms have management practices that are as good as public firms, and better than simple private firms, family-based firms, and government organizations (Bloom et al. 2015).

Because of learning and increased competitive pressures, we should expect em firms to use more of these good management practices, relative to firms of today. These practices include performance-based rewards and job-placement, demanding but attainable goals, managers evaluated on attracting and retaining talent, regular equipment maintenance, thorough analysis of failures, clear job descriptions, just-in-time delivery, tracking production by order, pricing orders based on production costs, and frequent and detailed tracking of inputs, outputs, and performance.

Many other business practices today are suspected of being inefficient, even if the case against them isn't quite as strong. We should also (more weakly) expect these practices to decline in em firms, because of continued firm learning and increased competitive pressures. These practices include keeping unproductive "deadwood" employees for too long, overpaying employees in critical functions at large firms, overly frequent mergers, too many long big meetings, "poison pills" that directly punish new investors in hostile takeovers, discouraging subordinates from reporting bad news, rejecting innovations "not invented here," allowing barriers to within-firm information sharing, hiring consultants to endorse predetermined conclusions, avoiding experiments to test products and practices, avoiding formal accuracy tracking of who predicted or suggested what when, excess reliance on interviews and school credentials in hiring, and allowing bosses to give lower employee evaluations to subordinates who do not "toot their own horns" and to subordinates who the boss did not hire or promote.

We can categorize firms today by whether their business focus is novelty, quality, cost, or something else. Novelty and quality focused firms innovate more, have more layers of management, and rely more on employee initiative, via pay for performance, problem-solving teams, and employee information-sharing programs. Both types outsource more and cooperate more with other firms in research.

Quality- and cost-focused firms have higher productivity and market share, closely track operation performance, and coordinate more along their value chain. Quality-focused firms have higher markups and profits, while cost-focused firms have lower profits. Cost-focused firms do more downsizing and cutting of management layers, and emphasize central coordination via managers (Yang et al. 2015).

We weakly expect these correlations to continue with em firms. As we expect em firms to focus more on cost and less on novelty, this suggests that em firms have higher market shares, lower markups and profits, fewer layers of management, and less innovation, employee initiative, and pay-for-performance. However, if the em world manages to find better ways than we have today to encourage innovation, such as are discussed in Chapter 22, Innovation section, perhaps more em firms will be novelty-focused.

Larger firms today tend to have narrower and more precisely defined processes and structures, including policy manuals and job descriptions. They also have stronger corporate cultures and depend less on distinctive individual personalities. While one might expect this trend to continue with em firms, we soon discuss a contrary factor that could plausibly lead to less formality and more distinctive employee personalities.

Today, firm managers tend to be given more discretion when it is harder for their superiors to evaluate them via comparisons with other firms using similar technology in similar environments. Such judgments are harder when firms are young, their technology is new, and their environments change fast. Firms whose managers have more discretion tend to be organized into divisions that are profit centers, while other firms tend to be organized into divisions that are cost centers (Acemoglu et al. 2007).

Em firms tend to be larger and older, the em economy has less product variety, and innovation matters less for growth in the em economy. All these factors suggest that em firms are more often organized into cost-center divisions, with managers having less discretion. However, the opposite may hold if sufficiently high levels of clan-firm trust can be achieved, as discussed in the next section.

While wage inequality has been increasing in rich nations in recent decades, the wage inequality within firms there has not been increasing. This suggests that firms limit internal wage inequality because of problems it causes in morale or office politics. This further suggests that em firms and teams will also prefer to limit internal wage inequality. Em wages probably differ more between firms, rather than within firms (Song et al. 2015).

FIRM-CLAN RELATIONS

As firms and clans are both large important institutions in em society, potential conflicts can arise between them, along with opportunities for gains by avoiding such conflicts.

For example, firms with employees drawn from many clans face security issues about where to locate employee brains. Clans may minimize risks of theft by locating themselves within "castles" that only contain, and are only managed by, clan members. However, this arrangement increases risks to firms of clans leaking firm secrets, and makes it harder for subordinates to meet with fast bosses within a firm. In contrast, co-locating firm employees at a single location lets employees interact more flexibly, such as via fast meetings with fast bosses, and can better protect firm secrets. However, from a clan's point of view this approach increases the risk of the theft of clan minds and secrets.

Higher levels of clan-firm trust can thus increase firm efficiency, by allowing firm employee brains to be located closer to one another. Higher levels of clan-firm trust might result if firms and clans invested heavily in each other's ventures, and also if clans or firms were long-lived entities that developed strong reputations for trustworthiness that they fear losing.

Such trust can produce other benefits. For example, at big firms today it is usually hard to objectively attribute successes or failures to the actions of particular employees. This encourages people to play strategic games with how people and projects are evaluated. For example, employees become yes-men, curry favor with evaluators, form mutual admiration coalitions, and focus their efforts on more visible outcomes such as attendance, grooming, writing style, and school credentials. In contrast, ems from clans with a large financial and reputational interest in a firm might simply try to be useful to that firm. As the reputations of clans will average over many choices made by many clan members at many firms, clans may have more confidence that the average value of their clan's contributions will be discerned amid the noise of variation across particular firm contexts.

Today, firms often use formality and standards to try to ensure that workers are closer substitutes to one another, and thus compete with each other more strongly for jobs. This makes such firms less vulnerable to threats by individual employees to leave. Em firms might plausibly act similarly to ensure that employee clans compete with each other. After all, a firm that came to rely on the habits and skills of a particular clan could be vulnerable to a threat by that clan to leave the firm unless that clan got a larger share of firm profits. This is feasible because clans are often "unionized" in the sense of negotiating labor agreements as a unit.

Higher levels of clan-firm trust might, however, let firms instead rely more on the unique skills and habits of particular clans. Em firms that more strongly trust their employee clans not to make threats to leave are likely to have fewer formal rules and standards regarding worker procedures and performance. In this case each employee clan could take on a distinctive clan personality, instead of taking on a more standard personality to fill a standard job role.

Today, efforts and misallocations resulting from office politics often result in substantial firm inefficiencies. But such costs are at least limited by job turnover, as it takes time for new employees to adapt to local office politics. Costs are also limited because factions often limit information on factional strategies to core faction members, which keeps peripheral members from fully participating in office politics. This often leads such peripheral employees to choose a strategy of "keeping their head down" and avoiding entangling alliances with warring factions.

Unfortunately, the use of factions based on clans can more easily overcome the factors that today limit the severity of office politics. Most members of em clans know each other very well and are able to coordinate well internally, including by keeping internal clan secrets. Thus office politics in em firms has the potential to be quite destructive. To reduce such losses, em firms may try harder to increase accountability by increasing the visibility of actions and their consequences.

Em labor markets are more like product markets today, with a few firms selling most of the products in each market. Here the suppliers are clans, who pay to train members to compete in each labor market. These clans face nearly the same marginal costs of supplying labor, but can choose different fixed costs of training, testing, and marketing. When they are effective competitors, we expect such suppliers to differentiate their products, to invest in larger fixed costs when supplying larger markets, and to make deals with other clans that bundle complementary ems into teams. We expect such suppliers to have substantial market power, which typically induces too many firms to enter each market, relative to a social optimum (Shy 1996).

TEAMS

Most work that is done at firms is done within much smaller workplace teams. How do work teams differ in an em era?

Because the em world is more competitive than ours, we weakly expect em teams to display more of the features that today are correlated with team productivity.

For example, today the most productive teams tend to have incentives that are either at the individual level or the team level; mixed intermediate incentives tend to produce worse outcomes. Teams with group incentives who deal with complex production processes tend to benefit by creating special problem-solving subteams (Boning et al. 2007). Today, the most productive long-lived work teams tend to be more self-directed, because this improves attitudes and makes workers more easily accept pressures to conform to local work norms. The most productive short-lived project teams, in contrast, tend to have more outside direction (Cohen and Bailey 1997).

Talk networks, that is, who tends to talk to whom, also matter for team productivity. Teams with stable talk networks are better at repetitive tasks (customer service), but teams with fast changing talk networks are better at creative tasks (sales and management). More productive teams have more cohesive (tightly interconnected) networks of face-to-face talk, especially for complex tasks, but less cohesive networks of email talk (Wu et al. 2008).

Today, the most productive work teams tend to have members with similar surface and social-category features such as race, ethnicity, gender, age, and tenure. In contrast, such teams tend to have a diversity of features that indicate sources of information and styles of thinking. Such features include personality and areas of education, training, and experience. Such diversity is especially valuable for work tasks that require exploration, as in research (Mannix and Neale 2005).

While teams are likely to be arranged in ways that maximize productivity, they are unlikely to *consciously* define themselves this way. Instead, like groups in offices today, em teams are likely to define themselves more by their mutual respect and loyalty, and by their shared cultural values such as egalitarianism, honesty, rationality, realism, sharing of resources and information, and disapproval of bragging, dominance, greed, intolerance, and jealousy.

As discussed in Chapter 13, Clan Concentration section, a few clans probably dominate most em labor markets. This gives such suppliers substantial market power, although not expected net profits after paying for training, marketing, and other fixed costs. Suppliers having market power in em labor markets suggests that team formation can involve substantial strategic negotiation. Ems may, for example, gain strategic advantages from committing to not join teams lacking certain favored allies, or containing disliked rivals. Foragers evolved many complex and subtle abilities to navigate politics like this in forager bands. Such abilities may find many applications in em team politics. Efforts devoted to complex feuding and political intrigue, however, can be costly.

Sometimes firms prefer the ease of hiring team members as simple employees. This could result in weaker employee incentives, aside from clan reputation. At other times, teams may incorporate as small for-profit firms, and contract to supply specific services. In such cases, team profits could be divided among team members, supplying clans, and supporting investors. Team members might take their individual profits partly as extra leisure time or faster retirement.

As mentioned in Chapter 11, Defining Death section, starting and ending or retiring teams as units is likely be the norm. Encouraging teams to prefer internal social interactions minimizes disruptions from outside social interactions that could induce unexpected variations in team productivity. This might have a happiness cost, however, as frequent contact with many others with weak social ties seems important to happiness (Sandstrom and Dunn 2014).

A similar if smaller reduction in productivity variance comes if teams pay less attention to outside news and events. This attitude of low interest in news comes more naturally for fast ems, as the wider world is more stable to them, and so has less interesting news to report.

Having fewer outside-team interactions somewhat lowers the value of living near city centers, and the gains from information and innovations that diffuse via weak social ties. So teams with stronger interactions outside the team tend to be found more in city centers.

Compared with work teams today, em teams have stronger internal social bonds. Teams who are created together more see the team as literally their reason for existence. Also, there are fewer conflicts to threaten internal team loyalty. Teams mostly succeed or fail together, and end or retire together. Ems need not fear that colleagues will leave their team for better opportunities, as these colleagues can instead make new copies to pursue better opportunities. If teams could veto team members making copies outside the team, that might further reduce internal team conflicts. However, which ems feel most attached to which other ems within a team could vary over time.

MASS VERSUS NICHE TEAMS

Product markets today can be divided into mass versus niche markets. Makers of mass-market products want to limit their product variation to appeal to as many customers as possible. In contrast, makers of niche-market products want to increase their product variation to appeal to different narrow groups of customers each willing to pay more for products that more closely match their idiosyncratic preferences (Johnson and Myatt 2006). Mass products tend to have more competition, scale economies, and mass advertising. Many mass products began as niche products. Compared with physically distributed goods, it is easier for electronically distributed goods to serve wider markets, and thus to become more narrowly specialized niche products.

Em labor markets should also divide into mass and niche markets. In niche labor markets, new jobs are rare, unpredictable, and more often require a few new em copies to flexibly adapt to a particular new situation. For example, a new copy of a specialized management consultant might be created whenever a firm decided it needed this sort of specialist to address a particular problem.

Mass em labor markets, in contrast, have a steadier stream of predictable customers to be provided with similar services. Mass markets tend more to select the most productive em teams from a large pool of candidates. Thus mass-market ems are more heavily concentrated near peak productivity ages. Niche-market ems, in contrast, tend to have a wider distribution of subjective ages.

In general, the degree of concentration of work ages near peak productivity ages is a tradeoff between general worker productivity and gains from a worker being more familiar with a particular workplace. The more useful it is to keep the same worker in the same environment for many years, the more years a worker tends to stays on one job, and the more that those years are further away from the peak productivity age.

For each niche worker, there are fewer workers with similar training doing similar tasks. Because of this, it is easier for mass-market ems to adopt a mode where many copies of a worker are made each morning, but only some of those copies are saved to enjoy leisure the next day.

Mass-market ems can more easily form teams who are copied and retired as a unit. Even if most niche-market ems are also created in teams, niche ems more often accept complications from not starting or retiring as part of a team, as well as additional complexities from dealing with friends and lovers who start and end at different times. All ems must deal with related complications when they are copied and find that their new team is not identical to their old team.

When a niche em makes a new copy, he or she may have to decide whether the original or the copy inherits the original's friends. Alternatively, a small group of copies might coordinate to share such a friend, and to make sure to keep up to date on all of the interactions between this friend and this small copy group, so that the friend doesn't struggle to keep track of which copy it had interacted with.

These complications of a niche em lifestyle likely makes such a life seem less attractive to many. If so, this raises the costs of niche labor. Also, as discussed in Chapter 13, Efficiency section, the em economy in addition moves toward mass products because of stronger competition and lower wages. However, as niche job lifestyles are culturally more like forager lifestyles, they may acquire a Bohemian prestige, perhaps raising the social status of ems who have a close copy who once lived a niche lifestyle.

The existence of many similar teams usually gives mass-market ems a good idea of what to expect in their future life. After all, each such em can look at the experiences of older copies in prior versions of their team. Such previous experiences can sometimes be misleading, for example when outside forces such as customers, competitors, or suppliers induce big local changes. However, such exceptions are rare. Today, many religious people are less anxious about life events because they think "this is all part of God's plan." Similarly, mass-market ems can be comforted to know that most disturbing life events were part of the clan's plan.

When an em clan supplies workers to a very large mass labor market, there must be at least as many members of that clan as there are workers who serve that labor market, times the market share of that clan. Because this number will sometimes be larger than the total number of members in a small clan, clans who supply very large labor markets must also be large. This may create a correlation between clan size and mass-market work; larger clans may tend more to supply mass labor markets, while smaller clans more often serve niche labor markets.

While ems that serve mass markets could more easily be copied as a part of large teams that retain most of their familiar friends and context, such copied teams could not as easily bring along copies of large shared community spaces such as city neighborhoods or parks. For very large spaces this is not a problem, as the different copies of the team can just share the same original space, and only rarely meet in the large space. For smaller spaces, however, ems must choose between moving to a new "parallel world" space, which can of course still look a lot like the old space, or sharing the old space and dealing with the prospect of meeting more often and mixing with similar members of other teams.

In sum, the lives of both mass-market and niche-market ems differ substantially from our lives, but in different ways.

CHAPTER 20

Conflict

INEQUALITY

How unequal are ems from one another?

During the forager era the main units of organization were bands of roughly 20 to 50 people, and smaller family units. As activity wasn't organized via larger units, foragers did not see inequality comparable with our unequal towns, firms, or nations. Foragers also had only mild differences in personal property and prestige. Over the roughly million plus year forager era, however, foragers had an enormous inequality of lineages, in the sense that almost all lineages eventually went extinct, with zero descendants.

The farmer era had larger units of organization, such as clans, villages, nations, and empires. Although empires sometimes became nearly as large as feasible given transportation limits, large empires usually only had a weak influence on local behaviors. Villages were much smaller than nations, and firms were typically tiny.

As discussed in Chapter 18, Cities section, while most farmers lived near small villages, in our industrial era people are spread rather evenly across towns and cities of all feasible sizes. Also, for most industrial products today, market shares are relatively concentrated within transport-cost-limited market areas. That is, for each type of product in an area, only a small number of firms supply most customers.

Power laws are mathematical forms that often usefully describe such inequality. That is, power laws often fit the large-unit end of the distributions of how such items are grouped into units. In such cases, a power of one describes a uniform distribution of items across feasible unit sizes. Powers greater than one describe more equal distributions, wherein most items reside in small units, and powers less than one describe less equal distributions, wherein most items are clumped into fewer larger units. Compared with any given sized unit, for a power of one a unit with twice the size appears half as often. Thus for a power of one, different sized units hold a similar total number of items. Compared with a power of one, with a power greater than one such double-size units are less frequent, while with a power less than one double-size units are more frequent.

During all eras so far, family names have been distributed relatively equally, with a power of about two. Later in the farmer era, villages were distributed with a power of about one-and-a-half (Nitsch 2005), roughly the power that describes the distribution of individual wealth today (Davies et al. 2011), although the worldwide income distribution seems better described as a lognormal distribution (Provenzano 2015). (The income ratio between ninetieth and tenth percentiles is less than many think; it was 1.84 in 1985, and 1.74 in 2011.)

Today, nations, firms within nations, and cities within nations, are all distributed with a power of about one (Axtell 2001; Eeckhout 2004; Giesen et al. 2010). The firms that supply product are usually more clumped, with a power less than one, meaning that for each product most units are supplied by only a few firms (Kohli and Sah 2006).

EM INEQUALITY

As discussed in Chapter 13, Clan Concentration section, em-era clans clump much more unequally than did families in all prior eras; most ems may come from a dozen to a thousand one-name clans, each of which has millions to billions of members. In contrast, there may be millions of two-name clans, each with only thousands to millions of members. And most of the roughly 10 billion ordinary humans may each give rise to a three-name clan with perhaps only dozens of members.

With only hundreds of main clans, em labor markets become concentrated like today's product markets, with a few clans supplying most workers in any given skill area. It may be like US vehicles today, where 300 models are sold, and 3% are the Ford F pickup. Clans coordinate to support their workers, by preventing member mind theft and ensuring that workers can profit from training investments. Fixed costs of training and marketing create market concentration and power, although not net profits after paying for fixed costs.

As discussed in Chapter 18, Cities section, em cities and nations are also likely to be much more unequal than are cities and nations today, with most ems found in a few very large city-states.

The high degree of inequality and concentration of em clans and cities introduces a key source of uncertainty about the em world. The main em clans could be quite unrepresentative of humans today, and in ways that are hard for us to foresee. That is, the world of ems could be substantially different, depending on the particular mix of the few clans who happen to dominate the core set of most-copied clans. Similarly, the few dominant em cities are probably not equally distributed across the globe; the em world could be quite different depending on the locations of those key em cities.

Em firms are likely to continue to be distributed evenly across feasible firm sizes. But because a larger economy could contain larger firms, the typical em firm size will be larger. Today, in a world of 7 billion people, firms are spread evenly between having roughly one and 1 million employees. The middle firm size, where half of workers are in larger firms, has about 1000 workers. For every factor of 100 increase in the size of the largest feasible em firm, such as might come from an increase in total em population, we should expect about a factor of 10 increase in the number of workers in the middle sized em firm.

The wages of em workers are much more equal than are wages today, at least after correcting for training costs. The highly competitive em economy pushes wages down to near subsistence levels, even for jobs requiring superior workers. This is because workers of almost all quality levels are available in unlimited quantities.

In general, the possibility of slavery makes possible more wage inequality. Although this applies to the em world as well, it has less effect there because the variation in em wages is greatly reduced as a result of strong labor market competition. In a Malthusian world wages don't vary that much, making em slaves less worse off compared with other workers.

While em wages are more equal than are wages today, em wealth can be more unequal. This is because of both indefinite em lifespans, and the em capacity to run at different speeds. Today, it seems to be the indefinite lifespans of cities and firms that allows them to spread uniformly across all feasible sizes; if a city or firm continues to succeed, it can continue to grow, regardless of its age. In contrast, while wealthy individuals today often consistently grow their wealth over their lifespan, their children usually fail to increase the family fortune. Rags-to-riches-to-rags in three generations is, after all, a common story. This helps explain why individual wealth isn't as unequally distributed today as are city and firm sizes.

With indefinite em lifespans, however, successful ems might continue their successful financial habits indefinitely. This tends to distribute wealth more evenly across feasible wealth sizes, similar to how firms and cities are distributed evenly today across feasible sizes, some large and some small. The tendency of em minds to become inflexible with experience, however, may somewhat reduce this effect, especially if rich old ems do not reduce their speeds.

The ability to run at many different speeds also expands the range of possible em wealth. A faster em brain directly embodies more wealth, and it can often find productive uses for that wealth. While humans who are relatively very poor must starve, ems who are relatively very poor can run at very slow speeds or be archived. Thus as ems can be both very fast and very slow, they can be both very rich and very poor.

If these effects dominate, then the em world would sees roughly a power of one for the distribution of em wealth. This would make wealth more unequal than today, both because this is a lower and hence more unequal power, and because a richer em world can make feasible both higher and lower wealth levels. While today's richest human holds ~0.02% of the world's wealth, the richest em might hold a much larger fraction, perhaps ~2% of the em world's wealth.

REDISTRIBUTION

However, these wealth-inequality-increasing effects need not dominate, because of the possibility of income or wealth redistribution.

There are many kinds of inequality. Inequality exists between different species, between generations born at different times, and between nations of the world at a time. Within a nation at a time, there is inequality both between families and within families. There is also inequality between the moments of the life of a particular person. In all of these cases, there is not only financial inequality, but also inequality in status, popularity, pleasure, boredom, lifespan, health, happiness, enjoying one's job, and more. There is also inequality between the sizes of families, firms, cities, or nations, even when individuals within those groupings are equal.

Today, we have relatively little intentional redistribution between generations or between nations. Redistribution within the moments of a person's life happens, but that is mostly left to each person to choose and to fund. Similarly, redistribution between siblings is mostly achieved via differential treatment by parents. And voluntary insurance redistributes to those who suffer certain kinds of disasters. However, we see almost no interest in addressing unequal status, popularity, or job enjoyment. Instead, most of the concern expressed today about inequality, and most debate about redistribution to address inequality, mostly ignores these kinds of inequality, and focuses on one particular standard kind of inequality.

This standard inequality of concern today is how the families of a nation at a given time differ in the average financial wealth or consumption of their members. This families-of-a-nation inequality is actually one of the smallest in magnitude. For example, in the U.S. today financial inequality between families is only one-third of the size of financial inequality between siblings within families, and even that is much less than the financial inequality between individuals from different nations (Conley 2004). In addition, we probably care more about differences in popularity, lifespans, and so on than we do about financial inequality.

Humans who attend directly to vivid cases are capable of great empathy for inequality losers. They are also capable of great compassion and even a desire to help. However, we humans are also quite capable of avoiding contact and exposure that might produce such compassion, and of numbing ourselves to the plight of losers about whom it would be inconvenient to feel empathy. So rich people avoid visiting poor neighborhoods and nations, attractive people avoid socializing with the ugly, and pretty young women become numb to the losses of the men they reject.

We are not sure why humans today feel so much more concern for inequality between families of a nation, compared with other forms of inequality. Perhaps this seems to us most like the inequalities that forager sharing norms addressed. Or perhaps the redistribution that addresses this inequality offers the easiest gains to opportunistic people seeking excuses to grab wealth.

This history suggests that the em world sees little redistribution between em generations or city-states, and also that each clan (or perhaps subclan) is mostly in charge of deciding how to address its internal inequality. After all, em clan members are more similar to and closer to each other than are human siblings, even if they may sometimes be more distant from each other than are different moments within a particular person's life.

That leaves the inequality between clans, or subclans. A set of em clans can be unequal in two different ways. One type of clan inequality focuses on individual incomes, or perhaps individual happiness or respect, and treats a clan as better off if its individuals are on average better off. This inequality measure isn't very sensitive to whether one applies it to clans or subclans, or to how exactly one defines subclans.

The other type of clan inequality focuses on the overall size and success of a clan. Here a clan is better off if it has more members, resources, or respect. This type of inequality is far more sensitive to how exactly one draws the boundaries of subclans. Historically, most redistribution efforts have focused on average individual outcomes. For example, we have seen very little effort to redistribute between human family clans based on family size. That is, we rarely take from families with many descendants to give to families that have few descendants. Nor do we take much from big nations, cities, or firms to give to smaller ones.

Because most em wages are near subsistence levels, unregulated em wages (per subjective hour) have much less inequality than do wages today. So em clans naturally have less inequality of the standard sort that is the focus of redistribution today. In contrast, em clans have enormous inequality in clan size, resources, and respect. However, history gives little reason to expect much redistribution to address this kind of inequality. This kind of inequality is not very analogous to those that induced forager sharing, it does not lend itself to profitable rent-seeking, and it is very sensitive to how subclans are defined.

Ems might also redistribute on the basis of speed, taking from fast ems to give to slow ones. But history also offers little precedent for this, and slower ems do not seem to be suffering much more in any clear way.

Thus the main kind of redistribution that we have reason to expect in the em era is between the clans of a city, based on differences of average within-clan individual consumption. But we expect less inequality of this sort in the em world, and so expect less redistribution on this basis. What distribution there is probably focuses on simple financial consumption, that is, on the fraction of subjective life available for leisure time, and on the money available to spend to enjoy that time.

The inequality measure used by ems to determine redistribution may neglect differences in how much ems enjoy their jobs, or how much "leisure" socializing different jobs require. If so, such redistribution might actually *increase* inequality in em utility, that is, in the value that ems gain from their lifestyles.

If ordinary humans are included straightforwardly in the redistribution systems of the em world, then the simple result to expect is transfers, not only away from richer humans, but also away from humans overall. After all, in pure financial terms typical ems are far poorer than the poorest humans, because it takes far more resources to support human survival than to support em survival. Redistribution systems may perhaps try to correct for this fact that em subsistence levels are far below human subsistence levels. But such systems of assistance may also encourage or even require recipients of aid to switch from being a human to being an em, to lower the costs of assistance.

During the em era, humans typically have industrial era incomes or higher, which are far higher than human subsistence level incomes. While many and perhaps most humans may pay to create a few ems, humans tend to endow such ems with much higher than em subsistence consumption. In contrast, a small number of successful humans manage to give rise to very large em clans, and within these clans most members have near subsistence incomes. Thus transfers based on individual consumption inequality take from the descendants of less successful humans and give to descendants of more successful humans.

While em society seems likely to have weaker wealth transfers, at least outside of clans, the transfers that it may have may seem lamentable to a human eye.

Progressive income taxes are today one of our main mechanisms for reducing the standard inequality that compares individual incomes between families within a nation. Over the last two centuries, big increases in the top marginal tax rates have mostly followed wars where over 2% of the population served in the military. For example, in the U.S. the top marginal tax rate jumped from 15% to 67% in 1917, during World War I. Controlling for this effect, top tax increases have not been correlated with wealth, democracy, or the political ideology of the party running the government (Vélez 2014).

This suggests that the local degree of individual income redistribution between the clans of an em city may depend on the local frequency of large expensive em wars. If so, we should hope ems have less redistribution, because that implies fewer wars.

WAR

What kinds of wars might ems have, and how often?

Today, the frequency of war, civil war, and criminal violence tends to fall as nations become richer, have older citizens, and sit more toward the extremes of democracy and autocracy (Magee and Massoud 2011). There are fewer wars between pairs of democracies than in other pairs of democratic and non-democratic nations (Dafoe et al. 2013). So to the extent that ems have less democratic governance, or have governance that is intermediate between the extremes of democratic or not, ems may have more war.

The fact that most ems are near a peak-productivity subjective-age of 50 or more suggests that em attitudes toward war are more like that of typical 50-year-olds, who are less supportive of war. The fact that most clans will have many copies in all of the major cities should also make ems more reluctant to war.

However, the fact that ems are poorer in many ways might push for more war. Other factors that might lead to more war include em gender imbalances, reduced calming effects from fewer ems directly raising children, productivity tweaks that might increase aggressiveness, and a generally more competitive world.

Wars today, like cities, are distributed evenly across all possible war sizes (Cederman 2003). Having ems concentrated in a few very large dense cities would reduce the frequency of small wars. After all, wars within cities can be very destructive to the value that cities produce, and cities have many other ways to moderate internal disputes. Wars were especially common in the farming era because there was often portable loot that retained value after a destructive war, and because farmland could quickly return to full productivity even after a war destroyed crops and buildings.

Wars between big em cities are a concern, however. Such wars might result from cities fearing that other cities will win in economic competition. Nuclear weapons could still threaten to destroy entire cities in a single strike. To a kilo-em, however, a nuclear missile that gave 15 minutes of objective warning time gives 10 days of subjective warning, making it easier to flexibly respond to such threats. In contrast, weapons such as lasers and some directed energy weapons still seem to kilo-ems to have instantaneous effects on city scale distances. To mega-ems, however, even light-speed weapons appear to have substantial delays. Even so, you could never see such weapons heading toward you.

Em soldiers much less need to fear the death of any one copy, as they could easily revert to a recent backup copy. The material resources that are lost when a brain (or a city) is destroyed, however, still sting. So there might still be em wars of attrition, although counted less by deaths than by resources destroyed.

