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Unlocking Frontier Technology:
The Policy Challenge of the Digital Economy

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INTRODUCTION

For many people, information technology has significantly helped sustain their quality of life during the pandemic. We are able to visit friends and relatives over video chat, to shop online, and to stream movies. Many people are able to work from home thanks to new technology. This should come as no surprise. Information technology has been creating new benefits for consumers, new well-paying jobs, and improved productivity growth for some time now. Large firms across the economy have been making huge investments in new information technologies that have delivered major social benefits.

These investments in software and hardware have accelerated in recent years, especially outside the tech sector. To just give a couple of examples, from 2015 to 2019, software and tech hardware investment in the waste management industry rose by 75 percent and 57 percent, respectively, as leading waste management companies built out digital platforms to deal with the increasingly complex flows of electronic and other types of waste.[1] Over the same period, hotel chains and other accommodation companies boosted software and tech hardware investment by 71 percent and 37 percent, respectively, to manage costs and revenues. Pharmaceutical benefit managers invested in sophisticated information technology systems to handle the complex prescription and pricing policies that are at the heart of today's drug distribution systems. And electric grid companies need complex monitoring and pricing systems to handle the new mix of renewable and non-renewable energy sources, and the flexible pricing models that come along with them.

The expectation is that these investments will eventually lead to broad gains in productivity in these industries, translating into a more prosperous society. Nevertheless, some large firm investments in technology have serious social consequences. Everyone is aware, for example, how social media platforms have helped misinformation to spread widely, misleading people about public health measures, vaccines, and political processes.

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Yet while misinformation is an important policy issue, it is not purely about digital technology—traditional media have also played an important role. Furthermore, only a few companies provide social media and there are deeper and broader problems raised by new generations of information technology.

More generally, recent economic research shows that increasing use of information technology has helped increase the dominance of large firms across the economy. This competitive advantage, in turn, has made it harder for new entrants and smaller firms, undercut innovation, exacerbated income inequality, and undermined government regulators.

These changes pose substantial challenges for policymakers. While we want to encourage firms to invest in new technology and to innovate—especially firms in those parts of the economy where productivity and use of technology has lagged—policy also needs to ensure that the knowledge of new technology and the benefits spread throughout society by opening up competition and increasing the flow of knowledge.

The problem is not "bigness" per se. Only large, complex systems can deliver these benefits, so we need large firms to innovate and invest in them. But policy can play a role in prompting or encouraging large firms to provide greater access to their technology and that can go a long way toward ameliorating the problems created by these new systems.

BACKGROUND

To understand this new information technology phenomenon—both the benefits and the harms—we have to realize that firms are using computer technology in different ways than they did in the 1980s and 1990s. Today, it is not so much about low-cost personal computers and shrink-wrapped software packages available to all companies, large and small, and to consumers. Instead, large companies are making huge investments in custom-built software to deliver innovative new services and products, often providing them with substantial competitive advantage. We see this in Big Tech, where Google pours enormous resources into improving its search algorithms and Amazon hires over 10,000 employees to work on Alexa, including improving the product's speech recognition.

But the phenomenon goes beyond Big Tech through all major sectors of the economy. Walmart uses information technology to manage logistics and inventory, providing greater selection in its stores at lower prices; these advantages have propelled Walmart to dominance in retail. Large banks use information technology and extensive customer data to tailor credit terms and target the marketing of card offers. This has brought consumers a major expansion of credit. It has also allowed the top banks to dominate the credit card industry. Leading auto manufacturers build cars with 50 or 100 computers and 100 million lines of software code, far more than, say, the Space Shuttle. This brings us myriad new features in our automobiles, but smaller auto manufacturers can no longer afford to design competitive car models.

The same is true in less glamorous but essential industries such as pharmaceutical benefit management and waste management. For the top PBMs like Caremark and Express Scripts, information technology is a key tool for setting up the complex formularies that determine what patients get reimbursed for their prescriptions, and what the manufacturers get paid in return. Discounts and rebates differ from drug to drug, and may depend on total amount sold as well as individual contracts.

