Can Innovation Policy Restore Inclusive Prosperity in America?

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ABSTRACT

Technological innovation is the engine of economic growth, and the key to raising living standards over time. America's role at the forefront of technological change has traditionally gone hand in hand with its position as the dominant superpower. However, U.S. productivity growth has been lackluster for the past decade, median wage growth has stagnated for almost 40 years, and inequality across people and places has soared. Meanwhile, geopolitical rivals, above all China, are making great strides toward challenging America's position as the dominant technological power in the global economy. The private sector will not solve these problems by itself. What can be done to boost American innovation? In this memo, I argue that three groups of innovation policies are the most effective way to spur U.S. technological progress and productivity growth: tax credits, direct subsidies, and human capital investments. Combining these tools into a Grand Innovation Challenge program would provide an industrial strategy to promote the dual goals of maintaining America's technological leadership and promoting inclusive growth.

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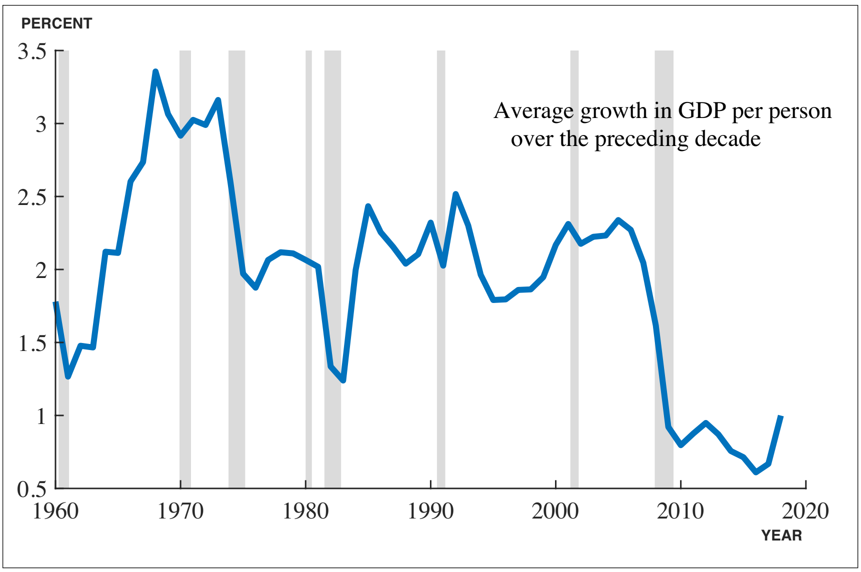
1. Introduction: Overview of the Challenge

America cemented its place as the world's economic and technological dynamo after the Second World War. Real Gross Domestic Product (GDP) per capita doubled between 1947 to 1973. Although U.S. productivity growth slowed after the 1970s oil shocks (see Figure 1), the period since the Great Recession of 2008–2009 has been particularly disappointing. Even before this most recent slowdown, however, the outcomes in the labor market have been awful among less-educated individuals. Since 1980, men who have less than a college education have experienced falling real wages (see Figure 2). Median real hourly pay among men fell by 6% between 1979 and 2017. The fruits of growth have not only been harvested more slowly, they have also been very unequally shared.

In the long run, innovation is the only way for an advanced country such as the United States to secure sustainable productivity growth. But what are the most effective policies to stimulate innovation? And how can they be shared more widely? This is the focus of my paper.

Before beginning, I start with the obvious question: Why should taxpayers fund innovation through the government?

