EPILOGUE

After Markets?

> The market process . . . may be considered as a computing device of the pre-electronic age.
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> —OSKAR LANGE, "THE COMPUTER AND THE MARKET," 1967

Throughout this book we advocate the transformative power of Radical Markets. But why exactly are markets so powerful? In this epilogue, we ask this question from the reverse direction: we ask, what are the limits of markets? Doing so allows us to speculate about a time when markets may be replaced by a more efficient method of economic organization.

Markets as Miracles

As we saw in chapter 1, many economists who were committed to the market economy also considered themselves "socialists." Yet in the early twentieth century, socialism became identified with central planning, thanks to the role of Marxism and the French Revolution in inspiring and justifying the economic policies of the Soviet Union. Central planning also received a boost from World War I, where national control of the economy for the purpose of war production was more successful than advocates of laissez-faire could ever have imagined. This led to a heated debate about whether central planning should be used in peacetime as well.

In the popular imagination, central planning could not succeed because it provided individuals with no incentives to work. People needed the prospect of riches, or at least wages, to get them out of bed in the morning. Yet incentives were quite strong in the Soviet Union, stronger, in many ways, than they are in capitalist countries. While there was less chance under Communism to grow rich, any prisoner of the Gulag knew the fate of those who "malingered."

Another popular argument against central planning was advanced by Nobel Laureate Friedrich Hayek in 1945. Hayek argued that no central planner could obtain information about people's tastes and productivity necessary to allocate resources efficiently.[1] The genius of the market was the way that the price system could, in disaggregated fashion, collect this information from everyone and supply it to those who needed to know it, without the involvement of a government planning board.

A related version of this argument, less well-known than Hayek's but actually more compelling, was made a few decades earlier. The brilliant economist Ludwig von Mises argued that the fundamental problem facing socialism was not incentives or knowledge in the abstract but of *communication* and *computation*.[2] To see what Mises meant, consider an illustrative parable proposed by Leonard Read in his 1958 essay, "I, Pencil."[3]

Read tells the "life story" of a pencil. Such a simple thing, one would at first think. And yet as you begin to reflect, you realize the enormously complex layers of thought and planning it would require to make a pencil from scratch. The wood must be chopped, cut, shaped, polished, and honed. The graphite must be mined, chiseled, and shaped. The ferrule—the collar that connects the wood shaft and the eraser—is an alloy of dozens of metals, each of which must be mined, melted, combined, and reformed. And so forth.

Yet what is most remarkable about the pencil is not its complexity but the complete lack of understanding that anyone involved in the manufacture of the eventual pencil has about any of these steps in the process. The lumberjack knows only that there is a market for his wood and some price that induces her to buy the needed tools, cut down trees, and sell lumber down the line of production. The lumberjack may never even know that the wood is used for a pencil. The pencil factory owner knows only where to purchase the needed intermediate materials and how to run a line assembling them. The knowledge and planning of the pencil's creation emerge organically from the process of market relations.

Now suppose that we were to try to replicate the market relationships with a central planning board. The board would determine how much wood to chop and when, the number of workers to employ at each stage of production, the correct places and times to produce, ship, and build. Yet, to do this effectively the board would have to understand a great many things. It would have to learn from each of these specialized producers the unique knowledge of her domain of expertise that allows her to earn a living—for example, whether the lumber would have a more valuable use elsewhere in the economy (to build houses or ships or children's toys) than as an input for pencils. Absorbing all this information once, while constantly receiving and processing the necessary updates to keep abreast of evolving conditions in each of these steps of the process, would overwhelm the capacity of even the most skilled managers.

And even if the board somehow had an unlimited capacity to absorb this information, it would still have the unmanageable problem of trying to act on this sea of data. Prices, supply and demand, and production relations in markets arise through a complex interplay of individuals each helping to optimize a tiny part of a broad social process. If, instead, a single board had to plan this entire dance, it would force a small number of individuals to contemplate an endless sequence of choices and plans. Such elaborate calculations are beyond the capacity of even the most brilliant group of engineers.

Mises wrote decades before the rise of the fields of computer science and information theory and lacked any way to formalize these intuitive ideas. Many of Mises's arguments were dismissed by mainstream economists, whose increasingly narrow mathematical approach to the field Mises disdained. Mises's critics, including Oskar Lange, Fred Taylor, and Abba Lerner, argued that the market mechanism was but one of many ways (and far from the most efficient way) to organize an economy. They viewed the economy purely mathematically, rather than computationally, and saw no difficulty *in principle* with solving a (very large) system of equations relating the supply and demand of various goods, resources, and services.