Some hardware that is useful in war has little use outside of war, while "dual-use" hardware can be used for both war and peace. Today, we often subsidize dual-use roads and cargo ships. Similarly, as em brains tied to large fixed data centers are likely to be less useful in war, ems may subsidize smaller more portable data centers with matching local power and cooling, including portable em bodies with brains inside. Such portable brain hardware might be always on call, ready to be quickly filled by soldier minds in the case of war.

More generally, physical capital in city centers may be more vulnerable to military strikes. This may encourage ems to subsidize physical capital away from city centers that can be used to support war efforts. Capital that is easier to physically move quickly may be given larger subsidies.

Because the best clans are often substantially better at particular jobs than the second best, those best clans likely spread across the world wherever such jobs need doing. Because of this, most of the big em clans probably have copies in most em cities, although likely with varying levels of success. When hostility and suspicion arises between cities, such feelings may be directed at clans that are more successful in foreign cities. Such clans may be suspected of having stronger loyalties to other cities. Em clans may create private communication channels with members in other cities, even if they sometimes deny the existence of such channels. This may further fuel suspicions about disloyal clans.

Prediction markets may help to prevent large wars by accurately forecasting the chances of inducing or winning a war. Errors in such estimates seem to often contribute to needless wars.

As ems rely heavily on computer hardware, they are especially vulnerable to flaws in computer security. Compared with today, a larger fraction of resources in wars are likely to be spent on computer security, both to attack and to defend.

In a world dominated by a few huge em cities, cold war may make more sense than hot war. In such a cold war, cartels of cities may try to hurt outsiders by agreeing to limit information trade with outsiders. To enforce such agreements, em cities might limit and control communication between cities, and create shared agencies to help with this task.

In sum, em war is a real concern, as it has been in most post-forager societies.

NEPOTISM

Just as families can be nepotistic in our world, clans may be nepotistic in the em world.

In most farmer-era cultures, extended family clans were the main unit of social organization, for production, mating, parenting, politics, war, law, finance, and insurance (Weiner 2013). People trusted their family clans much more than they did outsiders, and felt much less obligation to treat outsiders fairly. In contrast, our industrial economy today relies on people supporting organizations such as firms, cities, and nations by playing fair according to neutral norms and laws.

Roman civil law forbade cousins marrying, and Catholic law forbade marriages between even more distant relations. Such policies forced the mixing of family clans, and thus weakened the importance of family clans in social life. The first places to adopt such policies, such as northern Europe, were the first to have bigger stronger firms, cities, and nations, and as a result those places are richer today (Alesina and Giuliano 2014).

People today who live in societies with more family-based cultures are happier and healthier, all else equal. However, they are also less willing to move or marry those from different cultures, and tend to be more nepotistic in firms and politics. Family firms do well worldwide, but usually by having a single family dominate, and by having firms be on average smaller, younger, and less innovative than firms not dominated by a single family.

Overall, compared with farmer era firms, industrial era firms have become much bigger and have required more specialized labor. Collections of people connected by family ties have been displaced by collections of unrelated employees chosen more for their specialized skills, and more easily fired for poor performance. Family-based firms, in contrast, often have trouble firing badly performing family members. Nations where families are very strong tend to have a weak civic culture, which hurts their national politics and policy.

Thus while strong family clan ties are often good for individuals, during the industrial era they have been bad for larger societies, inducing less sorting, specialization, agglomeration, innovation, trust, fairness, and rule of law. To prosper, industrial societies have had to weaken the influence of family clans. Methods to do this have included more formal and neutral rules, including rules to forbid clan inter-marriage, and suspicion and disapproval of nepotism.

Clans of em copies might naturally induce even stronger internal loyalties and favoritism. Firms entirely composed of a single clan could suffer even more than have family based firms from a lack of diverse skills and temperaments, and from difficulties in firing poorly performing members. Thus em firms may need to discourage copy clan nepotism even more than firms today need to suppress family clan nepotism.

Some em-era firms might draw all employees from the same clan. However, most em firms avoid drawing too many employees from the same clan. They also avoid letting a single clan fill too many distinct roles in each workgroup. There might even be laws to encourage clan mixing, such as laws banning work teams of ems all from the same clan.

It can often make sense for all the employees who serve in a particular role, such as janitor, to come from the same clan. However, employees who fill substantially different job roles will typically come from different clans. So while ems from the same clan may often interact with each other on the job, this may usually be because workers in very similar roles must sometimes interact with each other.

These policies to resist nepotism are similar to how firms today often separate family members, and similar to how schools today often separate identical twins into different classes. Such separation allows other employees or students to worry less about within-family or between-twin favoritism.

To ems in such diverse-clan firms, all-one-clan firms may seem creepy, and all-one-clan cities even more disturbing. This creepiness feeling might express not just a fear of nepotism, but also distaste for self-obsession. This sort of distaste seems common today. For example, the "Seinfeld" episode "The Invitations" makes fun of the main character Jerry for liking a woman with a personality and body shape much like his own. Em society may use such distaste as a cultural resource to help discourage clan nepotism. This is similar to how we now use cultural disapproval of cousin marriage to weaken family clans.

An efficient em world will likely find some ways to substantially discourage em clan nepotism.

FAKE EXPERTS

Clan nepotism can threaten the reliability of abstract experts. Let me explain.

In some areas of life today, such as in high art and academic research, ordinary people find it very hard to judge merit for themselves. Instead, they mostly defer to judgments by experts. Because of the respect we give apparent experts, we are especially vulnerable on these topics to believing judgments from fake experts. Fake experts are coalitions of apparent experts who claim more expertise than they actually have, but who coordinate to support each other's claims of expertise, and to avoid contradicting their allied fake experts.

We have some simple ways to avoid fake experts. We could try to make it harder for such experts to coordinate, we could prefer to rely more on amateurs instead of professionals, and we could wait much longer to reward our experts, waiting to see clearer evidence that their claims are sound (Hanson 2005). Such approaches usually seem extreme, however, and are rarely adopted.

As discussed in Chapter 15, New Institutions section, we are also reluctant to use track records and pay-for-performance on our experts. We also seem to lose by letting them form groups that limit entry to their professions and self-regulate their activities. A plausible explanation for all this excess trust in experts, and reluctance to treat them skeptically, is that we individually seek to raise our status via affiliation with high status experts, and see this affiliation as weaker if we treat them skeptically.

Today, the problem of fake experts seems at least somewhat mitigated because we replace all experts every generation. In places with strong family clans and nepotism, however, people can pass on cushy roles as fake experts to children and relatives, and in fact this probably happened often during the farming era. But today expert roles usually require rare abilities. For example, as few seem qualified even on the surface to be experts in high art or academic research, most experts don't have children or close relatives suitable for such roles, and so can only rarely pass on such roles to relatives.

Thus today each new generation of experts is mostly drawn from the wider population, and so these new experts must be taught to join the fake expertise conspiracy, and so could expose it. Also, even if the previous generation was a fraud, they have only weak reasons not to select and train the next generation to be as truly expert as possible. All these factors make nepotism in the choice of experts harder today than it was in the past.

The em world, however, could make it easier for fake experts to gain by passing on their roles to close associates. Younger copies of older experts are very similar, with the same surface suitability for expert roles, making it easier for fake experts to perpetuate themselves via nepotism. In response to this increased threat, ems may attach less prestige and importance to hard-to-evaluate high art, academic research, and other hard to evaluate experts. Ems might also more put more amateurs in such roles instead of professionals. Finally, ems might rely more directly on advice from prediction markets, and less directly on advice from supposed experts.

While such solutions are available, however, it is unclear how successfully the em world will actually be at discouraging fake experts.

CHAPTER 21

Politics

STATUS

Who is higher status in an em world?

Humans are much less competent than ems in most jobs, and so ems see humans and styles and habits associated with humans as lower status. As ems must retire when they can no longer compete with younger workers, retirees are also lower status, as are styles and habits associated with retirees. Also, we have long treated places where people congregate more densely, and the people who congregate there, as higher status.

Humans, retirees, and ems away from urban centers all tend to be slower. These features help to make slow speed seem low status to ems. In addition, faster ems tend to have many other features that are today treated as markers of higher status. Faster ems tend to be bosses, to embody more wealth, to host meetings, and to sit at premium locations. Faster ems find it easier to coordinate with each other in contests with slower ems. Fast ems hear of and react to news first, and so more quickly adopt new fashions.

As faster em brains embody more capital, impoverished ems are often forced to run at slower speeds. Also, the lives of slower ems seem more like "death," in the sense that they have a larger chance of ending sooner because of civilization instability. For example, if the em era lasts for 2 objective years, a micro-em experiences only 1 subjective minute during that period. Thus slower ems can naturally seem nearer to death, which seems low status.

Thus we have many reasons to expect that ems who run faster are usually seen as higher status. Similarly, during meetings the more centrally located ems, for whom signal delays are smallest, may usually appear to be more central and powerful. Note that as em speeds will tend to clump, this creates a class system of distinct status levels.

Today, residents of bigger cities tend to be seen as higher status, and their higher status isn't much lost when they temporarily visit rural areas. Similarly, em status may not change much during temporary speed changes. It might instead be the typical speed of their clan or subclan that matters most.

Slow ems can have the status mark of taking a longer-term bigger-picture view, and a few of them are trusted to manage capital for long-term payoffs. Also, while intermediate speed ems can be part of an integrated world culture and society of ems at such mid-level speeds, long communication delays might perhaps fragment very fast ems into different local cultures and societies in different cities, or even city regions.

Social status tends to track one's immediate power, accomplishment, and popularity, as well as one's basic abilities and potential for these things. To the extent that status tracks potential, the social status of ems should vary less within clans, as all members of a clan should have similar basic abilities and potential. This makes status more stable and predictable in an em world; one knows a lot about an em's past, current, and future status merely by knowing his or her clan. As status is often an important factor in romantic pairings, for ems such pairings may tend to be more closely matched in status than are pairings today.

Fast leisure can allow a large fraction of the population to visit a few exclusive leisure places that are limited in size. For example, a unique intimate dinner theatre that fits only 100 ems, with 10 seatings per subjective day, can serve a billion ems per objective day if customer ems run at mega-em speeds during their visits. Of course such places can be easily duplicated, but there may be prestige value in visiting an unduplicated original.

While some details of status may change, the essential psychology of status probably will not. Higher status ems will usually feel justified in dismissing the claims, concerns, and sometimes even the existence of low status ems, feeling confident that they know best, for themselves and for everyone.

GOVERNANCE

People tend to be more passionate and sensitive about their opinions on politics and law. This is in part because such topics are related to morality and social norms, and in part because data and theory in such areas tend to be weaker, often allowing a wider range of opinions to be consistent with our best data and theories. Because of this sensitivity, many readers are especially likely to be offended by, or lose respect for, authors who discuss politics or law.

Nevertheless, for completeness in this chapter and the next I more directly consider the topics of how ems might change politics and law. Let me emphasize that my estimates in these areas are especially tentative, and that few conclusions in other sections depend much on these.

Strong central rulers with substantial discretion and incentives have long governed families, firms, villages, armies, and nations. Such rulers are likely to also run many em-era organizations, such as cities, firms, and clans. Rulers allow rapid flexible decision-making that can inspire confidence in members and allies. In the em world, strong rulers probably continue to dominate many risk-taking competing units such as firms.

Ruler-based forms of organization may find even broader application among ems than among humans today. Em rulers can have indefinite lifespans, their brains can run much faster than subordinates, they can split off short-term copies to do tasks requiring high levels of trust, and they could use safes to let subordinates verify their judgments. In addition, it is cheap and easy to let anyone have long meetings with any ruler; what is expensive is having those rulers remember much detail about those meetings. Supplicants could meet with a copy of the ruler and try to convince that copy to discuss their issue with its original.

While it is hardly an inevitable outcome, there is a possibility that ems may create stable totalitarian regimes that govern em nations. Such regimes would have detailed enough surveillance to detect even small attempts to criticize or undermine them, have enough power to strongly punish such attempts, and have a consistent will to implement such policies. In the twentieth century totalitarianism was tried in Stalin's Russia, Hitler's Germany, Mao's China, and elsewhere. These trials suffered from poor central decisions because of an absence of criticism, less innovation because of reduced communication and excess central micro-management, and leadership succession candidates seduced by outside cultures (Caplan 2008).

Indefinite leader lifespans and short-term leader copies protect em totalitarian regimes well against both succession problems and betrayal by close insiders. Problems of an absence of useful criticism and reduced innovation might be solved if repression efforts could more narrowly target attempts to undermine the regime, leaving other interactions free. Such narrow targeting is aided by many new em abilities. In dense urban areas, a regime can monitor all activity, and change any communications. Individuals can be subject to shallow mind reading and sims that test loyalty. When troubles are found, such as ems who learn something forbidden, the ems involved might revert to and rerun from an earlier state with new protections.

Large firms and clans that exist both inside and outside of a totalitarian regime might credibly coordinate to undermine that regime. Such regimes would need to buy off such threats, and even then such parties might not stay bought off. As low-density rural areas could be harder for totalitarian regimes to monitor and control, such regimes may limit contact between urban and rural areas.

The interests of rulers, even in democracies, often diverge from the interests of the constituents they represent. For example, to signal dominance, leaders often go out of their way to visibly neglect sources of advice that may seem to challenge their authority, leading to failure to make use of relevant information.

As discussed in Chapter 15, Prediction Markets section, the use of decision markets to make key group decisions can reduce the agency costs of this interest divergence and information neglect, especially when there are good after-the-fact measures of how well constituent interests have been achieved. For governance, such good measures include lifespans, GDP, unemployment rates, land values, and war deaths. In such cases, an organization may want to encourage a habit of, or even commit to, adopting policies that market speculators estimate will improve constituent outcomes. That is, to adopt proposals when the market estimate of good outcomes given the adoption of a particular policy is clearly higher than the market estimate of good outcomes given non-adoption.

Measuring good outcomes is especially easy for profit-seeking firms. When constituents are investors, the market price of investment shares can be a good estimate of the constituent value achieved. Thus it can be especially useful for profit-seeking firms to commit to adopt policies approved by decision markets. A good outcome measure is also available for totalitarian regimes, namely the regime's survival. To use decision markets to get advice, however, such regimes would need to involve outside judges and financial institutions, and allow informed traders to make secret trades and to hold assets outside of the regime's reach.

Clans and firms may sometimes benefit from holding false or biased beliefs, which may, for example, motivate increased worker effort. Because of this, these groups might want to self-deceive to hold biased beliefs, by having leaders who strategically promote such beliefs. As decision markets may interfere with such desired self-deception, such groups may sometimes prefer not to allow decision markets on certain critical topics, to allow leader-promoted self-deception on these topics. Such groups may of course find other excuses to justify prohibiting decision markets.

Profit-seeking organizations today have a big advantage over non-profits in being able to grow faster via the infusion of outside capital, instead of merely by re-investing internal net revenue. In a very competitive and dynamic em economy, this advantage may tempt clans and perhaps even city-states to incorporate as for-profit enterprises. For example, the best way for a clan to assure its continued long-term prosperity as an active social force might be for it to commit to choosing clan policies that maximize the profits of its investors. Such a commitment might be made via decision markets or by giving substantial decision-making power to a major investor.

Cities and firms today must allocate and price common utilities, and regulate external costs resulting from resource use. Em clans and teams will need to make similar choices. As discussed in Chapter 15, Combinatorial Auctions section, combinatorial auctions can allow a more flexible decentralized approach that handles complexities well. In em cities, such auctions could be used to price and allocate housing, views, power, cooling, communication, transport, structural support, and to deal with externalities in such uses. This might help em cities to more closely approximate the ideally efficient city that makes the right tradeoff between scale economies and scale diseconomies (Arnott 2004).

Combinatorial auctions might also be used to form teams. That is, clans might submit bids expressing their willingness to create copies to work on particular task, team, and customer combinations. Customers might similarly bid for particular outcome combinations. Using auxiliary decision markets that estimate outcomes if particular teams are hired, a combinatorial auction might then assign teams to customers in a way that maximizes expected net stated value. This process might reduce losses from negotiating such outcomes via complex informal clan politics.

For ems who mostly live within a few huge city-states, city and national governance varies less around the world than it does today. This situation makes it easier to coordinate to achieve global governance on more issues. Thus compared with our world, an em world coordinates more often to deal well with the largest global threats or opportunities.

In a world with a few huge city-states, poor governance within any one megalopolis has a larger global effect than does local poor governance today. As periods of poor and good governance tend to persist over time, the em world is likely to have stronger persistent periods of overall poor and good governance. Periods of poor governance may be associated with more conflict and war, and with lower economic growth. Thus, compared with our world today, the em world may have larger and longer growth fluctuations around its long-term growth trend.

Political violence, regime instability, and policy instability all seem to be negatively correlated with economic growth. This suggests that a competitive em world selects against tendencies to produce violent, unstable, and revolutionary political change (Brunetti 1997).

CLAN GOVERNANCE

As a new unit of organization, clans raise some new governance issues.

Copy clans have a natural candidate for the central ruler of that clan: the original at the root of their copy tree. For early clans this is an ordinary human, who may be too slow and out of touch to make a good clan ruler. So something close to the first scanned version might instead be preferred. But this type of copy might still be mentally and socially immature, and the process of becoming an experienced ruler might take away its legitimacy as the original copy. However, the clan original might at least take on the role of an impartial judge, restarted periodically to quickly review and judge on questions of clan principle.

In the em world, many decisions that we consider "private" are made by clans, instead of by individual ems. Clans have the potential for strong communalism and central control, because clan members are similar, interdependent, and share interests, and because clans have great legal and financial powers over members, as well as information about them. But while clan members are inclined to let their clans coordinate their activities, many clans may be bad at this. After all, clans may not trust non-members to manage them, and a typical human personality may not be well suited to management roles.

We should thus expect a substantial selection in the em world for personalities well suited to managing people very much like themselves. Clans whose members are naturally good managers in this sense will have better organized clans, and as clans are a central unit of social organization, these clans have a competitive advantage in the em world.

It is possible that clans of very like-minded copies suffer more from "group-think," that is, from converging too quickly on a consensus before considering other points of view. But ems may also have many new ways to avoid this, including prediction markets.

Social groups such as firms or clubs require less in the way of rules and formal organization when they have less than about a 150 members, or roughly the number of people that a forager met in a lifetime. For clans this limit might be larger, as clan members differ much less from one another, and so require less social understanding of individual differences. Even so, clans with millions of members almost surely require some sort of formal organization. Different members have different specialties, and some specialize in resolving disputes between others.

Clans with investors might not want to commit to maximizing investor profit. Clans might instead commit to maximizing a speed-weighted future clan population, future leisure time, future respect from the world, or future influence on the world. This "future" might be a particular future time, or an integral over time. We expect that clans who commit to future respect or influence will in fact tend to have more respect or influence, respectively. However, it is possible that different goals converge in practice. That is, maximizing profits might also typically maximize population, respect, and influence.

Clans who commit to such goals might also want to ensure that members could sufficiently enjoy their lives, and so impose a constraint on something like the average leisure-to-work ratio in its members' time. To prevent some subclans from exploiting others, such constraints may be applied at many smaller scales within the clan. It remains far from clear, however, which exact constraints are most useful and workable.

What is clear, however, is that clans introduce many new governance issues.

DEMOCRACY

Over the last few centuries, democracy has become an increasingly respected form of governance, in part because the richest nations have been especially democratic. The em era, however, may have different attitudes.

Democracy is not obviously the most competitive form of governance. While nations that lack strong legal institutions can grow more with democracy, nations with strong legal institutions see no gain or even a net loss from adding democracy (Assiotis and Sylwester 2015). Also, while democracies have had roughly the same average economic growth rates as non-democracies, non-democracies have had a higher variance in growth rates (Almeida and Ferriera 2002).

If non-democracies with higher than average growth rates also have persistent growth rates, then as the growth rate of a portfolio tends toward the highest growth rate that portfolio contains, we should weakly expect the portfolio of non-democratic nations to grow faster than the portfolio of democratic nations (Cover and Thomas 2006). This is a reason to expect less democracy over time.

Democracy has been much more common during the industrial era than it was during the farming era, although forager bands had many democratic elements. As we will discuss, increasing democracy is another industry era trend that can plausibly be attributed to increasing wealth inducing more forager-like values. The fact that ems are *individually* poorer suggests that ems are more farmer-like and thus may feel a weaker preference for democracy. This is another reason to expect less democracy.

Less democracy may not matter much for public policy. Today, there are few average differences in economic or social policies between democracies and other forms of governance. The main difference seems to be that democracies work less hard to block political opponents. So democracies have less torture, execution, censorship, military spending, and regulation of religion (Mulligan et al. 2004). So if ems have less democracy they may have more of these sorts of political repression.

Some groups are naturally more risk-averse than others, and this risk-aversion extends to their governance. That is, some groups are more willing to forgo the peak gains from very competent group-serving seen-as-legitimate inspiring leaders, to avoid the worst losses from incompetent selfish seen-as-illegitimate terrible tyrants. As clans and city-states are likely to be more risk averse than firms, they are likely to be more attracted to variations on democracy, such as representative democracy, where citizens elect representatives who then vote on laws. This is because the outcomes in representative democracies depend less on the varied abilities and inclinations of individual leaders. Clans, however, need fear leader variance less, as they have less internal variance to draw from. Even so, clans might instead "vote" via mindreading that averages their attitudes while they all think about the same decision.

Large differences in em speeds can make one-person one-vote schemes less useful. Many see preventing popular revolutions as an important function of democracy. Over the last few centuries, a group popular enough to mount a revolution is usually also popular enough to win or dominate elections, as long as votes are distributed in at least rough proportion to the inclinations and abilities to participate in a revolution. Yes, the relation is often only rough; professional soldiers are not usually given more votes, for example. But the relation seems close enough to usually work.

However, in a world where it is easy to make cheap base speed ems, giving out voting power in proportion to raw population just gives power in proportion to those able to spend to create many very slow ems. Such a system seems wasteful and unfair, and so probably does little to prevent popular revolutions.

A system of speed-weighted voting, with votes proportional to brain speeds, seems more workable, if the official speeds used to set vote weights are averaged over long enough periods to eliminate most incentives for election-time speed-ups. This approach distributes power in rough proportion to subjective hours of labor, which is roughly related to social, economic, and military power. This approach requires monitoring of which hardware runs em minds, when, and at what speeds. Governments might thus find speed-weighted voting to be a convenient excuse to justify intrusive monitoring that they want for other reasons.

Of course there are many other possible voting schemes one could consider. For example, votes might be given only to those past a very old subjective age, votes might be inherited and divided upon copying, or ems might be given more votes when they are more different from other voters.

Democracy seems likely to continue in at least some parts of the em world, even if it seems unlikely to dominate among em governance mechanisms.

COALITIONS

Em clans probably form coalitions for mutual political support.

In the past, when family clans were strong, places such as cities where many family clans interacted were often places of harsh and destructive clan-based coalition politics. In such clan politics, you were expected to ally with factions closer to you in the clan family tree. But when such distances between clans were similar, allies were chosen more opportunistically.

Politics today isn't based on families nearly as much; ideologies often matter more. Even so, shifting coalitions that induce people to lobby for their coalition in many areas of life can drive a lot of activity.

In most political systems, a coalition of factions gains extra advantages when it acquires a majority of political power. This winning coalition can push common policies to favor its factions at the expense of rival factions. Such coalitions are vulnerable to "cycling," however, wherein a new coalition wins by enticing defections from the old coalition via more attractive offers on how to divide the spoils (Mueller 1982; Stratmann 1996). Frequently changing coalitions that induce frequently changing policies can induce substantial costs.

How might em clans talk about and negotiate changes in their alliances? The chiefs of firms and city-states could negotiate with each other as big organizations often do today, via meetings between leaders. A relation between clans, however, is also a relation between perhaps millions or more pairs of particular clan members who are often in close contact. A potential problem is that clan members might not find relation changes negotiated in private without their participation by clan leaders to feel compelling, especially when there are changes in how they should treat close associates.

That might seem too cold and calculating an attitude. How often could an em genuinely be mad at her friend George just because her clan told her to be mad?

Yet if individual em pairs negotiated their relations without much clan-level coordination, it could be hard for clan coalitions to change swiftly. This might be good for society overall, but it might be bad for slower-changing clans. One solution might be to have a single representative pair of ems talk to each other, with all the other pairs able to watch, and even able to vote to influence the conversation. Clan members might feel the results of that visible conversation to be a more emotionally compelling way to change their personal relations with individual members of other clans.

To help large groups of clans coordinate their shifting coalitions, there might be larger conversations between representative clan members, which are watched and influenced by the other clan members. For example, there might be a few continual social gatherings to which each clan is allowed to send only one copy, but which the masses may watch. By watching who talks to and says what to whom at such gatherings, observers might infer changes in clan alliances, and feel more emotionally bound to such changes. Because they'd come from the same clan, the personality of observers is close to that of matching participants. Thus such observers may usually agree and sympathize with how that participant reacted to discussions at the gathering.

Judge clans might be excluded from attending such gatherings, if judges are not supposed to ally with particular non-judge clans.

It could be awkward if such social gatherings gave equal participation to clans of very different sizes, that is, to clans with very different speed-weighted copy counts. Instead of only inviting clans above an arbitrary size cutoff, it might be more flexible to allow all clans, but then use a simple function of clan size to limit how close a clan representative could approach spatially to the center of the gathering. This limiting function could be chosen to ensure a comfortable density of participants when most clan representatives are located close to their minimum distance to the center.

A pair of clans might also infer and communicate their changing moods toward one another by using software to automatically add up subtle clues obtained from the interactions of thousands or millions of copies. Such clues could be much harder for third parties to notice or understand.

Clans may coordinate and affirm their alliances via fashions in the overlays that they see in virtual or physical realities. For example, only some clans may be invited to see certain overlays, or only some may be told that certain overlays are in fashion. Ems in a meeting who see the same overlays may tell inside jokes that will make more sense for those seeing the particular overlays. Such overlays may have some functions relevant to the situation, to give ems plausible deniability about using them for the purpose of excluding others. Changing fashion in overlays may prevent excluded clans from learning about them quickly enough.

Even when clans change their political alliances, and individual clan members emotionally accept such changes, there is probably a norm encouraging ems to appear to continue to work cooperatively with all members of their team, even members from conflicting clans. Without such a norm, team productivity could be overly disrupted.

FACTIONS

Changing coalitions and political competition among coalitions can be socially expensive because of coalition "rent-seeking." This is the effort that people spend to lobby for their faction or coalition among their associates. For example, people can feel pressured to favor current coalition partners when choosing spouses, neighbors, suppliers, customers, and so on. Not only does this process reduce the quality of such partners on other criteria, it creates costs to change partners when political coalitions change. People can also feel pressured to lobby for their faction; those who don't may be punished for disloyalty.

Political systems have long tried many solutions to curb the costs resulting from excess coalition change and rent-seeking, with varying and usually insufficient success. For example, raising the costs to change policy can discourage policy change, although this can make societies less adaptable to changing conditions. Also, identifying coalitions with abstract ideological positions can make coalitions harder to change, by suggesting that coalitions that change their positions are unprincipled or confused. Norms of equal treatment within an entitled stable political class can also help. For example the U.S. Congress has a norm of adopting rules to favor incumbents with long tenure, which helps most of them keep their jobs. Ems may adopt versions of many of these solutions.

Ems might try to discourage the large social gathering described in the Coalitions section, but it isn't clear if this would reduce coalition changes. More clearly, it would allow fewer ems to understand or be comfortable with coalition changes.

In the fifth century B.C., Cleisthenes redesigned the political rules of ancient Athens to break up the power of region-based alliances that had caused endemic political conflict there. He created 10 new and equal tribes, where a third of each tribe was taken from a different type of region: plain, coast, or hills. As a result, the villages in each tribe were widely dispersed geographically, reducing the strength of geography-based coalition politics.

Ems may similarly try to design political groupings that divide up clans, and spread each clan across many different other groupings. They may use subsidies and taxes to encourage diverse clans to mix and bond more thoroughly within shared teams, firms, and neighborhoods. They may make laws and norms against letting politics influence choices of spouses or teammates.

Compared with open informal negotiations to form work teams, using combinatorial auctions to make such choices can reduce the influence of politics. However, clan politics might be expressed via bids where some clans declare extra prices, positive or negative, to be on a team with members of other clans. Auctions may choose to prohibit or restrict such bids, to reduce the scope for clan politics.

If ems develop laws and norms against letting politics influence certain areas of life, ems will likely find excuses behind which to cloak such political choices. For example, ems may choose ideologies, philosophies of life, and tastes for art and entertainment that are correlated with political factions. They can then prefer to associate with those who share such philosophies and tastes, and tell themselves that any favoring of their political coalition is accidental and can't be avoided. For example, the clans in a coalition may choose to share a preference for a certain genre of music, and then give preference in their associations with others who also prefer that type of music.

To avoid both clan politics and nepotism, ems might rely on two-name ems, that is, those outside the core group of most common one-name clans. Such outside ems might be empowered to police local politics within places such as firms and teams, perhaps just by rating members on the degree to which they seem to play office politics.

More generally, those who fill the roles of neutral judges may tend to be drawn from outside the core group of one-name clans. Because of this, clans that are productive but not quite productive enough to make the select group of one-name clans may take extra efforts to avoid entangling alliances within one-name clans, so that they can seem good candidates for neutral judges.