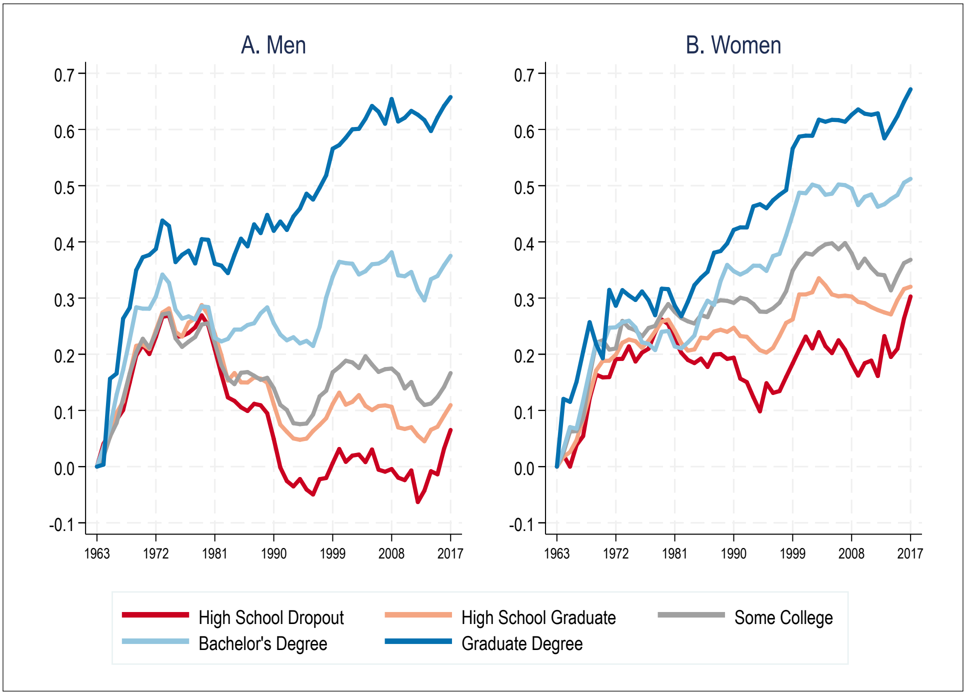
Figure 1: U.S. Productivity Growth



Source: Jones (2016)

Note: Shaded areas are NBER recessions

Figure 2: U.S. Wage Inequality Increasing Since 1980; Cumulative Change in Real Weekly Earnings 1963–2017



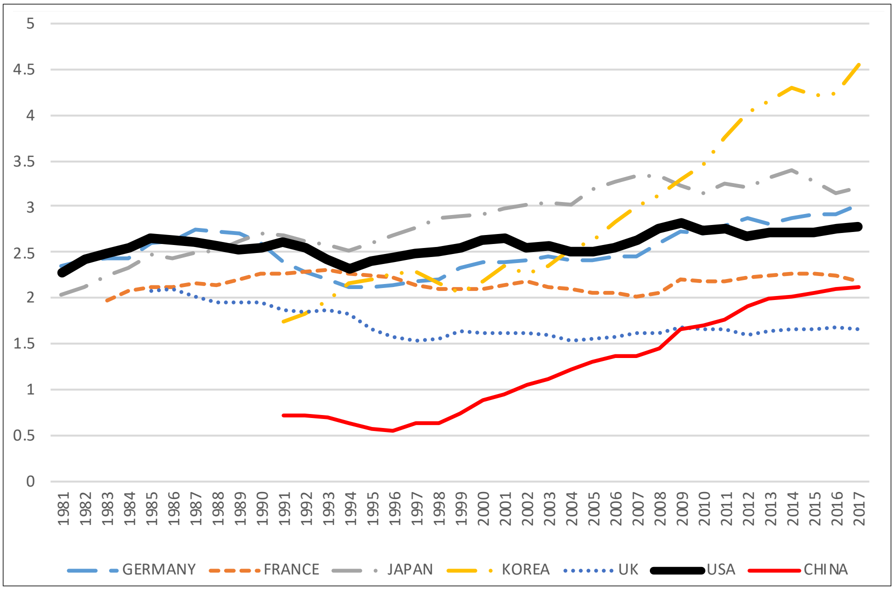
Source: Autor (2019); Working-Age Adults, Ages 18-64

1.1 Innovation Creates Growth

A premise of the argument for government intervention is that innovation is an important driver of aggregate growth. Figure 3 shows research and development (R&D) spending[1] as a fraction of GDP for major industrialized countries. Nations that devote more of their national income to R&D tend to be richer (e.g. Jones, 2016). The United States spends more on R&D than any other country ($495.1 billion), which accounts for roughly 28% of global R&D spending ($1.918 trillion) (National Science Board, 2018).

1 R&D is only one measure of innovation inputs and is not of course a perfect measure. It should be complemented with other metrics such as broader inputs to the creation of intellectual property and innovation outputs such as patenting, other IP, direct innovation measures. R&D does have the great advantage of being tracked over a long period of time and across countries in a broadly standard way and also measured directly in dollar terms.

