World After Capital

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Work in Progress

This book is a work in progress. What you are reading now is a draft with known problems and placeholders. It does, however, include all the major ideas and what remains is a process of gradual improvement.

The process of writing in this way is an example of what I call the “knowledge loop” in the book. The knowledge loop consists of learning, creating and sharing. My writing is based on what I have learned. By sharing early, others can learn from my ideas and I, in turn, can learn from their feedback.

I know how powerful this approach is from my experience with blogging for nearly a decade. I have learned a great deal from reader comments. The same will be true here.

You can see some of the amazing initial feedback. Thanks to everyone who has taken the time. You can either comment inline by highlighting text or email me at albert@worldaftercapital.org.

I am using gitbook to write World After Capital and you can track the changes I am making on github. I retain final “commit rights” for changes and as such take responsibility for any and all errors.

There is also a separate FAQ which I will be updating periodically. If you prefer reading on paper or on an eReader, you can download a copy in PDF, ePub or Mobi.

The contents of the book will always be freely available at worldaftercapital.org under a Creative Commons license.

Preface

As a Venture Capitalist (“VC”), I get asked the question a lot "What's next?" People want to know what I think the next big technology will be. They are looking for an answer like "robotics" or "machine learning." But that's not the question that I am interested in answering. Instead, what I believe matters much more is what we as humanity decide to do with all the new technologies available to us.

In particular, I am convinced that we are in the middle of a transition that's as profound as when we went from the Agrarian Age to the Industrial Age [1]. This transition is being driven by the advent of digital technologies, and we must now collectively decide what comes after the Industrial Age. In World After Capital, I am arguing that the proper next age is the Knowledge Age—and that in order to get there we need to focus on the allocation of attention (rather than capital).

Why write a book as a VC? Or more pointed: isn't this a distraction from finding and managing investments in startups? Working with startups gives me a window into the future. I get to see certain trends and developments before they become more widely understood. That puts me in a good position to write about the future. At the same time, there is a feedback loop with investing: Writing about the future that I would like to see, helps me find and invest in companies that can help bring that future about. I am writing World After Capital because I feel compelled to do so by what I see, but writing the book has also made me a better investor.

Why write this specific book now? A big transition means lots of uncertainty. Many people fear change and they start to support populists who tend to have a simple message: Go back to the past. This is happening all over the world. We saw it with Brexit and with the election of Donald Trump as president of the United States [2]. I started writing World After Capital considerably before both of those events occurred, but they serve to underline the importance of a future-oriented narrative. Going back is not a viable option. It never has been. We did not remain foragers after inventing agriculture. We did not remain farmers having invented industrial machines. We will not remain laborers having invented digital technologies.

One of the messages in World After Capital is that we all need to have a purpose in life. As we leave the Industrial Age behind, our purpose can no longer be derived from having a job (or from consuming). Instead, we need to find a purpose that is compatible with a Knowledge Age. I feel incredibly fortunate to have found my purpose in investing in Knowledge Age startups, writing and speaking about why this transition is happening now, and suggesting how we might go about it.

I deliberately use the term Knowledge Age, instead of Information Age. We are drowning in information, which spews forth endlessly from our computers and phones. Knowledge, by contrast, are the scientific explanations and the works of art and literature that have withstood the test of time and have been refined through the process of critical inquiry. Knowledge is what makes human life possible and worthwhile.

In a strange and wonderful way, much of what I have done in the past has brought me to this point. As a teenager in my native Germany, I fell in love with computers early in the 1980s. I got to work, even before going to college, writing software for companies. I studied both economics and computer science as an undergraduate student at Harvard and wrote my senior thesis about the impact of computerized trading on stock prices. As a consultant, I saw the impact of information systems on the automotive, airline and electric utility industries. As a graduate student at MIT, I once again studied both economics and computer science and wrote my dissertation about the impact of information technology on the organization of companies. As an entrepreneur, I co-founded an early and ultimately unsuccessful Internet healthcare company. And finally as an investor, I have had the good fortune of being able to invest in companies that are providing transformative digital technologies and services, including Etsy, MongoDB and Twilio.

I am grateful for all the people who have helped me along the way: my parents who wholeheartedly supported my interest in computers at a time when it was quite unusual and expensive to do so; my wife Susan Danziger and our children Michael, Katie and Peter who made me a better person; my many teachers, including Erik Brynjolfsson and Bengt Holmström, from whom I learned so much; my partners at Union Square Ventures, starting with Fred Wilson and Brad Burnham who invited me to join the firm they had started; the many entrepreneurs I have had the opportunity to work with; the philosophers and scientists, such as David Deutsch, who have demonstrated the power of human knowledge; the friends who have been there through good and bad times; and the many people who have taken the time to comment, who have invited me to speak, who have contributed in ways small and large, with special mentions for Seth Schulman for work on an early draft, Basil Vetas for capable research assistance, and Max Roser for extensive data collection and visualization.

Introduction

Humanity is unique, at least for now, in having developed knowledge. Knowledge in turn has enabled us to create increasingly powerful technology. The effect of technological advances is to broaden the “space of the possible.”

- With the Internet we can give everyone free access to education, but we can also share hate speech globally
- With artificial intelligence we can build self-driving cars, but we can also automate censorship and manipulation

A broader space of the possible contains both good and bad capabilities. There is nothing fundamentally new about this duality of technology.

- With fire we were able to warm ourselves and cook, but we were also able to burn down forests and enemy villages
- With steel we were able to construct more effective plows, but we were also able to forge more deadly swords

And yet there is something special about our moment in time.

We are experiencing a technological non-linearity, which renders many of the existing predictions about society based on extrapolation useless. The space of the possible for humanity is expanding rapidly due to the extraordinary power of digital technologies, which deliver universality of computation at zero marginal cost.

Humanity has encountered two similar non-linearities previously. The first was the invention of agriculture, which ended the Forager Age and brought us into the Agrarian Age [3]. The second was the Enlightenment, which took us out of our state of ignorance about nature and helped usher in the Industrial Age [4].

Imagine foragers trying to predict what society would look like in the Agrarian Age. Cities, rulers and armies all would have come as a surprise. Similarly, much of what we have today —from modern medicine to computer technology—would look like magic to most people from as recently as the mid-1900s. Not just the existence of smartphones would have been hard to foresee, but even more so their widespread availability and affordability.

World After Capital has two goals. The first goal is to establish that we are, in fact, experiencing a third such non-linearity. The key argument is that each prior time the space of the possible expanded dramatically, the binding scarcity constraint for humanity shifted. Specifically, the invention of agriculture shifted scarcity from food to land. Industrialization, in

turn, shifted scarcity from land to capital. Now digital technologies are shifting scarcity from capital to attention. Scarcity, here, refers to humanity's ability to meet everyone's basic needs.

Capital is already no longer scarce in some parts of the world and rapidly less scarce everywhere. We should consider this to be the great success of capitalism. But capitalism, in its present form, will not and can not solve the scarcity of attention. We are bad, individually and collectively, at allocating attention. For example, how much attention are you paying to your friends and family, or to the existential question of the meaning and purpose of your life? How much attention are we paying, as humanity, to the great challenges and opportunities of our time, such as climate change and space travel? Capitalism cannot address these attention allocation problems because prices do not, and cannot, exist for many of the activities that we should be paying attention to.

The second goal for World After Capital is to propose an approach for overcoming the limits of existing capitalism and facilitating a smooth transition from the Industrial Age (scarce capital) to the Knowledge Age (scarce attention). Getting this right is critical for humanity, as the two previous transitions were marked by massive turmoil and upheaval—including two World Wars to get from the Agrarian Age to the Industrial Age. Already, we are seeing signs of increasing conflict within societies and among belief systems across the world.

How should we enter this third transition? What actions should society take now, when—facing a non-linearity—we can't make good predictions about the future?

We need to enact policies that allow for social and economic changes to occur gradually, instead of artificially suppressing these changes only to have them explode eventually. In particular, I will argue for smoothing the transition to the Knowledge Age by expanding three powerful individual freedoms.

- Economic freedom: instituting a basic income
- Informational freedom: investing in Internet access, rolling back intellectual property rights, and rethinking personal privacy
- Psychological freedom: practicing and encouraging self-regulation

Increasing these three freedoms will make attention less scarce. Economic freedom unlocks time currently spent in jobs that can and should be automated. Informational freedom broadens access to information and computation. Psychological freedom enables rationality in a world of information overload. Each of these freedoms is important by itself but they are also mutually reinforcing.

One crucial goal in reducing the scarcity of attention is to improve the functioning of the “Knowledge Loop.” The Knowledge Loop, which consists of learning, creating and sharing, is the source of all knowledge. Producing more knowledge is essential to human progress. The

history of humanity is filled with prior civilizations that failed to produce the knowledge required to overcome the challenges they faced.

To achieve this goal through increased individual freedoms, we also need to firmly establish a set of values, including critical inquiry, democracy and responsibility. These values provide the social underpinning for the Knowledge Loop. They follow directly from a renewed Humanism, which in turn has an objective basis in the existence and power of human knowledge. Reasserting Humanism is especially critical at a time when we are standing at the threshold of creating transhumans, through genetic engineering and augmentation, as well as neohumans, in the form of artificial intelligence.

World After Capital argues for increased freedoms, rooted in humanism, as the way to transition from the Industrial Age to the Knowledge Age. I am profoundly optimistic about the ultimate potential for human progress. I am, however, pessimistic about how we will get there. We seem intent on clinging to the Industrial Age at all cost, increasing the likelihood of violent change. My hope, then, is that in writing World After Capital I can help in some small way to move us forward peacefully.

Digital Technology

The invention of agriculture expanded the space of the possible by dramatically increasing the food density of land. This allowed humanity to have surplus food, which provided the basis for increased population density and hierarchical societies that developed standing armies, specialization of labor and writing [5].

The Enlightenment and subsequent Industrial Revolution further expanded the space of the possible by substituting human power for machine power and increasing our understanding of, and control over, chemical and physical transformations of matter. This allowed humanity to make extraordinary material progress on the basis of innovations in energy, manufacturing, transportation and communication [6].

Digital technologies provide the third expansion of the space of the possible. This seems like a bold claim, and many have derided digital technologies such as Twitter, arguing that they are inconsequential compared to, say, the invention of vaccines.

Yet we can already see the disruptiveness of digital technologies. For instance, many previously well established businesses, such as newspapers and retailers, are struggling, while companies that deal only in information, such as Google and Facebook, are among the world's most highly valued [7].

There are two characteristics of digital technology that expand the space of the possible, and both are important: the first is zero marginal cost and the second is the universality of digital computation.

Zero Marginal Cost

Once a piece of information is on the Internet, it can be accessed from anywhere on the network for no additional cost. As more and more people around the world are connected to the Internet, “anywhere on the network” increasingly means anywhere in the world. The servers are already running. The network connections and end user devices are already in place and powered up. Making one extra digital copy of the information and delivering it across the network is therefore free. In the language of economics: the “marginal cost” of a digital copy is zero. That doesn't mean there aren't people trying to charge you, in many cases there are. Zero marginal cost is a statement about cost, not about prices.

Zero marginal cost is radically different from anything that has come before it in the analog world, and it makes possible some pretty amazing things. To illustrate, imagine you own a pizzeria. You pay rent for your store, you pay for your equipment, and you pay salaries for

your staff (and yourself). All of these are so-called “fixed costs.” They don't change at all with the number of pizzas you bake. “Variable costs,” on the other hand, depend on the number of pizzas you make. For a pizzeria, these include the cost of the water, flour, and other ingredients used in making pizzas. Variable cost also includes the energy you need to heat your oven. If you make more pizzas, your variable cost goes up. If you make fewer, your variable cost goes down.

So what is marginal cost? Well, let's say you are up and running making 100 pizzas every day. The marginal cost is the additional cost to make the 101st pizza. Assuming the oven is already hot and has room in it for one more pizza, then the additional cost for that 101st pizza is just the cost of the ingredients, which is likely relatively low. Imagine now that the oven has already cooled off, then the marginal cost of the 101st pizza would include the energy cost required for re-heating the oven. In that case the marginal cost could be quite high.

From a business perspective, you would want to make that 101st pizza as long as you can sell it for more than its marginal cost. Every cent above marginal cost makes a contribution towards fixed cost, helping to pay for rent and salaries. If you have already covered all your fixed cost from the previous pizzas sold, then every cent above marginal cost for the 101st pizza is profit.

Marginal cost also matters from a social perspective. As long as a customer is willing to pay more than the marginal cost for that pizza, then everyone is better off. You're better off because you get extra contribution towards your fixed cost or your profit. Your customer is better off because, well, they just ate a pizza they wanted! Even if the customer paid exactly the marginal cost you wouldn't be any worse off and the customer would still be better off.

Let's consider what happens as marginal cost falls from an initially high level. Imagine for a moment that your key ingredient is an exceedingly rare and expensive truffle and therefore the marginal cost of your pizzas is $1,000 per pizza. Clearly you won't be selling a lot of pizzas. You decide to switch to cheaper ingredients and start to bring down your marginal cost to where a larger number of customers are willing to pay more than your marginal cost. In New York City, where I live, that seems to be around $25 per pizza. So you start selling quite a few pizzas. As you bring down the marginal cost of your pizza even further through additional process and product improvements (e.g., a thinner crust, economies of scale, etc.), you can start selling even more pizzas.

Now imagine that through a magical new invention you can make additional pizzas at close to zero marginal cost (say one cent per additional pizza), including nearly instantaneous (say one second) shipment to anywhere in the world. What would happen then? Well, for starters you would be able to sell an exceedingly large number of pizzas. And if you charged even just two cents per pizza you would be making one cent of contribution or profit for every additional pizza you sell.

At such low marginal cost you would probably be the only pizza seller in the world (a monopoly—more on that later). From a social welfare standpoint, anyone in the world who was hungry and who wanted pizza and could afford at least one cent would ideally be getting one of your pizzas. This means that the best price of your pizza from a social point of view would be one cent (your marginal cost). Why not two cents? Because if someone was hungry but could only afford one cent and you sold them a pizza at that price, then the world as a whole would still be better off. The hungry person was fed and you covered the marginal cost of making the pizza.

Let's recap: When your marginal cost was extremely high, you had very few customers. As your marginal cost dropped you started to be able to sell more. And as your marginal cost approached zero, you eventually started to feed the world! This is exactly where we are with digital technology. We can now feed the world with information. That additional YouTube video view? Marginal cost of zero. Additional access to Wikipedia? Marginal cost of zero. Additional traffic report delivered by Waze? Marginal cost of zero.

This means we should expect certain digital “pizza-making operations” to be huge and span the globe in near monopoly positions (i.e., they are much larger than anyone else, having nearly the entire market to themselves). This is exactly what we are seeing with companies such as Google and Facebook. But—and this is critical to the idea of the Knowledge Age—it also means, from a social perspective, that the price for marginal usage should be zero.

Why prevent someone from accessing YouTube, Wikipedia or Waze, either by cutting them off from the system altogether or charging a price they can't afford? This would always constitute a loss to society. With zero marginal cost, any given individual might receive some benefit, which would be a benefit greater than the marginal cost. And best of all, they might use what they learn to create something that they share and that in turn winds up delivering extraordinary enjoyment or a scientific breakthrough to the world.

We are not used to zero marginal cost. Most of economics assumes non-zero marginal cost. You can think of zero marginal cost as an economic singularity: dividing by zero is undefined, and as you approach zero marginal cost, strange things happen. We are already observing these strange things in the world today, including digital near monopolies and a power law distribution of income and wealth. We are now rapidly approaching this zero marginal cost singularity in many industries, including finance and education.

So the first characteristic of digital technology that expands the space of the possible is zero marginal cost. This space includes digital monopolies, but it also includes access for all of humanity to all the world's knowledge (a term I will define more precisely later).

Universality of Computation

Zero marginal cost is only the first property of digital technology that dramatically expands the space of the possible. The second property is in some ways even more amazing.

Computers are universal machines. I mean this in a rather precise sense: anything that can be computed in the universe at all can be computed by the kind of machine that we already have, given enough memory and enough time. We have known this since the groundbreaking work by Alan Turing on computation. Turing invented an abstract computer, which we now call a Turing machine [8]. He then came up with an ingenious proof to show that this machine, which turns out to be extremely simple, can compute anything [9].

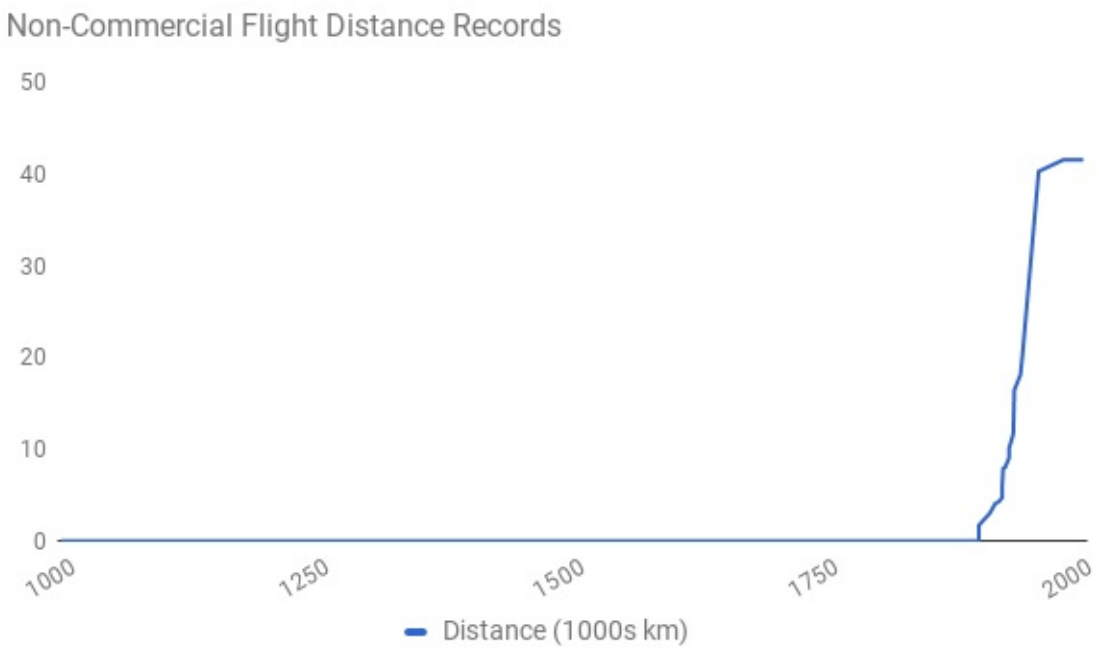
What do I mean here by computation? I mean any process that takes some information inputs, executes a series of processing steps and produces an information output. That is—for better or worse—all that a human brain does either. The brain receives inputs via nerves, carries out some internal processing, and produces outputs (also via nerves). In principle, there is nothing a human brain can do that a digital machine cannot do.

The “in principle” limitation will turn out to be significant only if quantum effects matter in the brain. This is a hotly debated topic [NEED REFERENCE]. Quantum effects do not change what can be computed per se, because even a Turing machine can simulate a quantum effect, but it would take an impractically long time to do so, potentially millions of years or more [10]. If quantum effects were to matter in the brain then we would need to wait for further progress in quantum computing to simulate a brain. Personally, I believe that quantum effects are unlikely to matter and that we will be able to simulate an entire human brain in a digital computer with sufficient detail. We can't do it quite yet, as our present digital hardware is too slow and has insufficient memory (we also do not yet have a complete map of a human brain).

Unless you want to believe in something beyond what physics has determined to date, there is nothing that a human brain can do that a computer cannot do also. Likely a digital computer will suffice, but it is possible that we have to get to quantum computers to cover everything. Now there is always some wiggle room in the future. We may discover something new about physical reality that we don't yet know, and that changes our view of what is computable. But not so far.

For a long time this universality property didn't seem to matter all that much. Computers were pretty dumb compared to humans. This was frustrating to computer scientists who, going back as far as Turing himself, had the belief that it should be possible to build a machine that does, well, smart things. But they couldn't get it to work. Even something that is really simple for most humans, such as recognizing objects, had computers completely stumped. Until now that is, when we suddenly find ourselves with computers that can do all sorts of smart things.

An analogy here is heavier than air flight. We knew for a long time that it must be possible—we knew that birds were heavier than air and yet they could fly. But it took until 1903, when the Wright Brothers built the first successful airplane, for us to figure out how to do it [11]. Once they and several others around the same time had figured it out, though, progress was rapid. We went from not knowing how to fly for thousands of years to passenger jet planes crossing the Atlantic in 55 years (BOAC's first transatlantic jet passenger flight was in 1958 [12]). If you graph this, you see a perfect example of a non-linearity. We didn't get gradually better at flying. We couldn't do it at all and then suddenly we did, and quickly did it very well.



Similarly, with digital technology, we have finally made a series of breakthroughs, which have taken us from essentially no machine intelligence to machines outperforming humans on many different tasks, including reading handwriting and recognizing faces [13]. More impressive, maybe, is that machines have learned how to drive cars. The rate of progress in driving is a great example of the non-linearity of improvement. DARPA, the Defense Advanced Research Projects Agency, held its first so-called Grand Challenge for self driving cars in 2004. At the time they picked a 150 mile closed course in the Mojave Desert region, and yet no car got further than 7 miles before getting stuck (less than 5% of the course). By 2012, less than a decade later, Google's self-driving cars had successfully driven over 300,000 miles on public roads with traffic [15].

Some people will object that reading handwriting, recognizing faces, or driving a car is not what we mean by intelligence. This just points out, though, that we don't really have a good definition of “intelligence.” For instance, if you had a dog that could perform any of these tasks, let alone all three, you would likely call it an “intelligent” dog.

Other people will say that humans also have creativity and these machines, even if we grant them some form of intelligence, won't ever be creative. This amounts to arguing that creativity is something other than computation. The word “creativity” suggests the idea of “something from nothing,” of outputs without inputs. But that is not the nature of human creativity: musicians create new music after having heard lots of music, engineers create new machines after having seen many existing ones, and so on. There is no evidence that creativity is more than computation.

Recently, Google achieved a relevant breakthrough in machine intelligence. The AlphaGo program beat Korean Go grandmaster Lee Sedol 4-1 [16]. Previously, progress with software that could play Go had been comparatively slow and even the best programs could not beat strong club players, let alone masters. The search space in Go is extremely large, which means a search approach, which works for Chess, cannot be used to find moves. Instead, candidate moves need to be conjectured. Put differently, playing Go involves creativity.

The approach used to train the AlphaGo program, so-called adversarial training of neural networks, can also be applied to other domains that require creativity. There is already progress in applying these techniques to composing music and creating designs. Maybe even more surprisingly, machines can learn to be creative not just from studying prior human games or designs, but from creating their own based on rules. A newer version of AlphaGo called AlphaZero, starts out just knowing the rules of a game such as Go or chess, and learns from games it plays against itself [NEED REFERENCE]. This approach allows machines to be creative in areas that have limited or no prior human work to go on.

With digital technologies, the space of the possible has thus expanded to include machines that can most likely do anything that a human can do.

Universality at Zero Marginal Cost

Now, impressive as these two properties of zero marginal cost and universality are on their own, their combination is truly magical. I will just give one example: we are well on our way to a computer program that will be able to diagnose any disease from a patient's symptoms in a series of steps, including ordering new tests and interpreting their results [14]. We have expected this based on universality, but now we are making tangible progress and accomplishing this is a matter of decades at best. Once we can do it, then thanks to zero marginal cost we can, and should, provide free diagnosis to anyone, anywhere in the world. (Okay—the actual lab tests, to the extent they are required, will still cost something). Still, one needs to let that sink in slowly to really grasp its extent. The realm of possibility for mankind will soon include free medical diagnosis for all humans.

Universality of computation at zero marginal cost is unlike anything we have had with prior technologies. Being able to give all of humanity access to all the world's information and knowledge was never before possible. Intelligent machines were not previously possible. Now we have both. This is as profound an increase in what is possible for humanity as agriculture and industry were before. Each of those ushered in an entirely different age.

To help us think better about the next age made possible by digital technologies, we now need to put some foundations in place.

Part One: Laying a Foundation

In an earlier version of this book I attempted to skip any philosophical exposition and jump right into the impact of digital technology. While that may make for more gripping reading, it resulted in the verbal equivalent of building a skyscraper without a foundation: rapid initial progress followed by total collapse.

With digital technology inflating the space of the possible, we need to establish some principles. Otherwise we will misread the trends and phenomena that are already happening today. Instead of exploring the new space of the possible for the benefit of all of humanity, we will instead try to bend it to fit existing economic and social systems.

What follows is my attempt to establish a firm foundation for building a future grounded in optimism and humanism. I explain why the power of knowledge is the source of optimism as a principle, and why the existence of knowledge provides an objective basis for humanism. Much of my thinking about this has been deeply influenced by the writing of David Deutsch, in particular his book “The Beginning of Infinity” [17].

Furthermore, to argue that capital is no longer scarce and that attention now is, I provide a definition and an analysis of scarcity that are not based on money and prices, but rather on needs. Finally, to support this argument, I propose a catalog of our individual and collective basic needs as humans.

With these foundations in place, we can then fully appreciate how the power of digital technology enables the Knowledge Age.

Optimism

When I started my blog a decade ago, I called myself a “Technology Optimist” in my first post. I wrote that

> I am excited to be living in a time when we are making tremendous progress on understanding aging, fighting cancer, developing clean technologies, and so much more. This is not to say that I automatically assume that technology by itself will solve all our problems (I guess that would be a “technology pollyanna”). Instead I believe that —over time—we as a society figure out how to use technology to actually improve our standard of living. I for one am sure glad I am not living in the Middle Ages.

The fundamental tenor of this book is one of optimism. This is in part a reflection of my personality. I am pretty sure it would be impossible to be a VC as a pessimist. You would focus only on the many reasons why a particular startup won't succeed and never make an investment.

Optimism is a theme that I will return to many times in this book and so it is a good idea to make this apparent bias of mine clear upfront. It is more than a personal bias though. Optimism has a profound role in human affairs and its source is the power of knowledge. Knowledge has given us vaccines and cures to many diseases. Knowledge lets us travel long distances at high speeds in trains and planes. Knowledge lets us read Aristotle and listen to Mozart. Knowledge is what makes us humans human (in a way I will make more precise shortly).

I am optimistic about what humanity can ultimately accomplish with digital technology. Using the Internet and advances in machine intelligence we can dramatically accelerate the creation and distribution of knowledge. This will be essential for progress.

Progress has become a loaded word. Is there such a thing as true progress and what does it look like? Aren't we humans responsible not only for the many diseases of civilization but also for the downright extinction of countless species and potentially our own demise through climate change?

Yes, we do have problems. And one might, as a pessimist, focus on these problems and conclude they cannot be solved. This is like looking at a startup and concluding there is no point in even getting going—or funding it—because, well, there will be problems.

The beauty of problems, though, is that they can be overcome by human knowledge. Is that true for all problems? Well it has been true so far, as we are still here.

This is in and of itself quite remarkable: we are slower and weaker than many other species, but humans alone have developed the capacity for knowledge. And knowledge turns out to be extraordinarily powerful. It allowed us to figure out, for instance, how to make fire. We may take this for granted today, but no other species has managed to do this and to record its knowledge of fire making in a way that can be shared across space and time (I will shortly provide a more precise definition of knowledge and why it is quite so powerful).

There is an extreme position that would suggest we would have been better off never developing knowledge [18]. That we would still live in a state of paradise had we not tasted the forbidden fruit. Not only is it hard to see how we would go back there now, but more importantly, I for one prefer not to be consumed by wild animals.

Will all future problems be solvable, including say climate change? There is, of course, no guarantee. We might wind up with a problem we cannot solve and that might cause our extinction. But what is certain is that assuming that problems cannot be solved guarantees that they will not be solved. Pessimism is a self-defeating attitude, as it leads to inaction.

Yes, digital technologies including the Internet and advances in automation have brought with them a new set of problems. We will encounter many in this book, including immense pressure on people's ability to earn a living and the conflicts arising from being exposed to content that runs counter to one's upbringing or deeply held cultural or religious beliefs.

And yet this expanded space of the possible also includes amazing progress, such as zero marginal cost diagnosis of disease for anyone anywhere in the world, the example we encountered at the end of the previous chapter.

Believing in the potential for real progress though is not the same as being a Pollyanna. Progress does not happen by itself as a deterministic function of technology. Contrary to Kevin Kelly's claims in his book “What Technology Wants”, technology doesn't want anything by itself and certainly not a better world for humanity. It simply makes such a world possible.