In aggregate, these large firm investments represent a major shift in resources. In 2019, firms spent $234 billion on developing custom software and software for the firm's own use; that's nearly as much investment in non-IT industrial equipment. The rapidity of this change represents an unprecedented shift of investment into a new technology. But it also changes the competitive landscape.

Big Tech provides prime examples of firms that leverage these large IT investments, but it is a mistake to see the phenomenon as primarily about Big Tech. First, Big Tech industries, perhaps surprisingly, account for a relatively small part of software development employment. Only about four percent of software developers work in software

publishing, internet publishing (including search), online shopping, and peripheral manufacturing industries, based on analysis of the 2019 ACS. Most developers work in the broader economy or they work for service firms that contract software development. Second, Big Tech is a relatively small part of the economy. The combined domestic sales of Amazon, Apple, Facebook, and Google are only 1.4 percent of US gross output. While there are some unique challenges that Big Tech platforms pose for antitrust enforcement (see below), it is important to look at the role of information technology in the entire economy.

THE NEW INFORMATION TECHNOLOGY

So, what is it that this new technology does? Mostly, it allows firms to better address individual consumer and business needs and desires by managing complexity, typically with large amounts of data. Walmart uses their system to dramatically increase the selection of goods available in their stores and to rapidly change the mix of merchandise in their stores as demand changes; this means consumers are more likely to get what they are looking for when they go to a Walmart and it facilitates one-stop shopping. Supermarket chains also use similar technology to increase merchandise selection and tailor pricing to different neighborhoods. Big banks are able to extend credit more broadly by tailoring credit cards and home equity lines to individual borrowers; their systems both manage risk and market effectively. Insurance companies similarly tailor a wide range of health insurance policies to individuals. And all sorts of goods from cars to jets to software have far more features that better meet consumer needs.

Software enables more selection, more features, individual tailoring and targeting. This sort of "mass customization" marks a real change bringing substantial benefits to consumers. Historically, large firms realized cost savings by limiting selection, features, etc., in order to produce at large scale; they realized efficiencies by mass producing and this gave them an advantage over smaller firms. Retail chains standardized store selection in order to realize cost savings with centralized warehousing and distribution; manufacturers realized cost savings by mass producing standardized goods. But these cost savings came with a tradeoff: the firms could only operate at large scale by limiting product features and variety, by only addressing least-common-denominator needs. Today, in industry after industry, software is changing that tradeoff. Today, large firms are realizing both low costs and responsiveness to individual needs.

And that is a real win for consumers, for workers, and for society generally. Consumer needs are met as never before. We get better products, services tailored to meet our individual needs, and, if we want it, more credit. The firms making these investments in new technology earn higher profits and realize greater productivity. And the workers at these firms also receive substantially higher pay than workers at other firms even for comparable jobs. Moreover, because these firms grow faster, they create more good jobs. In short, in the industries where firms are making large investments in this new technology, it is bringing the kind of economic growth that the national economy has been missing. Firms are not making these investments in every industry—outside of tech, only about half of industries, accounting for about two thirds of output, are making big investments in information technology. Yet enough of the economy is now affected so that the gains from these new technologies are improving the overall economic outlook.

But this change also has a downside: only a limited number of companies have made these investments and developed these systems. Only a limited number of companies in each industry have access