Figure 3: R&D as a Proportion of GDP in Selected Countries, 1981-2017

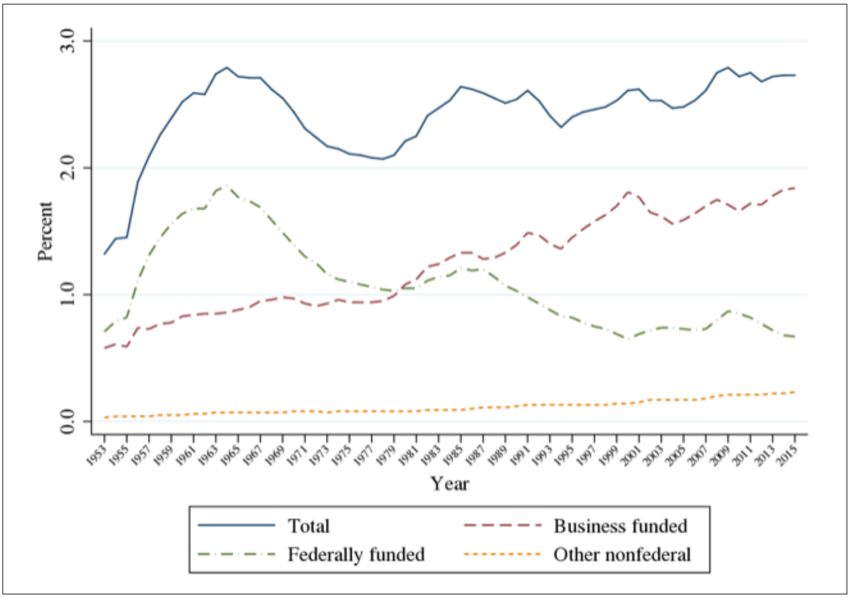


Source: OECD (2019)

Over time, however, the picture is less rosy. The United States has maintained an R&D-to-GDP ratio of 2.5% to 2.7% since 1981. By contrast, other countries, particularly in Asia (Japan, South Korea, and, most recently and spectacularly, China), have been devoting increasing amounts of national income to R&D. Furthermore, although U.S. R&D intensity has been stable since the mid-1960s, the composition of R&D spending has changed dramatically, as government funding has declined and private-sector funding has increased to fill the void (see Figure 4). Government tends to fund higher risk, basic research that private investors are often reluctant to take on. Therefore, public R&D investment tends to produce higher value, high-spillover inventions over a longer period of time. Despite the decline in government R&D funding, the private sector has also invested less in basic research over time (e.g., Arora, Belenzon, & Patacconi, 2018).

It is difficult to establish whether increased R&D has had a causal impact on economy-wide growth. Perhaps rich countries can lavish money on vanity research projects. Or perhaps there is a third factor, such as rising general education, that increases both GDP and R&D, and thus R&D has no direct effect on growth.

Figure 4: Composition of the Funding of U.S. R&D



Source: Bloom, Van Reenen, and Williams (2019)

To identify the direction of causality between innovation and growth, academic work has focused on data on industries and firms. There is now a substantial body of evidence indicating that R&D and other measures of innovation (such as quality-adjusted patents) do substantially raise productivity growth. Early work, summarized in Griliches (1998) focused on correlations over time whereas more recent work (e.g., Bloom, Schankerman, & Van Reenen, 2013) uses policy experiments to identify the causal impact.

1.2 But Innovation Can Also Increase Inequality

What is the impact of faster technological change on the labor market? The concern that new technologies will lead to mass unemployment has been with us since Ned Ludd apocryphally broke textile machines in 18th-century England. However, three centuries of technological progress have brought us higher incomes without falling employment rates. If anything, the opposite has been true as women entered the workforce en masse in the latter part of the 20th century.

There is more concern that technical change has biased demand toward more highly skilled workers for at least the last 100 years (Goldin & Katz, 2009). The increase in the relative wages of more educated workers in Figure 2 occurred despite a large increase in the numbers of workers with a Bachelor's or higher degrees. Many studies have confirmed skill-biased technical change accounts for much of these trends, more so than other factors such as globalization or institutional changes (see the surveys by Acemoglu & Autor, 2011 and Van Reenen, 2011a). Fundamentally, there is a race between technology and education. Technology increases the demand for highly skilled labor, but if the supply of education keeps up, as it did for most of the 20th century in the United States, then wage inequality need not rise. However, if the increase in education slows down, as it did for cohorts entering the labor market from the late 1970s onwards, the wage difference between more and less educated workers will rise.

This poses a challenge for innovation policy. Increasing the speed of technological change will increase growth, and, by increasing the size of the economic pie, this creates opportunities for all to benefit from, whether rich or poor. However, as the pace of technical progress speeds up, this will tend to benefit the more skilled, increasing inequality. This highlights the need for government to have complementary policies to ensure that the fruits of higher growth are shared equitably. Part of this is through taxes and benefits, but part of this is through ensuring continued increases in high-quality education and training for those from less prosperous families and communities.