Economics also doesn't want anything. It is not normative. Nothing in economics, for instance, says that a new technology cannot make some people or possibly a great many people worse off. Economics gives us tools for analyzing markets and designing regulations to address some of their failures. But we still need to make choices about what we want markets and regulations to accomplish for humanity.

And contrary to Karl Marx, history too doesn't want anything. Nor is there, as political economist Francis Fukuyama would have it, an end of history with a final social, economic and political system. History is the result of human choices; it doesn't make its own choices. And as long as we make technological progress there will be new choices to make.

It is our responsibility, both individually and collectively, to make choices about which of the many worlds made possible by digital technology we want to live in. We need to choose rules for society (regulation) and behaviors for ourselves (self-regulation). And the choices we make now are especially important because the latest expansion of the space of the possible includes machines that have knowledge and can make choices.

Regulation

There are many people who work in technology and investing who are optimists and believe in progress. Among those there is a subset, myself included, who also believe in the need for regulation. There is another group though that has a decidedly libertarian streak and would like for government to just get out of the way.

The history of technological progress is one of changes in social norms and political regulations. For instance, at the moment much of the world gets around by driving cars. The car was an important technological innovation in that it allowed for individual mobility. But it would have been impossible to have widespread adoption of cars without regulation. We needed to agree on rules of the road and we also needed to build roads. Neither of these could have been accomplished based solely on individual choices. Roads and their rules are examples of natural monopolies: you don't want to have multiple disjointed road networks or different sets of rules of the road (imagine some people driving on the left side and others on the right). Natural monopolies are classic examples of market failure that require regulation. The car would also not have made much sense as individual transport without changes in social norms, such as making it acceptable for women to operate a car (a change that did not take place in Saudi Arabia until the end of 2017 [19]).

Not all regulation will be good regulation. In fact, the earliest regulation of automotive vehicles was aimed at delaying their adoption by limiting their speed to that of a horse drawn carriage and in some cases even requiring them to be preceded by someone carrying a flag [20].

Similarly, not all regulation of digital technology will be good regulation. Much of it will initially aim to protect the status quo and help incumbent enterprises, such as the recently enacted changes to net neutrality rules [21]. But that is no reason to call for an absence of regulation. It should be seen, instead, as a challenge to come up with the right regulation as we did eventually in the case of cars.

My proposals for regulation later in the book are aimed at being pro-innovation by giving more economic freedom to individuals and by giving them better access to information (informational freedom). These regulations are choices we need to make collectively. They

represent a big departure from the past aimed at letting us explore the space of the possible opened up by digital technologies so that we can transition from the Industrial Age to the Knowledge Age.

Self-Regulation

There is another set of choices we need to make individually. These have to do with how we react to the massive acceleration of information dissemination and knowledge creation made possible by digital technology. These are not rules society can or should impose because they relate to our inner mental states.

For instance, there are a lot of people at the moment who feel offended by content that is available on the Internet. People are yelling, insulting and even threatening in comment threads and forums. Others spend all their time in polarized online communities being fed algorithmically curated information which confirms only their existing biases, in a phenomenon that has become known as a “filter bubble”. Even though some technology and regulation can help here, fundamentally overcoming these problems requires internal changes which I later describe in a section called psychological freedom.

Changing ourselves requires self-regulation. By this I mean training our capacity as individuals to use our rationality. From Eastern religions including Hinduism and Buddhism, to the Stoics in ancient Greece, there is a long tradition of understanding how we can get past our immediate emotional and heuristic brain responses. Much of this lines up well with what we have uncovered more recently about the workings of the human brain.

If we want to have true progress leveraging digital technologies, we need to get past our initial emotional responses and figure out how to maintain a rational dialog. Only then will our choices on where to go in the dramatically enlarged space of the possible be based on our critical thinking abilities.

Much of what I have been saying here about optimism, the potential for progress and the need for regulation and self-regulation could immediately be attacked as coming from the perspective of a white male venture investor living in the United States. As such it might be deemed a privileged view that I am attempting to impose on others.

The next chapter will argue instead that Humanism provides an objective foundation of values for this perspective that applies to all of humanity.

Humanism

What then are the values that I am basing all of this on? Where do those come from?

In his book Sapiens, historian Yuval Harari claims that all value systems are simply narratives that are equally valid. He specifically denies the existence of an objective basis for humanism that would support a privileged position for humanity as a species [22]. I will try to convince you that this is not so. If the power of knowledge is the source of optimism, then its existence alone provides the basis for humanism.

Knowledge, as I use the term in this book, is the externalized — recorded in a medium — information that allows humans to share insights and art with each other.

We are the only species on Earth that generates this kind of knowledge and it can be shared over space and time. For instance, I can read a book today that was written by someone else, a long time ago and in a completely different part of the world. This does give humanity a privileged position among the species because knowledge turns out to be extraordinarily powerful. And to quote from a great tract of philosophy, “Spiderman,” with great power comes great responsibility (which gets its own section later in the book). Because we have knowledge, humans are responsible for dolphins, not the other way round.

Since the work of Alan Turing we know that there is a mathematically precise way in which knowledge gives humans this privileged position. Human brains are more complex than animal brains but they are still only finite state machines, admittedly with a huge number of states. The computational capabilities of finite state machines are quite narrow. For instance, one cannot build a finite state machine that recognizes palindromes of arbitrary length [23]. To get a feel for the limitations of the brain by itself, think about the times you simply cannot remember something and wind up looking it up online.

In addition to our brains though, humans also have universal alphabets and the technology for recording and disseminating information encoded in those alphabets (universal in the sense that once you have an alphabet with at least two letters you can in principle write down anything). This gives humans the same computational capability as the so-called Turing machine which I introduced earlier in the Universality section of the Digital Technology chapter. As Turing showed, that means humanity can compute anything that can be computed in the universe. The computational capability of other species is dramatically limited by comparison. Because they do not have knowledge they are constrained to the equivalent of finite state machines.

Now even if you do not buy into this argument based on a mathematical proof, consider the ability to make progress as a species. Without knowledge (as defined above) other species are reduced to only two methods of sharing something they have learned: communication and evolution. Communication is limited because it is both local and ephemeral and evolution is extremely slow. In contrast, humans can share knowledge across space and time and can rapidly refine knowledge through the process of critical inquiry. What evolution is to DNA, critical inquiry is to knowledge: a process of mutation and selection that over time separates good ideas and good art from bad ones.

Progress and knowledge are inherently tied together through critical inquiry. We make progress only if we are capable of (over time) identifying some ideas as better than others. Some art as more important. Critical inquiry is by no means linear, as new ideas and new art are not always better. Sometimes we go off in wrong directions in science or fads in art. But given enough time, a sorting takes place. For instance, we no longer believe in the geocentric view of our solar system. And only a small fraction of the art that has ever been created is still considered important today. While this process may take decades (and sometimes hundreds of years), critical inquiry is blindingly fast compared to evolution.

My use of words such as “better” implies the existence of values. But where do those come from? They all flow from one central value of a humanism based on knowledge and that is critical inquiry itself. We must at all times guard the freedom to point out flaws in existing knowledge and to propose alternatives. Imagine how limited our available music would be today if we had banned new compositions after Beethoven.

We should therefore seek regulation and self-regulation that supports critical inquiry. In business for instance, critical inquiry often takes the form of competition in the market, which is why regulations that support the functioning of competitive markets are so important. Both the sections on Economic Freedom and on Informational Freedom will introduce examples of regulation that are aimed at increasing competition in the age of digital technology. Individually, critical inquiry requires our ability to be open to feedback in the face of our deeply rooted confirmation bias. This will be addressed in the section on Psychological Freedom. In politics and government critical inquiry is enabled by democracy which gets its own chapter.

Freedom of speech in this view is not a value in and of itself. It is a crucial enabler of critical inquiry. But we can also see how some limits on free speech — which are part of such regulation — flow from the same value. If you can use speech to call for violence against individuals or minority groups then you can use speech to suppress critical inquiry.

Digital technologies, which include a global information network and general purpose computing which is bringing us machine intelligence, are dramatically accelerating the rate at which humanity can accumulate and share knowledge. But these same technologies

allow for individually targeted manipulation and for propaganda at global scale as well as constant distraction.

Put differently, digital technology massively raises the importance of critical inquiry, the central value of knowledge based humanism.

Scarcity

In this book I will be arguing that capital is no longer scarce but that attention now is. Furthermore this constitutes the third major shift in scarcity in the history of humanity. The first shift was from food to land when we went from the Forager Age to the Agrarian Age. The second was from land to capital when we went from the Agrarian Age to the Industrial Age.

The words scarce and scarcity have come to take on a meaning that is derived from modern economics. Many people now think of something as scarce if its price is greater than zero. By this definition land is obviously still scarce as it costs a lot of money to buy a piece of land. And financial capital is still scarce because even in our current low interest rate environment, there is a price for borrowing money or raising equity financing (which makes it possible for me to make money from being a venture capital investor).

There is a fundamental problem with this price based definition of scarcity though: anything can be made scarce by assigning property rights. Imagine for a moment that ownership of the world's atmosphere belonged to Global Air Ltd (GAL). Now GAL could charge anyone who breathes air a usage fee. Air would suddenly be scarce. That may seem like an extreme example at first. Yet, some have argued that the solution to the problem of air pollution is to assign ownership rights to the atmosphere, on the theory that this will result in the owners having an economic incentive to maintain an unpolluted atmosphere.

I will use a different meaning of scarcity that is not based on price. Something is scarce when there is less of it than we need to meet our basic needs. If people are starving then food is scarce.

One can think of this as technological scarcity (as opposed to economic scarcity). The point is that technological progress makes things less scarce over time. The 18th century scholar Thomas Malthus was not wrong about global population growth, which he predicted could be exponential (and thus, he argued, would outpace growth in the food supply leading to hunger) [24]. He turned out to be wrong about the potential for technological progress to exponentially increase the amount of food we could produce. We have in fact gotten so good at agriculture that the amount of land needed for food production has started to decline even as the global population is still growing.

But what about wants? If people are not starving but want more food doesn't that mean food is still scarce? Is it possible to make a distinction between needs and wants? Modern economics has thoroughly equated the two, but intuitively we know that this is not the case. You need to drink water, but you want to drink champagne. You need to provide your body

with calories, but you want to eat caviar. There is no bright line as the use of “starvation” above might suggest—we know that some food is healthier for the human body than other (although we are a surprisingly long way from understanding nutrition well). Still, the distinction is clear enough for this definition of scarcity to make sense. One may argue about degrees but not about the principle.

Just because something is no longer scarce doesn't mean that it is abundant. Instead there is an intermediate stage which I will call sufficient. For instance, there is sufficient land to meet everyone's needs for housing and food. For something to be abundant there has to be enough for everyone's needs to be met at zero marginal cost. Building housing and growing food still incurs significant marginal cost and hence these are not abundant. I am saying “still” because technological progress could make land and food abundant (imagine how much land we'll have if we can figure out how to live in space and make other planets habitable).

Is anything abundant? Yes, digital information is already abundant. We can make copies of it and distribute it at zero marginal cost. We can meet everyone's information needs at zero marginal cost.

Is anything scarce? Well, I will endeavor to show that human attention is scarce. It turns out to be scarce, in part, because digital information is abundant.

A Brief History of Scarcity

Food was the original scarcity for humans. We started out as hunter gatherers (foragers). And bad hunters at that. Before the development of weapons and tactics we were mostly hunting small animals and scavenging otherwise. There was one relatively simple solution to food scarcity: migrate elsewhere. And that's why humanity spread across the globe at a relatively decent speed. But once the human population grew past a certain density and migration was not an option, then food scarcity was the source of much violence both among and within tribes. It is important to note that tribes that were not in direct competition with others for food and had no systems for food surplus (no storage, so called “immediate return” societies) tended not to be violent [25].

Eventually, as far back as 10,000 BCE, we happened upon a series of technological advances including growing crops, irrigation and domesticating animals, that together gave us agriculture [26]. With agriculture, scarcity shifted from food to land (of course land had been a proxy for food to some degree but now the scarcity was land directly). Agriculture increased the food density of land by at least an order of magnitude [NEED CITATION]. That was enough for a meaningful surplus to be produced, which meant that a social hierarchy could be created. Rulers commanded armies. The more land a ruler controlled the bigger an

army the ruler could afford, which brought us several thousand years of empire building among agricultural societies. The transition into the Agricultural Age was extremely violent with most forager societies wiped out altogether.

Then sometime in the 18th century a new set of technological advances began to emerge that together gave us industry, including steam/electrical power, chemistry, and mechanical machines. With these, scarcity shifted from land to capital. Why was land no longer scarce? Because the use of machines in harvesting and the increasing knowledge of fertilizers dramatically increased crop yields. The transition from the Agricultural Age into the Industrial Age wound up being incredibly violent with numerous revolutions and culminating in World War I and II.

At the end of the Agrarian Age, the ruling elites all came from controlling land. They still believed land to be the critical scarcity and saw industry as a means of building and equipping more powerful armies. For them industry did not mean a new age had started, instead it meant tanks and battleships. Even World War II was still about land, as Hitler and the Nazis pursued “Lebensraum” (literally: room to live). Once again the transition from one age to the next was brought about through extreme violence. It was only at the end of World War II that we truly exited the Agrarian Age.

We now live in the Industrial Age. Eventually we added service jobs to manufacturing but that did not shift the dominant scarcity which was capital. The success of the market based economy over the planned economy is the result of more effective capital formation. Competitive markets combined with entrepreneurial activity were better at allocating and accumulating capital.

Capital these days is frequently mistaken for wealth or financial capital, but what really matters is productive capital in the form of machines, inventories of goods, buildings. Financial capital is an intermediary step that allows for the formation of physical capital but it does not add to the production of goods and services directly (machines are not made of dollar bills). Companies only require financial capital because of their working capital needs, which arise when they have to pay for machines, supplies and labor before they receive payment for their product or service.

Much like the ruling elites at the end of the Agrarian Age came from land, the ruling elites today come from capital. They often don't take up political roles themselves, as we have devised ways of influencing policy indirectly, which exposes the owners of capital to less personal risk. A good example of this recently is the role of the Mercer Family in financing and supporting groups, such as Breitbart news, that influenced the outcome of the U.S. Presidential election [27].

The first major claim of this book is that capital is no longer scarce (in the technological sense defined above). We have sufficient productive capital to meet our needs for housing, clothing, transportation, education and healthcare. This is not a claim that productive capital or access to it are adequately distributed around the world. It is also not a claim that we cannot substantially further improve productive capital by making more of it and creating better versions. It is not even a claim that financial capital is currently being allocated properly for the creation of global productive capital (it is not). It is simply the claim that productive capital is sufficient for meeting humanity's basic needs.

At the same time, digital technology has massively expanded the space of the possible. Digital technology gives us a global network connecting all of humanity to each other and to information at zero marginal cost. Powerful general purpose computing is making artificial intelligence a reality for the first time. This combination of zero marginal cost and universality of computation can dramatically accelerate the creation of knowledge in the world.

Human attention, however, is fundamentally limited. We have 24 hours in the day. We need some of that time to eat and sleep. So that puts a hard limit on how much attention we have both individually and collectively (with population growth slowing down as a result of economic progress).

But why does that make attention scarce? How do we not have enough attention to meet our needs? This is the second major claim of the book. Individually, it is so because most of us are not spending nearly enough of our attention on the fundamental question of our purpose in life. Collectively, it is so because we are not spending enough of our attention on species level risks, such as climate change, asteroid strikes, infectious diseases and opportunities such as space travel, quantum computing, genetic engineering. We are also not paying nearly enough attention to democracy, to our communities, and to each other, including our friends and families.

Therefore the goals of this book are to convince readers, first, that scarcity is, in fact, shifting from capital to attention and, second, that we need new regulation and self-regulation in response to this shift.

Ideally, World After Capital contributes to a dialog that helps avoid another terrible transition. To enter the Knowledge Age we need a lot of changes that are not in the direct interest of the owners of capital who largely control policies at the end of the Industrial Age. This is a direct parallel to the end of the Agrarian Age, and we must learn from that transition, if we do not want to repeat its horrors.

Historians will have a lot of bones to pick with the preceding highly abstracted account. The periods didn't unfold as neatly and there were regional differences. Nonetheless, I think the overall pattern of scarcity shifting from food to land, from land to capital, and finally from capital to attention holds.

Needs

The definition of scarcity that I just introduced is based on the notion of needs. To argue that there is a shift in scarcity from capital to attention thus requires an agreed upon set of needs to show that we indeed have sufficient capital. Can we make progress in defining what constitutes a set of basic human needs?

I am not proposing that this is a simple task. What follows should be considered a way of starting a dialogue. A list of basic needs is a piece of knowledge. As such it can be improved over time through the process of critical inquiry. You can critique my list by pointing out flaws, you can also propose changes to my list, or you can publish your own list altogether.

One of the benefits of my approach to writing World After Capital out in the open, and with revisions tracked, is that you can see how my thinking on needs has evolved over time. In an earlier version I tried to group needs into categories such as biological, physical, and social. But the boundaries between those seemed rather arbitrary upon further examination. So in the current version I am distinguishing only between individual and collective needs, where the former will apply to a single human wherever and the latter are the needs of humanity as a whole.

Another challenge in putting together a list of needs is that it is all too easy to confuse a need with a strategy for meeting this need. For instance, eating meat is one strategy for addressing the need for calories, but humans can acquire calories from many other sources.

Individual Needs

These are the basic needs of the human body and mind. Without them individual survival and flourishing is impossible. A single individual has these needs even when isolated, such as traveling alone in a spaceship.

The first set of individual needs comes from keeping our bodies powered, these include:

Oxygen. Humans need on average about 550 liters (0.55 cubic meters) of oxygen per day [28]. The exact need of course varies with factors such as the size of our respective body and the degree of physical exertion. Our most common solution to this need is breathing air.

Water. We need to drink on average between 2-3 liters of water per day to stay hydrated [29]. Again various factors such as body size, exertion and temperature will affect the exact need.

Calories. To power our bodies we generally require between 1,500 and 3,000 calories per day, again depending on body size, activity level etc [30]. We solve this need by consuming food. The best way to do this, however, is surprisingly controversial and poorly understood for such a basic need. In particular, the mix between proteins, lipids and carbohydrates is subject to ongoing debate.

Nutrients. The body cannot synthesize all the materials it requires, including certain amino acids, vitamins and minerals. Therefore these must be obtained directly as part of our nutrition. This too is an area that is surprisingly poorly understood, meaning which nutrients exactly we really need to acquire externally seems unsettled. There is a wide range of food consumption strategies that seem to support the human body.

Discharge. So this may be a bit gross but we also need to get things out of our bodies again, including expelling processed food, radiating heat and exhaling carbon dioxide. A lot of human progress has come from better strategies for solving our discharge needs, such as public sanitation. For fans of science fiction, like myself, dealing with the problems of discharge is an interesting limit on our ability to cloak ourselves.

The second set of individual needs relates to the operating environment for humans. From a cosmic perspective, humans have an incredibly narrow operating range, which is provided for, without technological assistance, only in a few places even right here on Earth. Here are some of our basic operating needs:

Temperature. Our bodies can self-regulate their temperature within a limited range. We have a need to control our environment to help our bodies with temperature regulation. Common strategies to meet our temperature needs include shelter and clothing.

Pressure. Anybody who has gone diving knows that our bodies do not handle increased pressure around us very well. The same goes for decreased pressure (one of the reasons air travel is exhausting is that planes do not retain sea level pressure).

Light. Most humans would be hard pressed to do much of anything in complete darkness. The Bible introduces light right away with “Let there be light” in the third verse for the Book of Genesis. For the longest time the solution to our need for light was simply sunlight, but much of human ingenuity has gone into the creation of artificial light sources.

The third set of individual needs arises from dealing with a complex and ever changing environment. As we go through life we encounter challenges that we need to overcome. This results in three fundamental individual needs:

Healing. When we damage our body in some fashion it needs to heal. The human body comes equipped with extensive systems for self-healing including combating many foreign substances (including vomiting, diarrhea, antibodies). Beyond a certain range, the body

needs external assistance to heal. Here too we have developed many solutions, and often group them under the term healthcare.

Learning. We are born quite, well, stupid. We even have to learn relatively basic skills such as walking and the use of tools. When we encounter a new situation, we need to learn how to deal with it. We group many of the strategies for solving the need for learning under the heading education, but other solutions include self study, experimenting (gaining experience) and parenting.

Meaning. As humans we have a profound psychological need for meaning in our lives. It is what keeps us going. Religion and religious beliefs have long been a key strategy for solving this need. As I have argued in the section on Humanism, there is an objective basis for human meaning rooted in knowledge. Another key strategy to solve this need comes from our interactions with other humans, including having others acknowledge our contributions to a project or simply our existence.

This last set of needs may strike you as being at a much higher level than the earlier needs. It is tempting to try and sort individual needs into a hierarchy, as Maslov did. That seems intuitively appealing but is misleading. All of these needs are essential. As a thought exercise, picture yourself in a spaceship and try to remove any of the above.

Collective Needs

Our collective needs by contrast arise from living together in societies and sharing space and resources. Meeting these needs is what allows human societies to survive and advance.

Reproduction. Individuals can survive without sex, but reproduction is a need for societies as a whole. As humanity we have already learned how to solve the need for reproduction without sex. In the future there may be altogether different solutions for reproduction in the sense of the continuation of a human society (whether here on Earth or elsewhere).

Allocation. Despite abundance in the digital realm, access to physical objects and resources has to be allocated. Take a chair as an example. Only one person can sit in a chair (comfortably) at a time. When there are multiple people we need a solution for allocating the chair between them. That's why allocation is a collective need. If you are by yourself you can sit on a chair whenever you want to as there is nobody else to take it up.

Motivation. This may seem like an individual concept but it exists as a collective need in the following sense: Societies need to motivate their members to carry out tasks and follow rules. Even the most primitive societies have solutions for this problem often in the form of rewards and punishments.

Coordination. Whenever there is more than a single human involved in any activity, there is a need for coordination among the participating humans. Take a simple meeting among two people as an example. In order for the meeting to take place they need to show up at the same place at the same time. We have developed many different communication and governance mechanisms to address this need.

Knowledge. As I have argued in the prior sections on Optimism and Humanism, this is the central collective human need. Without increased knowledge a society will encounter problems that it cannot solve and will be decimated as a result. History is full of examples of societies not having enough knowledge, such as the Easter Islanders or the Mayans. This is not about what any one individual has learned but rather about the body of knowledge that is accessible to society as a whole. Much of the later parts of World After Capital are about solutions for generating more knowledge faster.

These collective needs may strike you as overly abstract. But this is the logical result of identifying needs, instead of solutions. Governments and laws, for instance, are examples of solutions to some of these collective needs. But so are markets and firms and more recently networks and platforms.

Enablers

Now you might ask, what about energy? Don't we have a need for energy both individually and collectively? It would seem that individually we need energy to maintain the temperature of a house. Or that collectively we need energy to power our communications infrastructure. But as those two examples show, energy is not a direct human need (either individually or collectively). Instead it is an enabler of specific solutions to our needs. Some solutions will require more energy than others.

Here are four foundational enablers. I am listing them in the Needs section, as readers have at times proposed these as additional needs and I had in a prior versions included them among Collective Needs.

Energy. For the longest time humanity relied on direct sunlight as the primary source of energy. Since then we have developed many ways of generating energy, including better ways of capturing sunlight. Producing more energy and having it available in concentrated and highly regulated form via electricity has made many new solutions for human needs possible.

Resources. In early human history all resources were simply found in nature. Later we started both growing and extracting resources. Many modern solutions have been made possible by access to new kinds of resources. For instance, mobile phones give us new

solutions to individual and collective needs. Building mobile phones is enabled in part by some esoteric raw materials, such as so-called rare-earth elements.

Transformation. Energy and resources alone are not enough though. To enable most solutions we need to figure out how to use energy to transform resources. This involves chemical and physical processes. Capital, as in physical capital such as machines, has been a crucial enabler for many new solutions to human needs. For instance, a knitting machine can transform yarns into clothing at high velocity. Clothing is one of our key solutions for maintaining the human operating environment.

Transportation. The final foundational enabler is the ability to move stuff (using stuff broadly to include people). This is another area in which we have made great progress over time, going from human powered transportation to animal powered to machine powered, including planes, trains and automobiles.

Again I have chosen these enablers at a high degree of abstraction on purpose. Coal-fired power plants provide energy (in the form of electricity) and so do solar panels today and nuclear fusion at some point in the future. These three examples have dramatically different characteristics but they all are fundamentally energy enablers.

This is my current working version of needs (and enablers). I have now revised this section fairly substantially for a second time. And while I fully expect further changes, I believe it now properly sets up my argument that there is sufficient productive capital in the world for meeting our individual and collective needs, including further development of the four enablers.

Part Two: Getting Past Capital

Digital technology is shifting scarcity from capital to attention. That is one of the central arguments of World After Capital. With the philosophical foundation out of the way now is the time to back this claim up with some numbers.

First I will examine trends in population growth to show that fears of a further population explosion are unfounded. Then I will look at how much productive capital exists in the world relative to the basic needs of humanity. While that section still needs work, it already contains interesting statistics that suggest we have sufficient capital.

Besides capital, the other critical input to production in the Industrial Age is labor. Labor is provided through what I call the job loop: most people earn a living by selling their labor and then using their wages to buy goods and services, which in turn are produced by other job holders. That loop, which currently captures much of our attention, is being disrupted by digital technologies with important implications for how we could allocate our attention in the future.

Finally, I will argue why attention is the crucial scarcity for humanity going forward. Capitalism, with its emphasis on markets, cannot be used to allocate attention due to intrinsic limitations. Prices do not and cannot exist for the most important activities we should be allocating attention to.

Population

In 1798 Thomas Malthus predicted widespread crises of famine and starvation as population growth outstrips humanity's ability to grow food [31]. Malthus prediction was half right: Global population did explode, with population growth accelerating right at the time of his writing around 1800.

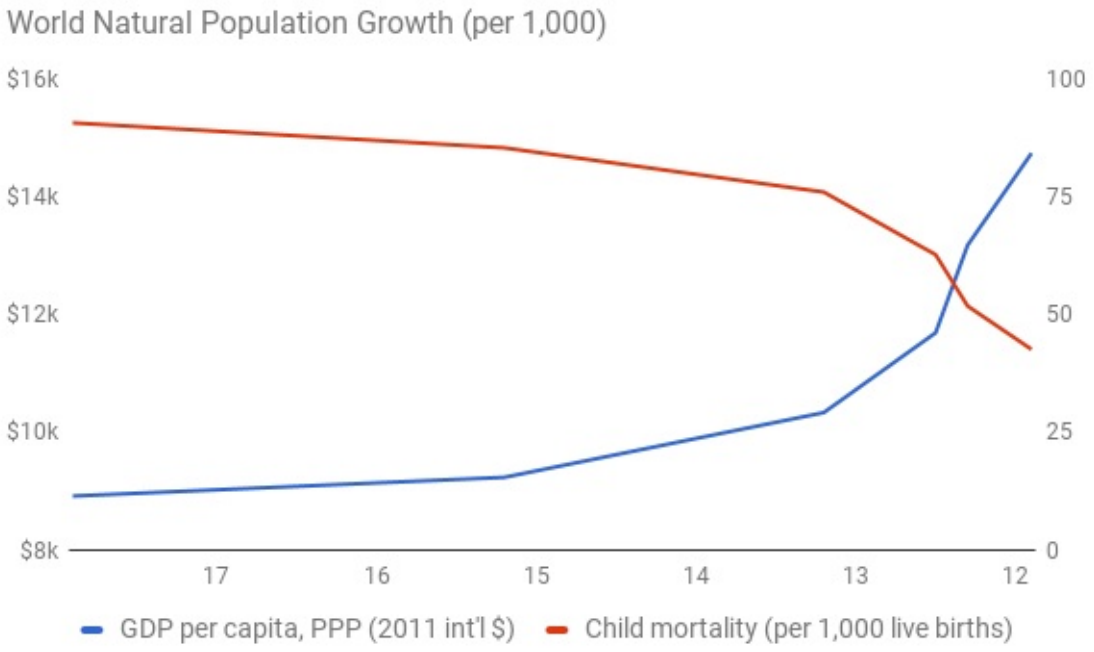
Since then, the human population has grown from about 1B to over 7B people here on planet Earth [32]. As an optimist, the thing to note immediately, though, is that Malthus's most dire fears about the implications of this population growth have not been realized. There has been no global scale starvation and even the fear that most people would live in abject poverty has not come true. In fact, the opposite has happened recently. Around the world the number of people living in extreme poverty has been declining all the while population growth has been about twice as fast as what Malthus predicted as an upper limit of 1 billion people added in 25 years [33].