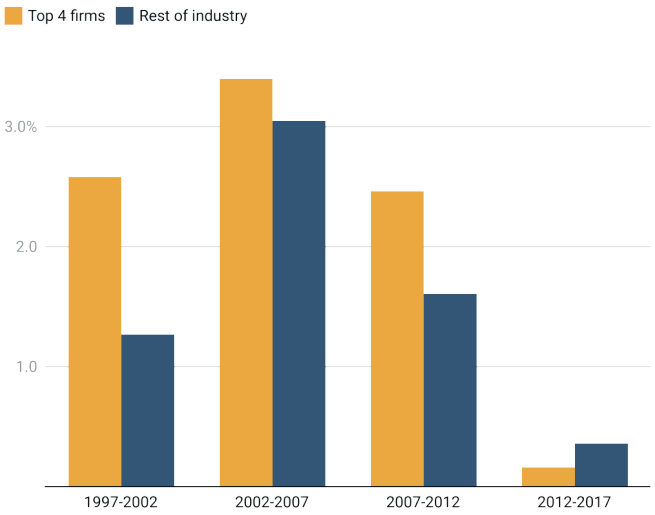
to the technology to take advantage of it. The new technology has not spread throughout industries and this is a sharp break from the past. Typically, major new technologies "diffuse" through the economy rapidly and this is important in spreading the social and economic benefits of the technology. For instance, General Motors introduced the automatic transmission in 1940. By the early 1950s, despite the shutdown of auto production during World War II, all major automobile manufacturers offered automatic transmissions. Partly this was because General Motors licensed its automatic transmission to rivals including Ford. Partly it was because other firms developed alternative versions independently. But the net result was that consumers and most auto firms benefited from this advance. Rapid diffusion of innovations was the hallmark of the US economy that brought us economic leadership.

Today, however, these major information systems—some of which were first created during the 1990s—are not spreading throughout industries so quickly. There are multiple reasons why diffusion has slowed. For one, because these systems are often used to differentiate the firm from its rivals, rather than to provide cost savings, licensing might not be profitable. If Walmart were to license its technology to Sears, competition between the two chains might intensify, cutting profits at both. While consumers would be better off, the retailers might be worse off, so they don't choose to license. Similarly, large banks do not license their credit card technology to smaller banks, nor do they allow customers access to their own data to share with other vendors.

Another reason for the slower diffusion is that these systems are large and complex and difficult to imitate. Also, workers are far less mobile today than they were in the past, making it difficult for rivals to obtain the needed talent. Engineers who want to form a spinout company to bring new technologies to market face greater obstacles than in the past, partly for legal reasons (see below) and partly because dominant firms are winning the "talent war," paying top dollar and hiring away skilled workers. It does happen—Zoom, for example, was started by an engineer who left Cisco—but not as often as in the past. Famously, beginning in the 1960s, engineers who left Fairchild Semiconductor created dozens of new semiconductor companies ("Fairchildren") that comprised the basis of US success in this industry. It appears to be much harder to form a spinout today.

PRODUCTIVITY GAP

Figure 1. Productivity Growth Gap. Annual growth in revenue per employee, comparing top four firms in each industry to remainder.



SOURCE: ECONOMIC CENSUSES, MEANS FOR 6-DIGIT INDUSTRIES, EXCLUDING MANUFACTURING, WEIGHTED BY SHIPMENTS.

As a result of this slowed diffusion, we are seeing a widening divergence between the top firms and the rest. There is a growing productivity gap. As seen in Figure 1, the top firms in each industry have been realizing substantially higher revenue growth per employee than are other firms (The most recent period indicates a slight reversal of the productivity growth gap, but not enough to change the long-term trends. Analysis of Compustat data shows the same pattern.) Productivity has grown at the top firms, but not among the rest. The technology brings

benefits, but because of limited diffusion, only to some firms.