In a simplified picture of the economy, ordinary people perform dual functions as producers (workers, suppliers of capital, etc.) and consumers. As consumers, people have preferences regarding different goods and services. Some people like chocolate, others like vanilla. As producers, they have different talents and capacities. Some people are good at doing math, others at mollifying angry customers. In principle, all we need to do is figure out people's preferences and their talents, and assign jobs to people who do them best, while distributing the value created by production in the form of goods and services that people really want. Rewards and penalties need to be de-

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termined to give people incentives to reveal their preferences and talents, and to ensure that they actually do what they are supposed to do. All of this can be represented mathematically and solved. That's why socialist economists viewed the economy as a math problem the solution of which only required a computer.

Yet the later development of the theory of computational and communication complexity vindicated Mises's insights. What computational scientists later realized is that even if managing the economy were "merely" a problem of solving a large system of equations, finding such solutions is far from the easy task that socialist economists believed. In an incisive computational analysis of central planning, statistician and computer scientist Cosma Shalizi illustrates how utterly impossible "solving" a modern economy would be for a central planning board. As Shalizi notes in his essay, "In the Soviet Union, Optimization Problem Solves *You*," the computer power it takes to solve an economic allocation problem increases more than proportionately in the number of commodities in the economy.[4] In practical terms, this means that in any large economy, central planning by a single computer is impossible.

To make these abstract mathematical relationships concrete, Shalizi considers an estimate by Soviet planners that, at the height of Soviet economic power in the 1950s, there were about 12 million commodities tracked in Soviet economic plans. To make matters worse, this figure does not even account for the fact that a ripe banana in Moscow is not the same as a ripe banana in Leningrad, and moving it from one place to the other must also be part of the plan. But even were there "merely" 12 million commodities, the most efficient known algorithms for optimization, running on the most efficient computers available today, would take roughly a thousand years to solve such a problem exactly once. It can even be proven that a modern computer could not achieve even a reasonably "approximate" solution—and, of course, today there are far more goods, services, transport choices, and other factors that would go into the problem than there were in the Soviet Union in the 1950s. Yet somehow the market miraculously cuts through this computational nightmare.

Markets as Parallel Processors

But all of this raises a question. If the problem is so hard to solve, how is it possible for the market to solve it? Consider Lange's quote from our epigraph.[5] The market is just a set of rules enforced by the government—not much different from a computer algorithm, although a very complex one. It's true that no single person invented the market. Yet the rules of the market are well understood, and economists are constantly telling people to implement them. Imagine that a new country is created, and its leaders ask a western economist how best to create an economy. The economist will tell them how to set up a market—the rules of contract and property law, for example. (Indeed, economists have been running around the halls of government of developing countries and the floors of start-ups for decades doing just this.) Aren't the economists just supplying a kind of computer program to the leaders, who by implementing it are engaging in a style of centralized planning?

To understand how the market solves the "very large system of equations," you need to know the key ideas of *distributed computing* and *parallel processing*. In these systems, complicated calculations that no one computer could perform are divided into small parts that can be performed *in parallel* by a large number of computers *distributed* across different geographic locations. Distributed computing and parallel processing are best known for their role in the development of "cloud computing," but their greatest application has gone unnoticed: the market economy itself.

While the human brain is wired differently from a computer, computational scientists estimate that a single human mind has a computational capacity roughly ten times greater than the most powerful single supercomputer at the time of this writing.[6] The combined capacity of all human minds is therefore tens of billions of times greater than this most powerful present-day computer. The "market" is then in some sense a giant computer composed of these smaller but still very powerful computers. If it allocates resources efficiently, it does so by harnessing and combining their separate capacities.

Adopting this perspective, we must ask how the market is "programmed" to achieve this outcome. The economy consists of a variety of resources and human capacities at a range of locations, along with a system for transmitting data about these resources among individual human beings. A standard approach in parallel processing is to take information local to one location in, say, a picture or puzzle and assign this to one processor, integrating these inputs on still other processors in a hierarchical fashion. Now apply this image to the economy. In every place, we take one of the computers (humans) available to us and assign it to collect information about that location's needs and resources and report some parsimonious "compressed" summary of all that data to other computers. For example, there might be a hierarchical arrangement of computers, with those responsible for particular locations on the ground reporting to a higher "layer" that integrates local areas and then upward from there.