1.3 Why Should Governments Promote Innovation?

Just because innovation causes growth does not mean that the government should necessarily support it, as market incentives could suffice. However, it is now well recognized that the market will generally fail to provide enough R&D since the knowledge that is created "spills over" from one firm to another. As one firm creates a new technology, other firms will incorporate learning from the original research without having to pay the full cost of R&D. Ideas are promiscuous; even with a well-designed, intellectual property system, the benefits of new ideas are difficult to fully monetize by the original inventor. Therefore, government investment is needed to ensure overall R&D investment reaches its socially optimal level.

There is a long academic literature documenting the existence of these positive spillovers from innovation (e.g., Bloom et al., 2013). Although firms receive some private returns from their R&D, the literature has consistently estimated that social returns to R&D due to spillovers are much higher than private returns, which justifies government-sponsored innovation policy. In the United States, for example, recent estimates suggest that social returns are about four times as large as private returns (e.g., Lucking, Bloom, & Van Reenen, 2018).

There are many other reasons why the amounts of R&D provided by the private sector will not be efficient (duplicative R&D, risk, financial market frictions, short-termism, business stealing, etc.) but knowledge spillovers are the most important reason.

2. Policy Measures to Address the Innovation Challenge

In Bloom, Van Reenen, and Williams (2019), we examine a wide range of innovation policies. Here, I look at three broad classes of policies—tax incentives, direct grants, and investments in skilled human capital—that have proven to be successful. I also discuss some policies that have proven to be less effective in promoting innovation.

2.1 Tax Incentives for R&D

An obvious approach to stimulating more innovation is through an R&D tax incentive to lower the cost of research. President Ronald Reagan introduced the Research and Experimentation Tax Credit in 1981 and most Organisation for Economic Co-operation and Development (OECD) countries have since followed suit. The policy costs U.S. taxpayers about $11.3 billion annually (National Science Board, 2018). The OECD (2018) reports that 33 of the 42 countries they examined provide some material level of R&D tax support. In France, Portugal, and Chile, which have the most generous incentives, tax incentives reduce the costs of R&D by as much as 40%. In contrast, the United States ranks in the bottom third of the OECD in terms of generosity toward R&D credits.

Do R&D tax credits work? In short, the answer seems to be "yes." We would expect to observe an increase in R&D when its tax price falls. However, this question is of interest to researchers because expert surveys suggest that R&D is driven by advances in basic science and market demand, rather than any fiscal concerns. There are now a large number of studies examining changes in the rules determining the generosity of tax incentives using a variety of data and methodologies (see Becker, 2015, for a survey). Many early studies used cross-country (Bloom, Griffith, & Van Reenen, 2002) or cross-U.S. states data (Wilson, 2009) to examine the relationship between changes in R&D and changes in tax rules. More recent studies use firm-level data and exploit differences in tax rules across firms before an unexpected policy change takes place. For example, firms below a size threshold may receive a more generous tax treatment, so one can compare firms just below and just above the threshold after (and before) the policy to tease out the real policy effect (Dechezleprêtre, Einiö, Martin, Nguyen, & Van Reenen, 2016). The literature on this topic generally concludes that a 10% fall in the tax price of R&D results in at least a 10% increase in R&D in the long run, and usually much more. This suggests that taxpayers get a big bang for their buck on R&D.

A concern for researchers and policymakers alike is that firms may just relabel existing expenditures as "R&D" in order to take advantage of more generous tax breaks. Chen, Liu, Suárez Serrato, and Xu (2018), for example, found substantial relabeling following a change in Chinese corporate tax rules. A direct way to assess the success of the R&D tax credit is to look at other outcomes such as patenting, productivity, or jobs. Encouragingly, these more direct measures also seem to increase (with a lag) following tax changes.

2.2 Direct Government R&D Grants

A disadvantage of tax credits is that they cannot be targeted at those areas where spillovers may be the greatest. One alternative is for the government to provide direct funding, either to academic researchers, such as through the U.S. National Institutes of Health (NIH), to private firms, such as through the Small Business Innovation Research (SBIR) program, or perform R&D directly in government labs.

Evaluating effectiveness in this context is challenging for at least two reasons. First, public research grants usually (and understandably) attempt to target the most promising researchers, the most promising projects, or the most socially important problems. That type of targeting and concentration of resources means that it is often difficult to construct a counterfactual for researchers, firms, or projects that receive public R&D funds. Second, it is often difficult to appropriately account for the potential crowd out (or crowd in) of private R&D by public R&D. That is, if one dollar of public R&D simply displaces another dollar of private R&D that would have otherwise been invested in the same project, then public R&D could have no real effect on overall R&D spending (much less on productivity growth, patents, or other outcomes).