PROBLEM: LIMITED ACCESS

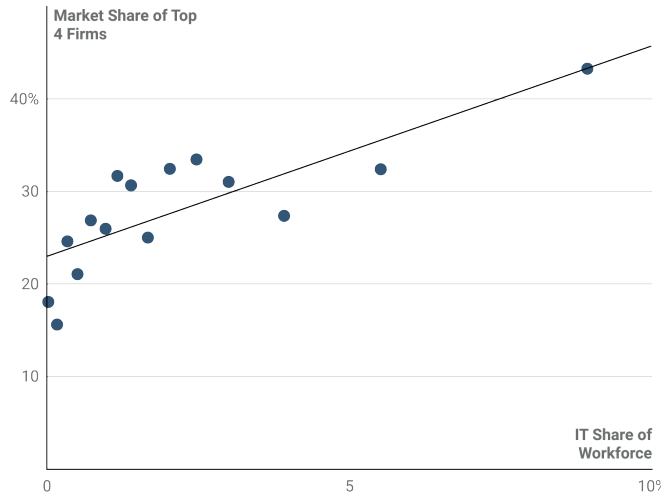
Regardless of the cause, this growing productivity gap poses difficulties for social welfare. An obvious problem is that when most firms do not become more productive from new technology, average productivity growth slows. But there are other, less obvious consequences to this new technology. In brief:

INDUSTRIES ARE MORE DOMINATED BY LARGE FIRMS

The market share of the top four firms, a measure of "industry concentration," has been rising.[2,3] That is, large firms are becoming economically more dominant and this is often seen as a problem for antitrust policy. Across the economy, we are seeing the rise of "winner-take-more" industries and not just in tech, but throughout all major sectors of the economy.

MARKET SHARE OF TOP FOUR FIRMS

Figure 2. Big firms dominate more in IT-intensive industries (excludes tech industries)



SOURCE: ECONOMIC CENSUSES AND CENSUS/ACS

This increase in concentration is not surprising given that the larger companies are more productive. Specifically, evidence shows that this increase in concentration is largely caused by rising spending on software and associated investments even omitting tech industries (see Figure 2).[4] Basically, in many industries, large firms are using new information systems to deliver better goods and services and their revenues grow as a result, comprising a larger share of industry revenues. Their increased dominance represents a reward to their innovation and investment, so that is not necessarily a problem. However, in the past when firms have become too dominant in their industries, they have sometimes abused their power, taking unfair actions against smaller competitors and against consumers or workers, slowing further innovation. Hence the growing dominance of large firms is a potential problem that antitrust authorities need to watch carefully.

DECLINING INDUSTRY DYNAMISM

Since Schumpeter, economists have held that "creative destruction" propels productivity growth—small firms with innovative technology and business models grow larger and ultimately displace incumbent market leaders. By a variety of measures, industry dynamism has declined over the last twenty years and information technology is complicit in this decline. The probability that a top four firm is displaced from market leadership is half of what it was during the late 1990s.[5] But this decline has taken place in just those industries where top firms have invested in proprietary information technology. This happens because dominant firm investments in information technology decrease the growth rate of smaller, innovative firms; smaller firms do not grow as fast when the market leaders invest heavily in information technology systems. A small retailer may come up with an innovative business format or sell innovative products, but it has a harder time competing today because it lacks the logistics and inventory management capabilities that a company

like Walmart has. Because the smaller retailer cannot offer the selection and responsiveness that a large company offers, it does not grow as rapidly as it would have in the past. This is important because economists have established that the slower growth of innovative firms, especially startups, accounts for much of the troubling decline in productivity growth.[6]

INCOME INEQUALITY

More productive firms pay their workers more and they grow faster, creating more jobs. By itself, that's a good thing—we want them to pay more. But because only select firms have the technology, only a minority of workers benefit. The gaps in firm productivity brought by information technology mean growing differences in pay and increases in income inequality. Extensive research has found that most of the rise inn income inequality over the last two decades has arisen from differences between firms—some firms pay more for comparable jobs and they recruit more highly skilled workers.[7,8,9] Much of this inequality is driven by differences in firm technology. The most IT-intensive firms pay 17 percent more than low IT-intensive firms for the same non-IT jobs and they also hire more highly skilled workers.[10] The average help wanted ad at an IT intensive firms offers a salary that is 36 percent more than job offers at low IT-intensive firms. The lucky workers who get to work at superstar firms earn more and often learn valuable skills related to the technology; but everyone else is left behind. The policy challenge is to spread the use of the new technology so that the gains can be more widely shared.