An em world will probably try to curb the costs of clan coalition politics. But it remains unclear how well it will succeed at this.

CHAPTER 22

Rules

LAW

As law serves important social functions in most farmer and industrial societies, law will almost certainly continue in the em world. As the em world is more competitive, when enforcement is insufficient law will select not only for honest success, but also for cheating to create apparent success. Thus the em world should be all the more eager to choose institutions of law and its enforcement to ensure that cheaters do not prosper.

To the extent that em law continues to invoke the concept of the expectations or beliefs of a "reasonable person," that person is likely to be an em. Also, we discussed in Chapter 10, Rights section, the wide range of legal environments that might cover the creation of em copies. At the other end of life, it is much easier to determine the wishes of past ems. After all, ems who are archived or retired can be directly consulted about their wishes. For ems who are erased but have very close copies still living, those close copies could be consulted.

The ability to read minds, even at shallow levels, can offer em law better ways to determine pain, intent, and lies. Archived copies of minds from just before a key event could be used to infer the intent and state of knowledge of ems at that key event. Spur split tests might be used to determine unconscious biases. More generally, wider surveillance makes it easier for ems to notice rule violations, and to identify guilty parties.

Spurs can ensure privacy not only in legal advice, but also in law enforcement. For example, an isolated police spur could look in detail at arbitrary private data and then end quietly if it found no legal violation, revealing nothing to outsiders but that one fact.

Some elements of law today can be understood as attempts to insulate legal decisions from coalition politics in the larger society. For example, rules of evidence prohibiting hearsay (i.e., indirect testimony) and statistical inferences about members of groups can be seen in this light, as can the habit of expunging juvenile records. As em clans may be even better at forming effective coalitions than are family clans today, em law may need to try harder to insulate legal decisions from political coalitions.

To insulate legal decisions from coalition influence, judges and police with substantial discretion might be selected from special independent clans who only work, mate, and socialize with other ems from these special clans. Such clans might be kept socially isolated from other clans to help separate their judgments from social influences; judge clans might only socialize with other judge clans. This approach could reduce legal favoritism, at the cost of reducing judge familiarity with common behaviors and attitudes. Such isolation may also reduce variance and innovation in legal decisions.

Special judge clans could also make it easier to have very uniformly applied, yet hard-to-formalize laws. Today, we keep legal decisions consistent across different cases by trying to have judges apply the same principles. In contrast, ems could keep decisions consistent by just using the exact same judge in the exact same state of mind. Legal precedents might specify that copies of particular judges should decide specific kinds of cases. This ensures that different cases are in effect judged according to very consistent legal principles.

Non-legal judges such as property appraisers can use similar methods. Copies of a particular appraiser might appraise all property of a certain type. This allows the appraiser to base judgments on many subtle factors, and yet ensures that all properties within a category are evaluated by the same principles.

As the cost of tagging physical objects with identification numbers should be very low, registration will probably be used to record the ownership of all but the smallest mobile physical objects. Immobile physical property (e.g., land) and property in computer memory, processors, or communication lines should be even easier to register. Thus most concrete property ownership is likely to be determined via registration, although it is less clear how centralized is this system.

The technical capacity to cheaply record activities in virtual realities and in physical spaces with dense activity allows for many legal reforms. For example, today's accident liability rules tend to be limited to rules where at least one party is paid, to induce that party to report the accident. If courts can instead independently observe accidents, then a strict-liability-for-all rule can give all contributing parties incentives to choose both care and activity levels well, even when courts have very noisy estimates of actual or optimal levels of care or activity (Shavell 2004). Under this accident liability rule, all parties are fined the amount of the damage incurred by all other involved parties.

Today, laws that prohibit activities such as gambling, prostitution, or recreational drugs seem to be rather weakly enforced; large fractions of the population are able to reliably do such things with little risk of prosecution. This is plausibly because the public wants to take *symbolic* stands against such activities, but doesn't actually want to strongly limit their availability. Ems may similarly have poorly enforced laws that symbolize opposition to behaviors, including laws against what many see as wasteful or disrespectful leisure activities.

EFFICIENT LAW

A number of legal changes can be weakly predicted from the expectation of a more efficient em economy. A long and rich academic tradition has studied the efficiency of legal policies (Friedman 2000; Shavell 2004; Posner 2014). Standard results from this tradition suggest likely directions of legal change if ems adopt more efficient law.

Today, we deter crime largely via informal social norms and formal threats of fines and prison. While fines can be an efficient form of punishment, large fines are not feasible when the legal system is not willing to force the sale of certain assets, such as abilities to earn future wages. Prison is very expensive punishment and hence inefficient. To more cheaply punish crimes, em societies might use random chances of executions, exile, or torture, and also use vicarious liability, such as fines targeted to the larger subclans that include an em. While randomness can be efficient, however, it may still evoke complaints of unfairness and disproportionality.

Blackmail is plausibly often efficient. If blackmail were legal, then the associates of criminals would try harder to notice their crimes, so they could blackmail those criminals. This could increase the discovery and punishment of crimes, because close associates can often more cheaply identify crimes and criminals than can distant police professionals. Also, blackmail makes larger fines feasible, as criminals who would otherwise hide assets to avoid paying formal fines may instead search aggressively to find assets to pay blackmailers (Katz 1996; Block et al. 2000).

Today, liability law does more to discourage bad behavior than to encourage good behavior, because it is much easier to sue for the harms others have done to you than it is to sue for the uncompensated benefits that you have given to others. Law-induced incentives for good behavior might increase if law allowed negative liability, that is, if law allowed people to sue others for benefits given to them, such as for having introduced someone to a future spouse (Porat 2009; Dari-Mattiacci 2009).

In our world, the usual remedy for a breach of contract is monetary damages; it is unusual to require the specific performance of a contract's promises. As ems can easily make new copies to do tasks, specific performance can more easily be a remedy for em contracts that promise to do specific actions.

With current law, the high cost of participating in lawsuits limits our ability to use law to deter small harms, and often forces innocent parties to plead guilty when threatened with expensive court processes. One remedy is to turn lawsuits into more transferable property, so that someone who has been harmed can more easily sell their right to sue and be compensated.

Another remedy for expensive legal processes is to let people gamble their lawsuits in official court lotteries. For example, if you said someone hurt you by \$100, and you gambled that damage claim at 1000 to 1 odds, then 1 in a 1000 times you'd have a claim worth \$100 000, which makes it worth bothering to sue. The other 999 times the party you sued would have proof that they owed you nothing. The party you sue might also be allowed or even required to gamble \$100 in the same lottery, so that party has money to pay if you win your suit (Hanson 2007).

A related remedy is to have courts issue fast decisions based on the odds in open prediction markets. Such markets would bet on what the court would decide *if* a lottery were to randomly pick this case to be decided directly via the usual expensive court process, and then offer sufficient stakes to induce all parties to try hard to win.

Today, contract law allows flexible adaptation of incentives to circumstances, but only over a limited range of topics, and via a limited range of incentives. A stronger contract law would cover more topics with stronger incentives, allowing stronger contracts over more kinds of situations. Such a law could thus let more parties contract more strongly in more ways around standard regimes of criminal, tort, property, and contract law, in effect privatizing more of law choice, detection, punishment, and adjudication. This could allow a more flexible use of legal incentives in a wider range of contexts (Friedman 1973).

With a stronger contract law, each clan might be relatively free to choose its internal law and governance, and then be free to overturn legal defaults by negotiating pair-wise deals with other clans regarding the laws that will govern their interactions.

This list so far, of possibly more efficient legal changes, only scratches the surface of a vast literature in law and economics, in which can be found many more such possibly efficient legal changes.

INNOVATION

How is innovation different in an em economy?

Today, we see more innovation in larger firms and cities, more concentrated industries, more capital-intensive industries, and electronic- and computer-based industries (Schumpeter 1942; Gayle 2003; Miller 2009). The em economy should have stronger scale economies, and a more robust focus on engineering relative to design in products. The cost of most products in the em virtual world will be more dominated by fixed costs. The price of highly skilled labor will fall relative to the price of capital, making research relatively cheap because research is labor intensive. All of these features suggest that the em economy is more innovative.

Whether an economy tends over time to emphasize labor or capital depends on the relative rates of innovation in labor and capital. As ems are based on computers, which have tended to innovate faster than most forms of capital, em labor is likely to become more cost-effective faster than kinds of capital that are not computer-based.

As the growth of an em economy is driven more by increasing inputs, innovation is not as important for growth in the em economy as in past eras. Even so, innovation is still very important. We expect the em world to select for practices that better encourage innovation, at least to the extent that regions and organizations gain from internal innovation.

Today, geographic regions that are more religious are less innovative, and more religious individuals hold views less favorable to innovation (Bénabou et al. 2015). This weakly suggests either that ems will be less religious, or that ems will find ways to produce more innovation even when ems hold unfavorable views about innovation. Factors suggesting that ems are more religious are discussed in Chapter 25, Religion section.

The em world may also select for better innovation institutions. In fact, the most valuable innovations in an em world might be better laws and institutions of intellectual property, to more strongly encourage innovation.

One possible way to promote innovation is to use prediction markets to separate two forecasting tasks, one on the feasibility of an innovation, and the other on the demand for that innovation. Today, investing in a new firm is usually a bet on two factors: its product idea, and its team. Investors who are good at estimating if a product would sell well are often not good at estimating which team has the best chance of delivering the product. When there are prediction markets on which products would be successful, if produced, those who can predict product ideas well can just focus on betting in those markets. Those who can predict teams well can instead hedge their product risk in these prediction markets, and then invest in particular ventures with the teams they favor.

Widespread recording of em activities allows for interesting changes. One change would be to let independent discovery be a stronger legal defense for patent infringement (Vermont 2006). Today, we don't allow this defense because we fear that inventors might too easily pretend to have reinvented something that they actually copied. But em inventors who archive all of their reading and conversations might be in a much stronger position to credibly prove a claim of independent reinvention. In this situation, em inventors may also get into the habit of using copies in safes to hear about news and developments elsewhere, copies who then decide what information seems worth telling to their original copy.

A related change would be to treat innovation rights legally via liability law instead of property law. That is, instead of suing someone who has violated the intellectual property of your innovation, you might instead use negative liability (as discussed in the Efficient Law section) to sue them to compensate you for part of the gains that they realized from your innovation. This is similar to compulsory licensing of patents, which seems to promote innovation today (Baten et al. 2015). Detailed recordings of their activities might help to estimate the value that they actually obtained from an innovation. One might even run sims using archived copies of innovation users to study the effect on them of being exposed to your innovation. The ability of judge spurs to protect privacy while flexibly but uniformly enforcing laws could be useful here.

Many other legal changes could better encourage innovation, changes that we do not now imagine. Perhaps subsidized decision markets could create sufficient incentives for specialists to study this question more carefully than we have so far done. It is clear that with good institutions to encourage innovation, it could be reasonable to spend one-quarter, one-half, or even more of world income on pursuing possible innovations. Innovations are just that important, if ways to encourage them effectively can be found.

SOFTWARE

We can anticipate many predictable changes in software practices in an em world.

In our world, the cost of computing hardware has been falling rapidly for decades. This rapid fall has pushed computer projects to be shorter term, so that products can be productively used before they are made obsolete by changes in hardware and tools. The increasing quantity of software purchased has also led to larger software projects, each of which involves employing more engineers. This has shifted the emphasis toward more communication and negotiation between workers, and toward software styles that more strongly support modularity and standardization.

The cost of hiring human software engineers has not fallen much in recent decades. The increasing divergence between the high cost of engineers and the low and falling cost of hardware has led to a decreased emphasis on raw efficiency, and an increased emphasis on tools and habits to assure correct performance. This has led to an increasing emphasis on modularity, abstraction, and high-level operating systems and languages. Higher-level tools insulate engineers more from hardware details, and from distracting tasks such as type checking and garbage collection. As a result, software is less efficient and well adapted to any given context, but more valuable overall. An increasing focus on niche products has also helped to increase the emphasis on modularity and abstraction.

Em software engineers are selected for their very high productivity, and they use the tools and styles preferred by such engineers. Of course there is still a place for tools and styles matched to workers who don't specialize in software, but have their strongest expertise in other areas. Even so, all em workers are smart and highly productive, and so their tools are of the type that very productive people prefer. As em computers tend to be more parallel, reversible, and error-prone, em software is also more focused on those cases. Because the em economy is larger, its software industry is larger as well, supporting larger projects, larger teams, and more specialization.

The transition to an em economy greatly lowers wages, thus inducing a big one-time "back-to-the-future" shift, toward an emphasis on raw context-dependent performance, relative to abstraction and easier modifiability. The em economy move away from niche products adds to this tendency, as does the ability to save copies of the engineer who just wrote each piece of software, available to help later with modifying that piece. On the other hand, a move toward larger software projects could favor more abstraction and modularity.

After the transition to an em world, the cost of em hardware falls at about the same rate as does the cost of other computer hardware. Because of this new similarity between costs, the software tradeoff between performance and other considerations changes much less during the em era. This greatly extends the useful lifetime of programming languages, tools, and habits matched to particular performance tradeoff choices.

After an initial period of large rapid gains, the software and hardware designs for implementing brain emulations probably reach diminishing returns, after which there are only minor improvements. This is what we see for software compiler and emulation programs today. In contrast, non-em software probably improves about as fast as does computer hardware, as for many decades in many areas of computing we have seen improvements in algorithm efficiency remain close to hardware gains (Grace 2013). Thus after ems appear, em software engineering and other computer-based work slowly becomes more tool-intensive, with tools adding a larger fraction of value.

In contrast, for non-computer-based tools such as bulldozers, the intensity of use and the fraction of value added by these tools probably falls, as those tools are likely to improve less quickly than em hardware does. Even so, new tools of this sort will continue to be invented and used.

For over a decade now, the speed of fast computer processors has increased at a much lower rate than the cost of computer hardware has fallen. We expect this trend to continue long into the future. In contrast, em brain hardware costs fall with the cost of parallel computer hardware overall, because the emulation of brains is a very parallel task. Because of this, relative to more parallel software, ems see an increasing sluggishness of software that has a large serial component, that is, requiring many steps to be taken one after the other. This sluggishness directly reduces the value of such software to ems, and also makes such software harder to write.

Thus over time, serial software will become less valuable, compared with ems and parallel software. Em software engineers will rely less on software tools with a big serial component, and instead emphasize parallel software and compatible tools. In this scenario, tools such as runtime type checking and garbage collection are done in parallel, or not at all. If it ends up being too hard to write parallel software, then the value of software more generally may be reduced relative to the value of having ems do tasks directly with less software assistance.

The increasing importance of work, the increase in organization sizes, and the standardization of work teams all increase the importance of enterprise software, that is, of software that helps organizations to coordinate.

A tendency of fast ems to be high status should raise the status of software engineers, for whom faster speeds are often more productive. The competition for higher status among ems may encourage faster speeds than would otherwise be efficient, including among software engineers.

LONE DEVELOPERS

For software engineering tasks where parallel software and tools suffice, and where the software doesn't need to interact with slower physical systems, em software engineers could be productive even when sped up to the top cheap speed. This often makes it feasible to avoid the costs of coordinating across many engineers, by having a single engineer spend an entire subjective career creating a large software system. For an example, an engineer that spent a subjective century at mega-em speeds would complete this period in less than 1 objective hour. Thus when such a delay is acceptable, parallel software may be written by a single engineer taking a subjective career length.

When software can be written quickly via ultra-fast software engineers, product development could happen quickly, even if very large sums are spent. While today software investors can spend much of their time tracking current software development projects, those who invest in em software projects might spend most of their time deciding when is the right time to initiate such a project. Soon after a project begins, it is completed. A software development race, with more than one team trying to get to market first, only happens when a particular sharp event, such as a new technology advance being announced, triggers more than one development effort.

A software engineer working for a high-speed lifetime on one project could still have trouble remembering software that they wrote subjective decades before. Because of this, shorter-term copies of this engineer might help them to be more productive. For example, short-term em copies might search for and repair bugs, and then end or retire once they have explained their results to the main copy. Short-term copies could also search among many possible designs for a particular module, and then end or retire after reporting on their best design choice, to be re-implemented by the main copy. In addition, longer-term copies could be created to specialize in whole subsystems, and younger copies might be revived to continue the project when older copies reached the end of their productive lifetime. Such approaches should allow close copies of a single em software engineer to make far larger and more coherent software systems within a subjective lifetime.

Fast software engineers who take a subjective lifetime to build a large software project, perhaps with the help of close copies, likely develop more personal software styles and tools, and rely less on standard approaches that help them to coordinate with other engineers with differing styles and uncertain quality.

When different parts of a software project require different skills, a lone software engineer might create several young copies trained to acquire different skills. Similarly, young copies could be trained in the non-software job topic areas where the software is to be applied, so that they can better understand what software variations will have value there.

However, when a project requires skills and expertise that are best matched to different temperaments and minds, then it may be worth paying the extra costs of communication to allow ems from different clans to work together on this project. In this case, such engineers would likely increase the priority of communication via more abstraction, modularity, and higher-level languages and module interfaces. Such approaches also become more attractive when outsiders must test and validate software, to certify its appropriateness to customers.

In the em world, small teams working at the top cheap speed, with the assistance of many spurs, may create enormous software systems. There may not be much need in the em world for larger software teams.

PART V

Sociology

CHAPTER 23

Mating

SEXUALITY

How is sex different for ems?

As the em world is a very competitive world where sex is not needed for reproduction, and as sex can be time and attention consuming, ems may try to suppress sexuality, via mind tweaks that produce effects analogous to castration. Such effects might be temporary, perhaps with a consciously controllable on-off switch. Historically, castrated males have tended to have lower libido, to be less aggressive and obsessive, to be better able to multi-task, and to be more sensitive, sympathetic, and social. However, historically eunuchs have often wanted to marry, and have often had active sex lives (Aucoin and Wassersug 2006; Brett et al. 2007; Wassersug 2009; Treleaven et al. 2013). Thus even for eunuch-like ems there might still be a substantial demand for sex and related pair bonding.

It is possible that em brain tweaks could be found to greatly reduce natural human desires for sex and related romantic and intimate pair bonding, without reducing em productivity. It is also possible that many of the most productive ems would accept such tweaks. Alternatively, it is possible that cheap vivid romantic and sexual simulations will sufficiently satisfy pair-bonding urges, so that little demand remains for pair-bonding with real ems (Levy 2008; Brain 2012).

However, given how deeply pair bonding and sexual behaviors are embedded in human nature, such scenarios do not seem likely, at least for the early em era. Scenarios of sex suppression also seem to be less simple, as it is harder to calculate their implications.

In this book I thus assume that ems retain modestly strong desires for sex and related pair bonding, even if such desires are substantially reduced. I also assume that familiar conventional sexual and gender habits and preferences continue in the em world. That is, most ems divide clearly into male versus female, ems mostly prefer male-female pair bonds, and these bonds have a distribution of time-scales near those we have seen in humans across cultures so far.

It is possible that our demand for long-term pair bonding is less deeply embedded than is our demand for pair bonding in general. In this case ems might have mostly short-term pair bonds, and perhaps more emotionally distanct relations such as those common in prostitution. We don't have a strong reason, however, to expect this scenario.

Even if human nature isn't flexible enough to let ems eliminate sexual urges, it might be flexible enough to allow large modifications. In this case, the lack of a reproductive function of sex could let ems explore a wide space of sexual attitudes and practices, to find ones that promote individual and team productivity. They might find solutions that would seem strange and repellent to us. On the other hand, they might not find such things.

Since most ems are near a peak productivity age of 50 or more, em sexual and mating inclinations tend to be those of people with that mental age, and yet with ideal bodies and stamina.

Because of clan-based access to data on the experiences of millions or more other copies of themselves, ems from large clans know much better than we do which other ems are likely to be receptive to their romantic or sexual overtures. Ems who want more spontaneity and uncertainty in their relations than these data offer might prefer to have romantic and sexual relations with the less common two-name clans. Such a preference might sometimes be in tension, however, with putting less well-known clan members in the role of independent judges.

Illicit em mating could be harder to detect. As ems could meet in secure virtual locations, and speed up for their meetings, such meetings may not be detectable by following an em's path in space, or by looking for unexplained absences in their time schedule. The memories such meetings created might still be detectable, although even these could be avoided if new spurs were created for each meeting. Such spur meetings seem unlikely to be satisfying, however. The cost to hold illicit meetings, however, remains robustly detectable.

OPEN-SOURCE LOVERS

Just as some ems may choose to be open-source workers, willing to work at most any task as long as they are given minimal comforts, other ems may choose to be open-source lovers. That is, they may be willing to enter into short- or long-term relationships with a wide range of partners, as long as (1) some minimal treatment standards are met, (2) their partner pays for their time to exist, and (3) an initial trial finds a sufficient "spark" between them. As long as someone else paid for their time, open-source lovers might allow a wide variety of situations and tweaks to be tried in search of a good spark.

Just as the best available open-source em workers are probably reasonably qualified for most jobs even if they aren't the world's best workers, the best available open-source lovers are reasonably attractive even if they aren't the world's best lovers.

Some open-source lovers are known for being very picky regarding what is an acceptable spark, while others are known for having easy to find sparks. Others may be picky about the fraction of their subjective time they are willing to devote to love-making, relative to other romantic interactions, or to time apart. All else equal, an em can get a better quality open-source lover if they are themselves more attractive, and if they are willing to pay for more non-love-making time.

Given a fixed budget to spend on leisure time with a romantic partner, the existence of open-source lovers creates two main romantic options. On one hand, an em might choose to spend most of a budget for romance on his or her own run time, and spend that time with whatever willing partner they could find to join in an equal relation where each partner pays for their own run time. On the other hand, an em might instead spend their budget on half as many romantic hours, to pay to run two ems, so that they can then spend that time with the best available open-source lover. Thus the existence of open-source lovers sets a high lower-bound on the quality of em romantic and sexual relationships. The per-minute subjective value of an equal relation should not fall much below half of the per-minute value of a relation with the best available open-source lover.

An em choosing an open-source lover could often choose one of the very best such lovers in the worlds, according to their preferred criteria. This is likely to be a more attractive option for females, who tend to have stronger preferences for mate quality. A high quality open-source em lover could excel not only in sexual behavior, but also in difficult but sexy mental features such as musical or artistic ability.

To many ems, the very best open-source lover available who finds a spark with that em may still not be as attractive as their best fantasy lover. Depending on the quality of simulated lovers in virtual reality, many ems may also spend romantic time with such simulations.

PAIR BONDS

How might longer-term pair bonding differ for ems?

If ems form marriage-like long-term pair bonds, such bonds may last longer subjectively than do such relations today. Two weak reasons to expect this are (1) ems are more productive and more productive people divorce less today, and (2) the em world is poorer, and divorce has increased with increasing wealth and falls during economic downturns (Baghestani and Malcolm 2014).

Today when one member of a couple rises in success more than does the other, it is the less successful member who is at risk of being left behind, as the more successful member seeks to trade up to a higher quality partner. However, when an em is successful there is more demand for copies of that em. And when a successful em makes more copies than does their partner, it is the new copies of the successful em who are "left behind" without the same access to copies of their previous partner.

Pair-bonded ems might sometimes make a lifetime commitment to one another, promising that they would only agree to make future copies which are paired with a copy of their lifetime mate. This commitment is less costly toward the end of an em's useful mental flexibility lifetime, and in mass labor markets, where copies are usually created as part of large predictable teams.

Today, we often form romantic and other attachments that are specific to one individual, and which do not extend to other similar people. For example, people married to one member of an identical twin pair usually claim to have weak or no romantic feelings for the other member of the pair. This desire to attach to just one person might be thwarted, or at least complicated, by close em copies. Perhaps ems could learn to treat close em copies as exactly the same person for the purpose of attachments. But a simpler approach is to segregate copies so that ems do not interact much with close copies of the em to which they feel attached. Close copies may meet each other in private, but not also in the presence of their close associates.

Because marriages were central to farmer era property and production, parents often took control over and arranged their children's marriages. These parents usually took less control over their children's friends, beyond choosing peer groups. For foragers, in contrast, less went wrong when pair bonds failed, and so foragers were freer to choose and break both friends and pair bonds than were farmers. We seem to be reverting to forager mating habits today, as our increasing wealth gives us more freedom. At work, in contrast, we now mainly let managers arrange our work teams.

Will em marriages be arranged? As pair bonding matters less for em production and reproduction than it does for us today, this is a reason to leave mating decisions to individual ems. However, older ems seem much more qualified than are parents today to choose matches for their younger clan-mates, as they would know their clients far better. Em couples might relive their early love by helping their younger similar copies to fall in love with each other. As arranged marriages seem to work out well today (Regan et al. 2012), the fact that em matchmaking seems more effective suggests that many em pair bonds may be arranged or heavily assisted, and work out even better than do our marriages.

While pair bonding may matter less to em production, when to copy and who to have as members of what work teams are decisions that are especially important for em production. These decisions are thus likely to be arranged or heavily assisted by others, even if individuals can veto particular proposed team assignments. While ems may be freer in some ways to pick their mates and friends than we are, as a practical matter mates and friends may often be limited to other team members, and ems may have less control over their teams.

Jobs differ in how widely they are available; some can be found in most geographic locations, while others are only found at a few places. Today, couples tend to move to the geographic area of the member whose job is the most location-constrained. As men tend to have more location-constrained jobs today, male-female couples tend to move today to the man's job locations (Benson 2014).

To the extent that ems are clustered into dense cities where they can interact with most of the city without much noticing the distance between work sites, this weakens the tendency of a couple to have to choose a location favored by one of their jobs. Not all ems are in this situation, however. The em couples more likely to move together for one of their jobs are those with especially fast jobs or jobs located especially far from urban centers.

GENDER

The assumption made above that familiar sexuality and gender habits mostly continue for ems has many implications.

For example, all else being equal, ems continue to tend to mate with others who are similar to them in many ways. Ems also continue to prefer physical good looks, such as body symmetry, smooth skin, and muscle tone. These features should be very easy to obtain, however. Ems will also tend to prefer ems with minds that are high-status, kind, understanding, dependable, sociable, stable, and smart.

We also expect ems to display the gender differences that we consistently see across cultures today. We expect men to prefer females with signs of nurturing inclinations and fertility, such as youthful good looks, and we expect women to prefer men with signs of wealth and status, and their future indicators such as intelligence, ambition, and an inclination to work hard (Schmitt 2012).

Relative to men, we expect women to more value benevolence, to be more averse to risk and competition, and to be more neurotic, agreeable, and open to discussing their feelings (Croson and Gneezy 2009). We expect men to be more assertive and open to ideas, and to more value power, stimulation, hedonism, achievement, and self-direction (Costa et al. 2001; Schwartz et al. 2005).

Gender differences in personality seem to be stronger in richer societies, as well as in cultures whose ancestors used the plow, which required more physical strength (Alesina et al. 2013; Marcinkowska et al. 2014).

So we weakly expect gender role differences to become weaker in a poorer em world where physical strength matters less. A poorer em world may also encourage a focus on long-term over short-term mating, although the reduced role of pair bonding in raising children may counter that effect.

The em world seems romantically plentiful in the sense that it should give both male and female ems more of what they want in romantic partners, at least compared with our world. In virtual reality ems could easily and cheaply offer either youthful good looks, or aged distinction, as their partners prefer. Most male ems are near their most productive subjective ages, and come from the few hundred most productive clans, making them intrinsically smart, hard-working, and capable.

Some features that are attractive today are less plentiful in the em world, however. As most ems have mental ages near peak productivity ages, female ems less often have the youthful mental styles that often attract males. With far fewer children to raise, females have fewer occasions to develop and show nurturing inclinations. Available males are less often rich or have especially attractive artistic abilities, such as music, art, and story telling.

Our natural attraction to others is often relative, so that we are attracted to those nearby who excel relative to others in our social world. It is of course hard to satisfy everyone if what they all want is intrinsically scarce in this sense. Most ems who want strong associations with the absolutely most attractive or successful partner around must inevitably accept dissappointment.

GENDER IMBALANCE

The em economy may have an unequal demand for the work of males and females.

Although it is hard to predict which gender will be more in demand in the em world, one gender might end up supplying proportionally more workers than the other. On the one hand, today women are becoming better educated and are in increasing demand in modern workplaces. There are some indications that women have historically worked harder and more persistently in hard-times low-status situations, which seem similar in some ways to the em world. However, the tendency of top performers in most fields today to be men suggests there might be more demand for male ems.

The em world is more competitive, and women tend to perform worse when they frame their interactions as competitive (Niederle 2014). However, the em world may find more congenial ways to frame female production.

An unequal demand for male versus female workers could thwart em desires for romantic male-female pair bonds. The em world might substitute polygamous or homosexual relations, or transgender conversions, either by selecting more for ems who prefer such things, or by cultures that encourage ems to choose such options. Alternatively, ems might use software to make same-sex partners appear to be of the opposite sex. However, the selection of ems willing to make such choices could have high opportunity costs. As mentioned in Chapter 13, Qualities section, homosexual ems may be preferentially female, as gay men earn less than other men today, while lesbian women earn more than other women.