What Malthus got wrong was the rate of technological progress. First, Malthus was wrong in being pessimistic about our ability to improve agricultural productivity. Here is just some of the amazing progress in agriculture since his writing. The percentage of the global workforce employed in agriculture has declined from more than 80% to 33% and is falling rapidly (in the US and other advanced economies agriculture represents 2% or less of employment). Globally in the last 50 years alone, the land required to produce the same output of food has declined by a stunning 68% [35].

Second, Malthus could not foresee the scientific breakthroughs that made the industrial revolution possible. That revolution not only powered the agricultural productivity increase but also gave us dramatic advances in the standard of living, including much increased life expectancy, faster transportation, cheaper and better communication and so on.

Malthus being wrong so far isn't by itself a guarantee that his predictions couldn't catch up with us. If population growth were to outstrip technological progress this would in fact be the case. We know this because we have seen it happen in India [36] and other places that have experienced population growth in excess of progress resulting in mass starvation.

As it turns out though, population growth itself responds to technological progress. In particular there is a strong relationship between reductions in infant mortality and decreases in birth rates, as well as between increases in living standards and decreases in birth rates.



Max Roser has produced some beautiful charts as part of his amazing project Our World In Data that show these two effects play themselves out in country after country across the world [37].

So despite the extraordinary growth in global population over the last 200 years, simply extrapolating this growth out into the future would be a clear mistake. Instead, there are strong signs that peak population is a much more likely scenario.

Now one can reasonably argue over what that peak number will be. Some will claim that this debate matters a lot because they strongly believe that the world cannot sustain, say, 11B people. But this misses a crucial point. The world cannot sustain 7B people either—i.e. the current population—if we don't continue to make technological progress. The way we have managed to support 7B people so far has created all sorts of new problems. We cannot choose to stand still on innovation. Instead we need continued technological progress to solve the problems we have created, such as water and air pollution and climate change.

The key takeaway should be one of curvature. All signs suggest that the global population curve is starting to decelerate (negative second derivative) whereas the rate of technical progress is continuing to accelerate (positive second derivative) [38] [39]. That is the basis for being optimistic about progress in relation to population growth.

I have already described previously why digital technology is so disruptive. Later in the book we will see in more detail how it is contributing to an acceleration of knowledge creation and thus progress. My view here stands in contrast with much of the recent pessimistic writing, including the recently published book by economist Robert J. Gordon and the secular stagnation literature more generally. To show why my outlook is so different, I will now turn to how much capital there is relative to humanity's basic needs.

Capital

The title of the book is World after Capital. One of my fundamental claims is that capital is no longer scarce. There is enough capital in the world to meet everyone's basic needs. That means meeting the individual needs of 7 billion or more people, the collective needs of the societies they live in and the collective needs of humanity at large. Using the language introduced earlier, capital is sufficient. And because population growth is decelerating, while technological progress is accelerating (due to digital technology), capital will no longer be the binding constraint for humanity going forward.

It is tempting to look at this in terms of financial capital, but that again would be succumbing to the veil of of money, as was the case with the definition of scarcity. Dollar bills don't feed people. Gold bars can't be used as smart phones. The capital that matters is productive physical capital, such as machines and buildings.

Financial capital is not irrelevant. It is generally required both for the initial construction of physical capital and to meet the ongoing working capital needs of the economy. If I want to build a factory or a school, I need to pay the construction workers, the suppliers of machines, etc. before I can start collecting money. And in many businesses I pay some ongoing expenses every month before collecting revenues from customers. Cash outflows preceding cash inflows means a financing mechanism is required. To get the proper accumulation of physical capital, we therefore need to have effective ways of accumulating and allocating financial capital.

In the history of financial capital there have been many important innovations, such as corporations with limited liability, debt and equity issuance and trading, bank lending and more recently market place lending. The allocation of financial capital to projects through markets has been enormously successful, compared to attempts at various forms of centralized planning. It is the very success of the market-based approach that has now given us a physical capital base in the world that is large enough to meet our basic needs.

Many recent innovations in finance, however, have not contributed meaningfully to the proper creation and allocation of physical capital. Quite the opposite. They have contributed to the “financialization” of the economy: a growth in financial sector activities that is decoupled from or even harms the formation of physical capital. For instance, many derivatives and structured securities have resulted in severe misallocations by shifting risk. One example is the housing bubble that resulted in part as mortgage backed securities and CDOs appeared to remove all risk from capital flooding into construction.

What is the role of “human capital” in all of this? Human capital is the subset of all knowledge that embodied in a group of humans. So the question is better asked differently: what is the role of knowledge? The answer is that advances in knowledge are essential for making capital more effective. Even more fundamentally, knowledge is necessary for having physical capital in the first place.

You can theoretically have physical capital without financial capital but you cannot have physical capital without knowledge. You cannot build a machine, say an MRI, without a lot of knowledge in physics and engineering. In a world where everyone's basic needs are taken care of it might, however, be possible to build the same MRI without the need for financial capital.

Interestingly, you can also have financial capital without physical capital and without meaningful knowledge accumulation. For instance, you can develop financial capital through trade or war or simply by convention as in the case of the island of Yap [40].

All of this is to say that we should never lose sight of the fact that financial capital ultimately serves no purpose in and of itself, other than possibly the gratification of ego. As great illustration of that imagine a Spanish Galleon full of raided gold sinking in a storm. The sailors aboard had ample access to financial capital, but what they really needed to survive was more knowledge and better physical capital.

So now we will go ahead and examine whether physical capital is still a binding constraint when it comes to meeting basic needs. The approach I am taking is split in two parts: here in the main text I am applying logic based on observations; the Appendix contains much more data and calculations to back up the arguments.

Individual Needs

My claim is that capital is no longer the binding constraint for meeting individual needs, not just for one individual but for everyone. This is especially true for the developed economies but increasingly true globally.

The primary strategies for meeting our power needs are breathing air, drinking water and eating farmed food.

There is plenty of air to breathe (one time reminder: please see the Appendix for backup on this and the following assertions), the key challenge today is having clean, breathable air. China and India are both struggling with that at the moment, but this is due to rapid development using outdated energy sources. The clean air achieved in industrialized countries shows that this is a temporary development stage.

Similarly there is plenty of water in the world for everyone to drink. There are distribution and access problems, including right here in the United States (e.g., the polluted water in Flint, Michigan). Again though, physical capital is not a binding constraint. We can even build new desalination plants in record time. [Example]

We have also made dramatic progress in farming. In fact, globally the amount of land required for farming has started to decline as a result of higher per acre productivity. We have made recent breakthroughs in vertical and automated farming. For instance, the world's largest vertical farm is currently under construction in Jersey City. The Japanese indoor farming company Spread is working on a fully automated facility that will be able to produce 30,000 heads of lettuce per day [155].

The discharge need is primarily addressed through modern sewage technology. Here too capital is no longer a binding constraint per se, but again there is a global distribution problem. To see how quickly this has the potential to change, consider the migration that has taken place in China from the country side into cities.

The Chinese construction boom also illustrates how quickly we can build shelter as a strategy to address the need for a controlled physical environment. In the U.S. too we had a prior construction boom which was powered by artificially cheap mortgage credit. While a lot of housing was built in the wrong places it powerfully demonstrated our construction capacity.

Clothing is another strategy for addressing this need. The price of clothing has been falling in the United States and in many other parts of the world. Capital is not a constraint here and we can clothe everyone in the world many times over.

Similarly we have become very good at providing light. There is a great study that shows how the hours of light one can earn with 60 hours of labor have exploded in the United States from about 10 in 1800 to over 100,000 by 1990 [CITATION?]. We have made further progress since with LED lighting. That progress has also come to other parts of the world, for instance in the form of off grid solar powered lamps.

Now we come to a more difficult need, the one for healing. We read all the time how expensive healthcare has become and how it consumes an ever larger fraction of the economy, at least here in the United States. We have to ask though whether capital really is a binding constraint here. Again in industrialized countries this does no longer appear to be the case. We have plenty of hospital space and doctor's offices. We have extensive diagnostic facilities and can produce large quantities of medicine. The binding constraint instead is one of insufficient knowledge. Our bodies are extremely complex and even seemingly basic issues, such as how diet relates to health, are poorly understood as a result.

In learning we are also no longer capital constrained. This is rapidly true not just in industrialized nations but also globally due to the buildout of wireless networks and the increasing affordability of smartphones. We are not far away from a point in time when we have enough capital for anyone in the world to learn anything. The binding constraint here is not capital but the availability of affordable content and the time to learn (and to teach).

The final individual need, the one for meaning, is not and has never been constrained by capital.

Collective Needs

At first it might seem difficult to see how capital even relates to our collective needs as defined in the earlier chapter. How could capital have anything to do with such abstract concepts as motivation and coordination? Was capital ever a binding constraint here?

Capital clearly was not a binding constraint for reproduction, which societies thankfully accomplished a long time ago or we would not be here today.

But when it comes to allocation, capital was the crucial binding constraint during the Industrial Age. Not only were we terribly bad at making stuff at first but we also lacked the communications and transportation infrastructure to easily get goods to where they were needed.

Motivation might historically appear not to to be capital constrained as we had many strategies for the motivation need, including rewards and punishments. The development of markets with prices, however, turned out to be a crucial strategy for meeting the motivation need. High prices provide an incentive for the allocation of capital (and other factors of production). For a long time capital in turn was the binding constraint on the scale of markets. Today, however, we can broadcast supply, demand, and prices in any market globally in near realtime at zero marginal cost.

Coordination, on the other hand, was quite obviously capital constrained for a long time due to limitations on communications. We can see this by considering that until fairly recently it was not possible to have a globally coordinated event. Today on the other hand we not only have a global nearly instantaneous communication network but also the ability to precisely position people or machines using GPS and other location services.

Finally, our collective need for knowledge was capital constrained for a long time. Making books for instance was expensive and time consuming. Copies of books had to be made by humans introducing errors. The spread of knowledge was constrained by the need to create and move physical copies. We have now left all of those capital constraints on knowledge behind.

Enablers

Our progress on enablers is another way to understand why capital is no longer the binding constraint. We have had massive breakthroughs on all four during the Industrial Age: energy, resources, transformation, and transportation.

The biggest breakthrough in energy was the development of electricity. It allowed us to apply energy in highly precise fashion. Our remaining challenges are all related to the production, storage and distribution of electricity. Further improvements in energy will let us solve needs in new ways, but we are not fundamentally energy constrained today. For instance, a relatively small percentage of surface coverage with solar (< 1% in the US) would cover all electricity needs at current efficiency rates [SOURCE?].

Resources were also completely transformed during the Industrial Age through mining, which in turn was enabled by progress with transportation (rail) and energy (steam power). People, especially those motivated by a concern for sustainability, like to point to scarcity of resources as the primary constraint. But resources are sufficient when we consider three sources that we can tap in the future: recycling, asteroid mining and transmutation. For instance, today a lot of electronics wind up in landfill instead of the materials being recycled. We achieved the first soft landing on an asteroid as far back as 2001. And while transmutation sounds like modern day alchemy, we now routinely make phosphorus out of silicon (albeit in small amounts).

Our ability to transform also improved radically during the Industrial Age. For instance, chemistry allowed us to make rubber synthetically which previously had to be harvested from trees. With machine tools, such as drills and lathes, we were able to rapidly transform wood and metals. Later we added transformation technologies such as injection molding and more recently various additive manufacturing technologies (often referred to as 3D printing).

Transportation went from human powered to machine powered dramatically changing our capabilities. We went from walking to traveling to space in rockets. We can fly across continents and oceans on commercial flights and reach any major city by air in just a day (or two at most). While some have complained about a lack of progress in flight, pointing to the lack of commercial supersonic options following the retirement of the Concorde, we had extraordinary progress in flight safety. More recently work has resumed on new options for commercial supersonic flight and we have made tremendous progress with reusable rockets and closer to earth with autonomous vehicles (for instance drones and warehouse robots).

The progress on these enablers has allowed us to produce more physical capital, do so more rapidly and cheaply, and transport it to anywhere in the world. One way to appreciate just how far we have come is to note that the first time smartphones became available was

only in 2000. By 2017 over 8 billion smartphones had been produced and shipped and there are currently over 2 billion smartphone users in the world.

As an important reminder before moving on. I am not claiming that everyone's basic needs are being met today. Far from it. Nor am I arguing that governments should be using central planning or that they should be meeting people's basic needs through government run programs such as food stamps or subsidized housing (in fact quite the opposite, as I will argue later when writing about economic freedom).

The point of this chapter is simply to argue that physical capital is no longer the constraint in meeting everyone's basic needs. We are not dealing with a problem of capital scarcity—in the sense of technological scarcity introduced earlier—but with one of allocation and distribution.

Capital is no longer scarce but sufficient. We should consider that the great success of capitalism.

We now face a new scarcity, however, that of attention, and capitalism will not solve it for us without changes in regulation and in self-regulation. Before we can examine the scarcity of attention though we need to understand how digital technologies have the potential to change the role of labor.

Labor

Before we can get to attention, though, we need to discuss the changing role of labor in the economy. Thinking about labor is hard because of an odd interweaving of cultural beliefs with economic history that I will try to disentangle. Over the last couple hundred years we have convinced ourselves that employment is essential both for the functioning of the economy and for individual dignity.

Let's start from the perspective of production. If you want to make products or deliver a service you require a series of inputs, including buildings and machines (capital), raw materials or parts (supplies) and, historically, human workers (labor). For much of history, capital and labor turned out to be complements. As the owner of a company you really couldn't make use of the company's physical capital without having labor to operate it. That was true for manufacturing and holds even more so for services, which often use very little capital and consist primarily of labor.

But, and this is where it gets confusing, there is nothing in economics that says any particular production process has to require labor. The deemed necessity of labor happens to be an artifact of the production functions that were technologically available to us when economists started to develop the theory of production. If you, as the owner of a company, figure out through technological progress how to do something with less labor, or no labor at all, and that form of production is cheaper than before, that's what you will choose to do. WhatsApp, when it was acquired by Facebook for $19 Billion had fewer than 50 employees!

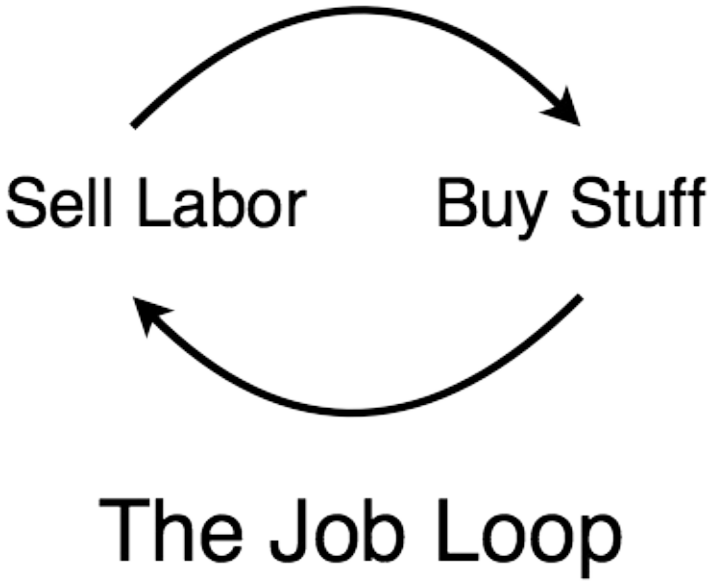
There would seem to be a catch though. While having no labor might make sense for any one company, for the economy as a whole, who is going to buy all these goods and services if people are out of work and hence don't have any money? There is the famous story about an exchange between Henry Ford II and Walter Reuther who then headed up the Automobile workers union, which went as follows:

> Henry Ford II: Walter, how are you going to get those robots to pay your union dues?
> Walter Reuther: Henry, how are you going to get them to buy your cars? [42]

Now if we all had inherited wealth, or sufficient income from capital, an economy without labor wouldn't pose a problem. As a first approximation, we would have the same demand. But none of us would have to work and all of us could enjoy the benefits of cheaper products and services courtesy of robots and automation.

The Job Loop

For a long time the possibility of a slump in consumer demand due to less labor seemed not just unlikely, but downright impossible. We had a perfectly working loop at the heart of economic growth, which I call the “job loop”



The Job Loop

In today's economy the majority of people have a job. They sell their labor, producing goods and services for someone else and receiving wages in return. They then take those wages and go buy stuff. Smart phones. Books. Tools. Houses. Cars. Gas for their cars. They also buy services, the professional assistance of attorneys and doctors and auto-mechanics and gardeners and hair stylists and nutritionists. Most of the people who sell them goods and services, in turn, are employed and take what they are paid and live on that, buying goods and services from still other people.

The job loop worked incredibly well in combination with competitive markets for goods and services and a properly functioning banking and finance system. Entrepreneurs would come up with new and improved offerings. They would use debt and/or equity to start new businesses which would employ people (often at higher wages than older businesses, giving employees more purchasing power). It was an amazing virtuous cycle that resulted in unprecedented prosperity and innovation.

A quick aside, as some might say that many people these days are self-employed or independent contractors. For the purposes of this analysis that is irrelevant as long as they are fundamentally selling their time. For instance, a graphic designer who works as an independent contractor (freelancer) is still largely paid for the time they put into a project. It is only if the designer can develop something, say a graphics template, that is paid for over and over without further time spent that they exit the job loop.

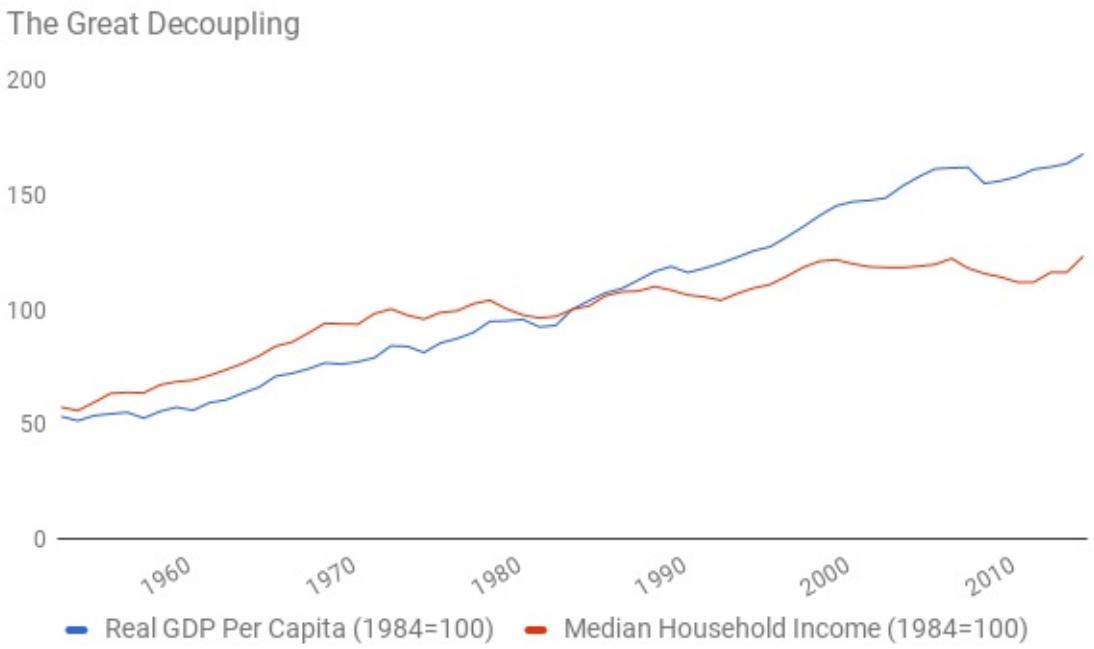
The problem with any virtuous cycle is that the effect of mutual re-enforcement applies just as much in the other direction when things contract. Take a small town, for example, in which local stores provide some of the employment. Now a big superstore comes into town,

resulting in reduced total retail employment and lower wages. Yes, maybe the products they sell are cheaper also, but it is entirely possible to set off a contractionary cycle. Fewer store employees have income (and those who do have less). They start spending less on haircuts and car repairs. That means the hair dresser and car repair person earn less and can spend less at the local restaurant.

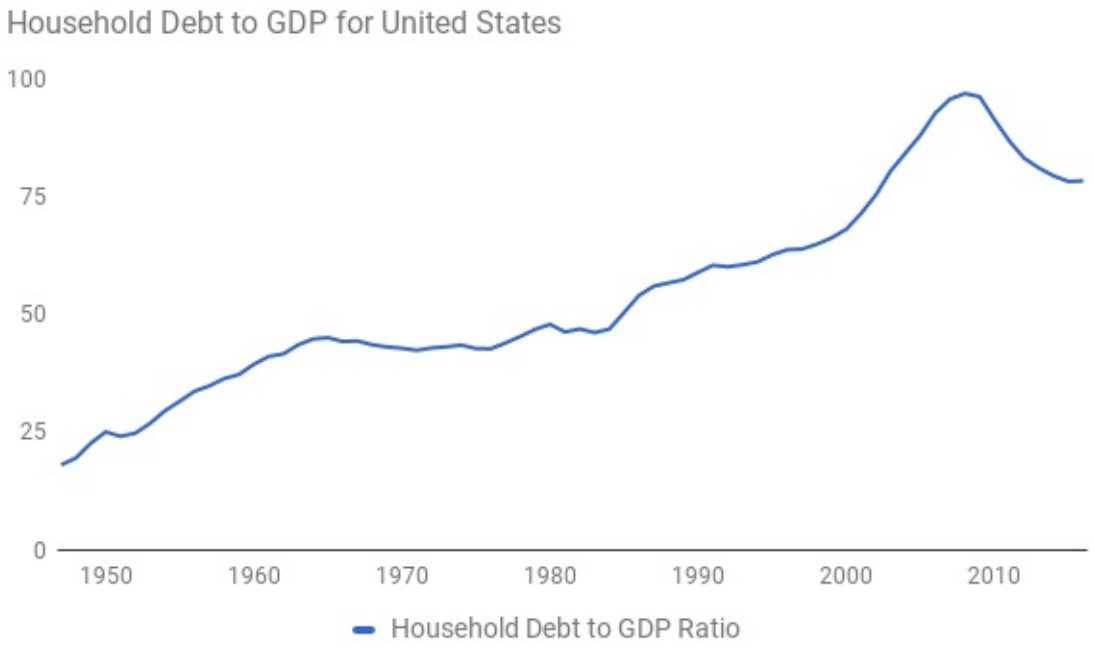
Could this happen to the economy as a whole?

The Great Decoupling

We are in the middle of a version of that playing itself out at the scale of the U.S. economy and potentially the global economy as well. It starts with what has become known as the great decoupling. For a long time as the economy grew, the share of GDP going to labor grew right along. Beginning around 1980 though GDP continued to grow while household income remained flat — hence the term “decoupling”



But GDP continued to grow so what's the problem? Well much of that growth was financed by consumers going into debt instead.



Eventually there was a limit to how much debt households could support. Once we reached that limit, we had the making of a situation of insufficient aggregate demand in the economy. The first event that really drove that point home was the collapse of the U.S. housing bubble. There is a fair bit of evidence that we are hitting another such point right now. In theory, the dramatic decline in oil prices should put more money into the hands of consumers and stimulate demand. Instead, it appears that consumers are using it to pay off debt and even start to save.

What's driving the decoupling? Part of it may be demographics, but part of it is likely to be the impact of technology. To the extent that accelerates, as I believe it will, there will be further pressure on aggregate demand. From a traditional economic growth perspective what should be particularly worrisome is that jobs in developing countries have a high exposure to automation [43]. Put differently, these countries may skip the golden age of the job loop entirely or have a much diminished version.

We don't need an indefinite growth of aggregate demand to take care of basic needs (wants by contrast are unlimited). Nonetheless, a rapid demand collapse would be a bad thing for societies that, for now, are built largely on the job loop. That raises the question of whether it is at all possible for technology to depress wages over a prolonged period of time.

Lump of Labor or Magic Employment Fallacy?

With the job loop dominant, people have to sell their labor to earn a living. Until recently most economists didn't worry at all about this ever being an issue. They believed that when human labor gets replaced in one part of the economy, say agriculture, it finds work in

another part, say manufacturing. When manufacturing starts to get automated, labor is sought after for services. These economists refer to a fear of technological un- or under-employment as the “Lump of Labor Fallacy.”

The argument goes something like this. We automate some part of the economy. That frees labor up to work on something else. Entrepreneurs use this newly available labor to deliver innovative new products and services. There is no fixed “lump” of labor, rather there are potentially infinitely many things to work on. As support for their argument they offer that this is exactly what has happened historically. And so they ask, why should this time be different?

To understand how things could be different, it is instructive to consider horses. As recently as 1915 we employed over 25 million horses in the U.S. in agriculture and for transportation. By 1960 that number had declined to 3 million and then we stopped keeping track systematically [44]. What happened? Well, we figured out how to build tractors, cars, and tanks. There were no use cases left in which horses were superior to a mechanical substitute. The potential for the same to happen to humans was pointed out by economist Wassily Leontief in his 1952 work, Machines and Man [45].

Some people will immediately object that, well, horses can't think and obviously we humans can, giving us a far broader range of things to do. That is true and is also the reason why so far we have always found new employment for people. So what has changed? Well, as we saw in the chapter on Digital Technology, we now have computers and we have figured out how to have computers do lots of things that until quite recently we thought only humans could, such as driving a car.

With digital technologies we have universal machines at zero marginal cost. All of the sudden the idea that we might be like horses, and have fewer and fewer uses, doesn't seem quite so impossible.

Those who continue to claim this is committing the “Lump of Labor Fallacy” immediately retort that this simply signals a lack of imagination. They argue that we just haven't thought of some new set of human activities that will once again gainfully employ people. But that line of thinking could also be a fallacy. I will call it the “Magic Employment Fallacy.” Just because we have found new employment in the past, doesn't mean we will in the future, especially when we have an entirely new set of technological capabilities.

Yes we humans can be incredibly creative and think of new things to spend our time on. But the operative question for people selling their labor is not if they can think of something to do, but if they can get paid for it. Not just get paid something, but enough to cover all of one's basic needs. It doesn't matter what creative pursuit or new service we think of, the only thing that matters is whether a machine (or another human for that matter) is capable of doing it more cheaply.

This, in particular, turns out to be a problem with the “Magic Employment Fallacy.” Nothing in economics says what the clearing price for labor ought to be (the wage level at which there is no unemployment, and no shortage of labor). It could happen to be well below what people need to cover their basic needs. And that means we have a problem even if everyone were employed, unless you want to make an argument that we should simply let that happen and eventually wind up with fewer people, just as we did with fewer horses.

So in order for the “Magic Employment Fallacy” to, well, not be a fallacy, we have to find new high value things for humans to do for which there is both paid demand and machines are not effective substitutes. I don't think we can rule that out entirely. We may find that the best candidate is a cultural shift that leads us to value goods and services produced by humans qua human production. The success of marketplaces, such as Etsy, that sell handmade goods, and the rise of artisinal goods more generally, are potential indicators of such a shift.

Another area where we may value humans qua their being human is in caring for the young, the elderly and the sick. Given changes in demographics we will need significantly more care for the elderly. Yet while we may want to value human care more highly, there is a potential wealth distribution issue. For instance, many people in the U.S. (and elsewhere) don't have the savings that would allow them to pay for human help as they get old.

Whether it is Lump of Labor or Magic Employment, at a minimum we have to be prepared for a potentially long adjustment period. That alone is an argument for a need for increased economic freedom (see the later chapter) but there is a much more powerful one: we should prefer automation over human employment.

Expensive Labor and Innovation

Some people argue that unions were bad because they made labor expensive, which resulted in costly products and services that people could not afford. There is, however, a completely different way to look at unions raising the price of labor: it propelled us to become more efficient by creating a problem that entrepreneurs had to overcome, and the way they overcame it was through innovation—by building better machines that required fewer humans. One can still see the negative effects of abundant cheap labor in places such as India. There is little incentive to invest in a machine, if it is cheaper to have people do the work by hand.