REGULATORY EFFECTIVENESS

The increased complexity of large IT systems also affects the ability of regulators to regulate. When products and services are controlled by complex software, regulation can be evaded or gamed. Indeed, software is an accomplice in many of the major regulatory failures of the last two decades across a wide range of industries.

The Volkswagen diesel emissions scandal, which came to light in 2014, shows how software can be used to evade regulation. Diesel powered vehicles have been touted as environmentally friendly because they emit less greenhouse gases than gasoline powered vehicles. However, they also tend to emit higher levels of nitrogen oxides which cause emphysema, bronchitis, and other respiratory disease. Manufacturers claimed to have addressed these harmful emissions with a fleet of so-called "clean diesel" vehicles. These vehicles performed well on EPA emissions tests. It turns out, however, they cheated.

The problem first surfaced when researchers at West Virginia University tested a "clean diesel" Volkswagen Passat under real road conditions. Expecting to find low levels of emissions, they instead found that the car emitted twenty times as much nitrogen oxides as it did during the EPA test protocol. Regulators suspected that Volkswagen had installed a "defeat device" to cheat on the test. In fact, the software code that controls the engine had been tweaked to detect whether the car was in testing mode or on the open road. In testing mode, the software kept emissions low; on the open road, emissions were allowed to go much higher so that the car could operate with more power. Volkswagen ultimately had to recall 11 million vehicles. Moreover, this cheat had been operating for many years and similar allegations have been raised against at least 10 other automobile manufacturers as well.

But regulators could not prove that there was such a defeat device without actually seeing the software code. Moreover, even though the code is embedded in every vehicle, it is illegal for anyone to access the code without permission of the manufacturers

under Section 1201 of the Digital Millennium Copyright Act (DMCA). Researchers had to get permission from the Librarian of Congress to see the offending code, against the objections of auto manufacturers. But the bigger lesson here is that when products and services now depend on millions of lines of software code, companies have unprecedented abilities to hide sophisticated tweaks to cheat that are hard to detect and can be far reaching. Regulators are simply overmatched.

Another example concerns the Boeing 737 MAX. When Boeing was redesigning the 737, they added a software feature in order to pass a test that the FAA required before certifying the aircraft. However, Boeing did not document the change and neither regulators nor pilots nor even many managers within Boeing knew about the tweak. As a result, when the first 737 MAX crashed in 2018, FAA regulators and critical executives within Boeing were not aware that the cause could have been a malfunction of the special feature. Only after the second crash did they realize that this might be the cause.

And software is also implicated in the subprime mortgage collapse that spawned the 2008 financial crisis. In 2007, as a declining housing market was sending many subprime mortgages into default, Ben Bernanke, Chairman of the Federal Reserve Bank, testified before the Senate that he saw no more than $100 billion in losses in the subprime mortgage market. He was mistaken. By November 2009, the International Monetary Fund estimated that top banks in the US and Europe had already lost over a trillion dollars in toxic assets and bad loans and they predicted that number would rise to $2.8 trillion.

Bernanke was so far off because multiple layers of software had hidden the real level of risk. First, financial institutions had gamed some of the straightforward models that ratings agencies used to determine the risk levels of financial instruments that combined multiple subprime mortgages. They were able to get packages of bonds labelled as being low risk, when in fact any fall in housing prices, while historically unusual, could lead to enormous losses. Second, the banks used their own software risk models to estimate their risk exposure, further obscuring the real risk level to regulators and to their own top executives. When the world is controlled by ever-more complex software, regulatory agencies and quasi-regulatory institutions such as insurance companies and ratings agencies are easily outmatched. They need greater in-house technical capacity as well as access to code and data in order to do their jobs effectively.