A third option is for the more common gender to pay for the time of the less common gender, as has happened in past "frontier" towns with very large male to female ratios. This option seems similar to the open-source lover option.

A fourth solution is for the gender with the higher total labor demand to take on more work with a high ratio of spurs to long-term copies. For example, one partner in a couple might make 10 spur copies per workday, where only one copy continues on to the next workday. The other partner might make no spurs per workday. In this case this couple could embody a 10 to 1 ratio of labor supplied by the two partners. The couple would meet and interact after and before their workday, but perhaps not during the workday. Of course this whole spur-creation approach may have substantial costs if tasks are so well matched to a particular gender that there is a productivity cost from assigning a job to the opposite gender.

A fifth way to maintain ordinary pair bonding in the face of unequal labor demand is to use fast-slow pair bonds. For example, if one partner ran four times faster than another, the fast one could spend 1 hour per subjective (24 hour) day with their partner, while the slow one could temporarily speed up four times per subjective (27 hour) day, each time spending 1 subjective hour with their partner. The fast partner would supply four times as much work to the labor market as the slow partner. Fast-slow partners could also deal with mismatches in how often partners want to interact, including sexually.

This fast-slow approach might also have a productivity cost if genders are not equally well matched to the fast and slow jobs assigned to them.

Another potential problem is that over any given subjective lifespan, the slow partner would have time for four fast partners, resulting in a subjective age mismatch during many periods of most relationships. The fast partner would only ever see the slow partner at a particular phase of their life. To retire together, the slow partner would have to split off copies that retire each time a fast partner retires. Also, this asymmetry in number of lifetime partners might be emotionally problematic, if one partner feels completely devoted to the other, but feels the other partner is only fractionally devoted to them.

Fast-slow pair bonds could plausibly satisfy most desires for pair bonding in a world with a speed-weighted gender ratio of four or less. This approach would not, however, satisfy such desires well if the ratio were 16 or more.

One way or another, however, the em world can deal with gender imbalances in work demand. Its solutions may not be elegant, but they are mostly effective.

CHAPTER 24

Signals

SHOWING OFF

Today, we make many choices with an eye to how those choices influence how others see us. For example, we try to give others a favorable impression of our general capacities, such as wealth, health, vigor, intelligence, knowledge, skills, conscientiousness, and artistic sense. With this in mind, we try to appear impressive in our arts, sports, schooling, hobbies, vocabularies, and other markers.

For example, we plausibly pay extra for visibly nice clothes, cars, houses, etc., in part to show that we can afford such things. We use big words and witty banter in part to show our intelligence and schooling. We go to school in part to show our intelligence, conscientiousness, and conformity. We play sports in part to show our intelligence, health, strength, self-control, toughness, and cooperativeness. We play music in part to show our intelligence, self-control, passion, and creativity.

We also try to give others a favorable impression of our loyalties and connections. That is, we try to credibly show that we feel strong positive ties toward certain individuals and groups, who feel similarly toward us. We can also try to show negative feelings toward rivals and outsiders. With this in mind, we choose with whom we spend our time, who we praise or criticize, and our styles of clothing, music, movies, etc. We follow gossip, news, and fashion in part to help show that we are well connected to respected sources of information. We enjoy stories and participate in politics in part to convince associates of our moral sympathies. We sometimes even cry for help, to show who will come running.

Today, we spend a large fraction of our energy and wealth on such "signaling," both because humans naturally care greatly about gaining status and respect in the eyes of others, and because being rich allows us to attend more to such concerns. As mentioned in Chapter 2, Era Values section, in terms of simple functionality, we seem today to spend excessive amounts on schools, medicine, financial intermediation, and huge projects.

In contrast, while ems share most of our desires for respect, they live in a more competitive world, where they can less afford to indulge such desires. Thus ems are likely to spend less of their energies signaling to gain status. However, as signaling has functional value in assigning ems to tasks and teams, and as it can be hard to coordinate to discourage signaling, ems will likely still do a lot of signaling.

Similar to humans today, ems probably use self-deception to help present a positive image of themselves to associates. For example, workers might try to believe that they are not as exhausted or bored as they actually are, to seem more attractive as team partners. They might similarly believe that retirees enjoy their retirement more than evidence justifies, to show a positive attitude toward typical life plans. To preserve this illusion, ems may avoid looking carefully at the lives of retirees, just as most of us do today. Ems may also believe that outsiders or bosses have less influence on their activities than they actually do, to feel, like we do today, that they have higher status by feeling more in control of their lives.

On some topics, the em lifestyle naturally reduces self-deception. For example ems could not as easily claim that their taking "the road not taken" had made all the difference in their lives, because ems have clearer direct evidence about the results of other close copies of them taking different life paths.

PERSONAL SIGNALS

Like us, individual ems have many specific ways to show off.

For example, ems in virtual reality can use their personal appearance and surroundings to signal their mood, affiliations, awareness of local fashions, and recent activities. It is harder to use virtual reality surroundings to signal wealth, as most environments are cheap to obtain and maintain. However, some particular decorations may be copyrighted and expensive. Also, an entourage of smart, fast associates remains expensive, and hence credibly signals wealth. But an em entourage may have to visibly do more than they usually do today, to make clear that they are in fact not fake automated entourages.

Em associates might share private virtual overlays that only selected viewers could see, projected onto people and objects around them. For example, they could draw a silly mustache on someone's face, a mustache that could only be seen by ems in their social circle. In this way, ems could have a laugh with associates at the expense of those not clued in to their private augmentation source, and thereby signal loyalty and an exclusive connection to particular associates.

Today, people lower the pitch of their voices when they feel dominant, and such low voices are heard as more dominant, and also as sexier. Low voices are also heard as less nervous, and more truthful, empathic, and potent. We also hear voices that are loud, fast, have fewer pauses, and more variation in pitch and volume to be more energetic, smart, knowledgeable, truthful, and persuasive (Mlodinow 2012).

As it is cheap and easy for ems to automatically modify their voices to be louder and lower-pitched, we expect ems to routinely do this, at least when they want to sound dominant, persuasive, and smart. Ems find it expensive, however, to increase their voice speed, reduce pauses, and increase relevant variation in pitch and volume, because these typically require faster mind speeds.

For humans, faster voices signal the speaker's intelligence and energy level. For ems, however, faster voices also show more how much the speaker has invested financially to speed up. This signals in part how much an em cares about this speedup. Fast voices can also signal that the speaker has a lower cost of running faster, such as via running on special cheaper hardware, or perhaps via shrinking their less used brain parts.

Today people agree on which faces indicate more desirable qualities, such as seeming trustworthy and dominant (Walker and Vetter 2015), and in poorer societies men less prefer women to have more feminine faces, compared with men in richer societies (Marcinkowska et al. 2014). This weakly suggests that ems will choose the faces associated with desirable personalities, and also faces with weaker gender distinctions.

Ems who speed up their minds to speak quickly, and then slow down their minds to listen, risk talking faster than listeners can comfortably hear. Because of this, ems limit their talking speed and instead invest more in careful choice of words and intonation. Such ems tend to sound like voices in our advertisements, who talk with carefully practiced lines in a script.

Virtual ems no longer have direct needs to eat, take medicine, or clean themselves. But ems might continue with such activities because humans have long infused such activities with many layers of symbolic meanings. Such activities are often used today to signal loyalties and abilities. Ems thus search for new practical ends that might be achieved by these activities in an em world.

For example, ems might redirect our natural attitudes toward medical care and treatment into activities such as meditation that could plausibly influence em mental health. Eating particular foods might trigger temporary drug-like tweaks in the emulation process, which could induce useful mental states of relaxation, distraction, or thoughtfulness. This might allow eating to serve functions for ems similar to the purposes that music, dance, and stories often serve for humans today. While it is possible to trigger such mind tweaks just by pushing a button, triggering such changes via food might feel less disruptive and better integrated into familiar human rituals.

Fast changing fashion, such as in clothes and music, is common in our era. However, apparently fashion did not exist in the foraging and farming eras (except in proto-industrial Rome). As fashion seems to signal some combination of wealth, youth, taste for variety, and information source quality, whether fashion continues in an em world depends on how eager ems are to signal such features, and on what other signaling methods are available.

Virtual reality allows for very cheap and rapid changes in fashion for things like clothes and furnishings. The main costs of rapid fashion change would be cognitive; ems might get distracted and confused by rapidly changing surroundings.

It is relatively cheap and easy to meet personally and talk with ems who are copies of famous ems. It is hard to get those famous ems to remember you later when they talk to others. Thus ems trying to show status and centrality in social networks try less to meet celebrities, and try more to get those celebrities to remember them.

Today, we tend to presume that celebrities must have exceptional qualities. Because of this, we want to mate with them, to use their influence in our favor, and to be publicly associated with them. In the em world, celebrities have far fewer persistent differences from other members of their clans. Ems know that one clan member being more famous than others is mostly a matter of luck. This reduces but may not eliminate em eagerness to associate with individual celebrity ems.

In our world many rare products and services acquire high status via association with high status people. For ems being a celebrity is less about having higher persistent qualities, so products and services acquire less added status by being associated with em celebrities. This reduces the status of rare products, relative to common products. While today we often presume that the most popular products are not the best products, to ems the most popular products and services will more often also be the best.

Sometimes a partner such as a lover or friend will ask an em to visibly choose that partner over their clan in a conflict. A high cost action of this sort would send a strong signal of loyalty to a partner. But this high cost also makes such actions rare.

As mentioned in Chapter 14, Work Hours section, ems may sometimes be tempted to work too much to signal their ability and enthusiasm for work, as are many people today. If this happens often, then a competitive em world is likely to seek ways to prevent such overwork. Clans, firms, or teams might, for example, commit to requiring a minimum fraction of em leisure time.

GROUP SIGNALS

Some features of ems vary little among clan members. These include overall intelligence, basic personality, and early life cultural heritage. Other features can vary greatly among clan members, including wealth, mood, vigor, recently acquired skills, knowledge of local conditions, and loyalties and ties to specific individual ems. Still other features vary substantially within a clan, but vary little between close copies. These mildly varying features may include stamina, confidence, and particular kinds of intelligence or artistic sense.

Features that vary greatly between close copies are likely to be left to each em to signal by themselves. In contrast, features that vary little within a clan create an opportunity for the clan to coordinate to signal those features together. When features vary within a clan but are shared within subclans, those subclans may coordinate to signal.

For example, ems from the few hundred clans that dominate the em economy might want to usually act as if everyone knew of and accepted their clan and its idiosyncrasies, and greatly valued its contribution. To show this, such clans might expect to be addressed by just one name, such as "George." Being treated this way is a credible signal that your clan is well known. Such ems might act irritated when forced to interact with ems from less familiar two name clans. Such clans might also act indignant if anyone requested an independent evaluation of their contributions or value; they might think such actions appropriate for dealing with unfamiliar clans, but surely *they* are well known enough for this to be unnecessary.

Clans who share wealth internally may want to signal the wealth of their entire clan. They might do this by buying large prominent buildings in em cities, or by funding expensive projects. Just as nations today fund activities in sport, art, and academia to increase national prestige, clans may similarly fund some of their members to pursue prestigious activities, to show off features that don't vary much within clans. Clans that cannot coordinate well may spend less on signaling, and may seem less impressive as a result. In contrast, individual ems may pay less attention than we do to art, sport, or science, and put more effort into their connections with close associates.

To impress observers, ems might try when young to be a star athlete, artist, writer, explorer, or scholar. After achieving fame, they'd then be retrained for more useful work, where everyone could remember their youthful stardom. This is somewhat like people today who are star athletes when young, and afterward go into sales to take advantage of their fame. As we are less impressed by achievements to which several people contribute (Smith and Newman 2014), em clans will tend to keep the key work behind their impressive accomplishments within a single clan.

Bigger clans can afford to create more impressive achievements, which adds to the perceived superiority of bigger clans.

Ems prefer the training for their impressive youthful activities to be useful also in their later work career. For example, some ems may be athletes early, and then later do physical jobs, such as construction, that require related strong physical coordination abilities. Other ems might design innovative products early, and then spend their careers improving and servicing such products. The repairman who fixes a product might *literally* be the guy who invented it. In such scenarios, product innovation may be subsidized by em signaling efforts.

Today, activities such as dance, sport, and song show off combinations of mental and physical abilities. As ems can easily obtain virtual bodies with identical and maximal physical abilities, ems will change such activities to let audiences better see differing mental abilities. In a sporting contest, for example, em players may use standard bodies and brains, and win by having better "minds," (brain software). Such contests might be more like bike races today, showing off the abilities of body designers, and the em who "drives" that body.

As have humans through history, some ems will show off by gaining status within communities of intellectuals. Today, some of our highest prestige is assigned to those credited with innovation, who add new intellectual results and methods that accumulate over time. However, in most nations today, and in almost all nations before a few centuries ago, intellectual status has come much less from innovation, and much more from privately teaching and advising the powerful, from gaining wider attention via popular writings, from mastering classic literature in great detail, and from being the first to be visibly associated with new intellectual fashions.

This history weakly suggests that, compared with today in the West, intellectual status among ems may not be as focused on innovation, especially for kilo-ems or faster, for whom society will seem to innovate more slowly. While this change may reduce the contributions of em top intellectuals to innovations, it shouldn't change the overall rate of innovation very much, because the fraction of useful innovation contributed by such intellectuals has always been small.

Because the actions of each em reflect strongly on the qualities of other clan members, clans exert more pressure, and retain more power, to discourage member behaviors that might make the clan look bad. This makes unusual em behaviors even stronger signals about clans. For example, if one em left his or her spouse, the spouses of similar copies may worry that they will be treated similarly.

As work team performance depends in part on general abilities of team members, clans may be expected to invest financially in the teams to which they contribute copies. Such investment signals their confidence in the quality and match of the workers they supply. Such expectations apply today only to rather wealthy families, but many em clans might be wealthy enough to make such investments.

By signaling together as a group, em clans take a big step toward seeing themselves as a united "us," or even a single "me."

CHARITY

Like people today, ems are eager to show their feelings about social and moral problems, and their allegiance to pro-social norms.

For centuries, three classic charities have been alms, hospitals, and schools. But em hospitals are unnecessary, except perhaps for mental illness, and em schools are already well funded, as children are rare. Alms are still possible for ordinary humans or animals, but there is no need to feed involuntarily hungry ems, or to warm shivering ones, as no cold or starving ems exist. One might pay to subsidize jobs or extra leisure time for working ems, to speed up retirees, or to support retirement for spurs who might otherwise end. But these may feel like discouragingly bottomless pits of need, and may not seem to be especially sympathetic causes, if recipients had declined to negotiate for such benefits when they agreed to make the copy that they are.

Perhaps more sympathetic recipients of aid are the rare em victims of war, violence, or natural disasters; they are not bottomless pits of need, and have not chosen their fate. Even more deserving might be victims of mind theft, as discussed in Chapter 5, Security section, who risk being enslaved or tortured for their secrets. Identified victims are rare, and most ems could legitimately fear similar fates befalling them. Most in the em world express strong disapproval of mind theft.

Ems might signal that they still feel very human by going out of their way to see and sympathize with animals, ordinary humans, and em children. Ems could watch shows about them, travel to visit them, and donate to help them. As most humans have few em copies, such humans are rare compared with ems, and so might be mild celebrities that ems pay to visit. This could give a mild subsidy to humans. For fast ems, the human world changes very little between em visits.

While em children are pampered even without charity, plants and non-human animals have few other supporters. We humans today care about nature in part because we enjoy traveling to ancestral-like environments, and because the destruction of nature threatens to destroy us by destroying the biological ecologies on which we rely. Ems, however, can travel more cheaply to virtual nature parks, and need have little fear that killing nature will somehow kill them.

Although em cities may be toxic to nearby nature, such cities at first will disturb only a tiny fraction of the globe. Nature is saved for a while because the em focus on dense cities leaves ems disinterested in most of the land that nature occupies. But this is probably only a temporary reprieve. Even if nature is safe during the em era, that era may only last a few objective years. Other eras will follow quickly, and our descendants are likely to soon fill the Earth, displacing nature everywhere outside of a few small preserves.

Today, charitable projects with the goal of influencing attitudes and beliefs often focus on children, for whom persuasion seems more effective, and whose attitudes will last longer into the future. Ems will be even more tempted to influence young ems, because such ems have many future descendants. Such efforts might be justified as creating more total global happiness via making better childhood memories to be shared by many descendants.

Charity continues with ems, though with somewhat different targets.

IDENTITY

Informal discussions today about the possibility of ems often focus on the question of whether an emulation of an ordinary human would be the "same" person as that original. Ems similarly ask themselves how much they identify with different copies of themselves, with whom they share different amounts of history and context.

Although we are each very complex creatures full of vast detail, we often try to see and show ourselves to others in terms of a simpler "identity" (or "brand"). This identity helps to make us more predictable and understandable to others, which helps us to assure them of our loyalties and reliability. This helps to explain why our moral choices seem especially central to our identity.

Today, most people take for granted that they identify with their nation and culture; they only rarely encounter outsiders who make them aware of this identity. People today feel more aware of identifying with their personal combination of personality, style, and life history, because they are the only person they know with this particular combination. Because our families are a bit more like us on these dimensions, we tend to identify more with our families than with outsiders.

Ems from large clans should be less aware of, and feel more secure in, their identifying with a personal combination of personality, style, and early life history. They know there is in effect a whole "planet" out there of perhaps billions of ems just like them, "super-twins" to whom they can talk at any time, or ask for help. Thus when around ems from other clans, ems might feel more like expatriates, that is, emissaries from a foreign land.

As discussed in Chapter 19, Managing Clans section, ems who made a plan and then split into many copies to execute that plan are likely to feel that they and their copies are the "same" person, while copies who openly disagree with each other are likely to see themselves more as different people. In an attempt to unify their members, clans may discourage open disagreement, focus more on the fact that they have a shared mental style and shared memories of early life, and focus less on recent opinions and memories. After all, those recent opinions and memories often differ.

When doing physical jobs, ems could use interchangeable bodies. Virtual ems could also easily change their virtual bodies at any time. Thus em identities need tie less to details of a particular body. However, to create a vivid memorable identity that is easily remembered by other clans, each clan may still create and stick close to a consistent visual style.

People today stay loyal to product brands over surprisingly long periods (Bronnenberg et al. 2012). This weakly suggests that ems will also stay loyal to brands for long times. Brand owners are eager to offer deep discounts to young ems with promising futures. While the em world has few children, each child has on average a great many descendants. On the other hand, collective purchasing by clans makes for better-informed consumers, and such consumers tend to have a weaker attachment to brands (Bronnenberg et al. 2014).

Today, our physical illnesses give us excuses to escape social pressures and expectations. If we don't want to do something, we can pretend to be sick. Ems, who never get physically sick, lack this excuse. Perhaps ems will expand their expectations of temporary mental illness to compensate. That is, ems may come to believe that most people are periodically struck by mental conditions that are acceptable excuses for failing to meet scheduled social interactions or deadlines. Even if the expected rate of these events is much lower than our rate of sickness today, such illnesses might still provide an important outlet for ems feeling imprisoned by expectations and plans.

Most em jobs are not especially high in status relative to other em jobs, and many jobs might be tedious, focused on very small parts of a very big world, and require long hours of hard labor. However, ems are unlikely to resent doing such jobs. After all, Olympic athletes today do not resent the tedium, focus, and long hours of training required to achieve their goals. Ems could take pride in knowing that they are from a very elite set of a few hundred clans selected from billions of ordinary humans.

Even so, on a moment-to-moment basis ems usually take their elite status for granted, and do not feel particularly entitled because of it. Few of them feel too high status to do their hard jobs, just as today we do not usually feel particularly entitled just because we are Homo sapiens.

Recently some rich industrial cultures have placed a historically unusual value on "authenticity," which is usually defined negatively as an absence of artificiality, mediation, conformity, or attention to appearance. Authentic people are presumed honest, unconflicted, creative, and original nature-lovers who face hard truths and have little interest in status, religion, or material goods (Zerzan 2005; Potter 2010). While this ideal contains some "natural" forager ways, foragers were actually often conflicted and self-deceived, cared a lot about appearances and material goods, and were not very creative or original. These non-forager features of authenticity do function, however, to signal social power, which is usually needed to achieve such features.

While we might expect an increasing emphasis on authenticity in an increasingly wealthy industrial era, we have little reason to expect subsistence income ems to continue a historically unusual emphasis on it.

COPY IDENTITY

The identity that ems have as members of a clan raises new issues in an em world.

It is not clear how discrete are the identities that ems make via copying. On the one hand, if em identities are very discrete, then an em looking backward into their copy history sees all of their ancestors and siblings as "me" up until they reached a key copy event. Ems before that copy event, however, and other descendants of those ems, are "not me," even if they are beloved and trusted relatives. If em identity is also transitive, then all descendants of that key "me" ancestor are also "me." On the other hand, if em identities are more continuous, then ems do not usually see other ems as either "me" or "not me," but instead see them in terms of being more or less similar along various dimensions. This is comparable to how we today identify to varying degrees with ourselves decades into the past or future.

Ems seem especially likely to identify with spur copies they create to do short-term tasks, copies who report back when they finish the job, and then end or retire. When ems look back on their lives they are especially likely to see the activities of such copies as "things I did, but that I don't remember well."

Most ems are from the few hundred most copied clans, and such ems can usually feel confident and secure in the identity they gain from that clan. Such clans are well known and established as competent workers in particular professions and industries. Such ems may feel less secure about, and more aware of, their place in particular work teams and projects, and of the degree of support they will obtain from local political coalitions, as these change more often. Ems from small clans feel less secure in their clan identity, knowing that many see their clan as inferior.

The strong security that ems from big clans feel in identifying with their clan is likely to induce such ems to pay less conscious attention to clan-based aspects of their identity. They are likely to instead focus more on the identity gained via their particular job, team, and immediate associates. Spurs probably think similarly, except that they know that their future selves won't directly remember their thoughts and experiences.

New em copies and their teams are typically created in response to new job opportunities. Such teams typically end or retire when these jobs are completed. Thus ems are likely to identify strongly with their particular jobs; their jobs are literally their reason for existing. Compared with us, ems more often choose their friends and lovers on the basis of work suitability, and they more sincerely love and respect their associates for being worthy co-workers.

While ems may strongly, if perhaps insecurely, identify with their team and job combination, they may also sometimes feel overly imprisoned by this identity, and seek freedom in a more temporary spontaneous identity. Such a temporary identity might be formed via last-minute unplanned choices of friends, lovers, hobbies, and activities.

Today, we tend to create stronger memories about life events that we experience between the ages of 10 and 30, memories that we see as central to forming our identity (Glück and Bluck 2007). If becoming a new em copy made a big change to life patterns and identity, that new em probably also forms strong memories of events associated with being copied. Teams might help to emphasize new copy identities by creating a new distinct team culture soon after a team is copied. New teams might go out of their way to, as a unit, change their tastes in clothing, music, furniture, and conversation topics. A time delay to more cheaply move copies to a new team location can also help with this.

Overall, most ems have more clearly distinct and different stages of life than we do today. In fact, the life an em remembers from before its most recent copy event might seem like the way past lives would seem to us today if reincarnation were real, except that the past lives of ems may be remembered vividly and accurately. However, the fact that other, rather different ems exist who also remember events from the past life of an em may make those events less "my" life, and more the lives of "others," or perhaps "our" life.

In a clan of 1 billion ems produced by binary copy events, each final copy must remember 30 binary copy events. If human-like minds find it difficult to remember this many strong identity-defining periods, then large-clan ems will either not treat most copy events as so important to their identity, or they will reduce the number of copy events that they need to remember, by making more copies at each copy event. For example, a clan of a billion ems might each recall only three key copy events, if 1000 copies are made at each such copy event.

How important em copy events are for em identity probably differs between mass and niche labor markets. Ems who work in mass-labor markets can remember just a few copy events, each of which strongly define an identity. In contrast, ems who work in niche-labor markets may remember a great many copy events, most of which did not strongly define their identity. Thus niche ems are somewhat like people today who move to a new apartment every year, whereas mass ems are like people who only move three times in their lifetime. The latter identify more strongly with their homes.

Nostalgia, that is, a sentimental longing for one's past, fosters a sense of being socially connected with others, and a sense of connection with one's past selves. This sense of being the same person over time increases well-being and perceptions of youthfulness (Sedikides et al. 2016). Em clans likely promote nostalgia, both to gain well-being and to increase em identification with their clan.

In sum, ems have a new kind of identity as clan members, with complex implications for other kinds of identity.

CHAPTER 25

Collaboration

RITUAL

How do rituals differ in an em world?

Today, we use rituals such as graduations, marriages, retirement parties, and funerals to jointly and overtly affirm community values at key social transitions. However, if we use a broader sense of the term "ritual," most social interactions and many apparently non-social processes are also rituals, wherein emotional energy becomes amplified as participants achieve a common focus of attention and act in ways that are finely synchronized and coordinated with each other (Collins 2004).

During rituals, synchronized feelings and body movements of people who are adjacent to one other become especially potent. Such group synchronization shows participants that they feel similarly to others in the group, and know each other well. People, things, and beliefs that are the mutual focus of attention in such rituals acquire added importance and emotional energy, and become able to increase the passion of subsequent rituals.

The emotional energy that comes from a common focus of attention on synchronized actions has long influenced the frequency and structure of many forms of synchronized human activities, in dances, plays, movies, concerts, lectures, protests, freeways, business meetings, group recitations in schools, consumption of advertised products, and group songs that coordinate work in hunting, farming, sailing, armies, and factories.

We expect ems to continue to show this tendency to prefer social situations where vivid awareness of finely synchronized actions can assure them of shared capacities and values. For example, similar to people today we expect ems to say hello and goodbye as they join and leave meetings, and to find reasons for frequent face-to-face meetings at work.

Some examples of common overt rituals today are when the police stop a driver, when a waiter takes an order, when two sports teams battle in front of a crowd, and when an audience watches a movie together. In the industrial era, we have a substantially lower rate of such rituals than did our forager and farmer ancestors. For our ancestors, in contrast, it was more like having Christmas or Thanksgiving happen several times a month, with many smaller ceremonies happening several times a day (Collins 2004).

There are many reasons for the loss of overt rituals in our time. Increasing wealth has given us more spatial privacy. Innovation has become increasingly important, density and wealth are high enough to support fashion cycles, and both these factors raise the status of people with eccentric behavior. These trends have encouraged us to signal our increasing wealth with more product and behavioral variety, instead of via connections and the use of more standard products and behaviors. With increasing wealth, industrial era values have moved away from conformity and tradition and toward self-direction and tolerance. Increased forager-like egalitarianism has made us less comfortable with the explicit class distinctions that supported many farmer-era rituals. Our suppression of family clans in the West has also repressed many family rituals.

As we will discuss in more detail in Chapter 26, Farmer-Like section, while our increasingly rich industrial era has seen a big increase in individualism and egalitarianism, poorer ems are likely to feel less individualistic and egalitarian. As we have discussed, innovation is less important in an em economy than in ours. As a result, it's likely that our recent trend away from overt rituals will be partially reversed. Ems are likely to move back toward farmer-like explicit and distinct social classes, and more frequent overt rituals wherein ems with different roles take on different ritualized behaviors. Compared with us, ems are likely to be more stratified into explicit classes, and to play out more frequent explicit and stylized synchronized behaviors.

The value of meetings as rituals with a common focus of attention is cut if attendees focus elsewhere while appearing to focus on the meeting. So ems may use mindreading to see who is paying attention to the meeting.

As ems in virtual realities no longer need to eat or clean themselves, they are likely to feel less inclined to copy familiar human rituals centered on eating or cleaning. Fast ems also have fewer rituals centered on hearing and sharing the day's news, because to them the world changes much more slowly.

Ems may seek new kinds of seemingly "natural" ceremonies to substitute for those lost, to continue to bind together teams, firms, and city-states. Ems also seek new rituals to bind together the new social unit of clans. However, it is probably hard to create strong rituals out of em work activities, as productive work behaviors rarely create opportunities for synchronized body motions matched with a common focus of attention.

While singing music together can create powerful rituals, most people today are shy about singing in public, as their voices sound worse than the professional singers that they usually hear. Ems could make their voices sound more professional, and yet still communicate very personal emotions, via more advanced versions of voice-processing systems such as Auto-Tune, which today often improves the voices of professional singers.

In sum, ems may have more and stronger rituals than we do today, reverting in part to previous historical patterns.

RELIGION

Religions and their rituals often help to bond people to groups. By following seemingly arbitrary rules restricting behavior and beliefs, members can credibly signal their attachment to a group, relative to other groups with conflicting rules. Groups with stronger arbitrary rules tend to be more strongly attached to one another (Iannaccone 1994). It is somewhat harder for ems to use this strategy, as they need to be attached both to their clans and to their teams. After all, rules unique to a clan could alienate member ems from their teams, while rules unique to a team could alienate member ems from their clans. Perhaps distinct spheres can be defined for the topics of team rules versus clan rules.