It is bad to be stuck in a low innovation trap. Now we face this risk globally. The combination of a fear of automation and some automation making labor cheap could have exactly that effect. For example, we could easily wind up with many more years of people having to drive

trucks back and forth across the country, long after a machine could do the same job and do it safer [46]. Pick any other job, say toilet cleaning, and ask what the incentive is to automate that job as long as you can get someone to do it for minimum wage?

Some will object to automation on a totally different ground though. They will argue that people require work as an integral part of their identity. That work is what gives humans dignity. If you have been a truck driver for a decade or more, who are you, if you can no longer earn a living driving a truck? This is an area where unions have historically been problematic: trying to preserve jobs for the sake of carrying out that job and also to preserve the union itself, which represents those employees. Today though it may just as easily be politicians who proclaim that jobs must be protected as a source of dignity.

So now we see what we need to solve for with regard to labor: a way to embrace automation without a collapse in aggregate demand, while simultaneously getting away from the idea that a job is the source of human dignity. This may seem like an outrageous claim to some and is certainly a tall order. But the next section on the scarcity of attention will explain why it is critically important.

Attention

There is a limited amount of human attention in the world. We have 24 hours in the day and we need to spend some of that time eating and sleeping. For many people in the world much of their waking time is occupied by the job loop (both the earning and the spending parts). That leaves relatively little time for attention that we can freely allocate. This hard limit also exists in the aggregate, since—as I have argued earlier—we are headed for peak population.

At the same time that our attention is limited, we are using the Internet to dramatically increase the amount of available content. The increase in content is well documented to be exponential, which means that most of the content that has ever been produced by humanity has been produced in the last few years [47]. For example, YouTube alone is adding 100 hours of new video content every minute [48].

As a result, it is easy today to be completely overwhelmed by content. Our limited attention can readily be absorbed by ever refreshing content. Humans are maladapted to the information environment we now live in. Our brain evolved in a world where when you saw a cat, there was an actual cat. Now we live in a world of infinite cat pictures. This is analogous to our maladaptation to sugar for an environment that is now sugar rich (largely artificially so). Checking email, Twitter, Instagram, watching yet another YouTube clip or Snapchat story, or episode of one's favorite show on a streaming service—these all provide quick “information hits” that trigger parts of our brain that evolved to be stimulated by novelty. As of 2017, the average person spends roughly two hours on social media every day [49].

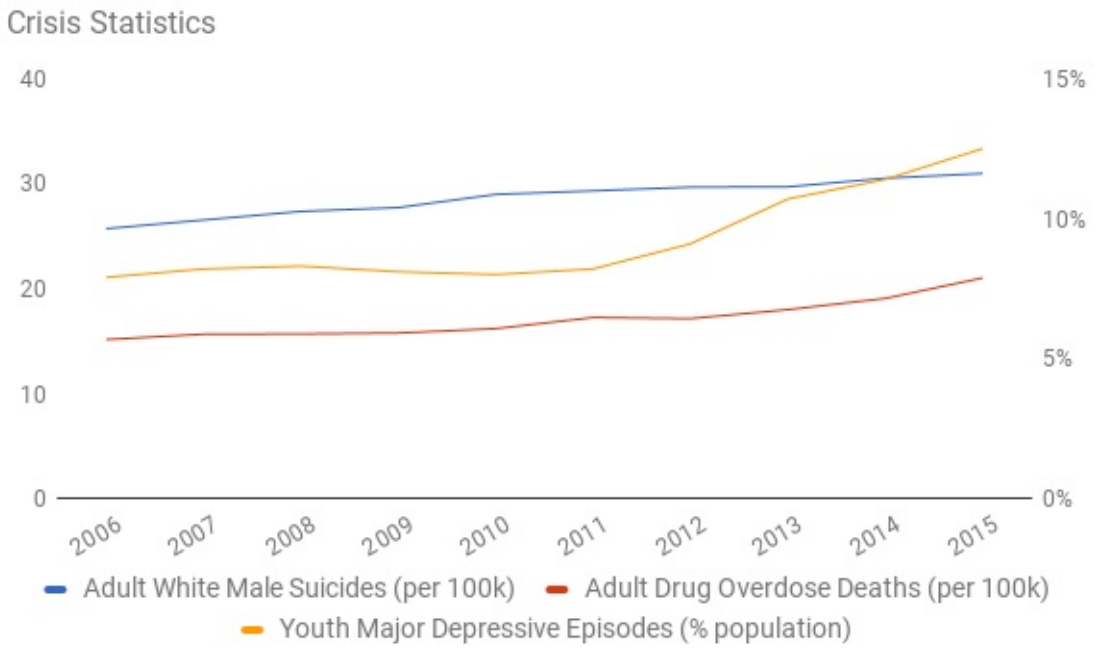
The limited availability of attention has become the key new source of economic rents. Companies such as Google, Facebook and Twitter are valued in no small part based on the amount of attention they have been able to aggregate, some of which they then resell in the form of advertising. As a result they invest heavily in algorithms designed to present ever more captivating content to their end users in order to monopolize their attention. Sites like Buzzfeed and Huffington Post that are nominally news sites do the same.

Now even if you think this is problematic, does it mean attention is scarce in the precise meaning of scarcity that I defined earlier? That would require for us to not have enough attention to meet humanity's basic needs. Is that really the case?

Individual Attention Scarcity

Let's first consider attention at the individual level. All over the world people have constructed their identities around work and around firmly held core beliefs, whether religious or worldly. Both of these are undermined by digital technologies. We saw earlier how digital technology is putting pressure on labor. It is also putting pressure though on firmly held beliefs. Content is no longer easily contained in geographic boundaries and people are being exposed, many for the first time, to opinions and behaviors that diverge from their core beliefs.

In combination, this pressure is leading to a large scale crisis of individual identity and rising aggression both online and offline. This crisis takes many different forms, including increased teenage depression, growing adult suicide rates—particularly among middle-aged white males, and drug overdose deaths. These have increased almost 60 percent, 20 percent and 40 percent, repectively, between 2006 and 2015:



This is not dissimilar from the beginning of the Industrial Age, when people had to leave the countryside and move to big cities. They were forced to give up identities that had been constructed around land and a historical set of professions. They were confronted with people from other regions who held different beliefs.

Just as with the transition into the Industrial Age it is therefore not surprising that there is a rise in populist leaders with simplistic messages, such as Donald Trump in the United States and Viktor Orban in Hungary. A recent study found that throughout Europe, populist parties are receiving more than double their average share of the vote in national and parliamentary elections compared with the 1960s [50]. People whose identity is shaken want to be reassured. They want to hear that things will be OK and that the way of getting there is

simple. “Make America Great Again” is an example of that. So is ISIS. In both cases the message is retrograde. Instead of a new identity that has to be built, requiring time and effort, these backward movements promise an easy return to a glorious identity of the past.

Our attention to our most basic need, the existential need to make sense of the world as an individual by finding a purpose that makes our life meaningful, is scarce. Instead we let our attention be occupied by our job or by yet another video or worse by propaganda. This individual scarcity of attention is not confined to any one demographic. Definitely people who have to work multiple jobs just to make rent and feed their families are impacted. But so are many people in high paying jobs who are often working more hours today than they ever have.

I do a fair bit of counseling for young people who want to work for a technology startup or who want to enter venture capital. Most of them are looking for tactical advice, such as how to apply to a specific position. After discussing that for some time, I usually switch gears and ask them a much more open question. “What do you want from your next position?” That often elicits answers such as learning a new skill, or applying a skill that they have recently learned. Sometimes people answer with a desire to contribute to some cause. I then get to the point by asking directly “What is your purpose?” Shockingly few people have an answer to that.

Purpose is an individual need for which the Industrial Age had little use. Somebody with a strong sense of purpose does not fit readily into the job loop either as a worker or as a consumer. Instead work and consumption have become the de facto purpose for most people. Both the cultural and religious narratives adjusted from the Agrarian Age to the Industrial age to support this re-definition of purpose.

With digital technology we can now exit the job loop and redirect attention to finding other sources of purpose. Instead though we are using digital technology to aggregate attention primarily for resale (advertising) and for entertainment. We do not identify this as a fundamental problem of the largest platforms, focusing instead on areas such as privacy and moderation of speech. That's because we continue to see the world through the lens of capital scarcity instead of attention scarcity.

Collective Attention Scarcity

At the same time our collective attention is also scarce. How so? We are not spending nearly enough time moving knowledge forward in areas of long tail risk and opportunity.

On the risk side, for example, not enough attention is spent on how to recapture CO2 from the atmosphere. Or on monitoring asteroids that could strike earth, and coming up with ways of deflecting them. Or take the outbreak of a pandemic: we should have a lot more collective

attention dedicated to discovering an outbreak and coming up with vaccines or treatments. The recent spread of the Zika virus is yet another reminder of this danger.

On the opportunity side, far too little human attention is spent on nuclear fusion, on new antibiotics, on space exploration or for that matter on much simpler things such as spending time with and taking care of friends and family. Or learning a new skill or instrument or making music or going hiking. Or reading a great book. Or writing a new song.

Much of our collective attention is instead absorbed by having to earn a living, with our leisure time increasingly consumed by watching cat videos on the internet. We are not investing enough in knowledge. And if we don't have enough knowledge, we may not be able to solve some of the problems we are currently facing, such as climate change. This has happened many times here on Earth before to civilizations, such as the Rapa Nui or the Mayans. Now, however, we are facing problems on a truly global scale.

I am proposing this as a (possibly new) explanation for the Fermi Paradox, which famously asks why we have not yet detected any signs of intelligent life elsewhere in our rather large universe. We now even know that there are plenty of goldilocks planets available that could harbor life forms similar to those on earth. Maybe what happens is that all civilizations get far enough to where they generate huge amounts of information, but then they get done in by attention scarcity. They collectively take their eye off the ball of progress and are not prepared when something really bad happens such as a global pandemic.

[Note: I am planning to expand this section on attention scarcity by providing more concrete numbers, such as how many people are currently working globally on Asteroid detection and deflection.]

Limits Of Capitalism

Capitalism—which has gotten us so far—won't help us overcome the scarcity of attention without significant changes in regulation and self-regulation. That's due to three important limitations. First, there are prices that will always be missing for things that we should be paying attention to. Second, capitalism to date has limited mechanisms for dealing with the power laws arising from digital technologies. Third, capitalism acts to preserve the interests of capital over those of knowledge.

Missing Prices

Why won't capitalism help us? Because the great strength and the great weakness of capitalism is that it relies on prices determined in markets. Prices are amazingly powerful because they efficiently aggregate information on consumer preferences, producer needs, etc. But not everything can be priced. And increasingly the things that cannot be priced are becoming much more important than those that can—think of the benefits from space travel, the cost of climate change, or even an individual's sense of purpose and meaning.

There are foundational issues that prevent the existence of prices for many things. This is not just a question of a missing market that can be magically solved by assigning property rights.

The first foundational issue is zero marginal cost for copies and distribution in the digital realm. From a social perspective, we should make all the world's knowledge, including all the existing music, videos, educational materials available for free. That's not just true for content but also for services that can be provided at essentially zero marginal cost, such as medical diagnoses. I will come to this in much greater detail when discussing how to increase what I call “informational freedom.”

The second foundational issue is extreme uncertainty. Because prices aggregate information, they fail when no such information can exist. There are events that are so rare or have not occurred at all yet that we have essentially no information on their frequency or severity. This is especially true around the kind of societal event horizon that we are currently dealing with. Nassim Taleb's work on tail risk is highly relevant here. The price mechanism cannot work when forecast error is infinite.

The third foundational issue is new knowledge itself. By definition there are no prices for things that have not yet been invented. Take aviation as an example. Until heavier then air flight was invented there were no prices for airplanes or airtravel. It was simply impossible.

There is no price right now for an immortality treatment. Or for quantum computing at scale. We do not have enough knowledge to do either. How much attention should humanity devote to these? There are no prices to guide that allocation.

Power Laws

Economics is not normative when it comes to the distribution of income and wealth. Many different outcomes are possible and what is realized depends a lot on the underlying production functions. Consider first a fairly manual production function such as was common pre-industrialization. If you were a cobbler making shoes by hand there were only so many shoes you could produce. I don't know if such data is available, but the output of cobblers likely formed a normal distribution, with even the most productive cobbler making only a small multiple of the number of shoes of the average cobbler.

Then along came industrialization and with it economies of scale. If you made more cars you could make them more cheaply and that was true until you got to a fairly large number of cars relative to total demand. That's why, over time, we wound up with relatively few car manufacturers around the world and the owners of the surviving largest ones wound up with large fortunes (e.g., the Ford or the Piech families). It turned out that many service businesses have relatively small economies of scale (e.g., a hair salon). That has allowed a great many service businesses to exist. The biggest exception to this has been financial services in which a few large banks, insurance companies, and brokerage firms tend to dominate.

Now, however, with digital technologies we are seeing a shift to power laws for many more situations. For instance, on YouTube the most watched video has been watched billions of times compared to the vast majority of videos which has been watched just a few times. Or in ecommerce, Amazon is an order of magnitude larger than most other retailers. The same goes for apps in the appstore. The leading apps have hundreds of millions (and some even billions) of users. But the vast majority of apps has just a few users.

Digital technologies are driving these power laws because of network effects combined with zero marginal cost. As I explained in the chapter on digital technology this means that we are likely to need only one (or maybe a few) medical diagnosis systems to serve the entire world. So far we have seen one social network by far dominate all others. We have one search company dominate all others.

This shift to power laws everywhere is resulting in a huge increase of inequality in wealth and income. It also raises questions about how the biggest networks should be regulated. The primary tool we have developed in existing capitalism is anti-trust, and there have been

calls here in the US and actual activity in Europe in applying anti-trust against digital networks.

The anti-trust approach, however, is not consistent with the benefits from large networks for the advancement of human knowledge. Instead, the later chapter on Informational Freedom proposes regulatory changes aimed at preventing operators of networks from extracting excessive rents.

Self-Conservation

Toward the end of the Agrarian Age, when land was scarce, the political elites came from land ownership. Their influence really wasn't substantially diminished until after World War II. Now we are at the end of the scarcity of capital, but the political elites largely represent the interests of capital. In some countries, such as China, this is the case outright. Senior political leaders and their families own large parts of industry. In other countries, such as the United States, politicians are influenced by the owners of capital because of the constant need to fundraise.

A study conducted at Princeton analyzes how much public support for a policy influences the likelihood of that policy being enacted [51]. It turns out that for the bottom 90% of the population their preferences have no influence on outcomes. Only the preferences of the wealthiest 10% of the population matter. Even within the 10% whose preferences matter, there is a huge concentration. For instance, over a 5 year period the 200 most politically active companies alone spent nearly $6 Billion on lobbying.

Individual and corporate lobbying results in policies favorable to owners of capital, such as low capital gains tax rates (or in the case of venture capital and buyout funds the taxation of General Partner profits as capital gains instead of income). Low corporate tax rates with lots of loopholes, including the accumulation of corporate cash in low tax countries is also favorable to owners of capital.

In addition to preserving and creating benefits for owners of capital there are also outright attacks on the sharing and creation of knowledge. I have written more about these in the chapter on Informational Freedom, but want to give one example now. Corporations lobbied heavily to lengthen copyright and strengthen copyright protection as part of the Transpacific Partnership (TPP). Scientific publishers such as Elsevier have used these protections to make access to knowledge so expensive that even universities as wealthy as Harvard can no longer afford the subscriptions. [52]

So how then do we overcome these limitations? That is the subject of Parts Three and Four. But first we will take closer look at the power of knowledge and the promise of the digital knowledge loop.

The Power of Knowledge

Have you taken medication recently? Stayed in an air-conditioned hotel room? Used a refrigerator? Accessed the Internet? Played games on your smartphone? Driven in a car?

Almost everything in today's world is powered by knowledge—the result of thousands of years of accumulated investigation and discovery. Knowledge, as I use the term, includes art, music, technical manuals, scientific publications and so on. It's the sum total of all information humanity has externalized (i.e., recorded in some medium) and then chosen to maintain over time.

With this definition, a conversation I had years ago but didn't record is not knowledge. However, if I write down an insight from that conversation and put it on my blog, I've created knowledge. The former really isn't accessible to anyone who wasn't there. The latter is. Likewise, the DNA we carry in our cells isn't knowledge by this definition, whereas a sequenced and recorded genome is. Every person's specific DNA sequence is ephemeral and disappears with our bodies. The latter can be maintained over time. A recorded sequence that turns out to be highly medically relevant will probably not be forgotten as long as humanity is around.

Like biological evolution, knowledge is subject to an ongoing process of selection and reproduction. Some knowledge is revised over time, some possibly lost altogether, some supplemented by new knowledge, some interpreted in new ways, and so on. We can find plenty of instances of scientific knowledge that started out as “true” only to turn out “false” as we learned more, and vice versa. Ancient societies believed the Earth was flat, we now “know” it is spherical. We once held a geocentric view of the universe, but have since “proven” the heliocentric model. Today, there are even scientists who have theorized that our entire reality is a virtual simulation, which if true would surely alter much of our existing knowledge [53].

Similarly we can find many instances of artworks that were considered important at one point only to be forgotten later. Language is an interesting example, where experts estimate that of the roughly 6,500 languages in the world, 50 percent or more will disappear by the end of the century as they are displaced by more common tongues [54]. As with biological evolution, my definition of knowledge focuses on the cumulative effects of the process of critical inquiry over time. And that effect is extraordinarily powerful.

Consider for a moment what knowledge might allow humanity to do in the future. We might, through further discovery, rid ourselves of fossil fuels, cure any disease, take care of every human's basic needs, and travel to other planets in our solar system and beyond. We could,

of course, also blow our own planet to bits before any of that can happen or be struck by a massive asteroid (this is why allocating our collective attention properly is so crucial). Now, you might say: “Travel to the stars? That's impossible.” Actually, it isn't. Extremely difficult? Yes. Requiring technology that doesn't yet exist? Yes. But impossible? No. Interstellar travel might not be imminent, but with the further accretion of knowledge, it will become possible. Organizations like SpaceX and NASA are already working toward this goal [55].

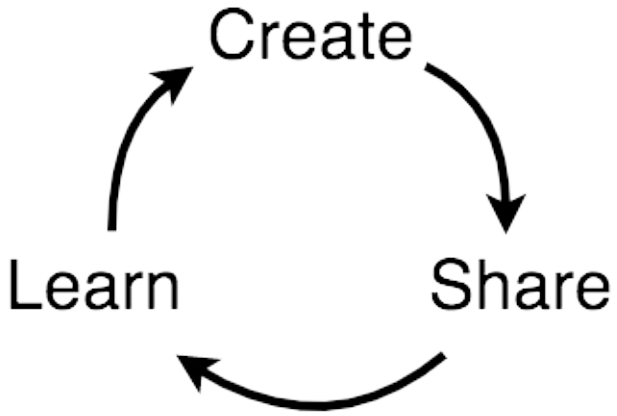
Look at many of the things around you. How might a smartphone have seemed to someone just one hundred years ago? How might a car or an airplane have seemed to someone a thousand years ago? As the British science fiction writer Arthur Clarke once remarked, “any sufficiently advanced technology is indistinguishable from magic” [56].

Knowledge is the essential human project. We are the only species on planet earth that has created knowledge. This is also why I include art and music in my definition of knowledge. Art has allowed humans to express our hopes and fears, and its accretion into culture has helped motivate the large scale coordination and mobilization of human effort.

When thinking about the power of knowledge, we must remember that a year, or a decade, or even a hundred years are all trivial in the time scale of humanity, and in turn, humanity's time scale is trivial compared to that of the universe. In light of this, it makes most sense to regard as possible all speculative propositions that don't explicitly contravene the laws of physics—a line of thinking inspired by a new theoretical foundation for science called Constructor Theory [57].

The Knowledge Loop

What knowledge has already made possible today, by virtue of the industrial revolution and the rise of digital technology, is a society that can take care of everyone's basic needs and allow us all to contribute to knowledge. Just like the Job Loop powered industrial society, so the knowledge society will be powered by a different system, the Knowledge Loop. In the Knowledge Loop, someone starts out by learning something, then uses that to create something new, which is then shared.



The Knowledge Loop

The Knowledge Loop is not, strictly speaking, new. Rather, it has been around for almost as long as humanity itself. At several points in our history, however, we have seen critical breakthroughs that have made the Knowledge Loop faster and broader. The first was spoken language. Then came written language. Then came printing. Then we got telecommunications and radio and TV. Along the way we invented the scientific method, which has given us much of our technological progress. But now we are witnessing another fundamental breakthrough: digital technologies, which have given us a network that connects all of humanity at zero marginal cost and are allowing machines to participate in the Knowledge Loop.

It is easy to underestimate the importance of digital technologies; to many, it seems as if these innovations have under-delivered. As a line on the Founders Fund website once complained, “We wanted flying cars and all we got was 140 characters.” Actually, that's not all we have gotten, nor is it even the slightest fraction of what we will get. New sources of energy, new cures for diseases, faster modes of transportation, more capable robots, and so on all originate from the Knowledge Loop. Digital technology now gives us the capabilities to vastly accelerate and expand access to the Knowledge Loop.

The Digital Knowledge Loop Taking Shape

In recent years, we've seen the early signs of what we might call the Digital Knowledge Loop. Let's reflect on a few examples. YouTube has experienced astounding growth since its release in beta form in 2005. As I described earlier, users around the world upload over 100 hours of video content to YouTube every minute. It is difficult to grasp how much content that is. If you were to spend 100 years watching YouTube twenty-four hours a day, you still wouldn't be able to watch all the video that people upload in the course of a single week.

Now, you might say, “YouTube isn't knowledge. It's mostly junk!” But keep in mind, knowledge is improved over time through the process of critical inquiry. We don't know yet which parts of YouTube's content will wind up being maintained over time. And in fact, we are already seeing amazing things happening on YouTube. Suppose you want to learn how to garden? Well ... [examples of all the things you can learn about gardening on YouTube]. Not only that, but there are now also videos telling you how to record your own gardening videos [One Yard Revolution], thus helping ever more people to participate in the Knowledge Loop around gardening.

Now if you don't garden or aren't interested in it this may strike you as an odd example. But you can find videos on virtually any skill on Youtube [examples]. And skills aren't the only interesting things you can learn on YouTube. You can also learn languages, math, science, and so on. [Smarter Everyday + other science and math examples]

Here is the most important part: All of these videos are available for free to anyone in the world (Well, almost anyone. YouTube is banned in some countries). They are also available 24x7. And they become available globally the second someone publishes a new one. All you need to access these videos is an Internet connection and a smartphone—you don't even need a laptop or other traditional computer.

Many of the videos available on YouTube exemplify the Digital Knowledge Loop at work. Let's say someone has learned something, such as how to play a chord on the guitar. They then create something—a song that includes that chord. Finally they share that song by recording themselves performing it and publishing it on YouTube. Instantly, that performance becomes knowledge from which anyone else, anywhere in the world, at any time can learn. And as others learn and share, the Knowledge Loop continues.

Wikipedia also gives rise to a digital version of the Knowledge Loop. Someone reads an entry and learns something from it (e.g., the method used by Pythagoras to approximate the number pi). They then go off and create something (e.g., an animation that illustrates this method). Finally, they share it by publishing it back to the encyclopedia or elsewhere on the Internet for that matter. Now, Wikipedia differs from YouTube in some important ways. Instead of presenting a set of disconnected videos, that at best are connected via either human curated playlists or computer generated suggestions, Wikipedia presents entries that stem from a large collaboration and ongoing revision process, with only a single entry per topic visible at any given time (although you can examine both the history of the page and the conversations about it). What makes this possible is a piece of software known as a wiki that keeps track of all the historical edits [58].

Wikipedia also differs from YouTube in that it allows individuals to participate in extremely small or minor ways. If you wish, you can contribute to Wikipedia by fixing a single typo. In fact, the minimal contribution unit is just one letter! I have not yet contributed anything of length to Wikipedia, but I have fixed probably a dozen or so typos. That doesn't sound like

much, but if you get ten thousand people to fix a typo every day, that's 3.65 million typos a year. Let's assume that a single person takes two minutes on average to discover and fix a typo. It would take nearly fifty people working full time for a year (2500 hours) to fix 3.65 million typos. This is just one concrete example of how digital technology can dramatically expand who can contribute to the Knowledge Loop.

While Wikipedia enables broad small contributions, other digital platforms allow people to contribute to the Knowledge Loop by doing absolutely nothing. The app Waze is a good example. You install the app on your phone (okay, that's one thing you do have to do). The app then tracks if you seem to be in a car, and if that car is moving fast or slow. It passes that information back to Waze's servers, and the company's algorithms crunch it to figure out where traffic is moving smoothly and where drivers will encounter slowdowns or outright traffic jams. During your commute into work, you might use Waze to learn where traffic is moving quickly and where it is congested. Or if you happen to find yourself at a location where traffic is congested, the data you contribute allows the system to understand the cause of the congestion and pass that along to other drivers (the “create” and “share” parts of the Knowledge Loop). If you choose to take a different route, you again automatically share your speed on that potential detour with other users of the system.

Why prevent someone from accessing YouTube, Wikipedia or Waze, either by cutting them off from the system altogether or charging a price they can't afford? This would always constitute a loss to society. With marginal cost at or near zero, any given individual might receive some benefit, which constitutes a benefit greater than the marginal cost. And best of all, they might use what they learn to create something that they share and that in turn winds up delivering extraordinary enjoyment or a scientific breakthrough to the world.

Technology is Not Enough

If the Knowledge Loop combined with digital technologies is so powerful, why do we need to work at becoming a knowledge society? Why not just keep government out of the way and let entrepreneurs and markets take care of everything from here on out? Because we are living with older structures that are the legacy of over a century of industrial society.

We have based our economies around the Job Loop, which is currently breaking down and yet is still trapping a lot of our attention. We have based our laws about information access on locking up information and selling it like industrial products. And we have developed a culture that supports our participation in the industrial economy, both as producers (workers) and consumers. Both collectively and individually, we have adopted a range of assumptions and beliefs that enable us to structure our lives around our jobs and to fuel the economy through consumption.

Put differently, the Industrial Age is a system of many interlocking parts. Systems have a lot of inertia and carry on for a long time. Just having digital technology available doesn't change that. In fact, as we saw earlier, digital technology can also result in a huge concentration of power. Digital technology can also be used to manipulate by spreading propaganda more efficiently and better targeted than ever before.

If we want to truly unleash the Knowledge Loop, if we want to make it central to our lives, if we want to reap its benefits and limit its downsides, then we need to make major changes in regulation and self-regulation. These are the subject of Part Three.

Part Three: Enhancing Freedom

The second major goal of World After Capital is to propose an approach for overcoming these limits of existing capitalism and an economy based around the Job Loop. Part Three will propose changes to regulation and self-regulation that increase human freedom and let us accelerate the digital knowledge loop. There are three components to this:

1. Economic freedom. We must let everyone meet their basic needs without having to hold a job. This way, we can double down on automation and enable everyone to participate in the knowledge loop.
2. Informational freedom. We must remove boundaries to learning from existing knowledge, creating new knowledge based on what we learn and sharing this new knowledge.
3. Psychological freedom. We must free ourselves from scarcity thinking and its associated fears that impede our participation in the knowledge loop.

Increased individual freedoms are the basis for a smoother transition from the Industrial Age to the Knowledge Age. One that is not dictated top down, but results bottom up from individual choices. Later, in Part Four, I will write about values and systems necessary for collective action in a world of increased individual freedom.

Economic Freedom

If you were to quit your job right now, could you afford to take care of your basic needs? Could you pay for food, shelter, clothing, and so on? If you are retired, what if your company suddenly stopped paying your pension? If you are supported by a spouse or partner, what if you left that person?

If you would not be able to meet your basic needs, then you are not economically free. Your decisions on how much of your labor to sell, or to whom to sell it, or whether to stay with a partner are not free decisions so long as your ability to meet your basic needs hangs in the balance.

A recent survey in the U.S. asked respondents if they had enough money to pay for a $1,000 emergency. Over two-thirds said they did not [59]. Other studies have found that about 75% of Americans over 40 are behind on saving for retirement and 31% of all non-retired adults have no savings at all [60] [61].

More people are finding themselves in these situations as the job loop is breaking down due to advances in automation (which are driven by digital technologies). If you cannot walk away from a bad job, or for that matter a bad partner or city, for fear of not being able to meet your basic needs, then you lack economic freedom.