THE POLICY CHALLENGE

In summary, new information technology is delivering an unprecedented responsiveness to varied consumer demand, creating new well-paid jobs at highly productive firms, and contributing to overall economic growth. Yet limited access to the technology is playing an important role in many of the major economic and social issues of the day: the growing dominance of large firms, slow productivity growth, rising economic inequality, and the failure of regulation. The challenge for policy is to ameliorate these negative effects while preserving as many of the benefits as possible to consumers, to workers, and to the economy. If policy can increase access to the technology, industries will be more dynamic, productivity growth will improve, inequality will be eased, and regulators will have key access to information. Policy needs to achieve a balance between providing greater access to the technology and preserving the incentives for firms to build these large systems that deliver substantial consumer benefit.

The problem is not “bigness” per se. Only large, complex systems can deliver these benefits, so

we need large firms to innovate and invest in them. But policy can play a role in prompting or compelling large firms to provide greater access to the technology and that can go a long way toward ameliorating the problems created by these new systems. Here are some general policy ideas that may help achieve this objective:

PROMOTE SELECTIVE SHARING OF CODE AND DATA

Specific industry regulation can compel or encourage companies to make some code or data selectively available. In many cases this can be done without significantly reducing incentives for these firms to invest in technology.

In some cases, the law already provides the means to do this. For instance, this is the case with so-called "open banking." Customer data has proved to be a key advantage for a handful of large banks in credit cards and other markets. Open banking provides bank customers or their designated agents access to their own data via a standardized software interface. Sharing of these data can increase competition and spread the use of predictive analytic technology for credit and can also enable entirely new kinds of financial services. "Fintech" startup firms offer the prospect of providing innovative sources of credit, financial management, advice, and other financial services. Fintech firms Mint.com (now Intuit Mint) and NerdWallet, for instance, provide consumers with an overview of all of their financial assets and liabilities in one place and to provide advice based on that overview. These are services that individual financial institutions cannot provide by themselves.

The Dodd-Frank Act of 2010 created the Consumer Financial Protection Bureau (CFPB) and gave it powers to compel financial institutions to provide consumer transaction data to consumers or their representatives and also to promulgate standardized data formats. However, the CFPB has not yet implemented such rules. Instead, financial institutions have resisted letting customers have the data of their own transactions, hobbling the fintech startups. The situation is very different in Europe and some Asian countries. Notably, in 2018 the European Union put into effect a directive that requires financial institutions to provide interfaces on a non-discriminatory basis.

In other cases, new laws may be needed to compel greater access, but in some cases, this is a clear necessity. In the example of the diesel emissions cheating, environmental regulators did not have legal access to the software code that implemented the cheating because of copyright protections in the DMCA. Yet without this access, regulators had difficulty proving that cheating was taking place. In some cases, mandatory sharing of code or data might undercut manufacturers' incentives to invest in innovation to a minor degree. But it seems pretty far-fetched to argue that regulators or their agents should be denied access to code for this reason. However, these regulators may also need to invest in more advanced cybersecurity precautions to accommodate the protection of new, sensitive datasets we want them to have access to.

ENCOURAGING OPEN PLATFORMS

Importantly, some firms have figured out how to provide greater access to their technology while maintaining or even improving their profits. They do this by "unbundling" and policy can play a role in encouraging firms to choose to unbundle. For example, during the early 2000s, Amazon had developed sophisticated IT infrastructure to handle the transactions required by its ecommerce website. Not only did their IT technology need to handle a huge number of transactions, but this volume was highly variable and growing rapidly. These IT capabilities provided Amazon with a key competitive advantage over other ecommerce companies. Yet in 2006, Amazon chose to make

its internal IT platform available to the public as Amazon Web Services (AWS). This introduction marked the beginning of the "cloud computing" industry, which has turned out to be enormously beneficial to small and medium sized firms as well as enormously profitable to Amazon. Amazon has also unbundled other capabilities, allowing other sellers access to its website and fulfillment services as well as allowing other fulfillment services integrated access to its website sellers.