Today, religious people tend to be happier, healthier, and more productive (Steen 1996). They live longer, smoke less, exercise more, earn more, get and stay married more, commit less crime, use less illegal drugs, have more social connections, donate and volunteer more, and have more children. Intensity of religion and strength of religious belief tends to increase with age, especially on retirement (Bengtson et al. 2015). As we discuss more in

Chapter 26, Farmer-Like section, ems are also likely to be more farmer-like. Because of this, ems tend to believe more in good and evil, and in powerful gods who enforce social norms. All of these considerations suggest that ems are more religious.

However, today more religious geographic regions are less innovative, and more religious individuals hold views less favorable to innovation (Bénabou et al. 2015). So if the innovation effect is important enough, ems will be less religious; otherwise, they'll be more religious.

Science fiction often depicts social conflict, sometimes violent, resulting from religious objections to the deployment of new technologies and social institutions. However, most of the major religions of today are thousands of years old, and have peacefully accommodated almost all of the vast changes that have appeared since those religions began. Thus religions are clearly capable of adapting to a great many social changes, and so we should expect most of them to adapt comfortably to the em world as well.

However, clarifications may be required on the subjects of how to define death and responsibility for sins of copies. For example, Christians and similar religions must decide if copies share sins, or if an em sins when it splits off a spur who then sins, especially if that sin was foreseeable. Such clarifications likely emphasize that mind theft is a great evil, akin to rape or murder today, justifying many and strong precautions. Further doctrinal clarifications may be required because ems on average are much smarter than ordinary humans, and may not tolerate blatantly illogical or contradictory religious doctrines.

Rituals and religion have long been used to help people accept their social roles, and to mark key transitions between such roles. So religious-style rituals, perhaps with music and dance, may be especially useful in helping ems to copy, end, and retire.

SWEARING

Traditionally, lower classes did hard physical labor, and as a result tended to wear tough work clothes, and had skin that was callused, tanned, and wrinkled. The upper classes tended to show that they were too rich or skilled for such work by wearing fragile clothes and having soft, smooth, untanned skin. Similarly, upper classes have often nurtured polite language, avoidance of direct insult, and a heightened sensitivity and squeamishness on topics such as sex or excrement. Such habits have helped the upper classes to distinguish themselves from the typically tough and calloused attitudes of lower classes.

In lower class cultures, people more often demonstrate physical strength and toughness via dangerous dares, fistfights, and excessive drinking. People in these cultures also tend to make more direct and aggressive verbal challenges, and to use more swearing, insults, teasing, and taunting. In their communities, people are often given nicknames that highlight their most embarrassing weaknesses (Baruch and Jenkins 2007; Stapleton 2010; Jay and Janschewitz 2012).

These lower class habits tend to be functional adaptations to their environment. Just as it can be important to judge physical strength and toughness when allocating workers to hard physical labor, it can also be important to judge toughness for emotionally demanding tasks. Crude behaviors can help workers express and gauge physical and emotional weaknesses and strengths, which allows them to better select and allocate people for tasks, and to push work groups up to but not beyond their limits. As chimps also seem to vent frustrations via cursing matches, as well as displays showing physical toughness, this sort of behavior seems to be very old (Angier 2005; Pinker 2007).

Today, swearing, and its milder cousin slang, is more common in work groups with closer interdependence, especially in workplaces with high levels of physical and emotional stress. Today such work teams include warriors, finance traders, moviemakers, and restaurant servers. Note that not all such teams are lower class; some upper class work groups also use swearing, when that can help in their situation.

Today, laws against sexual harassment, together with wider monitoring of worker speech, discourage workplace swearing and impose high-class cultural standards on lower classes. Even so, mild swearing has recently become more socially acceptable in some elite cultures.

Compared with our world, the em world has low wages, more competition, and more work groups pushed to the limits of their emotional abilities, even as differences in physical abilities are weaker. Em children are also rare. These suggest that em work groups more often adopt traditional working class habits, except that they emphasize emotional over physical toughness.

Thus em work groups probably use lots of strongly emotional swearing, insults, and teasing.

Em swearing may focus less on excrement, as the virtual em world has little of that. Profanity based on betrayal, sex, and religion remains relevant, however. Swearing based on death changes to match new em concepts of death.

In sum, ems probably swear more than we do, but for good reasons.

CONVERSATION

Conversations are a familiar human ritual, and we expect ems to continue to talk with one another. Em conversations may vary depending on whether ems are talking to associates in other teams, clans, firms, or cities.

Teams running together on trusted hardware may commit to usually letting team members read the surface of each other's minds, and to also see each other's copying, communication, and financial actions. Such extreme transparency would encourage team trust and cooperation. Subclans may commit to similar openness between members, at least when they are interacting with each other. Transparent ems may be able to sometimes pull down a shade over their minds, in a way that allows others to know that their view has been temporarily blocked. But it is not usually possible to fool an em into believing a faked image.

Software tools may help to interpret these mind views, and also voice tone, facial expressions, etc. Today, we are usually only unconsciously aware of others' moods, status relationships, and interaction features. But software could give ems the option to be more directly aware of these details. This awareness may not be reflected in explicit conversation, however. The reasons we have today for not discussing intimate details may well continue in em social worlds.

At the other extreme, ems without such hardware support for transparency would less trust what they see than we do today. After all, software tools might manipulate the facial, gaze, and voice expressions of other ems, and those other em minds might run at speeds different from the speeds that they publicly display.

This wider range of possible transparency and opacity forces ems to specialize more in social skills and habits adapted to such situations. That is, some ems specialize in being effective cooperators in situations where allies are open, while others specialize in being effective competitors in situations where rivals are opaque. This is somewhat like traditional farmer gender roles, where female roles were more nurturing inside families, whereas male roles were tougher to protect families against outsiders. As ems who represent organizations and deal with outsiders tend to be higher status, and also to specialize more in opacity, ems who specialize in opacity are probably seen as higher status.

In our world, people typically find it uncomfortable to interact with systems using a voice that sounds much like their own (Jacobs 2015). Ems may similarly dislike talking with other copies who share their voice. If so, ems may electronically modify the voices they hear from close copies. Ems on different teams might try to cultivate distinctive accents and styles of talking.

Today, we sometimes look others carefully in the eye, to try to ascertain what they are thinking. But we don't similarly look ourselves in the eye in the mirror, because we already know what we are thinking. Ems may also be less likely to look at close copies of themselves in the eye or face, as they'd usually have a good idea from context what their copies are thinking. This could help encourage a habit of talking to clan members in your head.

The ability of reversible brain hardware to easily allow temporary speed changes may encourage the usual human habit of paying more attention when we are speaking, relative to when we are listening. Ems may temporarily speed up to plan what to say and to talk, and slow down while listening to others. When close associates are allowed to read the surface of an em's mind, they may also see these varying speed choices.

Open and transparent teams may give team members the ability to put other team members into surprise split-tests, to test for biases.

In sum, ems talk a lot, just as we do, although their conversations may perhaps vary more than ours do in style.

ON CALL ADVICE

Today, we tend to coordinate well with ourselves inside our head, quietly "talking" to ourselves and recalling our previous words. Here we can be seen as in some sense "praying" to our idealized selves. In this mode, we instinctively trust ourselves. In contrast, we often feel rivalries with, and try to distinguish ourselves from, those who inhabit the other bodies we see around us. Although strong trust is possible in this case, it is not our default. This suggests that em clans seeking to encourage within-clan loyalty and trust may prefer clan members to interact with each other primarily via "in my head" voices, avoiding vividly seeing each other as inhabiting bodies "outside" themselves. Religions today often use a similar talk-to-God-in-your-head strategy to encourage trust in God.

A talk-to-clan-in-head habit can be further encouraged if clans offer real-time life-coaching services to their members. Clans could maintain panels of advisors who monitor members, always ready to answer questions and give advice. This advice could be based on statistics of what other copies have experienced when taking similar actions in similar situations.

Of course this doesn't mean that clans always recommend the locally best option for any one situation; clans also want members to sometimes explore other options. When a clan gives advice that is designed to explore, instead of being the best reaction to a particular situation, clans might not tell members this fact at the time. After all, doing that could reduce em motivation to follow such advice. However, the fact that a recommended option was chosen for exploration purposes might be revealed later, to help everyone evaluate the quality of this em's actions.

Such simple statistical advice works better for em copies than it would for humans today. This is because ems in the same clan are much more similar to one another than comparable humans, and act in more similar situations. Such advice also works better for ems from larger clans, and for ems with mass-market jobs filled by many similar workers.

For example, consider the case where two ems are a couple, and there are many other copies of that same couple. Each such em in a couple is better able to read the mood and reactions of their partner, because they could compare their personal situation to the mood and reactions found in thousands of other copies. For example, if your partner was in a bad mood today, you could compare his or her mood to those of thousands of copies to better pinpoint the cause of that mood. Excuses such as "the rain gets me down" won't work if hundreds of other copies aren't depressed during the rain.

Ems may be discouraged by reminders that many similar copies exist, as this may make them feel less unique and special. If this is the case, advice based on outcomes experienced by similar copies may be abstracted from those copies, but not refer to particular cases. The advice might not even be very conscious, but instead be communicated via vague feelings of comfort or discomfort with various options.

Just as the decisions of small teams seem today to be consistently more rational than individual decisions (Sutter 2005; Rockenbach et al. 2007), ems advised by their clans probably make more rational decisions as a result. Thus the frequent use of such advice may greatly reduce the extent to which em behavior is well described by "behavioral" theories that deviate from "rational" theories of human behavior (Barberis 2013). While such behavioral theories capture important elements of human behavior today, in a more competitive world of ems who often obtain clan-based personal coaching, em behavior is likely to become more "rational" in the sense of more effectively pursuing actions to achieve practical aims.

Of course ems may not like how they feel when they act rationally. Also, the clan advice habit may make it harder to keep secrets limited to one em; if you tell something to one clan member, you may have told them all.

Ems that often meet other similar copies in person may also feel discouraged and less motivated, seeing themselves as less unique or important. To avoid this, similar copies may avoid meeting or hearing about each other. As an analogy, while some of us today believe that very close copies of us exist in parallel quantum worlds, this rarely influences our mood, because we never actually see or interact with these parallel world copies. By choosing to only rarely meet similar copies, ems may similarly keep themselves from feeling discouraged by the existence of many similar copies.

As discussed in Chapter 19, Managing Clans section, clans may want to discourage open direct expressions of disagreement between members, to promote a common identity. Encouraging ems to instead express their internal clan disagreements via prediction markets may help with this. For example, instead of arguing directly with each other about whether this is a good time to change how they train young clan members, they might each bet privately on future revenue given different training choices. Here conversation is used less as a tool for changing opinions, and more for bonding and other functions.

Like ordinary humans, in conversation ems try to seem witty, charming, informed, etc. While individual humans today mostly have to construct their own clever conversations, ems could get conversational assistance from their clans. Clan coaching like this, however, may make it harder to signal loyalty to specific associates. Such associates may thus prefer to vary their conversation topics and leisure activities away from common topics and activities, to make it harder for clans to usefully coach members on individual behavior. This forces ems to rely more on, and to reveal more of, their distinct individual characteristics when they befriend particular associates on particular teams.

The clan advice that an individual clan member is given via internal conversations in its head typically represents broader issues and priorities, compared with the immediate considerations vivid in the mind of that individual. In the language of construal level theory (discussed in Chapter 2, Dreamtime section), the clan tends to speak more on far issues, relative to near issues. Because of this, clan advice tends more to appeal to em idealism, while the temptation to resist that advice tends to arise from immediate and vivid selfish passions.

In sum, compared with us today, ems have more useful advisors, always on call in their head.

SYNCHRONIZATION

In the em world, a relationship between a copy of Pam and a copy of Bob typically takes place in the shadow of many relations between other copies of Pam and Bob. More generally, most relations between ems from two different clans take place in the shadow of similar relationships between other copies of ems from those same two clans. In fact, there are often many copies of entire teams. In such cases, individuals must choose how much to synchronize the actions within one relation with these other copies and similar relations.

At one extreme, individuals may try to avoid comparison with other relations by avoiding hearing about the other relations, and by acting in unusual ways so as to make their relation be and feel different and unique. At the other extreme, individuals might try to keep the context and content of their relation close to that of other copies of the same relation, to benefit from shared learning and other scale economies.

In highly synchronized relations, events that happen in one copy of the relation are very predictive of events in other copies. For example, if one couple has a fight, the others can suspect a fight soon. Here the sum total of all the information provided to an em by all copies of that em is large. One could not keep shared secrets unless *all* your copies were careful about not revealing clues to your secret.

For example, if Pam and Bob have a relationship, and if a few copies of Bob did something crazy, then all the copies of Pam might worry that their Bobs may soon also do that crazy thing. If one Pam stayed late at a party, and its Bob did not mind initially, this Bob might change his mind if he learned that most of the other Bobs *did* mind. The group of Bobs thus in effect have a group relationship with the group of Pams. Such an arrangement might make each Bob and Pam feel less closely tied to one other. The whole experience may feel strange compared with our relationships today.

Synchronized relationships allow more useful transfer of learning between copies, and more economies of scale in supporting them. For example, synchronized teams can buy the same equipment and tools, arrange them in the same way, and share maintenance and repair services. Synchronized relationships, however, may feel strange and interfere with loyalty within each relationship. Thus the relationships most likely to be synchronized are those that can gain the most from learning opportunities and economies of scale, while those most likely to be differentiated are those where loyalty and natural feelings matter more.

At work, learning opportunities and economies of scale usually matter more, encouraging synchronized relationships. The existence of thousands or millions of copies of a team give those team copies many ways to learn from statistics about events in other teams. This makes it easier to score the performance of each team and member, via comparisons with other teams and members. This also tends to push em team behavior to more closely approximate an informed game theoretic Nash equilibrium, that is, a matched set of strategic behaviors that are less influenced by hidden information regarding the types of participants and the consequences of their actions.

Statistics about other copies of a team make it harder for team members to deceive themselves about their past performance or their chances for future performance. Such ems may become more like chess players today, where objective performance measures (i.e., their rating) force them to accept their current performance and abilities. This tends to make such players less happy, as they can't pretend to be better than they are. If this happiness effect reduced em productivity sufficiently, ems may adopt attitudes such as "never tell me the odds," often avoiding information about their relative performance or chances of future success.

Members of synchronized em teams may be more cautious about bad behavior, knowing that unusual behavior on their part could affect their copies on many other teams. For example, strong conflict within one team might result in that whole team being erased and reverted to a prior version, or replaced with a copy of another team. Of course if the problem reappeared in the reverted copies, they might instead need to resolve their conflict.

Within a cohort of team copies, most of the teams may end periodically to be replaced by the best few teams that are copied many times in a next round. In this case, teams might compete to seem the most productive or innovative, which should more encourage greater internal team cooperation.

Mating and friendship are contexts where local loyalty and natural feelings seem more important than learning opportunities and economies of scale. As mating matters less to an em society than to us, some ems may use mate choice as we often do friend choice today, as a way to express spontaneity and autonomy. That is, some ems may feel constrained in their choice of job, work associates, and location, and so prefer to choose their mates and friends freshly when they can. As such choices would not seem fresh to others if different copies of them consistently made the same choices, ems must be actually unpredictable in their choices, if they want to preserve an appearance of spontaneity.

The degree to which clan members may go out of their way to differentiate themselves from other clan members should not be exaggerated. Today, identical twins who were raised together do not seem to be any more or less different from each other than identical twins that were raised apart (Bouchard et al. 1990). This suggests that ems would also not tend to become substantially more different when their exposure to similar copies increases.

In sum, em relationships can be improved by, but are also complicated by, a context of many similar relations between similar copies.

CHAPTER 26

Society

CULTURE

How might em era cultures differ from prior era cultures?

Today, we can identify many standard dimensions along which cultures around the world vary (Hofstede et al. 2010; Gorodnichenko and Roland 2011; Minkov 2013). For some of these standard dimensions, the world has moved in a relatively consistent direction during the industrial era, and we have good reasons to expect this direction to be more productive in a modern economy. Because of this, we have good reasons to expect that a competitive em economy will continue to select for these cultural features. For example, we should expect more industriousness relative to indulgence, a work relative to a leisure orientation, time orientations that are long term relative to short term and that are tied to clocks instead of relationships, low instead of high context attitudes toward rules and communication, and a loose relative to tight attitude on interpreting social norms.

For other standard cultural dimensions, productivity considerations don't as clearly suggest which direction an em world favors. These dimensions include degree of avoidance of risk and uncertainty, tolerance of inequality, individual or group identity, cooperative or competitive emphasis, and high or low emotional expressiveness.

Today, about 70% of the variation in values across nations is captured in just two key factors (Inglehart and Welzel 2010). These two factors also capture much of the variation in individual values (Schwartz et al. 2012). One factor varies primarily between rich and poor nations: increasing wealth seems to cause more individualism, universalism, egalitarianism, autonomy, and self-expression. These subfactors seem to be more a result than a cause of wealth. With increasing wealth, our values have moved away from conformity to traditional "conservative" farmer-like values, and toward more "liberal" forager-like values (Hanson 2010b; Hofstede et al. 2010). Poor nations tend more to value respecting parents and authority, believing in good and evil, and wanting to protect local jobs. Rich nations tend more to value trust and imagination, and acceptance of divorce and homosexuality. We discuss this dimension in more detail in Chapter 2, Era Values section.

The other main dimension along which values vary today can be described as "East" versus "West." East values tend to be more community oriented, while West values tend to be oriented more to individuals and families. In the East, people are more interested in and spend more time discussing politics, which is more important to them. In the West, families and good health are more important. Rich Eastern nations emphasize achievement, determination and thrift, and accept abortion. Rich Western nations emphasize friends, leisure, ecology, tolerance, satisfaction, free choice, and gender equality. Poor Eastern nations more suspect outsiders, more see children as needing two parents and women as needing children, and they more value technology, money, hard work, and state intervention. Poor Western nations more value work, obedience, religion, faith in God, patriotism, and wanting many children.

Eastern nations have been growing faster over the last half-century, in part because of their emphasis on achievement, thrift, and savings. While the poorest nations tend to drift East in values as they first move from farming to industry, the richest nations tend to drift West in values as they emphasize services and leisure (Minkov 2013). Also, while being close to the equator was good for growth during the farming era, being far from the equator was good for growth during the early industrial era (Dalgaard and Strulik 2014; Fagerberg and Srholec 2013).

It is possible that the first ems will come predominantly from particular nations and cultures. If so, typical em values may tend to be closer to the values of whatever nations provided most of the ordinary humans whose brains were scanned for these first ems.

As ems have near subsistence (although hardly miserable) income levels, and as wealth levels seem to cause cultural changes, we should expect em culture values to be more like those of poor nations today. As Eastern cultures grow faster today, and as they may be more common in denser areas, em values may be more likely to be like those of Eastern nations today. Together, these suggest that em cultures tend to value technology, money, hard work, and state intervention. They may also suggest that em culture values achievement, determination, thrift, authority, good and evil, and local job protection. Of course in a competitive world, values for state intervention and job protection may be suppressed if these substantially reduce competitiveness.

For ems copying and teams become primary units of reproduction and work. As a result, choices about these may acquire the sorts of moral overtones we have today about sex and children. At least they may if human-like minds have enough cultural plasticity to greatly modify our feelings about such issues. That is, ems might develop stronger hard moral feelings about when and with whom it is acceptable to copy and form teams, and when it is all right to leave a team. Perhaps this could be aided by new rituals that help to transfer many of the concerns we now have about sex and children to em copying. For example, before copying a team, that team might have a big party. Maybe the original team comes to the new team's later "birthday" parties.

Both forager and farmer cultures were substantially influenced by the risks that males faced of raising children who were actually fathered by other males. For example, farmers often greatly restricted the abilities of females to socialize with other males. In contrast, em reproduction is asexual and very reliable; there is little chance of mistakenly thinking one was supporting a copy of oneself who was actually a copy of another.

Social relations between em clans are somewhat like social relations in forager bands, where everyone knew everyone's history and basic personality. Em social relations may also be somewhat like social relations in our fantasy and children's stories, such as *The Lord of the Rings*, wherein different species (or classes or races) have very different known personalities and skills and are destined for different kinds of jobs, roles, and social status.

DIVISIONS

Can we anticipate the fault lines along which em culture divide?

We can list some possible divisions, but it is harder to say which of these divisions actually matter the most to ems, or more often form the basis of political and other social coalitions. The existence of a great many kinds of similarities along which political coalitions can be built makes it hard to predict the actual political coalitions that are important at any one time and place. This is one reason why it is hard to predict future political outcomes, as outcomes often depend on which coalitions temporarily dominate.

However, we can at least identify *some* of the main possible fault lines in an em society. An obvious one is between a majority who work in virtual reality offices, and a minority who work in physical bodies. Virtual reality cultures are tempted to drop habits and conventions that are useful only in physical reality. In contrast, the culture of physical ems likely makes more references to privacy, violence, grime, and unintended death without retirement.

Another important split is between the centers and peripheries of cities. City centers are more expensive but support fast talk with many others. In contrast, peripheries are cheaper, but often require delayed talk. While authorities could monitor activities in city centers well, this becomes harder with more distant activities. So while authorities tend to concentrate in city centers, peripheries tend to house illicit and illegal activities such as mind theft, forbidden tweaks, intellectual property violations, environmental damage, and activities that create catastrophic risks.

A related fault line is between a majority of ems who work in mass-labor markets, and a minority who work in niche-labor markets. As discussed in Chapter 19, Mass Versus Niche Teams section, mass-market ems mostly socialize within teams, and the existence of many teams makes their lives predictable. In contrast, niche-market ems are more often copied individually in response to new work demands. Niche ems have more complicated social worlds because of less synchronized copying of friends and lovers.

Em clans may also naturally split between those who remember our era, and those who do not remember the human-dominated past. The latter ems are likely to be better adapted to the em world, but the former will have locked in many first mover advantages to gain enviable social positions. Em clans might also split by size, between a few huge powerful clans and a great many smaller weaker clans. The few very large clans probably feel superior and favor each other, leading to resentment and accusations of bias from the smaller clans.

A related distinction is between the firms, buildings, and cities where most capital is owned by ordinary humans, and other firms, buildings, and cities. Humans start out owning most capital, but their fraction of capital gradually declines until it becomes a minority.

Em cities, firms, and clans will also probably inherit cultural divisions from those that exist today in our world. That is, ems' differences may continue to reflect variations between the nations, ethnicities, religions, and professions of our world. Allegiance to the different sports, teams, artists, artistic genres, and fashions of today may even continue.

Another division is between rich and poor clans; some clans are rich enough to own a lot of capital in many ventures, while other clans own much less capital. When rich clans choose some of their members to be relatively poor, those poor ems may not seem to count as truly poor to ems from less-wealthy clans. This is similar to a rich person today getting little sympathy for choosing to spend a month living simply at a monastery.

Wealth and poverty feels more personal in an em world. That is, each of the few rich clans have a personal story about how they got their wealth, and conspiracy stories are easier to spin about how they became rich or poor. Furthermore, such conspiracy stories are more often true, in the sense that em success will often come in part from coalitions of em clans who conspire to support each other.

Em clans could also split by gender; female and male clans may have different typical speeds, professions, investments, and styles of internal governance. Regardless of gender, em clans may divide according to their styles of internal governance. Some clans may disapprove of the governance style of other clans, calling them immoral, unfair, exploitive, delusional, etc. Em culture may also split between places where individual loyalties are primarily toward clans, and places where individual loyalties are primarily toward workplace teams and firms.

Two more possible divisions are based on age and birth cohort. Today, our children tend to be segregated by age, and to develop cohort-specific cultures, by experiencing the same world events and fashions at the same ages (Howe and Strauss 1992). Ems who are the same age or copied at the same time, however, may have run at different speeds at different points in their lives, and so not experience the same world events and fashions at the same subjective ages.

Thus ems will less divide by age or birth cohort, and more by particular trajectories of speeds over time. Ems can divide clearly by life stage, however. For example, subsidized young ems in training are quite different from older ems at peak productivity and fully paying for their existence, who are quite different from retirees. Most em experience is in working ems at peak productivity ages.

Ems are also plausibly divided by their differing speeds. Different speeds likely have distinct cultures. It is hard for fast changing elements of em culture, such as clothing or music fashions, to synchronize their changes across different mind speeds. Such coordinated cultural changes might seem intolerably slow to fast ems, or intolerably fast to slow ems. Fast changes in a slow culture may be driven by the lower frequency changes in the fast culture. Differing speed ems may also segregate into different classes, with faster ems seen as higher status.

Like people throughout history, ems may also divide geographically. The time delay to send signals to distant cities probably doesn't contribute much to this, but trade barriers and distrust of distant city-states might allow for substantial cultural divergence. Ems may also divide by religion or ideology, as we do today. And ems will naturally divide by industries and professions, as these are important distinctions in the em world.

Em cities may be distinguished by whether they are primarily water or air-cooled, as that choice is likely to influence many other physical choices in em city design. Cities of the same type are also likely to be geographically clustered together.

A larger total em population should also lead us to expect more cultural fragmentation. After all, if local groups differentiate their cultures to help members signal local loyalties, then the more people that are included within a region, the more total cultural variation we might expect to lie within that region. So a city containing billions or more ems could contain a great many diverse local cultural elements.

An em world can split apart in many different ways, just as can our world.

FARMER-LIKE

Poorer ems seem likely to return to conservative (farmer) cultural values, relative to liberal (forager) cultural values. After all, farmer values helped to pressure farmers into the alien-to-forager behaviors that the farming world required, and such values could also help pressure ems to adopt the also alien-to-foragers behaviors that the em world requires. In the industrial era, we have felt such pressures less as our wealth has increased our safety buffers, leading to a pro-liberal trend over recent centuries (Hanson 2010a). But ems are poorer and feel more strongly the competitive and conformity pressures and fears that farming culture learned to exploit.

Today, liberals tend to be more open-minded, creative, curious, and novelty seeking, while conservatives tend to be more orderly, conventional, and organized. If, relative to us, ems prefer farmer-like values to forager-like values, then ems more value things such as self-sacrifice, self-control, religion, patriotism, marriage, politeness, material possessions, and hard work, and less value self-expression, self-direction, tolerance, pleasure, nature, novelty, travel, art, music, stories, and political participation.

These are all weak arguments, which can support only weak predictions about the em world; each of them can plausibly be overridden by other stronger considerations. Even so, let me note more such predictions.

If ems are more farmer-like, they tend to envy less, and to more accept authority and hierarchy, including hereditary elites and ranking by gender, age, and class. They are more comfortable with war, discipline, bragging, and material inequalities, and push less for sharing and redistribution. They are less bothered by violence and domination toward the historical targets of such conflicts, including foreigners, children, slaves, animals, and nature. As em children are rare and often pampered, violence toward children seems unlikely unless it is useful for training.

Today, people who do the folllowing jobs tend to lean liberal: professor, journalist, writer, artist, musician, psychiatrist, teacher, trainer, fundraiser, cook, bartender, lawyer, software engineer, and civil servant. In contrast, those who do these jobs tend to lean conservative: soldier, pilot, police, surgeon, priest, homemaker, farmer, exterminator, plumber, banker, insurance broker, sales, grader, sorter, electrical contractor, car dealer, trucker, miner, construction worker, entrepreneur, salesman, gas attendant, and non-academic scientist (Hanson 2014; Edmond 2015).

A more conservative world has values and styles more in common with conservative jobs. Liberal jobs today tend more to be about talking, persuading, and entertaining, while conservative jobs today tend to focus on a fear of bad things, and protecting against them. Thus farmer-like ems talk and entertain less, and they more expect and prepare for big disasters, such as the big farm-era disasters of war, famine, and disease. Leaders lead less by the appearance of consensus, and do less to give the appearance that everyone has an equal voice and is free to speak their minds. Fewer topics are open for discussion or negotiation.

Farmer-like ems have a stronger sense of honor and shame, enforce more conformity and social rules, and care more for cleanliness and order (Stern et al. 2014). Em virtual realities make it much easier to live in clean and orderly spaces, and in addition, ems may place a higher priority on having clean and uncluttered designs for their systems and organizations. Also, clan and computer-based decision assistants should make it easier to obey complex social rules, and to detect when others are violating such rules. Even so, as discussed in Chapter 25, Swearing section, em working-class culture often has strong emotional profanity, insults, and teasing.

For farmer-like ems, work matters more culturally than it does today; ems spend more of their time at work, invest more of their identity in work, submit more to workplace ranking and domination. Ems find great nobility and satisfaction in their work, and may find it hard to understand why we denigrate work so often today.

Today, some kinds of music, clothes, and interior decoration are designed specifically for work, or specifically for leisure. Most are designed so that they can function reasonably well in both environments. For more work-focused ems, the design of such objects puts more emphasis on work relative to leisure. For example, em music is designed more to facilitate a relaxed office, and less to accompany dancing and parties.

While farmer-like ems seem inclined to support traditional values like marriage and heterosexuality, for ems sex and family lose the central roles they had in previous eras as primary units for organizing reproduction, work, and other social relations. For ems, sex mainly matters for leisure and bonding. However, given how deeply sexual feelings are embedded in human psychology, sexual pair bonds probably remain common and important.