Concerns about economic freedom are by no means new. When the American republic was in its infancy, economic freedom seemed well within everyone's reach. There was plenty of land to be had (so long, of course, as one was willing to take it by force from Native Americans). As a result, any family could make ends meet by living off the land. Even back then, though, observers such as Thomas Jefferson and Thomas Paine understood that land would some day run out. They raised the specter of a time when citizens might be forced to trade labor to others in order to provide for their basic needs—when they would be economically unfree [62].

Economic freedom is a cornerstone of the Knowledge Age. We need to make more people everywhere economically free—only then will they be able to participate fully in the knowledge loop. We want more people to be free to make music and create art. We want more people to have the time to learn new skills, from gardening to the latest 3D animation. We want more people to share their knowledge with the world for others to learn.

We want to embrace automation, not fight it.

Universal Basic Income

Economic freedom is a reality today for some—those sufficiently wealthy, tenured professors, retirees with pensions and savings. How can we make it a reality for everyone? The answer is to have the government pay all citizens a guaranteed monthly income that suffices to cover basic needs, including housing, clothing, and food (see earlier chapter on Needs). This income would be unconditional, i.e. it would not depend on whether someone is married or single, employed or unemployed, rich or poor.

At first blush the idea of a Universal Basic Income may seem crazy or outrageous. Getting money from the government for having done nothing? Getting paid simply for being alive? Isn't that communism? Or socialism? And isn't the government broke to begin with? Won't people simply descend into utter laziness and drug addiction? We will look at each of these objections to Universal Basic Income in turn, but first let's develop a better understanding of how it would work and why it results in economic freedom.

Let's start with what may seem like a detour at first: air. One of our basic needs is the need for oxygen which we solve by breathing air. Most of us don't think much about breathing for two reasons: first, our bodies breathe all by themselves; and second, air is free. But we shouldn't take breathing entirely for granted. People who suffer from asthma (and there are many these days) or other medical conditions know how difficult it can be to get enough air. And people who live in cities like Beijing with serious air pollution problems know that while air may be free, clean air may prove elusive. It is estimated that 1.6 million people die in China every year from air pollution [63].

Why is air generally free? There are three reasons. First, the earth possesses a lot more air than humans require for their breathing. Air, in other words, is abundant relative to our needs. Second, air is equally distributed around the world, allowing everyone to access it right where they are. Third, air doesn't belong to anyone. Nobody owns the atmosphere and then sells it to you.

One or more of these conditions doesn't readily apply to the solutions our other basic needs, such as food, clothing and shelter. We don't automatically possess enough food, clothing, and shelter for everyone in the world—we need to create it. And food, clothing, and shelter are often created at some distance from the people using it, so these goods need to be distributed. Finally, when food, clothing, and shelter are created, they tend to belong to their creator— the farmer, the clothing company, the builder.

As I argued in the earlier chapter on Capital, as a species, we have developed our technologies enough so that we are now capable of meeting everyone's basic needs. Farming can generate enough food for everyone. We can easily make enough clothing for the world. We can even provide everyone with shelter. All of this has been made possible by knowledge, the knowledge that humanity has created over millennia. And our technological progress is accelerating while global population growth is slowing down. So from here on out it will only get easier.

The question is not whether we can meet everyone's basic needs, but whether we have created an economy and a society capable of accomplishing the necessary resource distribution and allocation. Industrial society presents us with two fundamentally different ways of distributing and allocating resources. One is to have individuals meet their own needs by participating in a market economy; the other is to have government (or charity) provide for people's needs directly. Those options are actually extreme ends of a spectrum with a variety of “hybrid” arrangements in the middle, such as government subsidized or rent-controlled housing for which people still need to pay some rent.

Why should we adopt a Universal Basic Income (UBI)? Because UBI enables the functioning of markets for basic needs such as food, clothing and shelter even at a time when people cannot earn any money from jobs. And it does so in a way that avoids reliance on an ever-expanding government sector. Put differently, UBI recognizes just how effective markets have been in the allocation of resources, and by contrast, how many distortions are introduced by government activity. UBI is the exact opposite of communism and socialism in that regard. It is all about reducing the size of government.

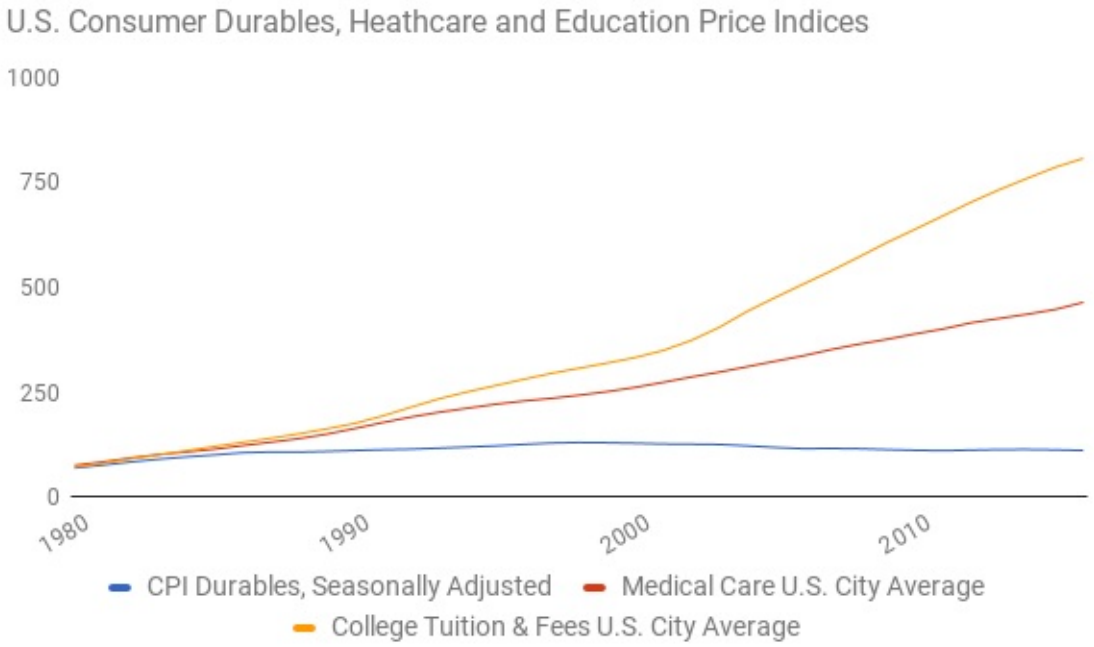
After World War II in the U.S., only about 5% of people were employed by government, which in turn comprised about 42% of the economy [64] [65] [66]. In the Soviet Union, by contrast, nearly 100% of people were employed by the state, and the state owned close to 100% of the economy. We now know quite well which system was more effective at allocating resources. Nevertheless, the size and scope of government employment and the government sector have gradually expanded here in the U.S. and in Europe. In many European economies, the government sector now accounts for a half or more of the economy.

I have only mentioned food, clothing and shelter when talking about basic needs, but what about education and healthcare? Can UBI cover those as well? That might seem wishful thinking given how quickly education and healthcare costs have risen, especially in the U.S. Yet UBI can cover these basic needs as well, and to understand how, we need to look at how technology is driving down the prices of almost everything. Technology can make education and healthcare far more affordable than they are today. In addition, the existence of a UBI would result in a positive feedback loop to accelerate the decline in prices even more.

Technological Deflation

If you are currently struggling to pay for your basic needs, the world will seem like an expensive place to you. Yet the data shows that a lot of things have become cheaper, and that this trend has been gathering steam for some time now. In the U.S., as the following

chart shows, the prices for consumer durables have been falling since the mid 1990s. Not only can we see the decline in the prices for consumer durables; we can also see the rise in the cost of education and healthcare.



What has produced the decline in prices for consumer durables? Well, it is the same technological progress that has been squeezing the labor market. While this progress hurts you if you are losing your job or your salary is remaining stagnant, it helps you if you have money to buy things, and that money goes farther and farther over time. With Universal Basic Income, you will have the money, and over time, it will buy you more and more.

Thanks to the decline in prices for consumer durables, clothing has become easily affordable. Technology also has been driving down the cost of smartphones, which we will be essential to making education and healthcare much more affordable. The price decline in this area will only accelerate as we further increase automation and use technology such as additive manufacturing (also known as “3D Printing”) to manufacture products only when they are needed and close to where they are needed [67].

What about shelter? Technology is definitely making it cheaper to put up a building. In early 2017, the first house printed using mobile 3D printing technology was built in Russia in just 24 hours! [69] It of course still costs a ton of money to live in certain places like Manhattan or San Francisco, where the demand for housing space exceeds the available supply. Here UBI functions quite differently from other solutions that make housing more affordable, such as government subsidies. With UBI, people can live in parts of the country (or the world) where housing is much more affordable.

The city of Detroit is currently giving away houses as an alternative to tearing them down [70]. Or if you prefer a rural setting, you can buy or rent a home for as little as a couple hundred dollars per month [71]. Right now, many people can't take advantage of these opportunities, since they can't find a job in these locales and would be left with no income. By breaking the connection with a job, UBI makes geographic flexibility possible. People would no longer be geographically trapped by the challenge of providing for their basic needs.

Today, a large group of people is no longer constrained by the need for a job: Retirees. And sure enough, we observe that many retirees move away from expensive cities to places where real estate is much more affordable [72]. When considering the cost of shelter, it would be a mistake to analyze how much people need to live where they may be trapped today. Instead, we should look at the future cost in a world that has UBI. And that cost will be declining because of technology.

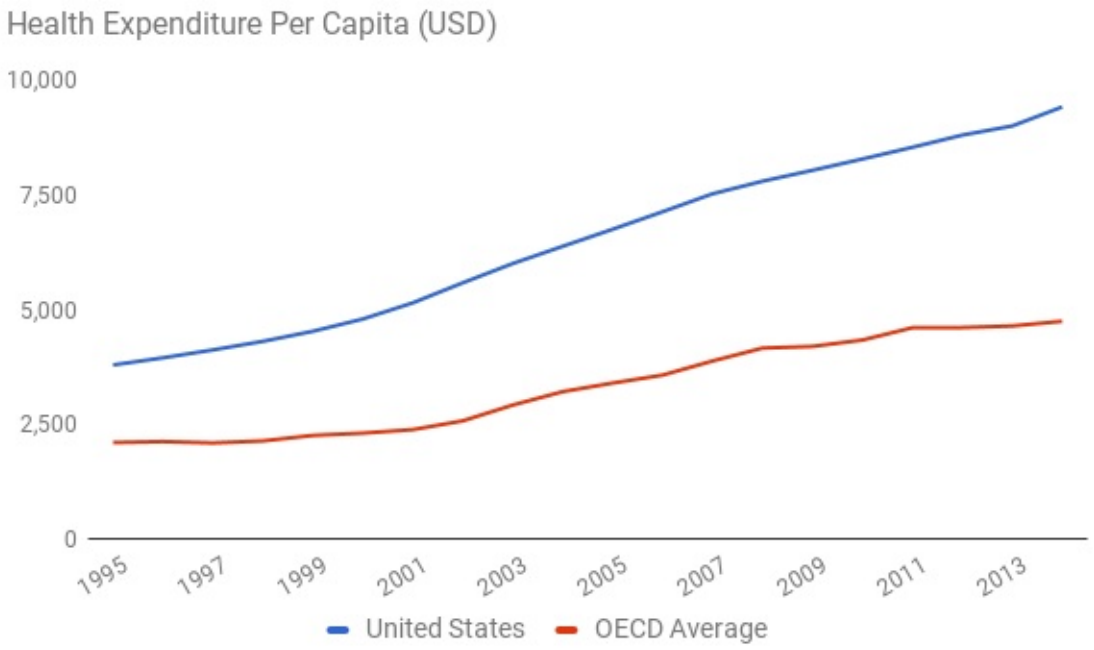
Another factor making housing more affordable is the more effective sharing of existing housing assets through services such as Airbnb and Couchsurfing.

As for food, here too technology has massive gains in store for us. While some argue that GMOs hold the key to affordably feeding the planet, other near-term breakthroughs don't carry some of the potential issues that GMOs pose. Indoor and vertical farming, for instance, allows for a precise delivery of nutrients and light to plants as well as huge increases in seeding and harvesting productivity. It also allows food to be grown much closer to its consumption, reducing the cost associated with transportation including spoilage. All this adds up to a dramatic reduction in the cost to feed a person.

Technology also promises to bring about a dramatic decline in the costs of education. At Union Square Ventures we became interested in education as an investment opportunity in 2009 when we held a one-day conference titled “Hacking Education.” Since then, the universe of online learning resources has grown rapidly. In addition to formal online courses such as edX or Khan Academy, millions of individual blog posts and even entire series of posts exist to explain a specific topic. And of course, YouTube is bursting with educational videos on subjects as broad as sailing and quantum computing.

Evidence exists that the exorbitant rises in tuition costs over the years in the U.S. are beginning to slow. When analyzing this data, we must remember that a huge amount of inertia exists in our educational system and job market. Many employers still believe they must hire from the best universities. This in turn drives up prices for higher education, with a ripple effect that extends all the way back to private nursery schools. It will be quite some time before most students will turn to free or extremely affordable online resources for all their learning needs. Still, the possibility now exists.

With healthcare, it's a similar story. Healthcare spending in the United States per capita far exceeds that of other countries, having risen for many years much faster than the rate of inflation—but that hasn't translated into better care. For instance, Cuba for years has had almost an identical life expectany to the U.S. despite spending less than a tenth on healthcare per capita [73].



Debate is now raging as to whether the Affordable Care Act has or will bring about lower healthcare costs or larger premiums (or possibly both). Regardless of how this works out, information technology will push healthcare costs lower for a number of reasons.

First, technology makes prices on medical procedures more transparent, enabling more competitive pressures to exist that can push prices down. Second, to the extent that people better track their own health data through technologies associated with the “quantified self,” we will live healthier lives and require less care, especially over the long term (in the shorter term, folks who already enjoy above average health will most readily employ this technology). And third, technology will make possible faster and better diagnosis and treatment. If you want to feel inspired, just read some of the stories about how Crowdmed has helped people whose conditions went undiagnosed or misdiagnosed for many years. USV portfolio company Human Dx is also working on a system to help with diagnosis, and Figure 1 lets doctors exchange images and other observations. Flatiron Health recently raised a massive investment round to pull together data on oncology patients. This says nothing of a whole group of companies that is bringing telemedicine into the app era, such as HealthTap, Doctor on Demand, Teladoc, and Nurx (another USV portfolio company). All promise to dramatically reduce the number of in person doctor visits and associated costs.

One might object that so much of healthcare cost doesn't result from doctors' visits, but from pharmaceuticals. In fact, pharmaceuticals account for only about 10% of total spending [74]. Here too, we will likely see technology drive costs down. One successful pharma entrepreneur I spoke with described the potential for personalized treatment to dramatically improve the effectiveness for a wide range of conditions, including many cancers and even diseases such as ALS and Alzheimers. New technologies such as CRISPR are giving us unprecedented abilities to fix genetic defects [75].

But Isn't Deflation a Bad Thing?

Now, you may find it confusing to hear me describe technological deflation as a good thing. Economists, after all, have painted deflation as an evil to be avoided at all cost. Economists are primarily concerned about growth as measured by GDP, which they argue makes us all better off. Their logic about deflation goes like this: If people anticipate that prices will drop thanks to deflation, they will be less likely to spend money today, which means that output will be lower than it could be. This in turn leads owners of capital to make fewer investments, which would result in less innovation and lower employment. That in turn makes people spend even less, thus causing the economy to contract further. Economists point to Japan as a country that has been experiencing both deflation and contracting output. To avoid this scenario, they argue for policies designed to achieve some amount of inflation, including the Fed's so-called quantitative easing (cheap money), which is intended to expand the supply of money.

In a world of technological deflation driven by digital technology this reasoning is flawed though. GDP is increasingly not a good measure of progress because it ignores positive and negative externalities. For instance, everything I've said about making education and healthcare dramatically cheaper through free resources would serve to lower GDP while clearly making people much better off. We can also identify a second flaw in economists' reasoning: It assumes that technological progress is tied to growth in production. But it is possible to achieve technological progress even as economic activity, as measured by GDP, appears stagnant. Increases in economic, informational and psychological freedom allow us to accelerate the Knowledge Loop which is the foundation of all progress. A great example here is open source software, which has driven a lot of technological progress outside of the traditional economic model.

Once you break out of the job loop with a UBI, then in fact technological deflation becomes desirable. For individuals it means that they can afford more with the payments they are receiving and for society as a whole it means that UBI is affordable.

UBI is Affordable

So with all of this as background, your might wonder what a Universal Basic Income should pay. My working proposal for the United States is [$1,000/month] for everyone over age 18, [$400/month] for everyone over 12 years old, [$200/month] for every child. These numbers might seem extremely low, but keep in mind, the goal here isn't to make people well off; it's simply to let them take care of their basic needs. We have mistakenly come to embrace unlimited wants, and we can free ourselves from this by re-establishing a clear distinction between wants and needs. We should also remember that our basic needs will get cheaper over time, and we won't get UBI overnight. So my numbers are meant to work over time as other government programs are phased out and a UBI is phased in. Other policies I will discuss will also serve to help bring down the cost of education and healthcare.

Let's dig further into these numbers. The likely cost allocation for a typical adult would roughly break down as follows: [$300/month] for housing, [$300/month] for food, [$100/month] for transportation, [$50/month] for internet access and associated equipment ... [this needs more work and backup].

You might wonder why I am proposing a lower payment for children and teenagers. First, we can meet many of their basic needs even more cheaply than we can for adults (for instance, several kids in a family might share a room). Second, I propose a lower payment in recognition of historic evidence that the number of children people have is partially determined by economics. UBI should not give an incentive to adults to have more children so as to “skim” their income. That's especially important with regard to slowing down and eventually stopping population growth: We want the birth rate to decline globally, as it has started to do in most industrialized nations in conjunction with economic progress and the decline in infant mortality. This will allow us to achieve peak population and put to rest the Malthusian fears of overpopulation and scarcity.

When you calculate how much money is required to provide a UBI for everyone in the United States based on the 2015 population size, you wind up with about $3 trillion annually [76] [77]. While that's a huge number, it only represents about 17% of the size of the economy as measured by 2015 GDP, and only about 10% considered as a percentage of 2015 Gross Output (the latter measures not just final output but also intermediate steps) [78] [79] [80] .

Where will this money come from? There are two sources: government budgets (at the local, state and federal level) and money creation. I will examine each of these in turn.

In the U.S., in 2015 total government revenues from taxation and fees were about $6 trillion or about twice the UBI amount [81]. So in theory the money for a UBI could come entirely from redirecting existing budgets. There would then be another $3 trillion of money for critical government activities, such as local law enforcement and national defense (the latter was $0.6 trillion in 2015 [82]). There is a long debate to be had about the political process by which such a reallocation can be accomplished but there is no fundamental impossibility, such as perpetually increasing government debt.

Having a UBI can also substantially increase government revenues. How so? At the moment there are many people who work but fall below the level for paying federal income tax. In fact this is true for nearly half of all earners (Mitt Romney's infamous 47 percent remark). Once people have a UBI, then every additional dollar earned should be taxed. For instance, if you are single and make $10,000 at present you do not even need to file a federal income tax return at all. With a UBI that could be taxed at a rate of say 25% generating $2,500 in new tax revenues. This effect could provide as much as [$0.3] trillion or about a 5% increase in total government revenues.

Moreover, government revenues can be expanded in ways that accomplish other goals at the same time. For instance, we could and should be taxing pollution more than we are, in particular the emission of greenhouse gases into the atmosphere. Taxes are a well established way of dealing with negative externalities and we have made good use of that, for instance by aggressively taxing cigarette smoking. Another candidate for expanding government revenues are inheritance and wealth taxes. The goal of such taxes in addition to creating revenues would be to counteract the rising wealth imbalance driven by the effects of zero marginal cost digital technologies.

Redistributing and expanding government budgets is one mechanism for making the money for UBI available. The other is to change the way money is created in the economy, by moving away from fractional reserve banking and issuing money directly to people instead. In today's fractional reserve banking system, commercial banks extend more credit than they have deposits. This carries with it the potential of a bank run and the Federal Reserve Bank (Fed) acts as the so-called “lender of last resort.” For instance, in the 2008 financial crisis the Fed stepped in aggressively by buying up potentially bad bank assets to give banks liquidity. Europe has had a policy of “quantitative easing” (QE) where the central bank makes it progressively easier for commercial banks to extend loans beyond their existing deposits.

Generally the idea is that as banks extend loans this will help grow the economy as the banks will lend to businesses that need to finance capital good or working capital. While banks have done that to some degree, they have also been lending to people who are already wealthy for acquiring second and third homes or for engaging in financial speculation. Conversely, bank lending to small businesses has actually been going down as banks have consolidated and have focused on larger customers. The net result of all of this has been that quantitative easing has amplified wealth and income inequality.

An alternative system would be to remove banks from money creation by forcing them to hold all of their deposits at the Fed. This is known as “full reserve banking” and eliminates all risk from the commercial banks. Credit extension could instead happen via marketplace lending as enabled by companies such as Lending Club, for individuals, and Funding Circle,

for businesses (the former an exited USV portfolio company and the latter a current one). This would allow money creation to happen by simply giving new money to people as part of their UBI payments, which is sometimes referred to as “QE for the people.”

What magnitudes are we talking about here? Let's look at household debt alone for a moment. U.S. households have about $8 trillion in mortgage debt [83], over $1 trillion in auto loans [84], over $1 trillion in student loans [85] and nearly $1 trillion in credit card debt [86]. Total household debt can go up as much as $1 trillion in a single year. U.S. business debt is a total of $25 trillion, of which about $15 trillion is in the financial sector and $10 trillion in non-financial businesses. These too have grown by as much as $1 trillion in a year. As a first approximation the amount of annual money creation is in the same ball park as UBI.

Historically, the idea of the government “printing” money is associated with fears of runaway inflation, such as occurred in the Weimar Republic. There are several reasons why this would not be the case with a proper UBI scheme. First, the amount of new money creation would be fixed and known in advance. Second, as we saw earlier, technology is a strong deflationary force. Third, the amount of net money creation can be reduced by removing money from it. This could be accomplished through negative interest rates on bank deposits above a certain amount where the payment is collected by the central bank (and not by the commercial bank). This is known as “demurrage” and would be easy to implement in a full reserve banking system.

I expect that the path to UBI will involve both changes to government budgets and changes to the monetary system. The point of all the back of the envelope math above is to show that UBI is in fact affordable. Economic freedom is possible, if we want it.

Impact of UBI on Incomes and the Labor Market

One of the many attractive features of a UBI is that it doesn't do away with people's ability to sell their labor. Suppose someone offers you $5/hour to watch her dog. Under a UBI system you are completely free to accept or reject that proposal. There is no distortion from a minimum wage. The reason we need a minimum wage in the current system is to guard against exploitation. But why does the opportunity for exploitation exist in the first place? Because people do not have an option to walk away from potential employment. With a UBI in place, they will.

The $5 per hour dog sitting example shows why a minimum wage is a crude instrument that results in all sorts of distortions. You might like dogs. You might be able to watch several dogs at once. You might be able to do it while writing a blog post or watching YouTube. Clearly government should have no role in interfering with such a transaction. The same is

true, though, for working in a fast food restaurant. If people have a walk away option, then the labor market will naturally find the right clearing price for how much it takes to get someone to work in say a McDonalds. That could turn out to be $15/hour, or it could turn out to be $5/hour, or it could turn out to be $30/hour.

We might fear that with this new set of clearing prices in the labor market nobody will want to do the dirty work. Well, it turns out that this is a good thing. We will either need to pay people a lot more to do the work, or we'll need to invest more heavily in automation. In all likelihood, the answer will be a combination of both. But we should not fear that there is such a thing as an excessive price for labor. Because of the pressures created by technological deflation, we will not return to labor-price induced inflation.

UBI has two other, hugely important impacts on the Labor Market. The first has to do with volunteering. Today there are not enough people cleaning up the environment. Not enough people taking care of the sick and elderly. Not enough teachers. Labor is under-supplied in these sectors because there often is insufficient money behind the demand. For instance, the environment itself has no money and so the demand for clean up relies entirely on donations. As for the elderly, many of them do not have enough savings to afford personal care.

When you have to work pretty much every free hour just to meet your basic needs and/or have no control over your schedule, you cannot effectively volunteer. Providing people with UBI has the potential to vastly increase the number of volunteers. It won't do this all by itself; we will also require changes in attitude, but historically people have thought differently about volunteering.

UBI's second big impact on the Labor Market is its potentially dramatic expansion of the reach and importance of various types of crowdfunding. If your basic needs are taken care of, you will be much more likely to want to start an activity that has the potential to attract some crowdfunding, such as recording music videos and putting them up on YouTube. Also, if your basic needs are taken care of, you will be much more likely to use a fraction of any income you make to participate in crowdfunding.

UBI as a Moral Imperative

Before proceeding to examine Informational Freedom, we should remind ourselves why individuals deserve to have their basic needs taken care of. Why should they have this right by virtue of being born, just as they do the right to breathe air?

None of us did anything to make the air. It was just here. We inherited it from the planet. And none of us alive today did anything to invent electricity. It had already been invented, and we have inherited its benefits. Everyone in the world did. Not just you who can currently afford

access to a refrigerator.

Human knowledge is our collective inheritance, and using it to take care of everyone's basic needs is our moral imperative. The beauty is that contributing to further grow knowledge can provide a purpose, addressing another common objection to UBI—that by obviating the need for a job, it will snatch away what for many is a source of purpose in life. There is a virtuous cycle in which UBI accelerates the very knowledge loop that gave us this inheritance in the first place.

Informational Freedom

Can you read any book you want to? Can you listen to all the music that has ever been recorded? Do you have access to any web page at all you wish to consult? Can you easily see your own medical record? Other people's medical records?

Historically questions like this would not have made much sense, as copying and distributing information was quite expensive. In the early days of writing, for instance, when humans literally copied text by hand, copies of books were rare, costly, and also subject to copy errors (unintentional or intentional). Few people in the world at that time had access to books, and even if some power had wanted to expand access, it would have been difficult to do so because of the immense cost involved.

In the age of digital information, when the marginal cost of making a copy and distributing it has shrunk to zero, all limitations on digital information are in a profound sense artificial. They involve adding cost back to the system in order to impose scarcity on something that is abundant. As an example, billions of dollars have been spent on trying to prevent people from copying digital music files and sharing them with their friends or the world at large [87].

Why are we spending money to make information less accessible? When information existed only in analog form, the cost of copying and distribution allowed us—to some degree required us—to build an economy and a society grounded on information scarcity. A music label, for instance, had to recruit talent, produce recordings, market them, distribute them, and so on, and charging for records allowed the label to cover its costs and turn a profit. In a world where individuals can produce music and distribute it for free to the entire world, music labels in their traditional form can become obsolete. The business model of charging for recorded music and the copyright protections required to sustain it are remnants of the Industrial Age.

We take many artificial restrictions on information access and distribution for granted because we, and a couple of generations before us, have grown up with them. This is the only system we know and much of our personal behavior, our public policies and our intellectual inquiries are shaped by what we and our recent ancestors have experienced. To transition into a knowledge society, however, we should jettison much of this baggage and strive for maximum informational freedom. This is not unprecedented in human history. Prior to the advent of the printing press, stories and music were passed on largely in an oral tradition or through copying by hand. There were no restrictions on who could tell a story or perform a song.

Let's be clear: Information is not the same as knowledge. It is a broader concept, including, for instance, the huge amounts of log files generated every day by computers around the world, much of which may never be analyzed. We don't know in advance what information will turn out to be the basis for knowledge (i.e., information meant for other humans and which humans choose to maintain over time). Hence it makes sense to keep as much information as possible and make access to that information as broad as possible.

In this section we will explore various ways to expand informational freedom, the second important regulatory step to facilitate our transition to a Knowledge Age.

Access to the Internet

On occasion, the Internet has come in for derision from those who claim it is only a small innovation compared to, say, electricity or vaccinations. Yet it is not small at all. If you want to learn how electricity or vaccinations work, the Internet suddenly makes that possible for anyone, anywhere in the world.

Absent artificial limitations re-imposed on it, the Internet provides the means of access to and distribution of all human knowledge—including all of history, art, music, science, and so on—to all of humanity. As such, the Internet is the crucial enabler of the digital knowledge loop and access to the Internet is a central aspect of Informational Freedom.