Amazon is hardly the only firm that has unbundled its technology. Others include Apple, Intuit, and Travelocity/SABRE. For example, the creation of the App Store by Apple in 2008 enabled even small developers to create mobile applications that used common services, significantly lowering the barriers to entry to global markets.

Business school professors are encouraging firms to find technologies that they can unbundle as a strategy to improve profits and growth.[11] Historically, unbundling has been key to the creation of some dynamic industries. The modern packaged software industry began in 1969 when IBM started selling software unbundled from computer hardware; the semiconductor industry blossomed after Bell Labs licensed its technology in 1956.

Indeed, the shift to cloud computing and open platforms has the potential for greatly accelerating the diffusion of best practices. Even small companies now have access to services that they could not possibly hope to achieve themselves.

But open platforms have their critics. The Subcommittee on Antitrust of the House Judiciary Committee recently released a report arguing for revamped antitrust enforcement of platform companies.[12] Indeed, platforms pose challenges to antitrust enforcement. In particular, platform companies have an incentive to charge below cost in order to grow their customer bases. Sometimes this takes the form of subsidizing one group of customers with revenues from another, for example, charging advertisers more to provide lower prices for subscribers. This sort of behavior makes it difficult to tell whether the company is engaging in predatory pricing that hurts competition. As a consequence, antitrust analysis is more difficult and complicated.

These problems are not altogether novel. Newspapers, for instance, have long charged subscribers below cost, effectively subsidizing subscriptions with advertising revenue. They have used low subscription rates as a barrier to competition and many newspapers have created local monopolies. The complexities of platform businesses, whether they are digital or physical, like newspapers, require a greater level of antitrust scrutiny. For this reason, greater expertise and more resources for antitrust enforcement might be a good thing.

But the key idea here is that we want to encourage companies to unbundle and to create open platforms that will spread the benefits of the technology and grow productivity and wealth. Policy should encourage companies to invest in creating open platforms even if that entails greater antitrust oversight. We want to encourage firms to innovate and invest and, because these are large complex technologies, large firms inevitably play a central role. When large companies are able to deliver major benefits to consumers and workers with new technology, the answer is not to break up these companies in ways that might eliminate the benefits; a better answer is to encourage them to open up so that the technologies are more widely shared, thus increasing competition and dynamism.

Remember here that such a policy would cover non-tech industries as well, where productivity growth has been much slower and large companies have arguably been less willing to create open platforms.

> "We want to encourage firms to innovate and invest and, because these are large complex technologies, large firms inevitably play a central role."

And antitrust authorities have tools to do this, although these tools have not been used much in recent years. Antitrust authorities and courts have long used compulsory licensing of patents and the divestiture of patents as a remedy for anticompetitive conduct, as a condition for a merger or acquisition, or where there is a pressing public need such as the under-supply of a needed vaccine. Similar actions can be used to encourage the creation of open platforms as well. Facing antitrust litigation, Bell Labs signed a consent decree in 1956 to share its knowledge; this action created the semiconductor industry. The threat of antitrust litigation nudged IBM to open up its platform in 1969, generating the modern packaged software industry. Of course, these tools have to be used carefully so as to not unduly reduce the incentives of firms to invest or innovate. However, careful economic studies have found that past actions involving compulsory licensing have been helpful to innovation overall rather than harmful.[13,14,15]

Another area where policy can encourage open platforms regards voluntary standard-setting organizations, those industry groups that promulgate interface standards for the Internet, telecommunication, and other technologies. These standards are often critical for spreading new technologies. But problems arise when firms renege on promises to offer their patented component technologies at fair, reasonable, and non-discriminatory license fees. Unfortunately, court decisions in recent years have tended to privilege patent rights over these promises. New rules are needed to ensure that open standards remain broadly accessible.

REMOVE BLOCKS TO EMPLOYEE MOBILITY

By multiple measures, employees today are substantially less mobile than they were 20 years ago. They change jobs, occupations, and location much less often. Yet employee mobility has historically been essential for the diffusion of innovations. Employees gain new skills and knowledge by working with new technology and that knowledge diffuses when they migrate to new firms. The drop in employee mobility makes it difficult for firms to gain the talent and skills they need in order to adopt new technologies.