Consider the following example. A person works on a farm and is in charge of ensuring that the farm is productive and that her family is happy. This person sends information about the farm and her family, not in its full richness and complexity, but in broad strokes, to district managers. One manager specializes in understanding the resources that farms need to operate—seeds, fertilizer—while another understands the resources that people living on farms need in order to be happy, including food and clothing. These managers would then aggregate these data and convey them to the next layer, perhaps a national wheat distributor or a regional supplier of products for use on farms. At every level of this chain, some information would need to be lost for the parallel processing to remain parallel and tractable: the farm manager could not detail every way in which a slightly better paved road would help in conveying goods to market or how slightly cleaner water would protect her crops. But at least she could report the largest and most important needs and hope that the loss of information only slightly reduces the efficiency of the resulting solution.

This arrangement has a flavor of central planning but also resembles a market economy. People specialize in different parts of the production chain and operate under limited information, yet are able to coordinate their behavior because the information takes a certain form. While people are experts on local conditions, they know little about economic conditions elsewhere. They know that grain prices are high and tractor prices are low, but not why this is the case. When they buy a tractor or sell grain, they don't tell the vendor or purchaser their life story, all the conditions on their farm, and so forth. They just place an order or offer so much grain at the going price.

This "price system" thus greatly simplifies communication between different parts of the economy. In fact, economists have shown that prices are the minimum information that a farmer needs to plan her operations effectively. So long as every important way that the farm could benefit or draw down resources from the outside world has a price attached to it, this is all the information the farmer needs to make economic decisions. Any greater information would be a waste, from a purely economic efficiency perspective, though it might be interesting from time to time to develop personal relationships. Conversely, if these prices were not available, there would be no way for a farmer to know whether it pays to use new tractors or rely instead on more labor, nor would she know how many seeds to plant for next season. The farmer without such prices could easily produce too little or waste resources on a tractor that could be better used for more labor, seed, or even consumption.

In this sense, prices are the "minimum" information necessary for rational economic decision-making.[7] No other system of distributed computing can be equally productive and yet require less communication.

Markets elegantly exploit distributed human computational capacity. In doing so they allocate resources in ways that no present computer could match. Von Mises was right that central planning by a group of experts cannot replace the market system. But his argument was mistakenly taken as implying that the market is "natural" rather than a human-created program for managing economic resources. In fact, there is nothing natural about market institutions. Human beings create markets—in their capacity as judges, legislators, administrators, and even private business people who frequently set up organizations that create and manage markets.

Markets are powerful computers, but whether they produce the greatest good or not depends on how they are programmed. We advocate "Radical Markets" because we believe that in the present stage of technological and economic development, when cooperation has grown too large to be managed by moral economies, the market is the appropriate computer to achieve the greatest good for the greatest number. If we see it as such, we can fix the bugs in the market's code and enable it to generate more wealth that is distributed more fairly.

By sharpening our understanding of the role and value of markets, the computational analogy clarifies our claim that the solutions we propose are based on extending the reach of markets. The COST on wealth radicalizes markets as it puts greater responsibility on individuals to articulate their values and gives them greater ability to claim things they value highly. QV does the same in the political sphere. Our ideas on migration give individuals more scope for determining the best path for where they live and work. Our proposals on antitrust and data valuation break up centralized power and place greater responsibility on individuals and small firms to compete, innovate, and make rational economic choices to allow for the distributed computation of optimal economic allocations. But all these proposals raise the question: if the market is just a computer program that harnesses the power of individual human intellects, will it still be necessary as computer power increases?

Markets as Antiquated Computers?

In a response to Hayek, Lange said, "Let us put the simultaneous equations (governing the market) on an electronic computer and we shall obtain the solution in less than a second."[8] The seed of truth in this claim had been identified just six months before Lange's death in 1965 by technology entrepreneur Gordon Moore.

Moore observed that the density of microchips and the computing power that could be achieved for a given cost doubled roughly every eighteen months. While this "Moore's Law" was a wild extrapolation rather than a well-founded principle, it has largely held up. Because of this rapid development of computational capacity, the dream of a computer network that can achieve the complexity of the human mind is no longer out of reach. Most engineers believe that in the near future, probably the 2050s, the total capacity of digital computers will exceed that of all human minds.