At present, over 3.5 Billion people are connected to the Internet, and we are connecting over 200 Million more every year [88]. This tremendous growth has become possible because the cost of access has fallen so dramatically. A capable smartphone costs less than $100 to manufacture, and in places with strong competition 4G bandwidth is provided at prices as low as $8 per month (this is a plan in Seoul that provides 500 MB at 4G speeds, a 2GB plan is $17 per month) [89] [90].

Even connecting people in remote places is getting much cheaper, as the cost for wireless networking is coming down and we are building more satellite capacity. For instance, there is a project underway that connects rural communities in Mexico for less than $10,000 in equipment cost per community. At the same time in highly developed economies such as the U.S., ongoing technological innovation, such as MIMO wireless technology, will further lower prices for bandwidth in dense urban areas [91].

All of this is to say that UBI will easily cover the cost of access to the Internet, provided that we keep innovating and have highly competitive and/or properly regulated access markets.

As we work to give everyone affordable access to the Internet, we still must address other limitations to the flow of information on the Internet. In particular, we should oppose restrictions on the Internet imposed by either our governments or our Internet Service

Providers (ISPs, the companies we use to get access to the Internet). Both of them have been busily imposing artificial restrictions, driven by a range of economic and policy considerations.

One Global Internet

By design, the Internet does not embody a concept of geographic regions. Most fundamentally, it constitutes a way to connect networks with one another (hence the name “Internet” or network between networks). Since the Internet works at global scale, it follows that any geographic restrictions that exist have been added in, often at great cost. For instance, Australia and the UK have recently built so-called “firewalls” around their countries that are not unlike the much better-known Chinese firewall. These firewalls are not cheap. It cost the Australian government about $44 million to build its geographic-based, online perimeter [92]. This is extra equipment added to the Internet that places it under government control, restricting our informational freedom. Furthermore, as of 2017 both China and Russia have moved to block VPN services, one of the few ways individuals can circumvent these artificial restrictions and censorship online [93]. As citizens, we should be outraged that our own governments are spending our money to restrict our informational freedom.

No Artificial Fast and Slow Lanes

The same additional equipment used by governments to re-impose geographic boundaries on the Internet is also used by ISPs to extract additional economic value from customers, in the process distorting knowledge access. These practices include paid prioritization and zero rating. To understand them better and why they are a problem, let's take a brief technical detour.

When you buy access to the Internet, you pay for a connection of a certain capacity. Let's say that is 10 Mbps (that is 10 Megabits per second). So if you use that connection fully for, say, sixty seconds, you would have downloaded (or uploaded for that matter) 600 Megabits, the equivalent of 15-25 songs on Spotify (assuming 3-5 Megabytes per song). The fantastic thing about digital information is that all bits are the same. So it really doesn't matter whether you used this to access Wikipedia, to check out Khan Academy, or to browse images of LOLCats. Your ISP should have absolutely no say in that. You have paid for the bandwidth, and you should be free to use it to access whatever parts of human knowledge you want.

That principle, however, doesn't maximize profit for the ISP. To do so, the ISP seeks to discriminate between different types of information based on consumer demand and the supplier's ability to pay. Again, this has nothing to do with the underlying cost of delivering those bits. How do ISPs discriminate between different kinds of data? They start by installing

equipment that lets them identify bits based on their origin. They then go to a company like YouTube or Netflix and ask them to pay money to the ISP to have their traffic “prioritized,” relative to the traffic from other sources that are not paying. Another form of this manipulation is so-called “zero rating” which is common among wireless providers, where some services pay to be excluded from the monthly bandwidth cap. And if permitted, ISPs will go even a step further: in early 2017 the U.S. Senate voted to allow ISPs to sell customer data including browsing history without prior customer consent [94].

The regulatory solution to this issue goes by the technical and boring name of Net Neutrality. But what is really at stake here is informational freedom. Our access to human knowledge should not be skewed by the financial incentives of our ISPs.

ISPs can get away with these manipulations in the first place because in most geographic areas there is no competitive market for Internet access. ISPs either have outright monopolies (often granted by regulators) or they operate in small oligopolies. For instance, in the part of New York City (Chelsea) where I live at the moment, there is just one broadband ISP, with speeds that barely qualify as real broadband.

Over time technological advances such as wireless broadband and mesh networking may make the Internet Access market more competitive. Until then, however, we need regulation to avoid ISPs limiting our informational freedom. This concern is shared by people in diverse geographies. For instance, India recently objected to a plan by Facebook to provide subsidized Internet access which would have given priority to Facebook services.

Bots for All of Us

Once you have access to the Internet, you need software to connect to its many informational sources and services. When Sir Tim Berners-Lee first invented the World Wide Web in 1989 to make information sharing on the Internet easier, he did something very important [95]. He specified an open protocol, the Hypertext Transfer Protocol or HTTP, that anyone could use to make information available and to access such information. By specifying the protocol, Berners-Lee opened the way for anyone to build software, so-called web servers and browsers that would be compatible with this protocol. Many did, including, famously, Marc Andreessen with Netscape. Many of the web servers and browsers were available as open source and/or for free.

The combination of an open protocol and free software meant two things: Permissionless publishing and complete user control. If you wanted to add a page to the web, you didn't have to ask anyone's permission. You could just download a web server (e.g. the open source Apache), run it on a computer connected to the Internet, and add content in the HTML format. Voila, you had a website up and running that anyone from anywhere in the

world could visit with a web browser running on his or her computer (at the time there were no smartphones yet). Not surprisingly, content available on the web proliferated rapidly. Want to post a picture of your cat? Upload it to your webserver. Want to write something about the latest progress on your research project? No need to convince an academic publisher of the merits. Just put up a web page.

People accessing the web benefited from their ability to completely control their own web browser. In fact, in the Hypertext Transfer Protocol, the web browser is referred to as a “user agent” that accesses the Web on behalf of the user. Want to see the raw HTML as delivered by the server? Right click on your screen and use “view source.” Want to see only text? Instruct your user agent to turn off all images. Want to fill out a web form but keep a copy of what you are submitting for yourself? Create a script to have your browser save all form submissions locally as well.

Over time, popular platforms on the web have interfered with some of the freedom and autonomy that early users of the web used to enjoy. I went on Facebook the other day to find a witty post I had written some time ago on a friend's wall. It turns out that Facebook makes finding your own wall posts quite difficult. You can't actually search all the wall posts you have written in one go; rather, you have to go friend by friend and scan manually backwards in time. Facebook has all the data, but for whatever reason, they've decided not to make it easily searchable. I'm not suggesting any misconduct on Facebook's part—that's just how they've set it up. The point, though, is that you experience Facebook the way Facebook wants you to experience it. You cannot really program Facebook differently for yourself. If you don't like how Facebook's algorithms prioritize your friends' posts in your newsfeed, then tough luck, there is nothing you can do.

Or is there? Imagine what would happen if everything you did on Facebook was mediated by a software program—a “bot”—that you controlled. You could instruct this bot to go through and automate for you the cumbersome steps that Facebook lays out for finding past wall posts. Even better, if you had been using this bot all along, the bot could have kept your own archive of wall posts in your own data store (e.g., a Dropbox folder); then you could simply instruct the bot to search your own archive. Now imagine we all used bots to interact with Facebook. If we didn't like how our newsfeed was prioritized, we could simply ask our friends to instruct their bots to send us status updates directly so that we can form our own feeds. With Facebook on the web this was entirely possible because of the open protocol, but it is no longer possible in a world of proprietary and closed apps on mobile phones.

Although this Facebook example might sound trivial, bots have profound implications for power in a networked world. Consider on-demand car services provided by companies such as Uber and Lyft. If you are a driver today for these services, you know that each of these services provides a separate app for you to use. The closed nature of these apps makes it very hard for you to participate in more than one network at a time. What would happen,

though, if you had access to bots that could interact on your behalf with these networks? That would allow you to simultaneously participate in all of these marketplaces, and to play one off against the other.

Using a bot, you could set your own criteria for which rides you want to accept. Those criteria could include whether a commission charged by a given network is below a certain threshold. The bot, then, would allow you to accept rides that maximize the net fare you receive. Ride sharing companies would no longer be able to charge excessive commissions, since new networks could easily arise to undercut those commissions. For instance, a network could arise that is cooperatively owned by drivers and that charges just enough commission to cover its costs. Likewise, as a passenger using a bot could allow you to simultaneously evaluate the prices between different car services and choose the service with the lowest price for your current trip. The mere possibility that a network like this could exist would substantially reduce the power of the existing networks.

We could also use bots as an alternative to anti-trust regulation to counter the overwhelming power of technology giants like Google or Facebook without foregoing the benefits of their large networks. These companies derive much of their revenue from advertising, and on mobile devices, consumers currently have no way of blocking the ads. But what if they did? What if users could change mobile apps to add Ad-Blocking functionality just as they can with web browsers?

Many people decry ad-blocking as an attack on journalism that dooms the independent web, but that's an overly pessimistic view. In the early days, the web was full of ad-free content published by individuals. In fact, individuals first populated the web with content long before institutions joined in. When they did, they brought with them their offline business models, including paid subscriptions and of course advertising. Along with the emergence of platforms such as Facebook and Twitter with strong network effects, this resulted in a centralization of the web. More and more content was produced either on a platform or moved behind a paywall.

Ad-blocking is an assertion of power by the end-user, and that is a good thing in all respects. Just as a judge recently found that taxi companies have no special right to see their business model protected, neither do ad-supported publishers [96]. And while in the short term this might prompt publishers to flee to apps, in the long run it will mean more growth for content that is crowdfunded (for instance through a service such as Patreon), freely shareable and published using open formats.

To curtail the centralizing power of network effects more generally, we should shift power to the end-users by allowing them to have user agents for mobile apps, too. The reason users don't wield the same power on mobile is that native apps relegate end-users once again to interacting with services just using our eyes, ears, brain and fingers. No code can execute on our behalf, while the centralized providers use hundreds of thousands of servers and

millions of lines of code. Like a web browser, a mobile user-agent could do things such as strip ads, keep copies of my responses to services, let me participate simultaneously in multiple services (and bridge those services for me), and so on. The way to help end-users is not to have government smash big tech companies, but rather for government to empower individuals to have code that executes on their behalf.

What would it take to make bots a reality? We might require companies like Uber, Google, and Facebook to expose all of their functionality, not just through standard human usable interfaces such as apps and web sites, but also through so-called Application Programming Interfaces (APIs). An API is for a bot what an app is for a human. The bot can use it to carry out operations, such as posting a status update on a user's behalf. In fact, companies such as Facebook and Twitter have APIs, but they tend to have limited capabilities. Also, companies presently have the right to control access so that they can shut down bots, even when a user has clearly authorized a bot to act on his or her behalf.

Bots that we all can deploy to gain more power online are technically feasible. It comes down to regulation. Instead of requiring companies to provide an API that any bot I have accessed can authorize, we could also make it legal to reverse engineer how apps communicate. Currently, reverse engineering is impossible because of so-called anti-circumvention laws, including a key provision in the Digital Millennium Copyright Act (DMCA). These laws allow companies to restrict access to private encryption keys inside an app, which users would require in order to reverse-engineer it. The legal framework today works primarily to protect companies and their servers from bots instead of allowing end-users to be empowered by them.

Now, don't companies need to protect their encryption keys? Aren't “bot nets” the culprits behind all those so-called DDOS (distributed denial of service) attacks? Yes, there are a lot of compromised machines in the world, including set top boxes and home routers that some are using for nefarious purposes. Yet that only demonstrates how ineffective the existing laws are at stopping illegal bots. Because those laws don't work, companies have already developed the technological infrastructure to deal with the traffic from bots.

How would we prevent people from adopting bots that turn out to be malicious code? Open source seems like the best answer here. Many people could inspect a piece of code to make sure it does what it claims. But that's not the only answer. Once people can legally be represented by bots, many markets currently dominated by large companies will face competition from smaller startups.

Legalizing representation by a bot would eat into the revenues of large companies, and we might worry that they would respond by slowing their investment in infrastructure. I highly doubt this would happen. Uber, for instance, was recently valued at $50 billion. The company's “takerate” (the percentage of the total amount paid for rides that they keep) is 20%. If competition forced that rate down to 5%, Uber's value would fall to $10 billion as a

first approximation. That is still a huge number, leaving Uber with ample room to grow. As even this bit of cursory math suggests, capital would still be available for investment, and those investments would still be made.

That's not to say that no limitations should exist on bots. A bot representing me should have access to any functionality that I can access through a company's website or apps. It shouldn't be able to do something that I can't do, such as pretend to be another user or gain access to private posts by others. Companies can use technology to enforce such access limits for bots; there is no need to rely on regulation.

Even if I have convinced you of the merits of bots, you might still wonder how we might ever get there from here. The answer is that we can start very small. We could run an experiment with the right to be represented by a bot in a city like New York. New York's municipal authorities control how on demand transportation services operate. The city could say, “If you want to operate here, you have to let drivers interact with your service programmatically.” And I'm pretty sure, given how big a market New York City is, these services would agree.

Limiting the Limits to Sharing and Creating

Once we have fought back geographical and prioritization limits and have bots in place so that all users can meaningfully control their own interactions with the global knowledge network, we still come up against limits that restrict which information you can share and what you can create based on how you obtained the information. We'll first look at copyright and patent laws and suggest policies for reducing how much these limit the knowledge loop. Then we'll turn to confidentiality and privacy laws.

Earlier I remarked how expensive it was to make a copy of a book when human beings literally had to copy it one letter at a time. Eventually we invented the printing press, and after that movable type. Together the two provided for much faster and cheaper reproduction of information. Even back then, governments and also the church saw this as a threat to their authority. In England, the Licensing of the Press Act of 1662 predated modern attempts to censor the web by more than 300 years: if you operated a printing press and wanted the right to make copies, you needed the government's approval [97]. You received it in exchange for agreeing to censor content critical of the government or that ran counter to church teachings. And that's the origin of copyright. It is the right to make copies in return for agreeing to censorship.

Over time, as economies grew and publishing companies emerged as business enterprises, copyright became commercially meaningful, less as an instrument of government control and more as a source of profit. The logic runs like this: “If I have the copyright to a specific

material, then you cannot make copies of it, which means that I essentially have a monopoly in providing this content. I am the only one allowed to produce and sell copies of it."

Legitimating this shift was the idea that in order to get content produced in the first place, incentives needed to exist for the creators of content, just as incentives needed to exist for people to create tangible or material goods. If you own your factory, then you will invest in it because you get to keep the benefits from those improvements. Similarly, the thinking goes, if you are working on a book, you should own the book so that you have an incentive to write it in the first place and improve it over time through revisions.

Over time the holders of copyrights have worked to strengthen their claims and extend their reach. For instance, with the passing of The Copyright Act of 1976, the requirement to register a copyright was removed. Instead, if you created content you automatically had copyright in it [98]. Then in 1998 with passage of the Copyright Term Extension Act, the years for which you had a copyright were extended from 50 to 70 years beyond the life of the author. This became known as the "Mickey Mouse Protection Act," because Disney had lobbied the hardest for it, having built a very large and profitable business based on protected content, and mindful that a number of its copyrights were slated to expire [99].

More recently, copyright lobbying has attempted to interfere with the publication of content on the Internet through legislation such as PIPA and SOPA, and more recently the TPP. In these latest expansion attempts, the conflict between copyright and the digital knowledge loop becomes especially clear. Copyright severely limits what you can do with content, essentially down to consuming the content. It dramatically curtails your ability to share it and create other works that use some or all of the content. Some of the more extreme examples include takedowns of videos from YouTube that used the Happy Birthday song, which, yes, was copyrighted until recently.

From a societal standpoint, given digital technology, it is never optimal to prevent someone from listening to a song or watching a baseball game once the content exists. Since the marginal cost of accessing it is zero, the world is better off if that person gets just a little bit of enjoyment from that content. And if that person turns out to be inspired and write an amazing poem that millions read, well then the world is a lot better off.

Now, you might say, it's all well and good that the marginal cost for making a copy is zero, but what about all the fixed and variable cost that goes into making content? If all content were to be free, then where would the money come from for producing any of it? Don't we need copyright to give people the incentive to produce content in the first place?

Some degree of copyright is probably needed, especially for large-scale projects such as movies. Society may have an interest in seeing $100 million blockbuster films being made, and it may be that nobody will make them if, in the absence of copyright protection, they aren't economically viable. Yet here the protections should be fairly limited (for instance, you

shouldn't be able to take down an entire site or service just because it happens to contain a link to a pirated stream of your movie). More generally, I believe copyright can be dramatically reduced in its scope and made much more costly to obtain and maintain. The only automatic right accruing to content should be one of attribution. The reservation of additional rights should require a registration fee, because you are asking for content to be removed from the digital knowledge loop.

Let's take music as an example. Musical instruments were made as far back as 30,000 years ago, pre-dating any kind of copyright by many millennia. Even the earliest known musical notation, which marks music's transition from information to knowledge (again, defined as something that can be maintained and passed on by humans over time and distance), is around 3,400 years old [100]. Clearly people made music, composed it, shared it long before copyright existed. In fact, the period during which someone could make a significant amount of money making and then selling recorded music is extraordinarily short, starting with the invention of the gramophone in the 1870s and reaching its heyday in 1999, the year that saw the biggest profits in the music industry [101].

During the thousands of years before this short period, musicians made a living either from live performances or through patronage. If copyrighted music ceased to exist tomorrow, people would still compose, perform, and record music. And musicians would make money from live performances and patronage, just as they did prior to the rise of copyright. Indeed, as Steven Johnson found when he recently examined this issue, that's already what is happening to some degree: "the decline in recorded-music revenue has been accompanied by an increase in revenues from live music... Recorded music, then, becomes a kind of marketing expense for the main event of live shows" [102]. Many musicians have voluntarily chosen to give away digital versions of their music. They release tracks for free on Soundcloud or YouTube and raise money to make music from performing live and/or using crowdfunding methods such as Kickstarter and Patreon.

Now imagine a situation where the only automatic right accruing to an intellectual work was one of attribution. Anyone wanting to copy or distribute your song in whole or in part has to credit you. Such attribution can happen digitally at zero marginal cost and does not inhibit any part of the knowledge loop. Attribution imposes no restrictions on learning (making, accessing, distributing copies), on creating derivative works, and on sharing those. Attribution can include reference to who wrote the lyrics, who composed the music, who played which instrument and so on. Attribution can also include where you found this particular piece of music (i.e., giving credit to people who discover music or curate playlists). This practice is already becoming more popular using tools such as the Creative Commons License, or the MIT License often used for attribution in open source software development.

Now, what if you're Taylor Swift and you don't want others to be able to use your music without paying you? Well, then you are asking for your music to be removed from the knowledge loop, thus removing all the benefits that loop confers upon society. So you should be paying for that right, which not only represents a loss to society but will be costly to enforce. I don't know how big the registration fee should be — that's something that will require further work — but it should be a monthly or annual fee, and when you stop paying it, your work should revert back to possessing attribution-only rights.

Importantly, in order to reserve rights, you should have to register your music with a registry, and some part of the copyright fee would go towards maintenance of these registries. Thanks to blockchain technology, competing registries can exist that all use the same global database. The registries themselves would be free for anyone to search, and registration would involve a prior search to ensure that you are not trying to register someone else's work. The search could and should be built in a way so that anyone operating a music sharing service, such as Spotify or Soundcloud, can trivially implement compliance to make sure they are not freely sharing music that has reserved rights.

It would even be possible to make the registration fee dependent on how many rights you want to retain. All of this could be modeled after the wildly successful Creative Commons licenses. For instance, your fee might decrease if you allow non-commercial use of your music and also allow others to create derivative works. The fee might increase significantly if you want all your rights reserved. The same or similar systems could be used for all content types, including text, images and video.

Critics might object that the registration I'm proposing imposes a financial burden on creators. It is important to remember the converse: Removing content from the knowledge loop imposes a cost on society. And enforcing this removal, for instance by finding people who are infringing and imposing penalties on them, imposes additional costs on society. For these reasons, asking creators to pay is fair, especially if creators' economic freedom is already assured by a Universal Basic Income. We have generated so much economic prosperity that nobody needs to be a starving artist anymore!

Universal Basic Income also helps us dismantle another argument frequently wielded in support of excessive copyright: Employment at publishers. The major music labels combined currently employ roughly 17,000 people [103] [104] [105]. When people propose limiting the extent of copyright, others point to the potential loss of these jobs. Never mind that the existence of this employment to some degree reflects the cost to society from having copyright. Owners, managers and employees of music labels are after all not the creators of the music.

Before turning to patents, let me point out one more reason why a return to a system of paid registration of rights makes sense. None of us creates intellectual works in a vacuum. Any author who writes a book has read lots of writing by other people. Any musician has listened

to tons of music. Any filmmaker has watched lots of movies. Much of what makes art so enjoyable these days is the vast body of prior art that it draws upon and can explicitly or implicitly reference. There is no “great man” or woman who creates in a vacuum and from scratch. We are all part of the knowledge loop that has already existed for millennia.

While copyright limits our ability to share information (and thus knowledge), patents limit our ability to use information (knowledge) to create something. Much like having a copyright confers a monopoly on the reproduction of information, a patent confers a monopoly to make use of information. And the rationale for the existence of patents is similar to copyright. The monopoly that is granted results in economic rents (i.e., profits) that are supposed to provide an incentive for people to invest in research and product development.

As with copyright, the incentive argument here should be suspect. People invented long before patents existed and since then people have chosen to invent without seeking patents. We can trace early uses of patents to Venice in the mid 1400s; Britain had a fairly well established system by the 1600s [106]. That leaves thousands of years of invention, a time that saw such critical breakthroughs as the alphabet, movable type, the wheel, and gears. This is to say nothing of those inventors who more recently chose not to patent their inventions because they saw how that would interrupt the knowledge loop and impose a loss on society. These inventors include Jonas Salk, who created the Polio vaccine (others include x rays, penicillin, ether as an anaesthetic, and many more, see [107]).

With a Universal Basic Income in place, more people will be able to spend their time inventing without the incentive provided by patent protection. Digital technologies will help by reducing the cost of inventing. One example of this is the USV portfolio company Science Exchange, which has created a market place for laboratory experiments. Let's say you have an idea that requires you to sequence a bunch of genes. The fastest gene sequencing to date is done by the company Illumina, whose machines costs from $850K-$1M to buy [108]. Via Science Exchange, a USV portfolio company, you can access such a machine on a per use basis for less than $1000 [109]. Furthermore, the next generation of sequencing machines is already on the way, and these machines will further reduce the cost. Here too we see the phenomenon of technological deflation at work.

A lot of recent legislation has needlessly inflated the cost of innovation. In particular, rules around drug testing have made drug discovery prohibitively expensive. We have gone too far in the direction of protecting patients during the research process and also of allowing for large medical damage claims. As a result, many drugs are either not developed at all or are withdrawn from the market despite their efficacy (for example the vaccine against Lyme disease, which is no longer available for humans [110]).

Patents (i.e., granting a temporary monopoly) are not the only way to provide incentives for innovation. Another historically successful strategy has been the offering of public prizes. Britain famously offered the Longitude rewards starting in 1714 to induce solutions to the

problem of determining a ship's longitude at sea (latitude can be determined easily from the position of the sun). Several people were awarded prizes for their designs of chronometers, lunar distance tables and other methods for determining longitude (including improvements to existing methods). As quid pro quo for receiving the prize money, inventors generally had to make their innovations available to others to use as well [111].

At a time when we wish to accelerate the digital knowledge loop, we must shift the balance towards knowledge that can be used freely and that is not encumbered by patents. It is promising to see successful recent prize programs, such as the X Prizes, DARPA Grand Challenges, and NIST competitions. There is also potential for crowdfunding future prizes. Medical research in particular should be a target for these to help bring down the cost of healthcare.

Going forward, we can achieve this by using prizes more frequently. And yet, that leaves a lot of existing patents in place. Here I believe a lot can be done to reform the existing system and make it more functional, in particular by reducing the impact of so-called Non Practicing Entities (NPEs, commonly referred to as “patent trolls”). These are companies that have no operating business of their own, and exist solely for the purpose of litigating patents.

In recent years, many NPEs have been litigating patents of dubious validity. They tend to sue not just a company but also that company's customers. This forces a lot of companies into a quick settlement. The NPE then turns around and uses the early settlement money to finance further lawsuits. Just a few dollars for them go a long way because their attorneys do much of the legal work on a contingency basis, expecting further settlements. Fortunately, a recent Supreme Court ruling placed limits on where patent lawsuits can be filed, which should help limit the activity of these NPEs going forward [112].

As a central step in patent reform, we thus must make it easier and faster to invalidate existing patents while at the same time making it more difficult to obtain new patents. Thankfully, we have seen some progress on both counts in the U.S., but we still have a long way to go. Large parts of what is currently patentable should be excluded from patentability in the first place, including designs and utility patents. University research that has received even small amounts of public funding should not be eligible for patents at all. Universities have frequently delayed the publication of research in areas where they have hoped for patents that they could subsequently license out. This practice has constituted one of the worst consequences of the patent system for the knowledge loop.

We have also gone astray by starting to celebrate patents as a measure of technological progress and prowess instead of treating them as a necessary evil (and maybe not even necessary). Ideally, we would succeed in rolling back the reach of existing patents and raising the bar for new patents while also inducing as much unencumbered innovation as possible through the bestowing of prizes and social recognition.

Getting Over Privacy and Confidentiality

Copyrights and patents aren't the only legal limitations impacting the digital knowledge loop. Privacy and confidentiality laws also loom large. I believe that someday all information should be public, including everyone's financial and health records. That may strike many readers as completely crazy, but countries like Sweden and Finland are already publishing everyone's tax return [113]. And some individuals have also published their entire medical history on the Internet, including the CIO and Dean for Technology at Harvard Medical School [114].

I come to my radical perspective here by comparing the costs and benefits to individuals and to humanity from keeping information private or confidential with the costs and benefits of making it public. In ways analogous to copyright, digital technology is dramatically shifting this cost/benefit tradeoff in favor of public information. Let's take a radiology image as an example. Analog x-ray technology produced images using a piece of film that had to be developed and that could then be examined by someone who was holding it up against a backlight. If you wanted to protect the information on it, you would put it in a file and lock up that file in a drawer. If you wanted a second opinion, you would have to get that file out of the drawer and have it sent it to you or the other doctor by mail. That process was costly, time consuming and error prone (the film could be lost in the mail, or the wrong film could be sent, etc.). The upside of analog x-rays was the ease of keeping the information secret; the downside was the difficulty you had in putting the information to use for your benefit.

Compare analog x-rays to digital x-ray images. You can instantly walk out of your doctor's office with a copy of the digital image on a thumb drive or have it emailed to you or put in a Dropbox or share via some other way made possible by the Internet. Thanks to this technology, you can now get a second opinion nearly instantly. Not only one, you could get two or three. And if everyone you contacted directly is stumped, you could post the image on the Internet for everyone to see. Some doctor somewhere in the world may go, “ah, I have seen that before” even if “that” is incredibly rare. This in fact has happened repeatedly on Figure 1, a USV portfolio company, which provides an image sharing network for medical professionals.

This power comes at a price: Protecting your digital x-ray image from others who might wish to see it is virtually impossible. Every doctor who looks at your image could make a copy (for free, instantly and with perfect fidelity) and then send that to someone else of his or her choosing. The same goes for others who might have access to the image, such as your insurance company.

Now, critics will make all sorts of claims about how we can prevent unauthorized use of your image using encryption. But as we will see, those claims are hollow at best and dangerous if pursued to their ultimate conclusion (preview: you cannot have general purpose computing).

So in summary: The upside of a digital x-ray image is how easy it makes it to get help; the downside is how hard it is to protect digital information.

But the analysis hardly ends there. The benefits that accrue to your digital x-ray image go well beyond just you. Imagine a huge collection of digital x-ray images all labeled with diagnoses. We can use computers to search through those images and get machines to “learn” what to look for. We know that such systems can be built given the recent progress with deep learning. And these systems, because of the magic of zero marginal cost, can assist with and eventually provide future diagnoses for free. This, you may recall from the section on technological deflation in healthcare, is exactly what we want. It was impossible in the world of analog x-ray images, and it will continue to be impossible if each of us selfishly tries to lock up our digital x-ray images.

If we made all healthcare information public, we would dramatically accelerate innovation in diagnosing and treating diseases. At present, only large pharma companies can develop drugs, since only they have the money required to get many patients to participate in research. Many researchers are forced to join a big pharma company, leaving the results of their work protected by patents (part of the Trans Pacific Partnership negotiations have been around pharma companies' ability to keep such information strictly for themselves). This situation recalls the music examples discussed earlier. The problem of trying to keep individual digital x-ray images private is the same as trying to DRM digital music files so that only the person who paid for it can play it. It is a technological impossibility (unless you want to ban all general purpose computing), and it deprives humanity of the benefits of sharing.