Policy affects mobility through employee covenants not to compete once they leave their employer and through state trade secret doctrines of inevitable disclosure that can prevent employees from taking new jobs. A large body of empirical evidence finds that non-compete agreements reduce mobility, especially of technical workers, reduce entrepreneurship, and reduce patenting.[16] While some evidence suggests non-compete agreements also increase employer incentives to provide training, on balance it appears that federal restrictions on the use of non-competes would bring net benefits by increasing access to new technology.

A related issue is immigration. Currently immigration laws for skilled workers significantly favor large companies, who have the institutional capacity to work with the complex regulations.

Foreign STEM PhD students are just as likely as their native counterparts to receive offers to work for a startup, but are 56 percent less likely to actually do so.[17] This difference is best explained by the complexity and uncertainty of the immigration system which pushed talented foreign-born workers towards incumbent firms with large HR departments. A rewrite of immigration laws could make it easier for smaller companies and startups to access the same high-end talent market that large firms are able to draw from.

RESTORING BALANCED ACCESS

Each of the policy ideas above involves important tradeoffs. Policies that encourage firms to selectively share code or data might reduce firm incentives to innovate or create cybersecurity problems; policies that induce firms to unbundle their technology might reduce firm incentives to invest in building large systems; policies that limit non-compete agreements might reduce firm incentives to invest in training employees. Policy needs to achieve a balance between incentives to develop and deploy large scale technologies and to also spread the adoption of those technologies broadly.

There is no easy way to find balanced policies across the board. In each area of policy, the challenges posed by new technology must be understood and specific policy changes tested. This calls for experimentation and it may take many experiments and many years to achieve the right results.

While these tradeoffs mean that new policies should be developed judiciously, it is also important to put the quest for balance in historical perspective. In the past, when technology has also put strains on social priorities, policy has been critical to restoring balance. During the late 19th and early 20th centuries, a new generation of large firms began exerting unprecedented power over society in the US. Thanks to economies of scale and financial combination, these firms exerted unprecedented economic power. Unfortunately, these firms too often abused that power, charging monopoly prices, selling unsafe or unhealthy products, abusing adult and child labor, and more. In response, political pressure grew for the government to curtail these abuses. First, the farmers and the Populist movement pushed for regulation of railroads and for the first antitrust laws. Later, the Progressive movement successfully pushed an agenda to extend federal government regulation over large areas of society including unions, child labor laws, drug and food safety, and other consumer protections. The newly empowered regulatory state balanced the social harms of the new enterprises against the benefits brought by their new cost-saving technologies.

> "In the past, when technology has also put strains on social priorities, policy has been critical to restoring balance."

Today we are again seeing unmistaken signs of a system out of balance: growing dominance of large firms; declining disruption; slowing diffusion of technology and an associated decline in productivity growth; growing income inequality; declining employee mobility; and a decline in the effectiveness of regulation. The time is ripe for careful policies to right the balance and speed technology diffusion.

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Based in Washington, DC and housed in The Progressive Policy Institute, The Innovation Frontier Project explores the role of public policy in science, technology, and innovation.

The future can be a better, more vibrant place, but we will need significant technological breakthroughs to get there. To solve climate change, cure diseases, prevent future pandemics, and improve living standards across the globe we need continued scientific advancement and technological improvements. The United States is particularly well-positioned to drive these advancements because we are on the frontier of knowledge ourselves. Even small changes to the way we govern and incentivize science and technology can have long-run consequences for the US and for the world.

To achieve the progressive goals we have for the future we need to fundamentally evaluate how policy impacts the rate of progress. The Innovation Frontier Project commissions research from talented academics and regulatory experts around the world to bring new ideas and ambitious policy proposals to these debates.

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