When this point has been reached, the computational critique aimed at Lange will no longer hold. In principle, the market could be replicated in silicon—replacing the distributed, parallel flesh-and-blood system that we are familiar with. The computers would tell people what to produce—distributing rewards and meting out sanctions as necessary—and distribute to people whatever they should consume. The technological problem in aggregating information can be solved. The public attention currently given to the rise of robots—as workers, servants, and lovers—has focused overwhelmingly on the micro level, the human-to-computer interactions that could result in physical or emotional harm. But if robots can drive cars, they can also make purchase orders, accept deliveries, gauge consumer sentiment, plan economic operations, and coordinate this activity at the level of the economy. At this macro level, the role of artificial intelligence in reshaping social organization has—bizarrely—received little attention. Whether such a system would work as intended, or its centralized authority be horribly abused, is of far more significance than the hot topic of whether a robot driver should be programmed to sacrifice a single passenger to save two pedestrians.

Meanwhile, behind-the-scenes information technology plays an increasing role in business planning. While our economy remains primarily driven by the interplay of markets, an increasing number of businesses organize logistics, production

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schedules, distribution channels, and supply chains in automated ways. These vast, successful corporations engage in the type of technical calculations that Lange envisioned for the central planner, albeit at a smaller scale. Walmart grew to be one of the most valuable enterprises in the world through its mastery of automated logistics and pricing, and yet is quickly being outstripped by the even further automated and centralized planning of Amazon. Uber directs a large part of the flow of transportation services in many cities. In short, vast corporations—islands of centralized planning in the ocean of the market economy—produce a significant amount of economic value by exploiting computational power.

Can Computers Plan You?

Despite its eventual defeat in the Cold War, the Soviet Union managed many impressive feats of development that eluded other countries. From the end of World War II until the early 1970s, the Soviet economy grew at an impressively high rate.[9]

In the famous 1959 Nixon-Khrushchev debate in a mock-up of an American kitchen, Vice President Nixon conceded the United States had fallen behind the Soviets in important areas of rocketry and science, but many observers nonetheless felt Nixon had prevailed in illustrating the diversity of choice offered by the capitalist system and its responsiveness to consumer preferences. The Soviet system, on the other hand, was legendary for the drab homogeneity of its cars, homes, food, and entertainment.

The problem for the central planner is that, while it knows that most people want cars, home, food, and entertainment, and can supply these things to them, it cannot estimate people's wants beyond a basic level. Mary wants a car that goes fast, Joe wants one that is safe, Manuel cares about handling, Naomi needs storage space for her sports equipment. The central planner, unable to distinguish among these and thousands of other preferences, gives everyone the same car, disappointing nearly everyone. The problem is reproduced for work as well: people have many different preferences about work conditions and types of work. Without knowing what these are, the central planner offers only the same basic amenities that it can reasonably assume nearly everyone wants, which undermines morale and raises the cost of production. Many economists believe that it was this inability to respond to, supply, and innovate for consumer (and worker) desires that made the Soviet system unsustainable.

And yet, recent developments in algorithms and computation that we discussed in chapter 5 have challenged these assumptions. Today, machines learn from the statistical patterns in human behavior, and may be able to use this information to distribute goods (and jobs) as well as, or possibly better than, people can choose goods (and jobs) themselves. We are very far from this point, but we can see the outlines of the route that we might travel. Let us start with an increasingly familiar phenomenon: machine learning–based recommendation systems drawing on existing market behavior. How does Netflix guess what movies you are likely to enjoy? Roughly, it finds people who are like you—who watch many of the movies you watch—and gives those movies ratings similar to your ratings. It then infers that you will enjoy movies you have not yet seen that your hidden doppelgangers have seen and rated highly. Pandora and Spotify take a similar approach in recommending music. Facebook and Apple's news services use similar methods to help guide consumers to the information they want to consume. Google uses related algorithms to determine the information, and product placements, most appropriate not just to your search query but to all the other things it knows about you. Amazon triangulates consumer preferences to suggest additional items to buy.

A central planning machine obviously could not rely on market behavior—markets would, by hypothesis, be gone! But it could derive information from people's behavior—as well as from their physical and psychological attributes, to the extent these are observable—and how it does this may well resemble what Netflix or Amazon does today.

To see how, start with a more homely example. In the medical systems in most advanced countries, even the United States, market choices have been eliminated or greatly curtailed. In a national health system, like the UK's, people do not receive whatever medical treatment they want, but must persuade government agents—doctors—that they suffer from conditions that warrant such treatment. The doctors verify patients' complaints through highly intrusive, physical (and often psychological) examinations. In the United States, most people use HMOs and other insurance systems. While they still have market choice among those systems, for all practical purposes they are in the same positions as British patients because Americans must persuade doctors of their complaints if they are to rely on their insurance, as most of them must.