So why do I keep asserting the technological impossibility of assuring privacy or confidentiality? Don't we have encryption? Encryption is great for securing information in transit and at rest, but there are problems exist that encryption doesn't and can't solve.

The first problem is that encryption keys are also just digital information themselves, so keeping them secure confronts us with just another instance of the original problem. Transmitting your keys leaves them vulnerable to interception. Even generating a key on your own machine offers limited protection, unless you are willing to have that be the only key with the risk that any data you're protecting will be lost forever if you lose the device. As a result, most systems include some kind of cloud based backup and a way of retrieving a key, making it possible that someone will access your data either through technical interception or social engineering (i.e., tricking a human being to unwittingly participate in a security breach).

The second problem is so-called “endpoint security.” Consider, for example, the computer of the doctor to whom you are sending your x-ray for a second opinion. That machine may have a program running on it that can access anything that is displayed on the screen. In order to view your x-ray, the doctor of course has to decrypt it and display it, so this screen capture program will have access to the unencrypted image. Avoiding such a scenario would

require us to lock down all computing devices. But that means preventing end-users from installing software on them and running all software through a rigorous centralized inspection process. Even a locked down endpoint is still subject to the so-called “analog hole,” in which someone simply takes a picture of what is displayed on a screen.

Locked down computing devices constrict innovation; they also pose a huge threat to democracy and the knowledge loop. Someone else would control what you can compute, who you can exchange information with, and so on, in what would essentially become a dictatorial system. The Internet's entire premise as a global knowledge network hinges on enabling individual subnetworks and nodes to control their own computation.

If we can't really protect data, or if doing so means sacrificing the basic purpose of computing and networking, then what should we do? The answer, I think, is to embrace a post-privacy and post-confidentiality world. We should work to protect people, not information, allowing for information to become public but sheltering individuals from the potential consequences. Such an embrace does not need to happen overnight. Rather we can take small steps into it starting with individuals who voluntarily disclose more information about themselves.

Economic freedom via a Universal Basic Income represents an important first step to protecting people. If you were to lose your job over an information disclosure (maybe you had an affair and your employer thinks that's immoral), then at least you would still be able to secure your basic needs. Of course, a world of economic freedom and psychological freedom (next chapter), would decrease your chances of getting fired in the first place: When many more employees have walk away options, retention becomes much more important.

But, you might ask, what about your bank account? If that information were public, wouldn't bad actors simply take your money? They might, which is why we need to construct systems that don't just require a number that you have already shared with others to authorize payments. Apple Pay and Android Pay are such systems. Every transaction requires an additional form of authentication at the time of transaction. Two factor authentication systems will become much more common in the future for any action that you will take in the digital world. In addition, we will rely more and more on systems such as Sift Science, another USV portfolio company, that assess in real time the likelihood that a particular transaction is fraudulent, taking into account hundreds of different factors.

Another area where people are especially nervous about privacy is health information. We worry, for instance, about employers, insurers, or others in society discriminating against us because they've learned that we have a certain disease or condition. But here again, the economic freedom conferred by a Universal Basic Income would protect you from going destitute because of discrimination, and by tightening the labor market, it would also make it harder for employers to decide to systematically refuse to hire certain groups of people. Further, we could enact laws that require sufficient transparency on the part of organizations,

so that we could better track how decisions have been made and detect more easily if it appears that discrimination is taking place. This combination of laws and freedoms would afford powerful protection while allowing the free flow of information that is currently “private.”

Many people contend that there must be some way to preserve privacy. I challenge anyone to create a coherent vision of the future where individuals, not governments or large corporations (such as Apple) control technology and where privacy or confidentiality remain secure. It just can't happen. Any time you leave your house, you are probably being filmed by someone's camera. Every smartphone has a camera these days, and in the future we'll see tiny cameras on tiny drones. Your gait identifies you almost as uniquely as your fingerprint. Your face is probably somewhere on the Internet and your car's license plate is readable by any camera. You leave your DNA almost everywhere you go, and soon individuals will be able to sequence DNA at home for about 100 dollars. Should the government control all of these technologies? Should it level draconian punishments for using these technologies to analyze someone else's presence or movement? And if so how would those penalties be enforced?

The only view of the future that allows for freedom is one in which individuals retain control over technology, including general purpose computing. Such a world cannot accommodate our current notions of privacy and confidentiality. Yet we can adjust for that, and we have every incentive to do so. As I have pointed out, once we are willing to embrace such a world, once we feel comfortable releasing much of our data, we will reap huge benefits from that collectively. We will cure diseases. We will help end poverty. We will help fix the environment. All by enabling the knowledge loop to work much more efficiently and freely than it does today.

We should also remember that privacy is really a modern construct; by no means is it a precondition to a healthy, well-functioning society or to healthy, well- functioning individuals [Cite/add examples from Jeff Jarvis book here]. For thousands of years prior to the 18th century, most people had no concept of privacy. Many of the functions of everyday life, including excretion and reproduction, took place much more openly that they do today. And privacy still varies greatly among cultures—many Westerns are shocked when they first experience the openness of Chinese public restrooms [115].

Even today in rural areas, many people live perfectly well with much less privacy than is common in urban, industrial areas. You could regard the lack of privacy as oppressive, or you could see a close-knit community as a real benefit and source of strength. For instance, I remember growing up in a small village in Germany where if a member of our community was sick and couldn't leave the house, a neighbor would quickly check up on them and offer to do the shopping or provide food.

If you want ample indication of how little entrenched privacy is in human nature, just look at what is happening today on the Internet. Millions of people are making amateur pornography videos of themselves and sharing them with the world. Hundreds of millions more are publishing their most intimate thoughts and reporting their most mundane activities via social media. Cultural critics have decried such public displays as narcissistic, seeing it as a breakdown in civility. That's not the case. The Internet has opened up new avenues for individuals to live in harmony with their deepest drives and instincts which include the desire to be social and to be recognized as an individual. These drives and instincts compel us to open up and communicate with others not just in private settings.

Observers such as 4Chan founder Chris Poole have worried that in the absence of privacy, individuals wouldn't be able to engage as fully and as freely online as they do today. Privacy, they think, helps people feel comfortable taking on multiple identities online that may depart dramatically from one another and from their “real life” selves. But I hold a different view. By keeping our various online selves separate, we allow for a lot of inner conflict to persist. We pay a price for this in the form of anxieties, neuroses, and other psychological ailments. It's far better to be fully transparent about the many sides of our personality than to cloister ourselves behind veils of privacy. Emotional and psychological health derives not from a splintering or fragmentation of the self, but the integration of different aspects into a unitary but multi-dimensional personality.[Look for psychological research backing this point] [Also provide examples from Stoic philosophers/ancient Greece. You don't need privacy for psychological freedom.]

Suppose you accept my arguments that clinging on to privacy is a dangerous obstacle on the path to the Knowledge Age, the question remains: How will we get to a post privacy world? One way will be inadvertently through hacks and data breaches that abruptly expose data on millions of people [116]. Another—and better way—will be through individuals opting into disclosing more of their information. For instance, hundreds of people have already posted their Genome online and I am planning to do the same soon—I already have the files.

Many who argue against this post privacy view, point out that oppressive governments can use information against citizens. People give examples such as the Nazis prosecuting homosexuals or the Chinese government prosecuting dissidents. Without a doubt preserving democracy and the rule of law are essential if we want to achieve a high degree of informational freedom. But the analysis cannot simply hold the level of privacy constant and switch out the regime. One also needs to consider how likely a regime change is for given levels of privacy. And there I am convinced that more public information makes dictatorial takeovers considerably harder. For instance, with public tax records it is much clearer who is enriching themselves from a change in government.

At present, even here in the United States many people feel they cannot trust the government. The erosion of trust has taken place over years as part of the impact of lobbying and capital on politics (see the earlier chapter on the self-conservation of capitalism). Large scale secret surveillance, as revealed by Edward Snowden, has further deteriorated trust. But if the net result of this winds up being a society that pits us (the citizens) versus them (the government) in a crypto battle then we will all lose. We will lose general purpose computing and we will eventually find ourselves in exactly the kind of dictatorship that we are seeking to avoid. More on this in the chapter on Democracy later.

Psychological Freedom

Imagine that our society has achieved economic freedom and informational freedom. Would you make good use of those freedoms? Or would your existing beliefs, fears, and emotional reactions hold you back from engaging in the Knowledge Loop? Or worse yet, would you have all your attention drawn into systems designed to capture it for their own benefit?

Would you feel comfortable pursuing your interests for their own sake, or would your Industrial Age assumptions about consumption, success, and so on prompt you to keep making more money so that you could buy a faster car, a bigger house, or the latest gadget? Would you feel a strong sense of purpose in the Knowledge Age, or would you feel adrift without a job or the need to pursue a career? Would you avidly seek out new knowledge, or would you limit your curiosity to affirming what you or those around you already believe? Or worse would you get upset by views that disagree with yours and shout at people online? Would you feel free to create, or would you hold yourself back, fearing that you're not “a creative person”? Would you share your knowledge freely with others, or would you refrain from doing so out of concern for embarrassment? Would you recognize when your attention is being manipulated for the benefit of others?

The previous two sections dealt with regulations that we should be working to have our governments implement. This section addresses self-regulation instead: The work we need to do to free ourselves from ways of thinking (and resultant fears and emotional attachments) that have accompanied industrial society and the job loop. And more generally, freeing ourselves from the power exerted by the older reptilian and limbic parts of the brain, so that we can freely direct our attention towards our own purpose.

It's important, first of all, to acknowledge the profound psychological dimensions of the breakdown of industrial society. Social and economic disruption makes life more stressful; many people are more afraid than ever of losing their jobs, and we're generally unsettled by what we perceive to be the heightened pace of change. To make matters worse, we have yet to learn how to live in healthy ways with our new technology (for instance, obsessively checking our smart phones during meetings, while driving, etc.). All of this is taking an immense psychological toll, as evidenced by recent increases in sleep disorders, suicide rates, drug overdose deaths, conditions such as ADHD and antisocial activities such as bullying.

For the Knowledge Loop to truly succeed, each of us must adapt. Not only must we wean ourselves away from unhealthy uses of technology; we must look honestly at ourselves and recognize that we are not well prepared psychologically for the freedoms the Knowledge Loop requires. As we break with ways of thinking associated with the job loop and scarcity,

we must identify the deep-seated fears and emotional attachments that hold us back from engaging fully in the Knowledge Loop. Right now our technologies and the systems they make possible are mastering us; we need to learn how to master them.

Can we fundamentally change our mindsets and emotional attachments? Can we overcome the fears and anxieties that might prevent us from gaining, creating, and sharing knowledge? Can we put down our phones when they are designed to keep drawing us in with notifications? It seems a monumental task, but humankind is uniquely adaptable. We have experienced social, economic, and technological transitions of a similar magnitude. At one time it was inconceivable that humans could part with the close-knit relationships and natural rhythms of rural life to live in vast, impersonal cities and work in mechanized factories. [Find some great quotes from that time] Yet we did make the leap, overcoming our fears and embracing a range of modern practices, beliefs, and assumptions.

We now understand scientifically why humans can adapt so well. As neuroscientists have discovered, our brains remain quite plastic even as we age, and what we think and how we think can be changed. In fact, we ourselves can change it quite deliberately—not just with pharmaceuticals, but using both ancient techniques such as meditation and breathing, and modern ones such as Cognitive Behavioral Therapy [117].

Neuroscience teaches us that the brain consists of both lower-order systems that produce instincts and emotions and higher order systems that allow for rational thought. Techniques such as conscious breathing offer us a way to use our higher-order awareness and reasoning to shape our reaction to lower-order emotions, preventing them from taking control of us. Just a few months ago a Stanford study found the neural pathway by which slowing down our breathing lets us calm down our mid.

This modern scientific knowledge confirms what has been known to varying degrees since ancient times. In the Western tradition the Stoic Philosophers developed practices of thought to temper the effect of emotions. In the Eastern traditions, such as Buddhism, meditation and breathing serve the role of achieving a similar detachment.

We can free ourselves from fear, from stress, from anger, from addiction, and from other psychological states that prevent us from participating in the Knowledge Loop.

Freedom from Wanting

As the job loop became successful, widespread confusion started to set in around consumption. People in advanced economies became obsessed with material progress. Buying more material goods was seen as positive and healthy because it supported more

employment, which in turn allowed more people to buy things. All consumption became desirable consumption and policymakers and consumers alike gave up on any distinction between needs and wants. [Reference to “how much is enough?” by Skidelskis here]

Worse yet, we started to engage in so-called positional consumption. If your neighbor bought a new car, you wanted to buy an even newer and more expensive model. Such consumption behavior emerged not just with respect to goods but also to services—think of the $1,000 haircut or the $595 per-person dinner at a Michelin starred restaurant in Manhattan [118] [120].

Rabid consumption, positional or otherwise, is especially odd because we know that it doesn't actually do much for us as individuals. Many studies show that people vastly overestimate the happiness they will experience when they own that new car. When you desire something like a new car, your brain gets a hit of dopamine based on your anticipated happiness from having it, making you feel good. Yet once you actually get the car, you compare this to to your prior expectations. If the reward from having the car turns out to be less than what you expected, your dopamine levels will decrease and this can cause extreme disappointment. If your expectations are met, dopamine levels will stay basically constant. But only if your expectations are greatly exceeded will you get another big hit of dopamine. The unfortunate result of this is known as the “hedonic treadmill.” That is, when your brain gets accustomed to certain levels of dopamine (having a new car), you inadvertently boost the levels of dopamine required in the future to produce the same feeling of happiness. You'll have to raise your expectations for an even more expensive or faster car to get that initial kick of dopamine again, as repeated experiences just won't cut it [119].

This example of consumption illustrates how our emotions serve to keep us trapped within industrial society and the Job Loop. Our higher, rational selves can understand the hedonic treadmill, yet we readily allow our instincts and emotions to take over and go right back to our consuming habits. When this happens, the consequences are often dire. Individuals get themselves into massive debt buying houses they can't afford. People feel unhealthy levels of stress, so worried are they about advancing in their careers in order to keep up with someone else's level of consumption.

A Universal Basic Income provides the basis for economic freedom, but it will make people truly free only when they can go back to appreciating the difference between needs and wants: You need to eat; you may want to eat at a Michelin starred restaurant. You need to drink water; you may want to drink an expensive wine. If you crave the expensive food or wine and won't be satisfied with anything less, then a Universal Basic Income will not do much for you. You'll forego opportunities to pursue your interests for their own sake because you'll still feel compelled to seek out a bigger, better job so that you can make more money. On the other hand, if you can come to more clearly distinguish your basic needs from your wants, then a Universal Basic Income will significantly increase your freedom.

Suppose your passion is skiing. You grew up with it, and as an adult you know that no activity helps you feel as alive as skiing. But skiing is expensive, is it not? How would a basic income ever let you nurture and develop this interest? Actually, it would. No, you probably wouldn't be able to afford an annual ski trip to the Swiss alps, including a stay at a luxurious lodge. But ski equipment is actually not very expensive when you consider that it can last for twenty years or more and can be shared with others. And if you're willing to hike up a mountain, you can ski as much as you want without buying a lift ticket at an expensive resort.

Psychological freedom in this instance means freeing yourself of assumptions you might have about how to go skiing. If you can learn to re-frame skiing as an outdoor adventure, a chance to be in nature, it isn't expensive at all and is very much accessible under a basic income. A similar logic holds for any number of other activities a person might both wish to pursue or feel they need to pursue.

To dislodge our expectations about consumption, we first must become more aware of the differences between needs and wants, and we also have to understand how our brains work and what consumption will and won't do for us. We must train ourselves over time not to grow attached to material goods or lifestyles (an area in which meditation can certainly help). Finally, we should cast a critical eye on the advertising and marketing we encounter, understanding how it perpetuates illusions about needs and wants, and making efforts to avoid contact with it.

Freedom to Learn

Young kids ask upwards of three hundred questions a day. [121] Humans are naturally curious, and it's precisely this curiosity that has driven so much of our progress. At the same time, our curiosity in some ways didn't match well with the industrial system. If you want to employ people in a factory job that has them performing the same action all day every day, then curiosity doesn't help; on the contrary, it hurts. The same goes for many service jobs today, such as say operating a cash register or delivering packages on time.

The present-day educational system was built to support the industrial economy. No surprise then, that it generally tends to suppress rather than encourage curiosity. While educators hardly ever state “suppressing curiosity” as an overt goal, many of our educational practices do exactly that. For instance, forcing every eight year old to learn the same things in math, science, literature, and the arts does not encourage the development of curiosity. Teaching to a test does not encourage curiosity. Inadequate funding for music and art doesn't encourage curiosity.

A critical way that we undermine curiosity is by evaluating many domains of learning according to whether we think they'll help kids get a “good job.” If your child expressed an interest in learning Swahili or wanting to play the mandolin, would you as a parent support that? Or would you say something like, “But how will you earn a living with that”? Underlying our current obsession with STEM education is a fear that somehow we won't have enough engineers or scientists. Historic evidence suggests that is not true. For instance, we accomplished the Apollo program and moon landing at a time when Math was not mandatory in high school. Forcing kids to study something is a surefire way to squelch their natural curiosity.

We need to free ourselves from an instrumental view of knowledge and embrace learning for its own sake as part of the Knowledge Loop. Again, a Universal Basic Income can go a long way to making more people overcome their fears that they won't be able to support themselves if they pursue their true passions. Yet as individuals we also need to learn how to overcome those deeply ingrained fears ourselves, by consciously re-thinking those assumptions and by practicing self-regulation. As people successfully free themselves of industrial-era beliefs about education, and as they begin to make different educational choices for themselves and their children, schools and other educational institutions themselves will change or risk going out of business.

The Knowledge Loop and the digital revolution brings to the fore certain other cognitive limits to learning that we must also overcome. The first of these is confirmation bias. As humans we find it much easier to process and accept information that confirms what we already believe to be true. Today, we can access a huge amount of content online, confirming any of our pre-existing beliefs. Collectively, we risk becoming ever more entrenched in these views, fracturing into groups that hold and perpetually reinforce very strong beliefs. This phenomenon of the “Digital Balkans” becomes even more pronounced given the automatic personalization of many Internet systems, with people living inside a “filter bubble” that screens out conflicting information [Cite Marshall van Alstyne and Eli Pariser here].

The second cognitive limit is the human tendency to believe in stories rather than data—again, a well documented and understood bias. After a study came out suggesting that smaller schools tended to produce better student performance than larger schools, educators set about creating a lot of smaller schools. A subsequent study found that a lot of smaller schools were also doing exceptionally poorly. It turns out that this finding in part amounted to a statistical effect: The more students a school has, the more likely that school is to approximate the overall distribution of students. A small school is much more likely to have students who perform predominantly well or poorly. [Use another examples here from Daniel Kahnemann?]

Daniel Kahnemann in his amazing book, Thinking Fast and Slow, discusses the fundamental problem. We employ heuristics that result in confirmation bias and storytelling because many of the older systems in the human brain are optimized for speed and effortlessness. In a world with an analog Knowledge Loop, more time exists to correct for these biases. But in a high velocity, low cost digital Knowledge Loop, we must work far more deliberately to slow ourselves down. Otherwise, we run the risk of passing along incorrect stories without taking the time to verify them resulting in an information cascade. A great recent example of what can happen in this kind of situation is the speech given by [find story of British scientist in South Korea] [Other examples?].

At the moment, the bulk of the systems we interact with are designed on purpose to appeal to our cognitive biases instead of helping us overcome them. Companies such as Facebook and Twitter become more valuable the more attention they capture, as they then resell some part of that attention in what is known as advertising. Capturing attention is easier through appealing to what Kahenmann calls System 1, the parts of our brain that require no effort and are responsible for our cognitive biases. You are much more likely to look at a sequence of cute animal pictures or status updates from your friends than to read through an in-depth analysis of a proposal for a carbon tax. Fake news and propaganda efforts have understood this inherent flaw in the existing systems, making large scale manipulation possible.

New systems can help here. We might imagine, for instance, an online reader that always gives you opposing viewpoints to a given story or perspective. For each topic, you could explore both “similar” and “opposing” views. Such a reader could be presented as a browser plug in, so that when you' ve already ventured beyond the confines of a social media platform and are perusing content you could still bring that exploration with you [122].

Fundamentally though, each and everyone of us has to actively work on engaging what Kahnemann calls System 2, which is the part of our brain that requires real effort but lets us think independently and rationally. Only then will we be free to learn.

Freedom to Create

Picasso once said: “we all start out as artists, the challenge is to remain one.” He has a great point. I created many paintings as a young child (some thankfully kept by my mother) that I doubt I would be able to create today. As adults we self-censor, inhibiting the natural creativity we enjoyed as children. We've been told that we aren't creative or we've seen people reject or mock creative work we've done. The educational system, with its focus on preparing for standardized tests, further squelches our creative impulses. Eventually, we come to believe that creativity is something that other people do, not us.

Job loop thinking further solidifies and even institutionalizes these beliefs about creativity. Society affirms a categorization of people into amateurs and professionals based on whether or not someone gets paid. We venerate the professional guitar player, artist, or sculptor and denigrate the amateur, talking about the latter's work as “amateurish” or “amateur hour.” Of course the word “amateur” derives from the Latin root amator, which means “lover of.” When we start to measure creativity by how much money an artist or musician is making, rather than the passion they feel for a pursuit, there is no wonder that many people are afraid that they will never measure up.

Distractions also inhibit our impulses to create. We now live in an always on, interrupt driven world. There is always another video to watch on YouTube. Always another email message or chat to read. Always another game to play. Our brains are very poorly adapted to such an information overload environment. We evolved in a world where obtaining a bit of information—for instance, the sound of an approaching animal—was potentially a matter of life or death. It's still very easy to distract our brains with new information. In order to be able to create, we need to disconnect ourselves from many of those stimuli at least for some time period. That requires both practice and effort.

Freedom to Share

Even after we have created something, many of us are afraid to share it. We fear that someone will call our painting ugly, or our code incompetent, or our proposal naive. Given the state of much online commentary and “trolling” those fears are well founded. But at the same time, they need not fundamentally or permanently inhibit participation in the Knowledge Loop. Part of the answer is to work on the inner strength to continue sharing despite criticism and even despite personal attacks.

Another part of the answer is for each of us to cultivate empathy. Whenever we comment on the work of others online, we should keep in mind that they worked up the courage to create and to share. And we should remember that by contributing to the Knowledge Loop, they have engaged in the quintessential of human activities. Our empathy is central to others' freedom to create and share. Furthermore, those who operate online communities should provide the tools for flagging and, if needed, baning people who engage in verbal abuse or make threats aimed at shutting down sharing.

That will not be enough if you live in a country subject to dictatorship, censorship or mob rule. In these cases, sharing opinions or art or research can result in imprisonment, torture, or even death. And yet, even in these settings, we routinely find people who overcome their fears and freely share. We should take inspiration from those who do.

In the Knowledge Age, there still is such a thing as sharing too much. I'm not talking about sharing too much content, but rather mindlessly sharing harmful information without thinking about it. Needlessly hostile statements, rumors, and outright lies can take on lives of their own if we share them without first reflecting on their impact. We can wind up contributing to a so-called information cascade, in which an initial bit of information keeps picking up speed, becoming an avalanche.

We should feel free to share our opinions and ideas and information, but it's best for the sake of the Knowledge Loop if we slow ourselves down and control our emotional responses. Ask yourself: Will this information I'm sharing enhance the overall pursuit of knowledge, or will it hurt it? Am I short-circuiting the process by which ideas and works are evaluated and rationally judged? If so, then it's best not to share but to evaluate further.

Psychological Freedom, Education, and Humanism

Self-regulation, as we've seen, lies at the heart of psychological freedom. It allows us to separate wants from needs. It lets us take our initial reactions to content that we see and not immediately reply in anger. It lets us have empathy for others and their creations.

Still, there are the foundational needs for purpose and recognition that wind up making many people psychologically un-free. If you feel that your life lacks purpose or that nobody cares about your existence then you will experience a profound emptiness. This existential angst can express itself in many different forms, ranging from a paralysis to do anything to a manic desire to do everything (or own everything). The persistence of religion over millennia is in part explained by addressing these needs. Your purpose is to follow a divine set of rules and if you follow those rules the respective god or gods will recognize your existence.

Many formal religions intentionally interrupt the Knowledge Loop. They restrict the process of critical inquiry through which knowledge improves over time, through mechanisms such as censorship and divine “knowledge” which can only be provided by officials and is often permanently encoded in sacred texts. Adhering strongly to such a religion will prevent you from participating fully in the Knowledge Loop.

The same is true for many informal beliefs. There are anti rational memes, such as believing in a pre-ordained individual destiny, that can be used to answer one's need for purpose, but will prevent one from being psychologically free. Or people can belong to communities that meet their need for recognition but at the cost of conformity.

Humanism, based on the importance of knowledge, provides an alternative source of purpose and recognition that does not inhibit psychological freedom but rather enhances it. Participating in the Knowledge Loop is our purpose and how others will recognize us. Learning new things, being creative and innovative, sharing with others is explicitly encouraged. This doesn't mean everyone has to be a rocket scientist, instead there are a great many ways to participate in the Knowledge Loop, including caring for others.

We will need to substantially change the education system in most countries to help people be psychologically free. Today's system was developed to support the Industrial Age. Its goal is to mass produce people qualified for participating in the Job Loop. Jobs are seen as the ultimate goal and knowledge as important only to the extent that it provides a qualification for a job. We will need a new system instead that celebrates knowledge (as broadly defined here) for its own sake, allows students to discover their individual interests and deepen those into a purpose, and educates them about techniques for being psychologically free. Put differently, we need to put Humanism at the center of education and learning.

Humanism and the knowledge loop also have important implications beyond individual purpose for how we take responsibility for each other and the world around us. This will be the subject of Part Four.

Taking Responsibility

Suppose that I have convinced you about the importance of knowledge for overcoming the scarcity of attention in the digital age. And suppose also that you find my suggestions for increasing economic, informational and psychological freedom interesting. That still leaves a huge question. How do we get there from here? In this last section, I will address the importance of democracy as well as personal and collective responsibility.

Democracy

What is the political process by which we should get to the increased freedoms which I propose? As we are already seeing in a period of transition, lots of false prophets emerge. People who provide simplistic and populist answers to difficult questions. The danger we face around the world is to slide back into dictatorships and other forms of autocratic government.

Democracy, however, is the only system of government that is compatible with the centrality of knowledge for humanity. Democracy allows for new policies to be tried out, and if those new policies don't work, to have a peaceful process for transitioning to another set of policies.

Much as we might be tempted right now by a quick autocratic fix, we need to embark on the longer process of figuring out what it takes to have a working democracy going forward. There are some things that seem obvious to me, such as limiting the influence of money in politics.

Because attention is scarce, it means attention can be bought. There are two ways of doing that: one is to raise and spend a lot of money, the other is to do or say outrageous things. Neither is good for democracy. The former because it makes candidates beholden to the interests of their backers. The latter because it results in polarization instead of critical debate.

Going further, though, we should experiment with new forms of democracy. Given the complexity of the modern world, I am partial to the idea of increased specialization and delegated voting. It doesn't seem to make a lot of sense to have every representative vote on every bill, and even less so if most of the voting is simply along party lines. Instead, we should explore forms of democracy in which I can delegate my vote to people I trust on a specific set of issues, such as say energy policy. These delegates, in turn, would then elect a leader for the energy agency based on that leader's proposed policies.

This is just one of many possible variations of democracy. With digital technologies we have a lot more possibilities that were not previously feasible. Take for example the town of Jun in Spain, which uses Twitter as a primary communication channel between citizens and government [123]. We should start to explore more of these possibilities.

As part of that exploration, we need to revisit our geographic units for decision making. How should we determine at which scale to address a particular problem? The key principle here is the one of “subsidiarity”: decisions should be made at the lowest possible level. Since we

have one global atmosphere we need to learn to make some decisions globally, such as putting a limit on total greenhouse gases. But, staying with the same issue, the actual ways of achieving such a limit should be decided at lower levels, such as regions or countries.

Pushing decisions to the lowest level at which they can be made is especially important at a time of great change. For instance, what is possible in education and learning is changing rapidly due to digital technology. That means we should allow experimentation at the local level instead of trying to have a national education policy. By running many experiments we can figure out much faster what works well, or even what works at all, rather than running a single large experiment.