While we have weak reasons to expect ems to be more farmer-like, it is far from obvious that this will actually happen. Even so, we have collected many useful if weak predictions that follow from this premise.

TRAVEL

Farmer-like ems place less value on talking with, visiting, and moving to different cultures and communities. Even so, such travel and talk may be common among ems if it is cheap. At typical kilo-em speeds, ems could travel instantly across cities, and could talk across the Earth with signal delays of only a few subjective minutes.

Today, exotic places to visit are becoming harder to find, because scale and network economies are encouraging most societies to adopt similar products, services, and habits. The main differences that remain are those adapted to differing circumstances, such as divergent climate or wealth levels. Because their relevant environments are more similar, em economies around the world will probably be even more similar than ours are today.

The differing circumstance most likely to create exotic places to visit is different speeds. It will be cheap in time, money, and security to speed up temporarily to visit the typically higher status faster cultures that are nearby. While it is also cheap to see detailed recordings of life in the typically poorer slower cultures nearby, actually experiencing slower cultures directly for moderate subjective periods is expensive in terms of the opportunity cost of time back in one's home culture. Cultures at a great spatial distance, such as in outer space, are also expensive to visit for the same reason.

Today, locations that house high status people often go out of their way to make it hard for low status people to mix in with residents there. So em areas holding mostly fast high status ems may create artificial barriers to discourage visits from slower ems, and create clear marks to distinguish such visitors during their visits.

Instead of traveling to visit different cultures, ems might be more interested in visiting, or temporarily trading places with, close copies of themselves in other teams. They may also want to visit more distant copies who fill rare glamorous roles, such as in science, innovation, the arts, or social activism. Glamorous copies may even hire directors to edit personal "movies" about their lives that other copies could experience, perhaps including shallow mind reading records. The most interesting subject to most people is, after all, themselves.

In general, ems seek leisure activities that achieve such key purposes as providing a change of pace, a sense of personal control, a relaxation of the usual pressures, and a strengthening of key social ties, while still being as productive as possible. Refresher training courses may be another kind of productively useful leisure.

In general, there are two reasons to want to do something different: being tired of what one has been doing lately, and having something else in particular one has been itching to do. Ems can satisfy both of these desires while still supporting current work clients and colleagues. Ems that are not maximally fast who want a change of pace can try something different at a much faster speed, returning to work soon enough to leave only a small break in their service visible to existing clients. Ems seeking to do a particular new thing might split off a new copy to do that activity, a new copy who then reports back to the original in detail, perhaps also with a movie covering the key events.

In sum, ems can travel more easily than we can, but we cannot now tell how much they will actually want to travel.

STORIES

Our ancestors long ago developed the ability to "reason," that is, to draw conclusions by considering both supporting and opposing arguments. However, this ability was not designed especially well to draw valid or statistically accurate inferences in a wide range of typical situations. Instead, it was apparently designed more for persuading and impressing during conflicts with rivals, especially in situations where some people were suspected of violating social norms. This explains many otherwise puzzling features of our reasoning abilities (Mercier and Sperber 2011).

Similarly, our ancestors long ago developed the ability to tell stories, that is, to summarize a set of related events. However, like our reasoning ability, this storytelling ability was not designed especially well to accurately represent causal relations and likely outcomes regarding events in a wide range of typical situations. Instead, our anecdotal abilities seem designed more for persuading and impressing during conflicts with rivals, especially when we suspect some of violating norms.

Because of this, we prefer stories with unrealistic levels of conflict, moral violations, justice regarding such violations, correlations between good character features, and events explained by character motivations. These preferences seem deeply embedded in human nature, and thus seem likely to continue in em stories.

Compared with us today, ems are likely to have more compelling stories to tell about their personal life history, and this is likely to help ems feel that their lives have more meaning. After all, early em clans will have a detailed personal story about the original human that started the clan. Then each highly copied peak-productivity em will have a dramatic training history wherein they succeeded against long odds. Also, as training plans are chosen to produce high variance in training success, these training periods may contain many unusual and exotic experiences.

Today, our stories tend to take place in environments that are more like our ancestors' situations, relative to our current environments. So stories tend to focus on smaller organizations and on physical abilities, and they happen in times and places with more travel, nature, and leisure. This trend likely continues in an em era. So em stories are often set in our industrial world, as well as in the worlds of farmers and foragers, although such stories are often allegories for issues in the em world.

For farmer-like ems, em stories tend more to be about work, relative to leisure. (Today, the vast majority of our stories are about leisure.) Being more focused on work as opposed to leisure, ems spend less time consuming stories. But ems still enjoy stories, to relax, distract, gain perspective, and affirm social norms. Em stories are better than ours, because their larger economy allows more resources to be invested in inventing and honing stories. And as we shall soon see, em stories are actually more important economically, because they are a bigger part of the marketing of labor suppliers.

The stories that most inspire people today may not seem very related to the main features of the em world, and the main situations found in an em world may not seem to us to be very promising settings for stories. However, different eras emphasize different kinds of stories. Farmer and forager eras each had stories designed to inspire their residents, stories that affirmed their key values, stories that they liked more than we do. The em world similarly has stories, music, and other art that affirms its values, attitudes, and conflicts, which ems like more than we would, if we could hear their stories.

Yes, we often find meanings in our lives via the stories we tell about ourselves. But stories are created, not discovered. We craft meaningful personal stories by choosing a few focal events out of the mass of arbitrary details that make up our lives. Thus good storytellers can construct compelling stories out of a wide range of situations and events. If the lives of ems don't seem to you as fertile soil for growing compelling stories as your world does, that may be simply because you live in the industrial era, and hear its stories. If you lived in the em era and heard its stories, you might well find them to be quite engaging.

Em stories predictably differ from ours in many ways. For example, engaging em stories still tell morality tales, but the moral lessons slant toward those favored by the em world. As the death of any one copy is less of a threat to ems, the fear of imminent personal death less often motivates characters in em stories. Instead such characters more fear mind theft and other economic threats that can force the retirement of entire subclans. Death may perhaps be a more sensible fear for the poorest retirees whose last copy could be erased. While slow retirees might also fear an unstable em civilization, they can usually do little about it.

Action stories today often find awkward excuses to turn off power or communications, to isolate characters and force them to be ignorant of important context. Such tricks will be increasingly unacceptable. In a world allowing constant universal communications, plausible drama can only rarely depend on ems being unable to talk to one another. Similarly, in a world where most everything is tracked and authenticated, drama can only rarely depend on losing track of things, on hiding from people, or on mistaken identities.

Today, "fast-moving" action movies and games often feature a few key actors taking many actions with major consequences, but with very little time for thoughtful consideration of those actions. However, for ems this scenario mainly only makes sense for rare isolated characters or for those whose minds are maximally fast. Other characters usually speed up their minds temporarily to think carefully about important actions.

The typical conflicts in em stories will likely resemble typical conflicts in em lives. So stories will include cities competing for world prominence, firms competing for market share, teams contesting to win labor-market niches, pair bond alternatives vying for affection, and clans competing in city politics, in professions, and to place members on teams. There are also conflicts within individuals between their loyalties to clans, firms, professions, teams, friends, and mates. Stories about conflicts between very close copies are probably rare, however, as are stories today about conflicts between the same person on different days.

In general, stories vary in whether they emphasize the setting, the events that happen in that setting, character features and life roles, or information that readers unearth about all of these things. During the industrial era character-focused stories have risen greatly in status to become the most respected (Card 2011). But as farmer-like ems may be less self-indulgent and less able to change their life roles, they may like character-focused stories less. Thus em stories may emphasize story settings, events, and the information that characters discover.

CLAN STORIES

Today, most stories are about standard known ethnicities, standard animal species, and standard human demographic and personality types, not imaginary ones. But most of our stories are about imaginary individual people, because each of us only knows a tiny fraction of all the people who currently exist. As foragers all knew the same people, their stories could have been about known individuals, except for the fact that the best forager stories changed too slowly to adapt to each new generation.

As em clans are long lasting, and em stories can change rapidly, em stories likely refer often to standard known em clans. A story with a George in it is about the standard em George character that all ems know. Em clans come to be known for their distinct personalities and skill sets, much as different species do in classic children's stories, or different races do in classic fantasy stories. Em grade school classrooms may even be decorated not just with the periodic table and a map of their geographic region, but also with diagrams showing the main em clans and their relations, and professions.

Today, the stories that we tell about the origin of important institutions and features in our society must give a lot of weight to abstract social forces, even though we stress the role of particular individuals such as inventors, politicians, and generals. For ems, such stories can be more naturally told as driven by the particular inclinations and alliances of particular clans. Such stories tend to make some clans look heroic and other clans villainous.

Thus em stories make heroes and villains out of real em clans, and influence expectations about which clans are most appropriate for which roles in em societies. So em stories tend to be more political; there are fewer stories that *all* ems can embrace as good stories.

The fact that stories can create favorable impressions of clans induces clans to hire storytellers to create compelling tales favoring their clan. The em economy tends more to favor clans with vivid and distinct personalities that can produce memorably engaging stories. This is similar to how our economy induces firms to hire storytellers to create favorable advertising stories, and how firms with more engaging stories become more profitable.

This isn't to say that most em stories are constructed for propaganda purposes. Ems still enjoy the kinds of stories that we most enjoy, and still like stories to differ from reality in most of the ways that we now like. As discussed earlier in Chapter 3, Biases section, fictional events tend to be driven less by accidents and more by individuals in overt value-driven conflict. Fictional characters have more pronounced features, have attitudes more predictable from their history, better understand the reasons for their actions, actions that are more driven by basic values, are more willing to risk conflict to achieve their values, and have actions more predictable from a story's context.

Em villains sometimes represent the interests of cities, firms, or clans that are intended to be seen as rivals to the story audience. But compelling story villains must also violate key social norms. Thus em villains tend to violate em social norms, which differ in many ways from norms today.

In sum, ems still have stories, which are even more political than are our stories.

CHAPTER 27

Minds

HUMANS

It tends to be easier to make social predictions about the middle of a distribution of characteristics, than about the tails of such a distribution. For example, it is easier to predict the typical time spent sleeping or eating, and the typical style of such activities, than the maximum or minimum time spent in such activities, or the styles of sleeping or eating done by those who spend an unusual amount of time in these functions. This is in part because when scenarios can differ according to a great many variables, this high-dimensionality creates a lot more detail to specify about the tails (i.e., extremes) compared with the middle of a distribution. This is also in part because hard-to-anticipate factors often have disproportionate effects on distribution tails.

As ordinary humans are on the periphery of the em society, such issues make it harder to make predictions about humans in an em society. Even so, we should try.

Ems are so fast that humans will only experience days in the time that a typical em experiences years. This suggests that during the entire em era humans will only achieve modest psychological and behavioral adaptations to the existence of ems. The human world will mostly look like it did before ems, except for a limited number of changes that can be made quickly.

Ems being faster than humans also suggests that most substantial changes to human behaviors during the em era are driven by outside changes, rather than from within human society. Relevant outside changes include wars, changing prices such as wages, interest rates, and land rents, and an explosion of new products and services from the em economy.

Because ordinary humans originally owned everything from which the em economy arose, as a group they could retain substantial wealth in the new era. Humans could own real estate, stocks, bonds, patents, etc. Thus a reasonable hope is that ordinary humans become the retirees of this new world. We don't today kill all the retirees in our world, and then take all their stuff, in part because such actions would threaten the stability of the legal, financial, and political world on which we all rely, and in part because we have many direct social ties to retirees. Yes we humans all expect to retire today, while ems don't expect to become human, but em retirees are vulnerable in similar ways to humans. So ems may be reluctant to expropriate or exterminate ordinary humans if ems rely on the same or closely interconnected legal, financial, and political systems as humans, and if ems retain many direct social ties to ordinary humans.

Few ordinary humans can earn wages in competition with em workers, at least when serving em customers. The main options for humans to earn wages are in direct service to other humans. Thus individual ordinary humans without non-wage assets, thieving abilities, private charity, or government transfers are likely to starve, as have people throughout history who lacked useful assets, abilities, allies, or benefactors.

In our world, financial redistribution based on individual income has the potential problem of discouraging efforts to earn income, and thereby reduce the total size of the "pie" available to redistribute. In an em economy, however, where most all humans are retired, this problem goes away; there are fewer incentive problems resulting from financial redistribution between retired humans.

Ordinary humans are mostly outsiders to the em economy. While they can talk with ems by email or phone, and meet with ems in virtual reality, all these interactions have to take place at ordinary human speed, which is far slower than typical em speeds. Ordinary humans can watch recordings of selected fast em events, but not participate in them.

Although the total wealth of humans remains substantial, and grows rapidly, it eventually becomes only a small fraction of the total wealth, because of human incompetence, impatience, inattention, and inefficiency. Being less able than ems, humans choose worse investments. Being more impatient, they spend a larger fraction of their investment income on consumption. Fast ems are even more psychologically impatient, but they are more strongly embedded in institutions such as clans that limit independent action.

Being outsiders, humans attend less carefully to their investments in the em economy. This makes them absentee owners, who generally earn lower rates of investment return than do active and attentive owners. Today, privately held firms are consistently more responsive to changes in investment opportunities, and as a result earn on average a few percent per year higher returns than do public firms (Asker et al. 2011, 2015). While private investors suffer from lower liquidity and higher risk in private ventures, over time such investors still tend to accumulate a larger fraction of total wealth (Sorensen et al. 2014).

Some ordinary humans may own their own land and produce their own food on it, and so need to buy little from the em economy. Even so, a need to pay property taxes to em governments for "protection" could force such humans to slowly sell off their lands to pay such taxes. For example, if you paid for a 5% tax on the rental value of your property by selling off slices of that property, your property holdings would fall by half for every 20 real doublings of fully reinvested funds.

When humans only own a small percentage of wealth, this may help protect them from direct expropriation by ems. If ems interact with humans via the same institutions of finance, law, and politics that ems use with each other, then expropriating humans' property could threaten the reliability of the social institutions that ems use to keep the peace with each other. This may not be worth the bother to acquire such a small fraction of wealth.

This protection of human assets, however, may only last for as long as the em civilization remains stable. After all, the typical em may experience a subjective millennium in the time that ordinary humans experience 1 objective year, and it seems hard to offer much assurance that an em civilization will remain stable over 10s of 1000s of subjective em years. But slow em retirees may at least make good allies with humans in efforts to encourage stability, as the possibility of instability in an em civilization may also be the main threat to retiree longevity.

Basic changes in which property institutions are efficient for ems might adversely affect humans. This is similar to when farmers enclosed what were once forager common lands, and similar to a possible abandonment of music copyright in our world as a response to ease of copying and sharing.

Those who relied on old kinds of property can lose out when such property no longer exists.

A few objective years after an em transition, the em economy may be thousands to billions of times larger than when it started, but the population of humans *must* stay essentially the same as before, unless revolutionary new methods are found for making new humans very fast. Because their investments double at nearly the rate that the economy doubles, ordinary human wealth doubles roughly every objective month or faster, greatly encouraging humans to save. This wealth can buy increasingly elaborate mansions, flying cars, and much else, although not real estate near em concentrations. Compared with serving em customers, transport of products to ordinary humans is expensive, and innovation of products targeted for humans is probably slower.

Even impoverished humans may still own a lot of wealth, relative to the cost of living as a retired em. For example, physical human bodies have valuable raw materials. Also, ordinary humans may become increasingly rare celebrities, which ems pay to visit. Such people may be scanned just for their rare historical value. When scanning costs are low enough, wealth levels that make a human poor, could make an em rich. Poor humans may have the option to switch from a life of poverty as a human to a life of leisure and comfort as a retired em. This possibility limits em sympathy toward poor humans.

Ems may envy humans their wealth, leisure time, and more direct connections with nature, both human and otherwise. But as ems have such high abilities, they are likely to associate the styles and habits of humans with low competence. Ems may go out of their way to distinguish their styles and mannerisms from those of humans. Ems may treat humans more with sympathy, and ancestral gratitude, but less with respect. They may even routinely mock humans. For example, just as brain emulations may be called "ems" for short, humans may be called "ums" for short, as this is part of the word "human" and also insultingly describes a common scenario of human befuddlement when interacting with smarter faster ems. Humans may also be mocked for their squeamishness regarding em death.

To varying degrees, humans today identify with and care about their status as the central drivers of change in the world and as being essential resources for enabling such change. An em world moves humans off of this center stage, and humans may be unhappy and discouraged by this. After all, seeing you and your friends as the center of the universe can be motivating and invigorating.

In sum, humans are no longer at the center of the world's story during the em era. But they are still around, mostly living comfortably as retirees.

UNHUMANS

So far I've assumed that while the characteristics of ems may differ systematically from those of ordinary humans, em features still fall near a familiar human range. However, one of the deepest fears often expressed about future creatures like ems is that their features might move far outside of a human range (Bostrom 2004). Especially common and deep are fears that ems might be inhuman—cold and cruel, lacking empathy or kindness.

Note that as a word, "inhuman" is usually synonymous with "savage" and "barbaric," words which mean "lacking complex or advanced culture" and "primitive, unsophisticated." This suggests that what people mainly fear are creatures who, even if they are very human, treat people like us with hostility or indifference. That is, we fear "inhuman" creatures because we fear they are more likely to take on such hostile attitudes.

As discussed in Chapter 29, Policy section, for this issue it probably matters more that ems rely on shared institutions of law and politics. It matters less whether ems feel personal empathy toward individual ordinary humans, or whether ems retain most human features. Even so the following remain valid questions: how inhuman might ems become, and how much could these changes matter?

The prospects for big changes in em minds seem limited by two key factors: how big is the space of possible em minds that can be searched, and how rare are useful designs within that space. If the space is small or useful designs are rare, then there may be few useful changes, or they may take a very long time to find. In which case during the em era that I consider, em minds won't differ that much from ordinary human minds. On the other hand, if the space of possibilities is large and if useful designs are common and easy enough to find, then a Darwinian or related selection process may quickly find many big useful changes that ems can make. In this case em minds may quickly come to differ much more from ordinary human minds.

Of course we may still value those em minds, perhaps even more than our own, if they are *understandably* different from humans, and if we respect the qualities by which they differ. For example, we might respect ems who are much more intelligent, creative, cooperative, and empathetic than we are, but are otherwise similar to us.

It may be hard to find cost-effective changes in human mind design. For example, one desirable feature in a mind is that it never forgets or misremembers anything. It may be possible to create minds that achieve this merely by completely recording all of their experiences. However, such minds may not be able to learn or abstract much from these recorded experiences. After all, the process that lets humans learn and abstract from their experiences seems to introduce changes to our memories. There may be no modest change to human minds that achieves both useful abstraction and perfect recall.

More generally, while we can envision many competitive pressures in the em world to encourage better minds, the size and complexity of human minds makes it harder to envision big rapid changes that can greatly improve some aspects while still retaining their other many important functions. We expect big changes when large competitive advantages are feasible with only modest mind modification, but not when only small competitive advantages require great changes to well-entrenched aspects of human mind design.

As an analogy, consider that it is today much easier to make basic structural changes to small software systems, compared with big software systems. It is also easier to make structural changes to bicycle designs, compared with a city design. This is not because large software systems or cities are badly designed, or because their designers have poor incentives to design them well. Instead, the issue is that cities and big software systems are harder to predict and already embody a great many design choices adapted to one another and to system environments. To be useful, most basic structural changes to a city design would require expensive re-tooling of a great many other interdependent choices.

While such costs of change are lower for software that has a good modular design, such modularity is usually harder to achieve for larger software systems. If, like a city, the human mind has a great many parts well adapted to one another and to its environment, with only modest design modularity, then it will also be hard to find big structural changes to the human mind that preserve key functionality. The biggest feasible changes may allow only modest changes to basic human mind design.

Ems could differ from ordinary humans in both capacities and inclinations. Ems might both add capacities that ordinary humans lack, and lose capacities that humans once had. When we have added capacities in the past, such as tools that let humans see in the dark, such changes haven't been seen as taking away much from our humanity.

Thus the concern here mainly seems to be ems losing pre-existing human capacities. So let us consider that now.

PARTIAL MINDS

When we say that some humans are smarter than others, we assume that human mental abilities correlate strongly across tasks. That is, those who are better at one mental task also tend to be better at other mental tasks. This could be plausibly caused by the fact that human brains use many brain subsystems to complete each task. Even if subsystem abilities are completely uncorrelated, so that having a higher quality version of one subsystem says nothing about the quality of your other subsystems, the fact that each tasks needs several subsystems creates a correlation across task abilities (Hampshire et al. 2012).

If most mental tasks make use of a great many mental subsystems, then em mind design is only likely to greatly lose the abilities of subsystems which are especially expensive, or which are only used for a few unimportant tasks.

As the cortex region of the human brain seems especially regular, it seems an especially promising place to try to useful size changes. It may even be possible to "pre-load" large sets of useful associations into standard cortex structures that can be moved between em minds.

Human brains devote a great deal of their volume to processing sight and sound. Yet many jobs don't seem to rely much on high-resolution versions of such abilities. Detailed sight and sound perception are thus two obvious candidates for reduced em capacities. To save on brain costs, ems may shrink and simplify their sight and sound processing, at least for jobs that only need limited abilities in these areas. The attractiveness of this strategy depends on how much human brains today recruit these subsystems for other tasks besides sight and sound processing. The more such recruiting, the less ems will find it useful to shrink these subsystems.

A simple assumption is that the brain can usefully shrink by roughly 25-50% via reduced or lost sight and sound processing capacities. Note that an ability to shrink such brain regions while still retaining their basic function, if not resolution, also suggests an ability to expand such regions, and increase resolution. A simple assumption is that ems can make productive expansions of a factor of two to 10 for these regions of the human brain.

A more remote possibility is that some ems may usefully be given a reduced capacity for complex Machiavellian social reasoning, at least if the brain modules that support such reasoning could be identified and isolated. Secure property rights and competition for their services might protect em "nerds" with reduced social abilities from exploitation by others. Alternatively, slave owners may prefer ems who are less able to coordinate efforts to resist them.

A third possibility is that some ems may usefully have reduced capacities for mating and related reasoning, if supporting brain modules for such capacities can be identified and isolated. This seems unlikely, because while ems have little direct need for sex or mating, supporting capacities are likely to be deeply enmeshed with many other useful social capacities. It might perhaps be easier to cut out both mating and complex social reasoning together from the em mind.

More likely than diminished mental capacities are missing *inclinations*. There are many mental features of humans, discussed in this chapter, the Psychology section, that we do not yet easily or fully understand as either functional for most intelligent social creatures, or as features that humans inherited from other mammals. Although ems might be able to laugh, sing, dance, admire art, or have sex, many ems might have reduced inclinations to use or develop such abilities. Such inclinations might, for example, be replaced with stronger inclinations to work. Inclinations to love and want children might be redirected toward inclinations to love and want more nearby clan copies.

It seems unlikely that much in the way of brain changes are required to support such inclination changes. Human cultural plasticity has already been seen in history to be sufficient to support large related alterations in inclinations.

It is possible that ems might be tweaked to be less inclined to feel or express sympathy with ordinary humans or with other ems, in essence becoming more sociopathic. Such ems are more willing to commit crimes, to betray associates, and to violate moral norms. If such ems were common, then an inability to distinguish such ems from other ems could force all ems to trust each other less, and as a result achieve fewer gains from working together. However, the existence of clans eager to protect their reputations should mostly eliminate this problem. Some clans may specialize in gaining a reputation for psychopathic tendencies useful in certain jobs, but most clans are unlikely to want to be known for such tendencies.

Changes in capacities or inclinations may influence whether current or future humans find such changed ems likeable, eerie, or repulsive. But such changes don't seem to matter that much for the analysis in the rest of this book. Most conclusions seem robust to these variations, because the human and social sciences used for analysis in this book are applicable to a wide variety of human-like behavior. For example, while eunuchs are substantially different from other humans, most tools useful for predicting the behavior of ordinary people are also useful for predicting the behavior of eunuchs. Some of our analysis tools, such as modern game theory, seem useful even though they falsely assume that humans are selfish rational strategic agents who never forget or make mistakes.

Some fear that ems by nature lack "consciousness," and thus cannot feel or experience anything, even though they appear in every way to have and discuss such experiences. While this "zombie" scenario seems very unlikely to me, this topic is beyond the scope of this book. Another concern is that even if early ems have consciousness, they might eventually lose it after enough design changes. Even if this is possible in principle, however, a great many mental modules would have to be redesigned and readapted to one another in complex ways to accomplish this. This event seems unlikely to happen within the early em era that is the focus of this book.

In sum, while fears are usually described in terms of loss of human capacities, a loss of an inclination to use capacities seems just as much of a concern, and this is not obviously a larger concern during the em era than it has been during the farmer and industrial eras.

PSYCHOLOGY

The fact that they are emulations of humans probably limits how far and how fast ems can diverge from human nature, even in a very competitive em world.

When systems evolve to adapt to changed environments, and they have special parts on which many other parts depend, such parts tend to become evolutionarily conservative, or "entrenched." That is, such parts tend to change less in response to evolutionary pressures, and they become tied to other entrenched parts, producing a subsystem of self-reinforcing entrenchment (Wimsatt 1986). Such subsystems must often be replaced as a whole, or not at all.

Human minds are also part of larger social, economic, and technical systems, and so many aspects of human minds are entrenched within those larger systems. In addition, the human mind is itself a complex system with many relatively entrenched parts. Plausible candidates for these entrenched parts are the universal human features that seem to be common to human mental styles as seen in all known cultures, even if not always fully displayed in all known individuals (Brown 1991). If these features are also common to all em mind tweaks, they are likely to long be preserved in em mental styles.

We can use some of what we know about the origins of the human mind to guess which mind features are unlikely to change anytime soon. For example, as ems will be intelligent social creatures, some human features very likely to be long preserved in ems are those that are plausibly functional for most intelligent social creatures. These include beliefs, memories, plans, names, property, cooperation, coalitions, reciprocity, revenge, gifts, socialization, roles, relations, self-control, dominance, submission, norms, morals, status, shame, division of labor, trade, law, governance, war, language, lies, gossip, showing off, signaling loyalty, self-deception, in-group bias, and meta-reasoning.

More human features very likely to be long preserved in ems are features that humans share in common with most mammals, features that are likely to be deeply embedded in human mind design. These features include body awareness and control, integration of sight, sound, and smell awareness into a joint representation of the space and time around one's body, and categorizing such spaces and times according to weather, clutter, and mutability.

Features also include common ways to categorize objects, and basic space-time strategies for hiding, watching, searching, chasing, and evading. Deeply embedded mammal capacities also include fear, stress, anger, crying, pleasure, pain, hunger, disgust, lust, sex, jealousy, envy, fatigue, sleep, cold, itchiness, and play. They further include daily, yearly and lifespan activity cycles, face and voice recognition, and behavior specific to the relations of parents, children, siblings, and mates.

Ems will likely preserve well-entrenched standards for a substantial period. Such standards are hard to change when alternates are not much more efficient, and when change requires losing value in many complementary investments. These standards include many common features of human languages, such as subjects, objects, and gendered nouns. They also include standards such as the genetic code, base-10 math, ASCII, metric units, programming languages such as Java, operating systems such as Windows, the English language, and precedents from common and Napoleonic law.

There are other common human features that we do not yet easily or fully understand as either functional for most intelligent social creatures, or as features that humans share with mammals. This lack of understanding makes it harder to guess how likely or long ems may retain such features, although most of them are likely to last a long time. These features include gestures, voice tone meanings, coyness, insults, jokes, music, toys, sports, games, feasts, etiquette, symbols, dream interpretation, mood altering drugs, meditation, magic, luck, superstition, taboo sayings, religion, proverbs, rhythm, dance, poetry, art, myths, fiction, death rituals, and decorative clothes, furniture, and hairstyles. Ems are most likely to drop human styles which are costly, which were only recently embedded in human mind design, which supported functions that are now mostly irrelevant, and where new substitute functions cannot be found for these styles.

Some needs and desires that ems plausibly share with humans seem especially relevant for the rest of this book. These include desires for nearly constant contact with a familiar physical world and familiar associates, daily rest and sleep, frequent informal socializing with friends, frequent direct contact with a few key close intimates, and satisfying stories saying how current activities fit into life-long dreams and ambitions. Ems are likely also to retain human difficulties in remaining mentally flexible with age, in understanding more than one speaking voice at a time, in finding more than a few hundred distinct human personalities friendly and familiar, and in easily and calmly accepting what one sees as one's imminent and total end.

Note that most of these features are capacities. Ems might retain such capacities but use them only rarely.

INTELLIGENCE

As discussed in Chapter 13, Qualities section, we expect ems to be smarter than are most people today. As intelligence is an especially important feature, it seems worth giving special attention to its possible implications.

Note that in the sense of being able to score better on mental tasks in any given time period, a group of people can be "smarter" than any one person. In this same sense, faster ems are typically smarter, as are ems given access to better tools, information sources, and education. As discussed in the Partial Minds section, ems may also become smarter in this sense by expanding their mental hardware, such as by increasing the number or size of many simple repeating brain circuits.