It is predictable that in the near future all routine medical functions will largely be determined by machines. Doctors who currently perform these functions will be replaced by medical assistants who act as administrative interfaces between patients and machines. Diagnoses will be statistical estimates derived from data about the patient's body and behavior—which just means that people's "preferences" for medical treatment are derived from data rather than from choices

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made in a market setting. The underlying assumption is that people want "health," and the planner will give it to them within the limits of medical technology; patient "choice" in any conventional sense plays no role, except of course that people are allowed to refuse treatment if they don't want it.

Combine the Netflix/Amazon example with Britain's National Health Service, and one can imagine how a planner might act in other economic sectors. Some people want fast cars, others want safe cars, and still others want cars with large storage capacity (or, as we expect, car services rather than actual cars). In the old-style Soviet System, the planner might know only a few things—that a person needs to live far from work in an area devoid of public transportation, for example. In a more sustainable system, the planner needs to know consumer preferences about speed, color, handling, storage space, vehicle size, and so on, and how these preferences change over time and across place. How would the planner estimate a person's preferences along these dimensions?

Like Netflix or Amazon, it would need to draw on the data traces the person has left in the world, deriving estimates of preferences based on how people who have produced similar data traces have acted in similar conditions. This is the domain of machine learning. If people's phones show they are physically active, prone to call their parents, and enthusiastic about taking photos; their Netflix account shows that they like animated movies and romantic comedies; and their search record shows an interest in climate regulation and other liberal causes, then it may turn out that a Prius is the car for them, and they do not even know it. When it shows up at their door, they are grateful that, unlike their great-great-grandparents, they were not required to delay their purchase until after reading *Consumer Reports*, test driving fourteen different models, and debating the merits of tail fins with their friends. People will not make choices but simply accept goods and services sent to them by computer programs.

Or consider entertainment. Spotify and Pandora already allow people to request a stream of music that they will like, making choices on a case-by-case basis unnecessary. People like these services because the traditional method for deciding whether to purchase music—which involves listening to a lot of stuff you don't like, reading reviews, talking to music store clerks, and engaging in other time-consuming and not always enjoyable activities—is so cumbersome. But Spotify is the dark ages compared to the future of consumption. Suppose that it were possible, based on tracking the movements of the eyes of a viewer, for an algorithm to determine which parts of a movie appealed to him in what ways; technologies like this are, in fact, already in use for marketing purposes.[10] Further, suppose that, based on cross-referencing these eye movements to those of other viewers, it were possible to determine which other movies might interest him. Finally, suppose that these inferences were so reliable and accurate that the viewer, while initially skeptical, came to rely on them so implicitly that he almost always chose to watch the first video presented to him by the artificial intelligence system.

In this scenario, we could say that the viewer is "choosing" his future consumption based on the way he chooses to move his eyes when watching the film and that other viewers are simply giving him advice through their eye movements about what he might like. But choice seems like a metaphor rather than a phenomenologically accurate term for the relevant behavior. Eye movements are largely subconscious and rarely feel subjectively like choices. The pathways through which the viewing activity of other people led to the delivery of a particular move to a particular person would be obscure to everyone. The automated process would form a consumption pattern out of the collective intelligence created by digital computation and dispersed human sensory perceptions fused together. At some point, “market” may no longer seem to be the right word for economic organization, though central planning might not, either.

Could such processes guide major life decisions—what house to buy, what career to embark on? Would they guide political judgments and romantic involvements as well? Would people be freed to live more meaningful lives or deprived of the ability to do so?

Like most long-term predictions about the future, these questions are beyond the ability of scientific analysis to answer. Certainly, such a world, characterized by the combination of massive computer power and big data supplied by a voluntary (or possibly legally mandated) system of continuous surveillance, poses obvious dystopic risks. No individual or small group of individuals could be trusted to direct such a system, as the temptation to abuse would be overwhelming. But whether it would be possible to govern it in some (Radically) democratic manner, in an auditable algorithmic way, or according to a quasi-decentralized form of distributed computing, is far from certain. It is also unclear whether technology will ever advance to the point where computers outstrip human minds or whether human minds may themselves advance faster and maintain the present equilibrium favoring the market.

While we leave such speculation to the writers of science fiction, we remain confident that for at least a few generations, markets—Radical Markets, that is—will remain the best method of large-scale social organization.