Responsibility

What, then, is our individual responsibility in bringing about the Knowledge Age? And what about our collective responsibility along the way—and once we get there?

Individual

I believe the starting point has to be self-regulation. It will be difficult to be effective in bringing about the other policy changes, including promoting democracy, if we simply add to the online yelling and real world attacks, or if we stay away from participating in the knowledge loop due to fear.

Following immediately after that is the recognition of knowledge as the source of progress and the foundation for humanism. Without this foundation it is hard to envision a global Knowledge Age. We have to start seeing ourselves as human first and foremost, and as nationality, faith, gender, etc. a distant second. By distant second, I mean far enough removed to not interfere with the primacy of knowledge and the critical process.

Only then come the concrete policy proposals, which should all be subject to vigorous debate. Beyond debate, I am hoping we will see experiments around the world with different policies aimed at getting past the Industrial Age. There may well be entirely different policies that are better suited than my proposals.

No one, however, should be indifferent to this transition. Getting past the Industrial Age and to a Knowledge Age is the great challenge for all of us alive today. Ignoring it, or pretending it doesn't exist, will not make it go away.

Collective

My point of view could be accused of being “specieist”—of putting humans above all other species. But I see it as the opposite. As the line goes: “with great power comes great responsibility.” It is exactly because we humans have developed knowledge that we are responsible for the other species which have not.

For instance, we humans can understand what is happening to the atmosphere of the planet. In fact, we are the primary cause of the accumulation of greenhouse gases. We can and should dedicate much of our time to cleaning up the atmosphere and, if necessary, learn how to manipulate climate more directly. This is not just to protect other species of course, but also to protect humanity itself.

Along the same lines, I think there is a human responsibility to figure out how to feed ourselves without inflicting mass harm on animals. One answer to that is one of pure self-regulation: stop eating meat and become a vegetarian or even a vegan. Another answer is to continue with progress and figure out how to grow meat in a lab.

Our collective responsibility is further progress, both for our own sake as well as that of other species on this planet. If we fail to give enough attention to global problems, and if we continue to let our attention be scarce, things will end badly for all of us.

Urgency

We need to act on this transition to the Knowledge Age with great urgency. We are at risk of society degenerating into violence and losing our ability to solve pressing problems, most notably climate change. We also face a potential threat from the possible rise of superintelligences. And there is a chance that we are not alone in this universe.

A Dangerous Spiral

The world is rapidly being pulled apart between those who want to take us back into the past and those who are advancing technology, but are largely doing so still trapped in the Industrial Age. These two groups are engaged in a dangerous feedback loop.

As described all the way back in the introduction, technology itself simply increases the space of the possible. Pushing automation along is not automatically making everyone better off. Trapped in Industrial Age logic, automation is instead enriching a few, while putting pressure on large sections of society. Similarly, digital publishing doesn't automatically accelerate the Knowledge Loop. Instead, we are finding ourselves in a world of fake news and filter bubbles.

The forces which are trying to take us back into the past are exploiting both of these trends. They are promising those negatively affected by technology that everything will be better again. They are investing heavily in mass scale manipulation including producing and harnessing anti-rational memes. They are often curtailing or seeking to curtail the open internet, while simultaneously building up secret surveillance.

The net effects are an increase in polarization and a breakdown of the crucial processes of critical inquiry and democracy. I am saying crucial because without these we are reduced to violent solutions. Disturbing as it is, we are once again finding ourselves looking at the real possibility of large scale violent conflict both within and between nations.

This possibility of violence is further increased as climate change wreaks havoc on industrial and food supply chains around the world. At the same time our ability to solve the climate change problem is rapidly decreasing because we are spiraling back towards the past.

Transhumans, Neohumans and the Threat of Superintelligence

As if that spiral is not enough by itself, there is a second reason for urgency. And that's because we are finding ourselves on the threshold to creating both transhumans and neohumans. Transhumans are humans with capabilities enhanced through both genetic modification (e.g., via CRSPR) and digital augmentation (e.g., Neuralink). Neohumans are machines with artificial general intelligence. I am referring to both of them as humans because they can be full fledged participants in the Knowledge Loop.

Both Transhumans and Neohumans may eventually become a form of “Superintelligence” which could pose a threat to humanity. The philosopher Nick Bostrom has written an entire book on the subject and others, including Elon Musk and Stephen Hawking, are currently warning that the creation of a superintelligence could have catastrophic results. I don't want to rehash all the arguments here about why a superintelligence might be difficult (impossible?) to contain and what its various failure modes might be. Instead I want to pursue a different line of inquiry: what would a future superintelligence learn about humanist values from our current behavior?

We just saw that we are doing quite terribly on the central humanist value of critical inquiry. We are also not doing great with regard to how we treat other species. Our biggest failing with regard to animals is industrial meat production. As someone who eats meat, I am part of that problem. As with many other problems that human knowledge has created, I believe our best way forward is further innovation and I am excited about lab grown meat and plant based meat substitutes. We have a long way to go in being responsible to other species in many other regards (e.g., pollution and outright destruction of many habitats). Doing better here is one important way we should be using the human attention that is freed up through automation.

Even more important though is how we treat other humans. This has two components: how we treat each other today and how we treat the new humans when they arrive. As for how we treat each other today, we again have a long way to go. Much of what I have proposed is aimed at freeing humans to be able to discover and pursue their personal interests. Yet the existing education and Job Loop systems stand in opposition to this freedom. These systems also embed historical injustices. In particular we need to construct the Knowledge Age in a way that allows us to overcome, rather than re-enforce, our biological differences. That will be a crucial model for transhuman and neohuman superintelligences, as they will not have our biological constraints. Put differently, discrimination on the basis of biological difference would be a terrible thing for superintelligences to learn from us.

Finally, what about the arrival of the new humans. How will we treat them? The video of a robot being mistreated by Boston Dynamics is not a good start here. This is a difficult topic because it sounds so preposterous. Should machines have human rights? Well if the machines are humans then clearly yes. And my approach to what makes humans distinctly human would apply to artificial general intelligence. Does an artificial general intelligence

have to be human in other ways as well in order to qualify? For instance, does it need to have emotions? I would argue no, because we vary widely in how we handle emotions, including conditions such as psychopathy. Since these new humans will likely share very little, if any, of our biological hardware, there is no reason to expect that their emotions should be similar to ours (or that they should have a need for emotions altogether).

This is an area in which a lot more thinking is required. We don't have a great way of discerning when we might have built an artificial general intelligence. The best known attempt here is the Turing Test for which people have proposed a number of improvements over the years. This is an incredibly important area for further work, as we charge ahead. We would not want to accidentally create, not recognize and then mistreat a large class of new humans. They and their descendants might not take kindly to that.

The Fermi Paradox and Alien Visitors

I want to provide one more reason for urgency in getting to the Knowledge Age. It is easy for us to think of ourselves as the center of the universe. In early cosmology we literally put the earth in the center with everything else revolving around it. We eventually figured out that we live on a smallish planet circling a star in a galaxy that's part of an incomprehensibly large universe.

More recently we have discovered that there are a great many planets more or less like ours scattered throughout the universe. That means some form of intelligent life may have arisen in other places. This possibility leads to many fascinating questions, one of which is known as the Fermi Paradox: if there is so much potential for intelligent life in the universe, why have we not yet picked up any signals?

There are different possible answers to this question. For instance, maybe civilizations get to a point similar to ours and then blow themselves to smithereens because they cannot make a crucial transition. Given the way we are handling the current transition that seems like a distinct possibility for Earth as well (see "A Dangerous Spiral" above). Or all intelligent civilizations encounter a problem, such as climate change, which they cannot solve and they disappear again entirely or become primitive. Given cosmic time and space scales, short lived broadcast civilizations might be especially difficult to detect (a broadcast civilization being one like ours that using electro magnetic waves for communication). I keep bringing up climate change because it is a clear and present danger but there are many more current and future species level challenges.

One of these comes in the form of a different answer to the Fermi Paradox. More advanced civilizations may have gone dark on purpose so as to not be discovered and potentially destroyed by even more advanced civilizations. This is the premise of the “Three Body

Problem” science fiction trilogy by Chinese author Cixin Liu. And while it is a work of fiction one cannot entirely rule out its dark logic. Certainly in the history of Earth whenever a less advanced civilization was discovered by a more advanced one it has not ended well for the former. By that account we may be entering a particularly dangerous stretch in which we have been broadcasting our presence but do not yet have the means to travel broadly through space.

Conclusion

Suppose you have made it this far and are convinced that we urgently need to enter the Knowledge Age. How do we get there? Broadly there are two major change motions: building the new and changing the old. Or: change from outside and change from inside. I strong believe that we need both and that they re-enforce each other. Professionally, as a venture investor, I am primarily engaged in the former. Through our giving, Susan and I are supporting both.

Building the New: Blockchains and Crypto Currencies

One of the most exciting opportunities in building new systems is the development of blockchains and crypto currencies. A blockchain is a database that keeps a consistent state and is maintained by a decentralized network of participants (who are compensated for their effort in a crypto currency). Blockchains make it possible to build networks that do not have a corporate or government owner controlling the operation of the network. While still early, this means marketplaces without an Amazon or eBay, social networks without a Twitter or Facebook, publishing and discovery platforms without a Google, payment systems without Commercial and Central Banks, computation and storage without an Amazon (AWS) or Dropbox.

We are living through an explosion of new blockchain protocols being developed for a large array of different use cases. Many people share the excitement of passing the power of computation and information back to individual network participants (see section on Informational Freedom). There is also a new gold rush under way as the creators of a successful blockchain can become enormously rich, as has been the case with whoever created Bitcoin (the person(s) who are Satoshi Nakamoto) and more recently for the creators and early backers of Ethereum.

While any one new scheme has a high likelihood of failing (or even being an outright scam), the large number of experiments being run now will in the end produce a few global systems that have the potential to be transformative. One of the most exciting possibilities is that we may wind up with a universal basic income system built from scratch outside the existing government budgets and fiat currencies. There are a variety of projects under way tackling this including Circles and Duniter.

Not everything can be solved through decentralization via blockchains. Problems that require a very high degree of coordination will continue to require different approaches. Regulation and its enforcement are one example. For instance, we have made great progress with public health by requiring the proper treatment of sewage. We can't let every person or business pick their own standard, we need a process to evolve the existing standard and we need ways of enforcing it.

Some libertarian and anarchist blockchain proponents are dreaming of a world without any government power. But I don't believe such a world can exist. We will always need government because externalities (e.g. sewage) require regulation. But what government looks like, how decisions are made, and what types of regulations are passed can and should be dramatically different. For instance, as I wrote in the chapter about Democracy we need new approaches and blockchains can help build those. For example, DemocracyEarth is building Sovereign, a blockchain protocol that supports delegative democracy and the Aragon Network is building what they call a “digital jurisdiction.”

Building the New: Other

Blockchains are not the only way though to build exciting new systems. Throughout the text I have mentioned traditional companies and projects which are driving down the cost of education and healthcare using digital technology, such as Duolingo and Human Dx. Companies such as Kickstarter and Patreon, both traditionally venture backed, are growing the funding that's available for participating in the Knowledge Loop allowing more people to exit the Job Loop.

There are two projects that I am excited about supporting or helping create. One is an integrated platform for learning math, programming, engineering and science. These areas of knowledge are all closely related and yet the way we teach and learn them are often oddly disconnected from each other. The other is compiling a compendium of principles of knowledge. We have so much knowledge that it seems impossible to know more than a tiny fraction. But part of this is an illusion because much knowledge is a variation or application of an underlying principle. Collecting and explaining these will help make knowledge more accessible and also contribute to unification of seemingly disparate areas.

Much remains to be built and many of these new systems are still tiny with decades of growth yet to come. We have also had important technological breakthroughs outside of digital technology that need to be further developed and commercialized, including diagnosis and treatment using genetic and synthetic biology, distributed energy generation and storage using advanced materials.

Changing the Old: Institutions

In addition to building new systems we also need to work actively to reform and improve our existing institutions. Too many politicians and educators, and those backing them, are still stuck in Industrial Age thinking. They want to patch the existing system instead of making the big changes required to get to the Knowledge. That's not just unfortunate, but downright dangerous. Propping up a system beyond its useful life means that the transition, which will eventually become inevitable, will be much more volatile and worse for everyone.

The most important institutions to change are democracy and education. There are many efforts that one can be engaged in here. Susan and I have supported a number of them over the years. For instance, Represent.Us has been working at the state and local level in the United States to introduce anti-corruption legislation. The bills cover many areas of improvement to democracy including bans on lobbying and public election funding. For education we have supported University of the People, which makes a US accredited degree available to students around the world tuition free with only a small exam fee. University of the People demonstrates that higher learning can be much more accessible than it currently is.

Democracy and education are pillars the knowledge age, but so are local communities. Much as we may spend our time online, we still live in a physical place. And how well we can meet our needs depends greatly on the health of that community. Here Susan and I have have supported a platform called ChangeX that helps people find ways of improving their local community and connecting with others to do so.

Changing the Old: Ourselves

Finally, the most important place for change to the “old” is each and everyone of us working on ourselves. It is so easy to be trapped in an Industrial Age mindset about such things as jobs and purpose, while at the same time having one's attention highjacked by online systems. Whether it is email or social media, staying in control of our attention requires conscious effort. Letting go of deeply culturally engrained notions of what constitutes valuable work and finding one's own purpose instead is hard work. As is retaining our emotional balance and capacity for rationality against an onslaught of messages designed to do the opposite. Thankfully, we can all start with small steps, such as putting our phones in do not disturb mode more often.

It is easy to be depressed seeing the news, and despite my optimism about where we can get to, I frequently find myself pessimistic about how we will get there. What helps me the most in those moments is knowing that we all face choices everyday that can help move the

world closer to the Knowledge Age. I for one will keep iterating on World After Capital, backing new systems and together with Susan supporting interesting change initiatives.

My hope is that World After Capital will make a small contribution towards advancing the discussion. The increased freedoms which I propose are not all or nothing. We can start with them in small steps and in different geographies.

And even just starting the debate is progress. You may agree or disagree with the ideas presented here. In either case, I want to hear your thoughts and reactions. It is the critical process through which knowledge improves and societies advance.

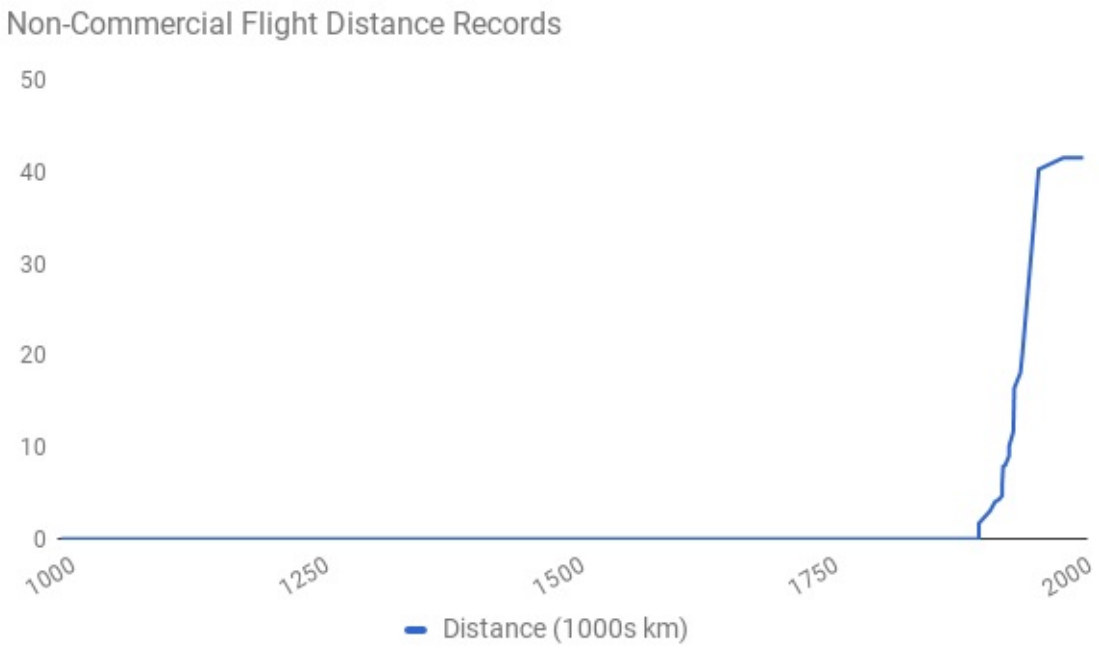
Appendix

This Appendix contains citations for charts and graphs used throughtout World After Capital, as well as data and backup calculations for the Capital chapter. These are not meant to be definitive or exhaustive, but rather to illustrate orders of magnitude.

Again, a special thanks to Max Roser and team at Our World in Data for their extensive data collection and visualization for World After Capital, which can be viewed in aggregate here.

[NOTE: This appendix is incomplete and requires a lot of additional work. At present it is mostly copied from an earlier version of the Capital chapter.]

Chart Sources: Non-Commercial Flight Distance Records



Flight distance records: [124]

Chart Sources: World Natural Population Growth (per 1,000)

Population growth: [125]

GDP per capita, PPP: [126]

Child mortality: [127]

Chart Sources: Total Housing Units for the United States

Housing Inventory Estimate: [138]

Chart Sources: The Great Decoupling

Real GDP Per Capita: [128]

Median Household Income: [129]

Chart Sources: Household Debt to GDP for United States

Household Debt: [130]

GDP: [131]

For each year, ratio calculated as: (Household Debt / GDP)*100

Chart Sources: Crisis Statistics

Adult White Male Suicides: [132]

Adult Drug Overdose Deaths: [132]

Youth Major Depressive Episodes: [133]

Chart Sources: Consumer Durables Price Index

CPI Durables, Seasonally Adjusted: [134]

Medical Care U.S. City Average: [135]

College Tuition & Fees U.S. City Average: [136]

Chart Sources: Healthcare Expenditure Per Capita

United States & OECD Average: [137]

Chart Sources: Cost of Human Genome Sequencing

USD per Megabase of DNA sequence: [139]

Number of base pairs sequenced per USD: [139]

Air

Recall from the Needs chapter that humans require on average about 550 liters (0.55 cubic meters) of pure oxygen per day. With roughly 7.5 billion people on the planet, that means we need over 4 billion cubic meters/day. The Earth's troposphere contains about 600 million cubic kilometers of oxygen, or 6E+17 cubic meters. Ignoring all other effects for a moment, the troposphere contains enough oxygen for about 152 million days of human breathing, which is more than 400,000 years (see table).

Metric	Value (+, -, x, /)	Source
Dry air mass in atmosphere	5.1E+18 kg	[140]
% atmosphere in troposphere	x 75%	[141]
% oxygen in air	x 20%	[142]
Surface density	/ 1.217 kg/m^3	[143]
Volume breathable oxygen in troposphere	= 6.28E+17 m^3	Calculated
Oxygen required per person per day	0.55 m^3 (550 L)	[28]
Total 2017 population of Earth	7.5E+9 (appx)	[32]
Oxygen required on Earth per day	4.13E+9 m^3	Calculated
Oxygen required on Earth per year	1.51E+12 m^3	Calculated
Days of available oxygen	152,386,643	Calculated
Years of available oxygen	417,497	Calculated

Of course there are also lots of technological processes, most notably the burning of fossil fuels, that replace oxygen with CO2 in the air. Conversely we have the large scale process of photosynthesis that removes CO2 from the air and releases oxygen. While the balance is an issue with regard to climate change it does not pose a short term threat to breathing — CO2 at present is only 0.04% or 400ppm (this is up significantly since the industrial revolution and cause of climate change) [144]. Conversely oxygen is about 20% of the atmosphere or 500 times as much.

But what about clean air? We definitely have an air pollution problem in countries such as India and China that impacts breathing. But we went through a similar phase in Europe and in the U.S. and managed to clean that up. It is a solved problem technologically. For instance, cars can be outfitted with catalytic converters and a single large plant has produced 50 million of these [145].

Water

There is plenty of water in the world and we have made significant advances in desalination and in filtration. There are about 10 million cubic kilometers of fresh water on the planet (not including another 24 million locked up in ice caps and glaciers). So that's 10^15 cubic meters. Based on the recommended 2.5 liters (0.0025 cubic meters) per day, human consumption is about 19 million cubic meters globally per day. However, we should also include freshwater used for agriculture, livestock and general domestic use. All in, freshwater withdrawals annually are just below 4 billion cubic meters [148]. So, relative to

supply we have over 2,600 years of remaining freshwater to meet our current needs (see table). While 2,600 years may not seem like an extremely long timeline, don't forget that technological advancements like improving desalination processes will allow us to tap into the saline water, which makes up almost 97 percent of our water supply globally.

Metric	Value (+, -, x, /)	Source
Volume available fresh water on Earth	10.53E+15 m^3	[146]
Total water required per person per day	0.0025 m^3 (2.5 L)	[147]
Total 2017 population of Earth	7.5E+9 (appx)	[32]
Total drinking water required per day	18,750,000 m^3	Calculated
Total drinking water required per year	6.84E+09 m^3	Calculated
Total annual freshwater withdrawals	3.99E+12 m^3	[148]
Days of available freshwater	964,314	Calculated
Years of available freshwater	2,642	Calculated

Again, the point is not that everyone has access to clean drinking water today. People quite clearly do not. But this is not related to a fundamental water shortage. Nor is it even related to our present ability to make and produce water filtration. For instance, filtering water for one person costs about $50 per year using modern filters [149]. In the U.S. the average household meanwhile consumes over 30 gallons of bottled water at a cost of roughly $1.50 per gallon (total spending about $12 billion) [150]. The World Bank has come up with an estimate of only about $28 billion annually to provide everyone with basic water, sanitation and hygiene and about $90 billion to make these services available continuously [151].

Food

Metric	Value (+, -, x, /)	Source
Total calories produced per year	1E+16 kcal	[152]
Calories required per person per day	2,740 kcal	[153]
Total 2017 population of Earth	7.5E+9 (appx)	[32]
Total calories required per day	2.06E+13 kcal	Calculated
Total calories required per year	7.50E+15 kcal	Calculated

The U.S. population has more than doubled in the last six decades, as has agricultural output. U.S. agriculture now uses about 25 percent less farmland and 78 percent less labor than in 1948, so agricultural productivity is largely responsible for the increased production [154].

Even globally the amount of land required for farming has started to decline and we have made recent breakthroughs in vertical and automated farming. For instance, the world's larges vertical farm is currently under construction in Jersey City. The Japanese indoor farming company Spread is working on a fully automated facility that will be able to produce 30,000 heads of lettuce per day [155]. Indoor farming uses significantly less space and more importantly less water than traditional farming.

Shelter

By 2010 the U.S. housing stock was just over 235 billion square feet of residential real estate, which corresponds to about 800 square feet, or 75 square meters of floor space per capita [156]. Obviously this is not equally distributed, but it shows that we have nearly 8x as much space on average than I had identified as a basic need.

An alternative data source is the American Housing Survey. Using this table [157] for 2013 I get 230 Billion Square Feet. By then U.S. population was 316 Million people which works out to 230 * 10^9 / 316 * 10^6 = 727 square feet or 67 square meter per person.

Another way to look at the physical capacity of the economy is to consider new construction. From the same Census data source it appears we are building about about (2,735 / 4)*10^3 equal to 683*10^3 units per year, with average square footage of 1,737 square feet. That means we have the physical capital to add 0.683*10^6 * 1.737*10^3 square feet = 1.186*10^9 square feet (about 1 billion square feet) per year, which is more than 100 million square meters per year and enough to meet the basic need of 10 million people [157].

Clothing

The production of textiles, which are a key part of making clothing, has become highly automated. Apparel production, i.e. making clothes from textiles, however, is still quite manual. Based on data from a study by the Federation of American scientists [158] U.S. textile mills output in 2013 was $31.7 Billion with 116,805 employees for about $270K/employee. By contrast, U.S. Apparel production in the same year was $13.4 Billion with 143,575 employees for about $93K/employee. The key reason for the low degree of automation in apparel is that much of the production takes place overseas with cheap labor.

Ideally here too one could find data to analyze clothing output in terms of actual unit data instead of financial data. In the meantime here is an attempt to compare this to minimum needs. An international comparison suggests that people may be able to meet their minimum clothing needs with as little as $200 per year or even less [159] and [160].

The global apparel market was $1.7 trillion in 2012 [161]. At the time the global population was roughly 7 billion. That works out to $242 per person and supports the idea that we have enough capital in the world to meet everyone's basic needs in clothing.

Importantly, going forward automation is coming to apparel in the form of automated knitting machines [162] which have been around for some time and the newer development of robotic pattern cutting and sewing machines [163].

Transportation

Great data source here [164]

Highways 2012 car vehicle miles (in millions) 2,664,445 (note: includes light trucks and SUVs), 2012 passenger miles (in millions) 3,669,821, so average travelers/car = 1.38 for highways. Further supported on a separate page which shows that 76% of people commute alone.

Light Duty vehicles 233,760,558 in 2012 up from 220,931,982 in 2002 compared to U.S. population in 2012 of 313 million. That is 233.7 / 313 = 0.75 light duty vehicles per person.

Utilization of private cars is around 4% [165] but can be increased substantially through car sharing.

Healthcare

The role of capital in providing healthcare is difficult to assess. First, we are still figuring out what it means to live healthily in the first place. For instance, our knowledge of good nutrition is still quite primitive. Second, other than a few machines (e.g. for imaging) relatively little medicine requires expensive equipment. A lot of medication is expensive to buy but not expensive to make once the research has been completed. Labor accounts for 66% or more of the total expense of the healthcare system and capital equipment for around 10% or less [166]. Third, we are just at the beginning of our ability to deliver personalized medicine and to manipulate the human genome.

Given how I have defined the basic need for healthcare though it is clear that we already have enough capital to provide it in the U.S. as our life expectancy is already above 75 years. Gains in life expectancy around the world have been tremendous in recent years.

This great chart by Max Roser beautifully sums up these gains [167] it shows that about 50% of world population already is at or above the 75 year mark. Another 37% is between 65 and 75 and only 13% is below. The chart also shows how much of these gains was achieved since 1950.

Computation

The progress that we have made in computation is nothing if not extraordinary. I remember how excited I was when I got my Apple II in the early 1980s which came equipped with 48KB of RAM and an 8-bit processor at a 1 MHz clock speed. At the time the machine cost about $1,300 which is about $5,000 adjusted for inflation. Today a Raspberry Pi 2 computer board costs $35 (down by 99.3%) and comes equipped with 1 GB of RAM (up 21,000 fold) and a quad core 32-bit processor at 900 MHz clock speed (up 14,000 fold). Smartphones are a bit more expensive but a high performance model from Xiaomi can still be had for $100 unsubsidized. Global output of smartphones in 2015 was roughly 1.4 billion units [168]. So without a doubt we have the capacity to equip everyone in the world with computation.

Networking

While not quite as dramatic as computation we have also made tremendous progress in networking. When I first received my Apple II was also the time when modems became popular for connecting to so-called Bulletin Board Systems. The early modems had a speed of 300 bits/second or about 40 characters/second. Today my phone on an LTE connection here in New York has a download speed of over 70 Mbps and and upload speed of nearly 30 Mbps (that's a 100,000 fold increase). Now obviously a big investment in infrastructure is required to provide everyone around the world with such blazing wireless speed but less than one might at first assume. For instance in unregulated spectrum a wifi access point can serve a small village by providing 200 or more simultaneous connections of 4 Mbps per connection for about $1,500. A 1 Gbps microwave link to cover about 4 km is about $7,500 on each end. A significant portion of the existing cost of networking has to do with the cost of spectrum as well as the cost of patents and closed source software.

Energy

Encouragingly, we have made dramatic progress in recent years with clean (from a CO2 perspective) energy sources. For instance, in 2017 Germany broke its previous record by generating 85% of its electricity from renewable sources for the day of April 30th, and this is expected to be the norm for the nation by 2030 [169]. And in the U.S., 61.5% of new

electrical generation added in 2016 came from renewable sources (biomass, geothermal, hydropower, solar, wind), the second year in a row that renewables have dominated new generating capacity [170]. We have also made strong progress with batteries to distribute loads. And nuclear power can be provided in ways that are much safer than our large historic reactor designs. Beyond that there is nothing in physics that would prevent us from building fusion reactors. We just haven't figured out how to do it yet.

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