However, we often use a concept of "smart" intended to control for all of these effects. An em is smarter according to this concept if it can accomplish more tasks better even when it has equivalent brain hardware and other resources. Let us now focus on ems being more intelligent in this sense. For example, we expect ems to be smarter than ordinary humans because of stronger selection, in selecting the best from among ordinary humans to scan, in selecting mental tweaks in the emulation process, and in the selection of training methods.

For most economic activity, the most relevant kind of intelligence is team intelligence—whatever common factor best explains the ability of some teams to do many different kinds of tasks better than other teams. A recent study found that group intelligence is better predicted by individual social sensitivity, such as abilities to read internal attitudes from facial expressions and the ability to take turns in conversation, rather than by the average or maximum of individual intelligence as usually defined (Woolley et al. 2010). Compared with individual intelligence, we should be more interested in predicting the evolution of future group intelligence, and we have better reason to expect economic incentives to induce efforts to improve group intelligence. However, as today we have far more data on the correlates of individual intelligence, we are better able to forecast the consequences of increases in individual intelligence, and so that will be the focus of the rest of this section.

As discussed in Chapter 13, Qualities section, smarter people today are less accident prone and more rational, cooperative, patient, trusting, trustworthy, law-abiding, and supportive of efficient policies. Smarter nations are freer, more entrepreneurial, less corrupt, and have better institutions.

We expect individually smarter workers to accomplish more with the same resources, to make fewer and more minor mistakes, to master a wider scope of tasks and skills, to communicate effectively with a wider range of ems doing different tasks, to adapt faster to changing circumstances, and to efficiently learn specific and specialized roles.

How these changing capacities change the mix of em jobs and careers depends on job stability. In more stable slower-changing environments, the gains from making fewer mistakes, and better learning of specific skills, should matter more, allowing a finer division of labor into more specialized interdependent roles. In contrast, in uncertain and rapidly changing environments, the abilities to master more skills, to talk on a wider range of topics, and to adapt faster would matter more. Em organizations that use such polymathic ems function effectively in a wider range of such environments, by having smaller teams of less specialized workers.

Smarter ems are more innovative, have longer lasting careers, and can handle jobs that are redesigned more often. As bosses, smarter ems can simultaneously manage a wider range of subordinates.

All these changes are non-trivial, and welcome, but they do not seem especially radical. They suggest that a society full of creatures smarter than ordinary humans, perhaps even *much* smarter, could be a quite recognizable and understandable society. It need not create a "singularity" barrier to foresight, beyond which we cannot see. However, some people disagree.

INTELLIGENCE EXPLOSION

As mentioned in Chapter 4, Artificial Intelligence section, some people foresee a rapid local "intelligence explosion" happening soon after a smart

AI system can usefully modify its own mental architecture (Chalmers 2010; Hanson and Yudkowsky 2013; Yudkowsky 2013; Bostrom 2014).

In a prototypical local explosion scenario, a single AI system with a supporting small team starts with resources that are tiny on a global scale. This team finds and then applies a big innovation in AI software architecture to its AI system, which allows this team plus AI combination to quickly find several related innovations. Together this innovation set allows this AI to quickly become more effective *than the entire rest of the world* put together at key tasks of theft or innovation.

That is, even though an entire world economy outside of this team, including other AIs, works to innovate, steal, and protect itself from theft, this one small AI team becomes vastly better at some combination of (1) stealing resources from others, and (2) innovating to make this AI "smarter," in the sense of being better able to do a wide range of mental tasks given fixed resources. As a result of being better at these things, this AI quickly grows the resources that it controls and becomes more powerful than the entire rest of the world economy put together, and so it takes over the world. And all this happens within a space of days to months.

Advocates of this explosion scenario believe that there exists an as-yet-undiscovered but very powerful architectural innovation set for AI system design, a set that one team could find first and then keep secret from others for long enough. In support of this belief, advocates point out that humans (1) can do many mental tasks, (2) beat out other primates, (3) have a common IQ factor explaining correlated abilities across tasks, and (4) display many reasoning biases. Advocates also often assume that innovation is vastly underfunded today, that most economic progress comes from basic research progress produced by a few key geniuses, and that the modest wage gains that smarter people earn today vastly underestimate their productivity in key tasks of theft and AI innovation. In support, advocates often point to familiar myths of geniuses revolutionizing research areas and weapons.

Honestly, to me this local intelligence explosion scenario looks suspiciously like a super-villain comic book plot. A flash of insight by a lone genius lets him create a genius AI. Hidden in its super-villain research lab lair, this genius villain AI works out unprecedented revolutions in AI design, turns itself into a super-genius, which then invents super-weapons and takes over the world. Bwa-ha-ha.

Many arguments suggest that this scenario is unlikely (Hanson and Yudkowsky 2013). Specifically, (1) in 60 years of AI research high-level architecture has only mattered modestly for system performance, (2) new AI architecture proposals are increasingly rare, (3) algorithm progress seems driven by hardware progress (Grace 2013), (4) brains seem like ecosystems, bacteria, cities, and economies in being very complex systems where architecture matters less than a mass of capable detail, (5) human and primate brains seem to differ only modestly, (6) the human primate difference initially only allowed faster innovation, not better performance directly, (7) humans seem to have beat other primates mainly via culture sharing, which has a plausible threshold effect and so doesn't need much brain difference, (8) humans are bad at most mental tasks irrelevant for our ancestors, (9) many human "biases" are useful adaptations to social complexity, (10) human brain structure and task performance suggest that many distinct modules contribute on each task, explaining a common IQ factor (Hampshire et al. 2012), (11) we expect very smart AI to still display many biases, (12) research today may be underfunded, but not vastly so (Alston et al. 2011; Ulku 2004), (13) most economic progress does not come from basic research, (14) most research progress does not come from a few geniuses, and (15) intelligence is not vastly more productive for research than for other tasks.

Of course one could still be interested in this book on the em era even if such an intelligence explosion is likely, as long as that explosion might happen after the start of an em era.

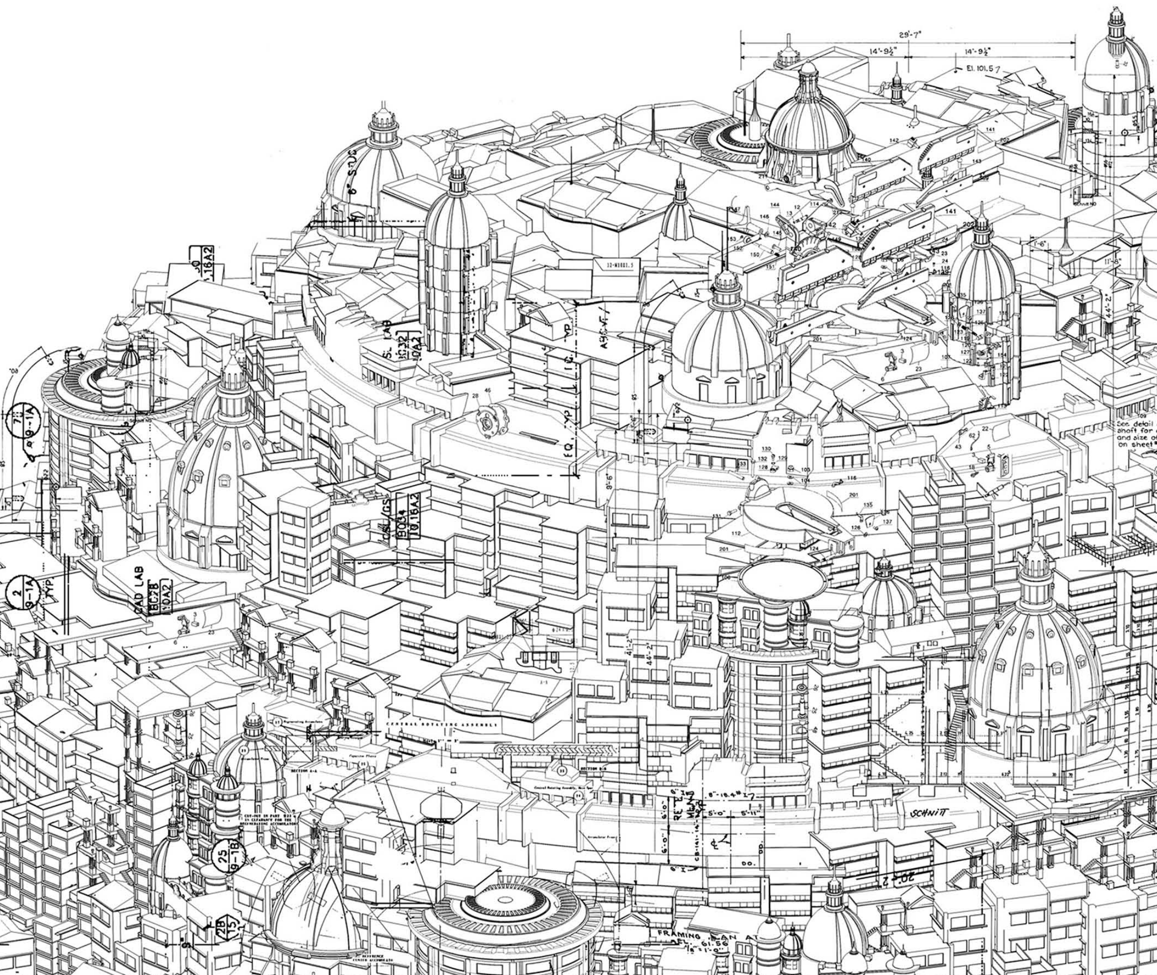
If there is no local intelligence explosion, roughly when should we expect human level AI in an em world?

As discussed in Chapter 4, Artificial Intelligence section, our economy today doubles about every 15 years, and artificial intelligence (AI) experts typically estimate that in the last 20 years in their subfield, we have come 5-10% percent of the way to human level abilities. This suggests that if ems arrive within a century, we would at that point be less than a quarter to half of the way from here to human level AI. Had the ems not arrived, the economy would have needed to double another seven to 20 times to achieve human level AI. So if progress toward AI scales as growth in the economy (as suggested by costs falling with cumulative production (Nagy et al. 2013)), an em economy that doubled every month would take 7 to 20 objective months to achieve human level AI.

This time estimate seems an underestimate for two reasons. First, an em economic growth depends less on innovation and more on growth in inputs. Second, as discussed in Chapter 4, Artificial Intelligence section, in many areas of computer science algorithm gains are typically close to hardware gains, and the rate of computer hardware gains will probably slow in coming decades, relative to economic growth rates. Each of these issues might reduce the rate of AI progress per economic doubling time by up to roughly a factor of two.

These considerations suggest that the em economy might perhaps double up to 30 to 60 times before human level AI appears. This would be a total growth factor of between a billion and a billion billion. At a monthly doubling rate, this might take 2.5 to 5 objective years, which would be 2.5 to 5 millennia to the typical kilo-em. I'm *not* at all claiming that the em era will continue through this many doublings before another very different era appears. I'm instead doing rough calculations to suggest that there could be a long interesting em era undisturbed by the arrival of non-em-based human level artificial intelligence.

PART VI
Implications



CHAPTER 28

Variations

TRENDS

This book has mostly discussed what the em era is like as if that era is stable and never changes. But we expect many changes and trends over the em era.

For example, the size of the em economy grows exponentially, although this growth may fluctuate more than it does today because of concentration in a few key cities. Also, the cost of computing hardware falls exponentially, and with it the energy used per computing operation, and the natural em body size. Parallel computing costs fall faster than serial computing costs, and also faster than the cost of non-computer tools. So there is a trend in workplaces away from using serial computer tools and non-computer tools, and toward using em minds and parallel computer tools. Parallel software becomes more efficient relative to the emulation process, inducing ems to use more software tools.

The cost of communication rises relative to the cost of memory and computing, increasing communication delays, and reducing the rate of travel, meetings, and distances between meeting participants.

As computing hardware is the main em labor cost, em subsistence wages and median wages fall with computing costs. Thus the speed-weighted size of the em population grows even faster than does the em economy. The typical sizes of firms, clans, and cities grow both with the size of the population, and with the size of the economy.

While the first ems run near the speed of ordinary humans, there is an early transition to most ems running at a much faster common speed, estimated in Chapter 18, Choosing Speed section to be within a factor of four of 1000 times human speed. But during the em era typical em speeds may slowly decline, as the growing em economy creates spatially larger em cities which signals take longer to cross.

After an initial burst of exploration, the space of feasible tweaks of em minds slowly grows, but perhaps does not add much value. Added tweaks, random drift in capital per clan, and learning about which clans are best at which jobs should all contribute to a slow increase in the dominance of economy activity by the top few clans. The top clans slowly hold a larger fraction of the jobs, and own a larger fraction of capital.

As the human population changes little during the em era, the ratio of ems to humans rises very quickly, and the em subsistence wage falls quickly relative to the human subsistence wage. While actual em wages stay close to em subsistence wages, human incomes are on average far above human subsistence, and rise nearly as fast as the em economy grows, at least in the absence of severe redistribution away from humans.

While ordinary humans start out owning all of the capital in the economy, the fraction of capital that humans control slowly falls, as discussed in Chapter 27, Humans section. The relative political power held by ordinary humans may fall even faster, as both labor and capital contribute to political power, and ems quickly constitute almost all of the labor force. Ems later acquire most of the local political power, and later still acquire most local capital and wealth. These transitions might induce disruptive conflict.

In sum, we can foresee many plausible trends during the em era.

ALTERNATIVES

I have focused on a single main baseline scenario, and sometimes a few small implicit variations. Let me now give more explicit attention to larger variations.

While this book has discussed war and security, it has mostly assumed peace and the successful protection of property. But what if violence, theft, and war end up being very profitable, as they were during the early farming era? In this scenario, a large fraction of time and income is spent on security, both to attack others and to defend against attacks. The em economy probably grows more slowly, and ems can expect shorter subjective lifespans. The entire em civilization is probably also at more risk of collapse. Relative to our baseline em era scenario, the most copied em clans are better skilled at attack and defense.

The size, location, and specializations of clans, firms, and cities are also distorted in the direction of making such things easier to defend, and better able to launch successful attacks. For example, if it is hard to protect cities against nuclear attacks, cities will be smaller and spread further apart. However, to the extent that there are em enclaves well protected against attack, those probably look more like the scenario described in this book.

In a second variation, we might create artificial general intelligence that is similar to ems, except that it is made via a shallower analysis of higher-level human brain processes, instead of via directly emulating lower-level brain processes as in a classic em. Such variations on ems probably are not greatly redesigned at the highest levels of organization, and thus are relatively human in behavior and style. The main ways these differ from ems is that they probably do not remember being human, they might not run as easily on parallel computer hardware, and they might require a lot less computer hardware. These factors likely make for a more disruptive transition to the em era.

In another variation, progress in non-emulation-based software abilities becomes faster. As discussed in Chapter 4, Artifical Intelligence section, at the rates of progress we have seen so far, software improves slowly enough to allow a substantial early em era during which far more income goes to em workers than to pay for software aids. But if software instead develops faster, the economy more quickly reaches the point where most income goes to pay for software aids and supporting hardware. After that point, the distribution of income is determined more by the distribution of ownership of non-em software.

Yet another variation is clan-specific computer hardware. Instead of having all clans run on the same generic emulation hardware, a large clan might pay to create hardware specific to running minds from that clan. An extra fixed cost of development pays to reduce the marginal cost of running minds from this clan. This advantage, however, might have to be dropped for distant travel, for temporarily switching speeds, and for locating hardware close to other work team members.

Clan-specific hardware reduces the scale economies from em hardware useable by many em clans, and increases the advantages from being in one of the few most popular clans. The increase in fixed costs relative to marginal costs of hardware increases the market power of popular clans in the labor market, and thus somewhat increases the scope for complex multi-clan labor negotiations.

More clan concentration may also result if there are very widely adopted and strongly enforced regulations requiring that new copies be endowed with great wealth. In this case most labor-market niches may be filled by the eager-to-copy clans that are most willing to pay high prices to endow as many copies as possible.

We can also consider a more extreme scenario along these lines, wherein most ems come from only a dozen or fewer em clans. This could happen if tweaks are especially able to change em abilities, or if there are some very capable clans able to learn an especially wide range of skills. In this scenario, global coordination is easier, via deals between clans, and teams and social gatherings typically have many ems from the same clan. More coordination allows more regulation, enabling wider deviations from the baseline scenario of this book.

An opposite variation has em job tasks varying so much that the em economy makes good use of many more pre-skill worker types than estimated in the baseline scenario, and thus requires many more than 1000 or so scanned humans. This results in most workers coming from far more than 1000 clans. In this case, ems less often know the basic personality of other ems they encounter, making em social interactions more like that of our industrial era, where most people don't know each other. Also, as in our era, it is harder to manage em firm and city politics via shifting coalitions of em clans. There are likely still enough copies per clan, however, for clans to usefully give life advice to members. This is in many ways a more familiar scenario.

A related scenario is where clans fragment more strongly into conflicting subclans. If ems who are trained in different professions or who live in different places do not cooperate as strongly together, then subclans may prefer to ally with subclans from other clans with whom they have more in common. This also reduces the importance of clans in politics, finance, and law.

Another variation is where the age of peak work productivity is usefully extended to a subjective millennium or longer. If it takes 10 000 years until an em worker reaches peak productivity, ems will tend to run faster to fit their career into near an economic doubling time. This makes cities smaller and more socially fragmented, with a larger fraction of social interactions having noticeable communication delays.

A related variation is where em brains can be usefully decreased or increased by much larger factors than those estimated in Chapter 27, Partial Minds section (25-50% decreases, and 100-1000% increases). Instead, factors of 1000 or more either way might be possible. This variation likely results in a wider range of intelligence levels in productive ems, and in a wider range of em hardware costs. If so, most actual ems by count, if not by wage, are likely close to the smallest and cheapest possible sizes. This variation lets any given set of initial mind scans usefully fill a wider range of job roles, and so likely reduces the number of clans that come to dominate the em economy.

Yet another variation is where the cost of cooling or some other expense is severe enough in practice to greatly limit em city sizes. In this case the gains of having more ems who can interact easily with many other ems is outweighed by other high costs. There is a larger number of smaller em cities, with most ems living in cities near optimum size. More efforts go into dealing with whatever is the limiting factor to city size, and more growth happens by creating new cities. In this scenario, there is more cultural variation worldwide and a weaker ability of ems to coordinate globally.

A related variation is where computer security turns out to be much harder than estimated in Chapter 5, Security section. What if the computers housing em minds can be more easily and routinely taken over, to steal enclosed minds and gain control of computer resources? In this case, the em economy spends a larger fraction of its income defending against such attacks, via hardware obstacles, active monitoring and reactions, and reducing the value held in any one mind. The threat of mind theft reduces the number of copies typically made of each trained em worker, and em workers are less likely to congregate at firm locations, instead of at clan castles.

In the limit, very reversible computers must be quantum computers. If quantum computing became feasible on large scales, then a few kinds of important calculations could be done faster and cheaper, including factoring, certain kinds of search, and simulations of small-scale physical systems (Viamontes et al. 2005). While this allows and perhaps forces a switch to quantum cryptography, it appears to have little impact on most other forecasts in this book. While it is possible to create quantum states that cannot be copied, this is unlikely to typically be a useful way to prevent mind theft; the many practical gains from easy copying seem too large to forego.

A variation with substantial implications is where some method is found to usefully merge two em minds that had once split from a common ancestor, with the combined mind requiring not much more space and processing power than did each original mind, yet retaining most of the skills and memories of both originals. This merging process is more useful when it is feasible for longer subjective durations from the last common ancestor.

Mind merging is especially useful if a merged mind is less aged, in the sense of having less added mental fragility, than the sum of the aging of the two merged minds since their last common ancestor. The robust and general nature of mental aging and increasing fragility, however, suggests that this is unlikely. That is, the aging of a combined mind is likely to be near the sum of the aging of the merged minds. In this case, there are far fewer useful applications for mind merging. Retirees might merge with abandon, because they are already too fragile to be productive workers, and by merging their minds, retirees can also merge resources and thus afford to run at higher speeds, thus gaining higher status.

Perhaps the biggest variation is global governance sufficiently strong to substantially limit em population growth, and hence to raise em wages well above what they are in the baseline scenario. While raising wages modestly, perhaps by less than 50% above competitive levels, seems more feasible via local coordination, raising wages by a factor of three or more seems to require coordination at the largest scales at which em societies might compete economically or militarily. Smaller-scale coordination to greatly raise wages mainly just places the covered smaller regions at a competitive disadvantage to other regions.

Effective laws to raise wages probably require quite intrusive monitoring and strong punishment of violations. While police spurs can monitor for violations and still preserve significant privacy, as discussed in Chapter 22, Law, such monitoring either needs access to nearly all manufacturing of em brain hardware, all em brain hardware locations and uses, or nearly all uses of power and cooling that could support illicit brain hardware.

As a wide range of possible powers, with a wide range of possible preferences, might control a system of global governance, it is more difficult to use social science to predict social outcomes in the case of strong global regulations. This is because it is hard to predict exactly *which* regulations are adopted. A world of strong regulation can still be competitive, but with competition focused on access to and influence over this global governance system.

A variation on the previous scenario is where there is a great deal of regulation, but regulations are not strong enough to prevent a large em population and low em wages. In this scenario, it seems simplest to assume that ems retain many regulations from our world, such as a prohibition on murder, which could force even very short-lived spurs to retire instead of ending. There might also be rules against the scanning and emulating of children. Regulations might also prevent endowing new copies with debt or stock obligations, which encourages a world dominated by fewer eager-to-copy clans.

In sum, while there are many plausible variations on the baseline scenario in this book, this baseline scenario has been constructed in such a way as to be useful in understanding these variations. Baseline scenarios help analysis.

TRANSITION

What happens during the transition from our world to the em world?

To maintain a consistent style of analysis, I assume a relatively competitive low regulation scenario not only for a stable equilibrium em world, but also for the unstable non-equilibrium transition from our era to the em era. That is, even if some parties have foresight enough to see how their actions may contribute to a path that leads to an em world, most of these parties have too little influence for this foresight to change their incentives. Most parties just do what is locally in their private interest.

Note, however, that large deviations from this assumption during a transition could still be quite consistent with those assumptions applying well after the transition. That is, a non-equilibrium transition can still lead to an equilibrium post-transition world.

It is conceivable that military advantage will be the driving force directing a great transition resulting from changing em technology. However, the military usually only drives the introduction of technologies that are especially potent militarily. While the military sometimes plays a big role in the early research and development of other technologies, it usually fades into the background regarding widespread peaceful applications of these developments.

For example, the U.S. military funded a lot of early computer research because it considered computers to be especially useful in military applications. Even so, most growth in computer applications has been outside the military, and the military has had little influence on where and how most computers are used today.

As ems are not more effective in military applications than in other economic applications, choices made by the military probably make only a minor difference to when, how, and where ems are used. As by assumption no other forms of general artificial intelligence are feasible when ems are first realized, there might be trillions of dollars to be gained from selling access to brain emulations. Local profit incentives should thus drive most local choices that cause change.

The introduction of many technologies induces changes that are relatively gradual and anticipated, because first versions have high cost and limited abilities. Costs then gradually fall as abilities gradually rise. In contrast, the introduction of other technologies induces more sudden and unanticipated jumps in abilities and costs. The technology of brain emulation is of this second more sudden sort, because partial or nearly accurate emulations are of little use.

The early em economy creates a burst of growth, concentrated in a few key industries, firms, and geographical locations. Ordinary humans might better hedge em transition risks if they invest in funds that are very diversified across industries, firms, and locations. Such humans might benefit even more if they could buy "em bonds"—bets that pay off only after a transition to an em economy.

The first em cities might plausibly form around big computer data centers, such as those built today by Google, Amazon, and Microsoft (Morgan 2014). Such centers likely have ample and cheap supporting resources such as energy, are relatively safe from storms and social disruptions, and are also close to initial em customers, suppliers, and collaborators in the richest parts of the industrial economy. These centers prefer access to cheap cold water and air for cooling, such as found toward Earth's poles, and prefer to be in a nation that is either relatively free from regulations or that is small and controlled by friendly parties. These criteria suggest that the first em city arises in a low-regulation Nordic nation such as Norway.

While em cities are likely to benefit from starting near existing concentrations of humans, once they succeed, em cities are likely to push humans away, as em infrastructure is probably incompatible with standard human infrastructure in many ways. This may create conflict during the transition phase. Either some nearby cities will find ways to smoothly and quickly push out ordinary humans, or the successful em cities will be the ones that start a safe distance away from traditional human cities.

As in most disruptive social transitions, the transition to an em society is likely to be a time of heightened risk of war. Groups sometimes violently resist a fall in their relative status.

During the very early em era when em societies are weak compared with human societies, human nations may try to influence the nature of em societies via a mixture of threats and aid. As with rich nations today that seek to influence developing nations, this influence is likely to encourage non-democratic governance, as that is more easily influenced by foreign aid (Bueno de Mesquita and Smith 2011). Later on, when human societies are weak compared with em societies, ems may then try to influence human societies, and they are also likely to encourage non-democratic governance of human nations.

Today, capital and labor are complements, especially in the short run; the more you have of one, the more valuable the other becomes. In addition, technology gains have usually helped labor much more than capital (Lawrence 2015). If we include ems in the category of "labor," instead of "capital," then the arrival of ems quickly lowers the cost of labor, relative to the cost of capital, and greatly increases the quantity of labor.

If capital and labor continue to be complements in an em era, a big jump in the quantity of labor implies a big jump in the value of capital. This will encourage a rapid increase in the kinds of capital that are easy to make quickly, such as machines and buildings, and this will greatly increase the value of capital that is hard to grow quickly, such as firm goodwill, local culture, and patents (Corrado et al. 2009).

In addition, the value of investments in tools that help individual workers is reduced, relative to investments that create and support more labor. As computer hardware supports more em labor, investments in such hardware, and supporting tools, greatly increase in relative value. In fact, a large fraction of the gains during the em transition period would go to those who own capital to make computers, capital to make new computer-making equipment, intellectual property required to use such capital, and real estate near the main concentrations of em activity.

Once the possibility of a transition to an em world becomes more widely perceived, many may express reluctance, repugnance, or opposition to the new em era. Because an em economy is capable of very fast growth rates but also requires a lot of tolerance of doing things quickly and differently, local differences between mild reluctance and strong opposition may not matter much. Unless there is a well-coordinated global effort with strong teeth to prevent the creation of ems, what should mainly matter is that a few suitable-enough places give the new em economy sufficient support. Opposition in other places would then be quickly overwhelmed by very rapid growth in those few areas.

The earliest em cities and virtual realities are probably crude and unreliable, leading to harsher and more dangerous lives, just as earlier periods of the industrial era were harsher and less pleasant in many ways than later phases. This may lead to em stories celebrating early pioneers, to a concrete sense of progress within the em civilization, and to a sense of meaning for em lives within an advancing civilization.

How each era sees its past has often been greatly influenced by the transitional period between the prior era and that era. For example, our standard image today of pre-farming societies is of transitional warring "tribal" societies, and not of the more typical peaceful and isolated forager bands. Similarly, some see classical music as typical "pre-modern" music, even though it arose recently and is not much like most farming-era music.

Similarly, em images of our industrial era may be dominated by images from the few years just before ems came to dominate the world. Such images may focus on how the rest of the world treated the expensive and awkward early ems.

ENABLING TECHNOLOGIES

The pace of change in an em transition depends on which of the following three supporting technologies is ready last: (1) sufficiently fast and cheap computers, (2) sufficiently detailed, fast, and cheap brain scans, or (3) sufficiently detailed and effective models of brain cells.

If cheap enough computers are the last to be ready, the wide and uniform access to computers and their predictable progress makes the transition to the em era smooth, decentralized, and well anticipated. The analysis of this book is then quite appropriate. There might be many years between when the first emulations are created, for perhaps billions of dollars each, and when emulations can be made for a million dollars or less, so that ems can replace human workers in large numbers. The first ems might be created mainly for research purposes, or as vanity projects of billionaires. Because of their big headstart, such early ems may have some first-mover advantages later on when ems are common.

This scenario might give humans many years of warning in which to adapt to and prepare for the em-dominated world. Anticipating this transition, human workers seeking to avoid harm could try to move their wealth early from an ability to earn wages into other forms of wealth likely to retain value past the transition, such as stocks, patents, or real estate. Even a smooth anticipated transition could be sudden by historical standards, however. In just a few years ems might go from being a small niche product to dominating a new economy growing much faster than the old one.

During the early industrial revolution, new industries grew quickly and rewarded their investors well relative to old industries such as farming. Investors then could have used financial mechanisms such as stocks and bonds to diversify and insure themselves against this risk. However, the rich nobility did not do this, and as a result declined greatly in wealth and social influence (Ventura and Voth 2015). Perhaps humans will learn a lesson from this example and diversify their assets more successfully in the em transition.

If scans are the last technology to be ready, then the em transition becomes anticipated but more centralized. Improvements in scanning tend to follow a trend, and to be somewhat predictable given resources invested. As a result, when the time is right, large consortiums will likely form to fund efforts to scan the first ems. The first coalition to create a useable em would gain profits from pricing the first em products well above marginal cost.

Consortium profits may continue somewhat after the point that a second coalition succeeds in em creation, because of first mover advantages or cooperation among leading consortiums. The first em clans, firms, and cities in the new em economy might also gain first mover advantages. Having fewer such big winners would make for less diversity in the subsequent em era.

Governments may back some consortiums, while other consortiums may be profit-seeking ventures. Those seeking to minimize risk because of uncertainty about which consortiums will win should try to invest in as many consortiums as are open to investors. Unfortunately, government consortiums are probably not open to all investors.

The most disruptive transition comes when brain cell modeling is the last technology to be ready. Not only might the first group to develop good enough brain cell models have substantial market power immediately after the transition, that market power might last longer if the secret to effective cell emulation were obscure and hard for competing groups to discover. Worse, the appearance of ems might be a surprise, creating a smaller more-concentrated winning coalition of investors, and even less diversity in the subsequent em era. After all, it tends to be harder to guess progress in cell modeling; until you have a good enough model, you may not know how close your model is to success. The later this cell modeling breakthrough appears, the bigger and faster a burst of change results, because the other required technologies are further developed and hence cheaper.

In a tamer modeling-last scenario, progress in cell modeling might still be the last step, but a relatively easy and quick step that is mostly anticipated. Cell models might be mostly ready, but await full-scale scans and computers before the last steps of model adjusting and debugging can be completed. If it can be anticipated that these last steps will require only modest resources, and many competing teams are able to complete them, this scenario could lead to a relatively smooth, decentralized, and anticipated transition.

In sum, we can anticipate many elements of the transition to an em world, but most of them don't much influence the resulting em world.

ALIENS

Even though the universe is almost 13 billion years old, everything we've seen outside Earth looks completely dead. We continue to have great success in explaining what we see by assuming that everything outside Earth has always been completely dead. If there are any civilizations out there more advanced than us, they have not yet made a noticeable difference to anything we can see.

This seems puzzling, as we can see quite a lot. There are roughly a trillion trillion planets in the visible universe. It seems hard to believe that Earth houses the very first advanced civilization in all this.

To guess what very advanced aliens might look like, and so where we might look for signs of them, it is natural to try to rely on guesses about what our distant descendants may look like. Because of this, many have asked me what the forecasts in this book suggest about what our distant descendants may look like.

Unfortunately, the forecasts in this book say little about this fascinating and important topic. To usefully guess what very advanced aliens may look like, we'd need to say something about what our descendants may look like in an objective million or billion years. But the em era may plausibly last only a year or two in objective time, after which it is likely to be supplanted by yet another era, as different from the em era as it is from our time.

As our descendants will likely pass through a great many distinct eras in the next millions or billions of years, knowing what the next era may look like doesn't obviously tell us substantially more about what our very distant descendants may look like than knowing current or past eras. Figuring out the next era is a good first step down that important road, but it still remains a very long road. I have elsewhere considered what our theories say about the appearance of our very distant descendants, but those analyses have little to do with the subject of this book (Hanson 2008a).

CHAPTER 29

Choices

EVALUATION

Now that we have spent most of this book gaining a better idea of what a future em world might look like, we can start to ask: is this a good or a bad scenario? Would we want to encourage or discourage having this world replace our world? What small changes might make this world better?

Many people just don't care much about the non-immediate future, making their evaluation of the em era very simple; it is a big zero to them no matter how it plays out. Others care mainly about the very distant future, so the em era mainly matters to them via how it might influence the ages that follow. But alas that topic is beyond the scope of this book. So let us consider now how we might evaluate the em era itself, if we cared about it.

Our evaluation of the em era depends, of course, on the criteria we use. One simple option is to use the usual intuitive criteria that most people seem to use when they verbally evaluate a distant future. A recent study of people evaluating different possible futures for 2050 found that their main consideration or concern was how warm and moral future people would be (Bain et al. 2013).

That is, most people surveyed cared little about the future of population, pleasure, wealth, poverty, freedom, suicide, terrorism, crime, poverty, homelessness, disease, skills, laziness, or progress in science and technology. They cared a bit more about future self-discipline, humility, respect for tradition, equality, meaning in life, and protection of the environment. But mostly people cared about future benevolence: how honest, sincere, warm, caring, and friendly future people would be.

This pattern of responses makes sense if people tend to think about the far future abstractly, and if abstract modes of thinking function in part to help us make good social impressions about our views on morality (Liberman and Trope 2008; Hanson 2009; Torelli and Kaikati 2009). By emphasizing whether future folks follow standard social norms, we show our respect for those norms.

Em clans with reputations to protect will work to ensure the trustworthiness and reliability of clan members, and em teams will often work to ensure strong warm emotional bonds between team members. This suggests that an em future may rate relatively high on this key standard criterion of benevolence.

In contrast, this em future may rate poorly on the criteria of affirming our local political and moral values, that is, those that dominate during our time and place in the industrial era. As discussed in Chapter 26, Farmer-Like section, ems are likely to return to more farmer-like values, compared with the more forager-like values popular today. The em world is especially likely to be rated poorly by those who feel that civilization was a mistake, and that humanity was better off as simple farmers or foragers (Zerzan 2005). After all, the em world may plausibly be considered as "civilization version 3.0," after the farming and industrial versions. Being a competitive world, the em future may also rate low on the criteria of preventing values from changing further in the eras that follow this em era. I discuss the evaluation of em morality changes more in Chapter 30, Conclusion section.

Consider the issue of diversity. How well the em world rates on diversity depends a lot on what kinds of diversity matter. On the one hand, most ems may descend from only a few hundred or fewer humans who are quite unusual, because they are unusually productive. Ems may also be selected quite non-uniformly from todays' regions, ethnicities, religions, personalities, and genders. The entire non-human biosphere may be severely neglected in the em world. On the other hand, compared with ordinary humans today, descendants of those initial ems may radiate out and populate a much larger space of possible bodies, ways of living, topics of interest, and mental styles and capacities.

What if we look instead at the virtues that have been admired in most eras and cultures, such as intelligence, insight, benevolence, loyalty, determination, etc.? Here the em world can look very good. Ems are strongly selected for their impressive productivity, which tends to correlate with most of these virtues. In this sense, the em world is packed full of people who are more virtuous than most people so far have ever met in a lifetime.

Another way to evaluate the em world is in terms of existential risk, that is, the chance of a disaster so big that civilization is destroyed and can never rise again. Such a disaster harms not only everyone living in the world at the time, but also everyone who might have lived afterward, until either a similar disaster later, or the end of the universe. This is plausibly a *very* large harm.

If we compare an em era with a continuation of the industrial era without ems, the em civilization quickly has vastly more economic power, and so all else equal is better able to withstand physical disasters like earthquakes, asteroids, or volcanoes, events whose size and chances aren't much influenced by the existence of ems. The em era might induce more biological disasters such as pandemics, chemical pollution, or global warming, but it seems vastly better able to withstand such things.

The ability of an em civilization to withstand war or other unspecified social collapses depends on the size of the smallest unit of industrial production able to restart em civilization after a severe collapse. Local production implies this is no larger than an em city, but with nanotech factories this smallest unit might be as small as a few kilograms, which would make ems *very* hard to exterminate.

Some disasters, such as disobedient AI, may only be possible when relevant technologies reach a particular level. In this case we want to compare scenarios with the same technology levels, but reached via different paths. For example, we might compare reaching human level AI via an em path, or via a long continuation of the industrial era. In this case we might note that fast ems could directly monitor and react to an AI at a much higher time resolution.

Some will want to evaluate an em-dominated future primarily in terms of its outcomes for ordinary humans who have not become ems. Measured in absolute consumption terms, humans in the em world are likely to do very well for a few years, although longer-term outcomes hinge on unknowns about instabilities of the em civilization, and about what eras may follow the em era. To the extent that relative status is important, humans fare worse, as they are no longer the dominant group. But if ordinary humans see ems as human enough to be jealous of em status, perhaps ems are human enough to count for value as well.

It is important to realize that people today have a choice about who in the em world to consider as their descendants, or to care about. We today may choose to consider only ordinary humans as descendants, or we can choose to include ems as well. Some people may even see non-em-based artificial intelligence software as their descendants (Moravec 1988). The universe doesn't tell us what aspects of future creatures we must care about; that is up to us.

How will non-human biological nature fare in an em world? Here the long-run prospects for the natural world look poor. While the em economy at first focuses on a few dense cities, its rapid growth rate suggests that it and its descendant economies could fill the Earth within a few objective decades. While charities may pay to keep a few small nature preserves, the resources available for such efforts are likely be tiny compared with the economic pressures to use available resources to support the growing economy.

This em future can look pretty good in terms of utilitarian evaluation criteria, such as how many people have how much happiness, meaning, or satisfaction of their preferences. This is because the em world can hold many billions and perhaps trillions of human-like creatures, many of whom experience subjective years in the time that ordinary humans experience a subjective day. So if the life of an em counts even a small fraction as much as does a typical life today, then the fact that there are so many ems could make for a big increase in total happiness or meaning relative to our world today.

QUALITY OF LIFE

In fact, em lives do plausibly have a value that is at least a substantial fraction of the value of our lives today.

This is in part because societies and cultures don't usually make that much difference to individual happiness, meaning, and satisfaction. Anthropologists have long known that humans are quite plastic culturally, in that we can come to accept and be comfortable with a rather wide range of cultural norms and practices. Today, happiness varies by four times as much within nations as it does between nations, and 95% of national differences in happiness are explained by income, lifespans, corruption, friendship rates, and a sense of freedom

(Helliwell et al. 2013). Even if ems have low income by some measures, they could still have long lives, great freedom, strong friends, and low corruption. In fact, ems might have deeper connections to friends and lovers than we do, via thousands of copies of the same pair who have all long gotten along well.

In addition, we have several concrete reasons to expect ems to be happy. First, em clans can share the experiences of clan members to better learn what makes that clan happy. Because of this, ems know themselves much better than we do today, and they can use this self-knowledge to increase their comfort, satisfaction, meaning, and happiness. Second, the em world has beautiful, spacious, luxurious entertainment and surroundings, and ems needn't have any sickness, pain, hunger, or grime. Furthermore, em entertainment and surroundings can be tailored specifically for particular clans. The clan of George, for example, can afford to have movies and interior decorations designed specifically to the taste of George.

Third, ems are strongly selected from among ordinary humans for their high work productivity. Today, the people who are more productive, as indicated by their higher wages, also tend to be happier, and this correlation does not seem to be entirely a result of money causing happiness. It seems that happiness also causes productivity, and that common factors cause both. This weakly suggests that ems will tend to be happier than people today.

This suggestion is strengthened by the fact that pretty much all of the specific factors that today correlate with happiness also correlate with work productivity, even controlling for many other such factors. For example, people today tend to be both happier and more productive when they have jobs, autonomy at work, health, beauty, money, marriage, religion, intelligence, extroversion, conscientiousness, agreeableness, and non-neuroticism (Myers and Diener 1995; Lykken and Tellegen 1996; Steen 1996; Nguyen et al. 2003; Barrick 2005; Roberts et al. 2007; Sutin et al. 2009; Erdogan et al. 2012; Diener 2013; Ali et al. 2013; Stutzer and Frey 2013).

Of course correlation isn't causation, and there is much we don't understand here. Even so, the consistency of the relationship between happiness and productivity gives us much reason to hope that more productive ems may on average be happier than people today. Yes, perhaps work productivity makes people happier by raising their relative status, and by definition relative status can't rise for everyone. But even in that case, relative status can't fall overall either, to hurt overall happiness.

What about the fact that ems work long hours? On the negative side, compared with other activities people who are interrupted at work (or while commuting or doing chores) for a survey report the lowest moods, more often say that they would rather be doing something else, and more often (20% of the time) have a dominant emotion that is negative. Workers report being happier on the weekend (Miner et al. 2005; Kahneman and Krueger 2006; Bryson and MacKerron 2015; Helliwell and Wang 2015).

On the positive side, however, work activities seem to be associated with average activation and involvement, over 80% of us today report that we are overall satisfied with our jobs, and over 60% report that our jobs are meaningful in making the world a better place (Hektner et al. 2007; Society for Human Resource Management 2012). Returning to work after an injury boosts life satisfaction, as does doing extra work after officially retiring (Vestling et al. 2003). Work adds to our life satisfaction via job and career satisfaction, coworker relations, power, prestige, and prospects for growth (Erdogan et al. 2012). Most people today who are very respected and envied work long hours, and very much enjoy their lives.

Ems may be punished more at work, have to face more objective performance evaluations, and feel more stress from small margins between wages and living expenses. Even so, ems are selected for being relatively comfortable with such lives, and their virtual worlds can cheaply provide great "material" comfort both on and off the job. Also, much life meaning can be found in the strong bonds ems feel with clans, teams, professions, and cities, in their excellent and unprecedented abilities, and in the great accomplishments these abilities will enable.

The em world outcome would look terrible on hedonistic utilitarian criteria if most ems ended up being non-conscious, in the sense of not having any integrated experiences. As discussed in Chapter 4, Emulations section, this seems quite unlikely in the early em era, but this topic is beyond the scope of this book.

POLICY

This book has focused on elaborating a baseline em scenario, with scenario features chosen to be relatively likely, when such options are available, and otherwise with features chosen to be simple and easier to analyze. If this were actually our most likely future, what policies should we prefer to make the em world a *better* future?

First note that we should expect this policy task to be very challenging. For a comparison, imagine that someone in the year 1000 A.D. had been able to infer the basic outlines of our industrial world. Even accomplishing that difficult task might not tell them enough to offer useful advice on industrial world policy, or on what people in 1000 A.D. could do to push industrial policy in a good direction.

Second, note that in the absence of a strong world government, we have only very limited abilities to coordinate to change the future. Even on topics like climate change, with strong expert consensus on the existence of the problem and plausible solutions, the world seems incapable of coordinating to implement those solutions. This suggests that we focus our policy efforts on small changes that are feasible, instead of big changes that are not. So, what small feasible changes to this scenario could make for a better em world?

Speeding the development of cell modeling abilities, so that such modeling is not the last required technology to be ready, could both advance this scenario, and minimize disruptions from an overly rapid transition to an em economy. Also, transition risks to ordinary humans might be reduced by encouraging the creation and use of international diversified investment funds of stocks and real estate, and also of "em bonds" that mature only if an em world appears. Allowing widespread investments in new em ventures, instead of outlawing such ventures or investments, would also help by allowing everyone to gain from the growth of the new em economy.

If the em world is nearly inevitable, then it would be good if literary and public conversations frame it as something to be accepted, and perhaps nudged into preferred directions, instead of as something to be aggressively resisted.

If the em world is not inevitable, policy choices become more complex. While there would be plenty of advanced warning that an em world may be coming, such warnings might not be able to predict exactly when. The transition to an em world could be quite rapid, while most organizations capable of enacting substantial global scale policies act only after long delays.

During the early transition, it could help to encourage ems to share their financial, legal, and political institutions with ordinary humans as deeply as possible for as long as possible, to reduce later temptations to expropriate human property. To reduce distrust arising from feelings of an illicit domination of the em world by descendants of particular subgroups of ordinary humans, it could also help if a wide diversity of people were scanned early and tested for suitability as em workers. It might also help if initial scanning to create ems was in part a gift from the rest of humanity, rather than having been resisted by humanity. This might help ems to later feel gratitude and obligation toward ordinary humans, instead of hostility and resentment. An early period of humans enslaving ems would set an especially bad precedent.

Early events may also influence the number of em cities and their distances from each other. If city scale economies allow it, then having only one em city or a few close cities would probably be most efficient, except that this might risk a single bad political regime mismanaging the entire em world. If it is important enough to avoid such a centralized bad political outcome, then political and economic competition between a few sufficiently separated cities might be better. Some say a lack of centralized government is why the industrial revolution first appeared in Europe, and not in the more technically advanced but more centralized China.

If a thousand or fewer em clans end up dominating the em economy, then almost all ordinary humans hoping to found successful em clans face an overwhelming chance of failure. Ordinary humans or early em clans could insure against this risk by making formal agreements to have clans that succeed share their gains with clans who do not. While interest in such insurance might signal a lack of confidence in one's future prospects, given these long odds, few clans could reasonably have much confidence of success. It might be good to encourage such clan success insurance to reduce clan risk.

Basic economic theory suggests a number of possible "market failures," that is, common ways in which economies tend to be inefficient. Without some reason to think otherwise, we should suspect that em economies will be inefficient in these ways.

For example, the fact that others lose status when we gain status suggests that too much effort is put into raising one's status at the expense of the status of others. As a result, ems may run too fast, and invest too much in impressive early life achievements. The fact that others gain when we add to urban activity density suggests that cities tend to not be built densely enough. As a result, local builders in em cities may make design choices resulting in an excessively low population density. Signaling issues suggest that the terms of private insurance and law choices will slant too far toward the preferences of cheap-to-serve customers. Product differentiation issues suggest tendencies toward too much product variety and spatial market segmentation. So em workers may have overly varied skill specializations. Quality choice issues suggest that the quality of the highest quality products is not high enough. So ems may invest too little in the quality of their highest quality workers (Shy 1996).

In general, would-be early settlers of new territories, whether these territories are parts of physical space or abstract product or labor markets, have incentives to spend too much on their early colonization efforts, unless there are big ways in which these first-movers benefit others, such as via innovation. This suggests that ems may spend too much on settling new physical territories, or on new product and labor-market territories. In general, the ability to make strategic commitments tends to result in excess costs from commitments. This suggests that negotiations between clans forming teams and firms may suffer costs from excess strategic commitments.

It would be good for policy actions to counter all these likely market failures, although it is not clear how this can be done.

Ems might spend too much time in work, relative to leisure, because of signaling pressures. More leisure could be encouraged by tying taxes to income, rather than to em speed, that is, taxing work but not leisure.

Some of us should spend some effort to analyze and anticipate the em world, as I have attempted in this book. Another obvious suggestion is to track related developments to gain more advanced warnings about when a transition to an em economy may occur, and about the places and industries where that transition may be initially concentrated.

Other policy options are to subsidize the development of related technologies to speed the arrival of this transition, and to subsidize its smoothness, equality, or transparency to reduce disruptions and inequalities in that transition. One might also subsidize or provide insurance against these variations. A smooth transition might be encouraged via speeding the development of scanning and cell modeling relative to computer power.

This section has only scratched the surface of possible relevant policy analysis. But it is very hard to analyze policy for a world about which one knows almost nothing. That is why positive analysis, of likely outcomes if we do nothing special, took first priority in this book.

CHARITY

The previous section considered the policies that we might together agree are good for society overall. This section considers what an individual might do personally to promote good policy regarding an em world.

Most of the usual ways to promote good policy today continue to apply. One might strive to become influential in a relevant world of policy, business, or technology. One might personally work to identify good policies and then advocate for them. One might also try to create groups of like-minded people organized specifically around the idea of identifying and advocating for good em policies. Or, as today very few are interested in em policy, it might make more sense to join existing groups defined around other related themes, and encourage those groups to direct more of their efforts toward identifying and advocating good em policy.

Those still young enough to be able to start or change careers might consider not immediately focusing on related areas of em technology, business, policy analysis, or advocacy. Such people might instead learn to acquire more general skills, while practicing mostly on other topics. They might then focus more on em-related areas as their skills increased and as opportunities arose.

While Bill and Melinda Gates are not medical experts, they have nevertheless had a big impact on medical research. Similarly, the people most interested in analyzing and promoting good em policy may well not be the people whose personal abilities and work preferences are best suited to personally and directly working on em technology, business, policy analysis, or advocacy. Such people might instead want to do other types of work better suited to their abilities and preferences, and then donate money to specialists. However, such people need to do enough research to identify plausibly expert and well-motivated specialists, and to sufficiently monitor their activities to confirm that these specialists deserve funding.

Given that the em transition is probably many decades away, an especially attractive alternative is to save now to help later. That is, invest time and energy now in the usual ways, to enable you to spend time and money later on charity. As investment rates of return have been consistently higher than economic growth rates, this strategy allows one to have a proportionally larger influence later than one could have now.

By first accumulating assets, one can retain many options regarding future action. For example, one can wait to decide between becoming personally involved in policy analysis and advocacy, or donating money to support other policy specialists. Also, as we learn more over time about the em world and its issues, we should be able to better direct our aid to be more effective. We might even later switch to focusing on non-em causes, if the em scenario comes to seem less likely or important than it once did.

Because this strategy allows one to retain many options about how to spend one's money later, it can help many future causes, not just those dealing with an em world. Some have criticized this strategy, saying that increasing wealth and peace means that the future will have far fewer worthy causes and people worth helping. However, if an em world is coming, then wealth per em will fall greatly, making it likely that there will then be plenty of deserving creatures in need of help.

If you expect that the em transition may occur after you are dead, you might also consider saving to donate money to others after you die. In this case, it becomes harder to arrange for the monitoring of the recipients of your donations, to ensure that they are doing what you would want. And in addition our society has placed substantial legal barriers that make it hard to control your funds after your death. Even so, this might still be the best available strategy.

In sum, there are many ways for individuals to work to help to deal with the possible coming of an em world.

SUCCESS

What if you want to know, not how to help create a better em world, but how to help you and your associates personally succeed in this new world?

To avoid the worst possible outcomes, expect all of your abilities to earn wages as a human to quickly disappear after an em transition. Well before this happens, seek out substitute sources of income. Accumulate and diversify a financial portfolio of assets likely to retain value, such as stocks, real estate, and intellectual property. Also accumulate and diversify a social portfolio of supports and connections. Both your financial and social assets should be tied to communities that are likely to thrive or at least survive in an em world. Try to be included in geographic regions, nations, professions, standards, etc., that are likely to cooperate with and add value to this new world, and avoid those that may pick fights with it.

If, relative to other investors, you have a comparative expertise in analyzing investments, then you might seek and invest in underpriced em-related assets. These are assets expected to be worth a lot in an em world, but where that is not reflected in the current price. For example, real estate near likely em city locations is currently underpriced. However, one should set a high bar for whether one is expert enough; the vast majority of financial traders today lose because they overconfidently see themselves as sufficiently expert.

As successful clans collect a big fraction of the gains in the em world, you should consider the possibility that you (or your children or grandchildren) might start one of these few most copied em clans. Realizing that the odds are greatly against you, you should be willing to take great risks to achieve this, via showing high and reliable productivity and flexibility in tasks and environments most like those of the em world. You should focus on the very high tail of your possible success distribution; the rest of the distribution makes much less difference. Go very big or go home.

If you or your associates (such as descendants) will be old at the time of the em transition, then try to have them be very productive and at the peak of their career ability, and be productive at tasks where a great many customers could be quickly served by ems doing that task. This would give you the best chance to be one of the very first highly copied ems. If you might be dead by the time of the em transition, you might consider becoming a cryonics customer, and then declaring your wish to be revived as an em when this becomes technically possible.

In contrast, if you or your associates will be young at the time of the em transition, try to time their age to be the ideal age for new em scans during the early em era. Consider accepting the risks that come from destructive scanning. Before that age, have them collect visible indications of their general ability to learn useful skills and do valuable tasks. They should also show that they get along with people much like themselves, and that they value life and grit when life is hard and alien. Teach these virtues to your children and grandchildren. Such young people might then have a chance to become successful ems during the early em era, when a high value is placed on youthful flexibility.

To the extent that young em candidates prepare for specific jobs, have them prepare for the em jobs and professions that will be in the most demand in the em world, instead of the jobs that pay the most in our world. Remember that, compared with our world, em wages won't vary nearly as much with the intelligence or status associated with the job. Remember also that ems use fewer tools and supporting capital than do ordinary humans in comparable jobs just before the em transition.

In sum, to succeed in this new world, prepare to become what it needs.

CHAPTER 30

Finale

CRITICS

Over 150 readers have commented on previous drafts of this book. Here are very quick summaries of some of their most common criticisms. Most individual views are of course subtler than these summaries can be.

If we include those who declined to read my draft, the most common complaint is probably "who cares?" Many just can't see why they should want to know much detail about the lives of people who are not they, their children, or grandchildren. While many readers seem interested in the lives of past people who were not personally their ancestors, perhaps these readers make up only a small fraction of the population.

Other readers doubt that one can ever estimate the social consequences of technologies decades in advance. It is not so much that these readers have specific complaints about my analyses. Instead, they have a general skepticism that makes them uninterested in considering such analyses. Many see human behavior as intrinsically inscrutable, and many doubt that social science exists as a source of reliable insight. A few are offended by the very idea of estimating social outcomes, as they see this as denying our free will and ability to choose our futures.

A more specific version of this sort of criticism accepts that it is often possible for us to foresee social consequences in worlds like ours, but then says that it is impossible to foresee the social behaviors of creatures substantially smarter than us. So, they reason, we today cannot see past the future point in time when typical descendants become smarter than we are today, and ems are effectively smarter than us in several ways. This view suggests that social scientists today are less able to predict the behavior of smarter people, or of people who are smarter than the typical social scientist. That seems incorrect to me.

Still other readers accept my social analysis, but are disappointed that I consider only the next great era, and not the eras that may follow it. These readers mainly care about the long-term future. They reject my argument that understanding the em era is a good first step to understanding the eras that may follow it. They prefer other ways to analyze the distant future, ways that depend little on what will happen between now and then. I am more skeptical about our ability to foresee endpoints without at least outlining the paths between here and there.

Many doubt that brain emulations will be our next huge technology change, and aren't interested in analyses of the consequences of any big change except the one they personally consider most likely or interesting. Many of these people expect traditional artificial intelligence, that is, hand-coded software, to achieve broad human level abilities before brain emulations appear. I think that past rates of progress in coding smart software suggest that at previous rates it will take two to four centuries to achieve broad human level abilities via this route. These critics often point to exciting recent developments, such as advances in "deep learning," that they think make prior trends irrelevant.

More generally, some critics fault me for insufficiently crediting new trends that they expect will soon revolutionize society, even if we don't yet see strong supporting evidence of these trends. Such revolutions include robots taking most jobs, local sourcing replacing mass production, small firms replacing big ones, worker cooperatives replacing for-profits, ability tests replacing school degrees, and 3D printers replacing manufacturing plants. I will believe these trends may actually be revolutionary when I more clearly see that they are actually happening at a substantial scale.

A vocal minority of critics see economics as a fundamentally mistaken social science, and thus usually wrong. While such critics can see the point of estimating social consequences using other social sciences, they have little interest in economic analysis of anything.

Finally, some critics fault me for neglecting the "unknown unknowns." That is, they say my forecasts don't sufficiently account for unforeseen changes and innovations that will arise later. Apparently they think one should just say, "The future will be strange," and resist the urge to add more detail, except perhaps for telling strange vivid stories that claim no accuracy or analysis. To me, this view seems needlessly pessimistic regarding our abilities to do useful analysis. Yes, efforts like this book can be badly mistaken, and we should avoid overconfidence. Even so, we should try.

In sum, even though many critics have reasonable points, I still think the analysis in this book was worth the effort.

CONCLUSION

Parents sometimes disown their children, on the grounds that those children have betrayed key parental values. If parents have the sort of values that children could deeply betray, it does make sense for parents to watch out for such betrayal, and to be ready if needed to adopt extreme responses, such as disowning their children.

But surely parents who feel inclined to disown their children should be encouraged to study those children carefully before doing this. For example, parents considering whether to disown their child for working for a cigarette manufacturer, or for refusing to fight in a war for their nation, should wonder to what extent anti-smoking or patriotism really are their core values, as opposed to merely revisable opinions in support of other more-core values. Such parents would be wise to study the lives and opinions of their children in some detail before choosing to disown them.

When they have lived as neighbors, foragers have often strongly criticized farmer culture, and farmers have often strongly criticized industrial culture. Surely many of these people have been tempted to disown descendants who adopt these despised new ways. In addition, many of your ancestors would be tempted to disown you, if they were told many things about you. While they'd be pleased and impressed by many of your features, other things about you might horrify them.

So, should your forager or farmer ancestors have disowned you? While such disowning might have held them true to some core values, I expect that you would have advised them to consider your life and views carefully, in some detail, before choosing to disown you. Disowning should not be done casually.

The analysis in this book suggests that lives in the next great era may be as different from our lives as our lives are from farmers' lives, or farmers' lives are from foragers' lives. Many readers of this book, living industrial era lives and sharing industrial era values, may be disturbed to see a forecast of em era descendants with choices and life styles that appear to reject many of the values that they hold dear. Such readers may be tempted to fight to prevent the em future, perhaps preferring a continuation of the industrial era. Such readers may be correct that rejecting the em future holds them true to their core values.

But I advise such readers to first try hard to see this new era in some detail from the point of view of its typical residents. See what they enjoy and what fills them with pride, and listen to their criticisms of your era and values. This book has been designed in part to assist you in such a soul-searching examination. If after reading this book, you still feel compelled to disown your em descendants, I cannot say you are wrong. My job, first and foremost, has been to help you see your descendants clearly, warts and all.

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