There are several ways that public R&D influences private firms. First, public R&D funding directed to academics can generate spillovers to private firms. Azoulay, Graff Zivin, Li, and Sampat (2019) exploit quasi-experimental variation in NIH funding across research areas to show that a $10 million increase in NIH funding to academics leads to about 2.7 additional patents filed by private firms. Second, private firms themselves sometimes conduct publicly funded R&D. Moretti, Steinwender, Van Reenen, and Warren (2019) use changes in military R&D spending, which is frequently driven by exogenous political changes, to look at the impact of public subsidies for military R&D. They document that a 10% increase in publicly funded R&D (to private firms) results in a 3% increase in private R&D, suggesting that public R&D crowds in private R&D and raises productivity growth. A third example is Howell (2017), who examines outcomes for SBIR energy R&D grant recipients, using a winner versus losers' comparison. She estimates that early-stage SBIR grants roughly double the probability that a firm receives subsequent venture capital funding, and that receipt of an SBIR grant has positive impacts on revenue and patenting.

Two other aspects of public R&D support are worth mentioning. First, a substantial share of public R&D subsidies go to universities, which is sensible from a policy perspective as spillovers from basic academic research are likely to be much larger than those from near-market applied research. There is certainly a correlation between areas with strong, science-based universities and private-sector innovation (e.g., Silicon Valley, Route 128, etc.). However, these clusters could arise for many reasons. Andrews (2017) provides the best evidence suggesting the existence of a positive causal effect of universities on innovation outcomes. He analyzes the founding of new colleges in the United States between the mid-19th and mid-20th centuries, comparing counties where colleges were built with second-choice county locations, and documents a 32% increase in long-run patenting in counties where universities were located.

2.3 Human Capital Supply

The policies described above would increase the demand for R&D workers. However, since R&D workers are in short supply, there is a risk that such demand-side policies would bid up the salaries of these highly skilled workers, without necessarily increasing the volume of R&D. This not only increases inequality, but also is a waste of American taxpayers' tax dollars. Existing estimates of this effect have not found them to be large (e.g., Bloom et al., 2002), perhaps because of skilled immigration. Nevertheless, such general equilibrium effects are always tough to pin down empirically.

A better, long-run way to increase innovation may be to increase the supply of innovative human capital. This increases the volume of innovation directly as skilled workers are more likely to invent, but also indirectly, by reducing the equilibrium cost of R&D workers.

There are a wide range of policy tools that could be employed to increase human capital. Given the extensive evidence for skill-biased technical change, we would expect these policies to stimulate faster technological diffusion. This is because technology and human capital complement each other. More technology increases the demand for skills; for the same reason, more human capital makes it easier to design and implement new technologies. The most direct policy to expand frontier innovation, however, would be to increase the quantity and quality of inventors. There have been many attempts to increase the number of individuals trained in STEM (Science, Technology, Engineering, and Mathematics). Evaluating the success of such policies is very challenging given the fact these policies tend to be economy-wide, with effects that will play out only in the long run. As noted above, several papers look at the location, expansion, and regulation of universities as key suppliers of STEM workers and track their influence on innovation and growth. The overview in Valero and Van Reenen (2019) suggests universities increase local growth through a variety of mechanisms, including the increase of STEM workers and their subsequent innovation. Other papers using more precise natural experiments also find grounds for optimism that increasing the supply of STEM workers raises innovation (Hausman, 2018; Andrews, 2019; Toivanen & Väänänen, 2015; Bianchi & Giorcelli, 2018).

Another source of innovation-relevant human capital is skilled immigration. Historically, America has had a relatively open immigration policy that has helped to make the nation a magnet for global talent. Immigrants make up only 18% of the labor force aged 25 or more, but constitute 26% of the STEM workforce, own 28% of higher quality patents, and hold 31% of PhDs (Shambaugh, Nunn, & Portman, 2017). Much research supports the idea that immigration boosts innovation. For example, using state panel data from 1940–2000, Hunt and Gauthier-Loiselle (2010) document that a one percentage point increase in the share of college graduates who are immigrants increases patents per capita by 9% to 18%.[2]

Another way to increase the quality of the supply of R&D talent is to consider the barriers that talented people face when becoming inventors in the first place. A growing body of literature matches administrative data on income to an individual inventor's name on patents and finds that children born in low-income families, women, and minorities face important barriers to becoming successful inventors ("Lost Einsteins"). Bell, Chetty, Jaravel, Petkova, and Van Reenen (2019a), for example, document that American children born into the top 1% of the parental income distribution are 10 times more likely to grow up to be inventors (as measured by being named as an inventor on a patent application or grant) than are those born in the bottom half of the distribution. The majority of this correlation is unrelated to ability and, instead, is causally related to the extent to which a child is exposed to inventors during childhood, such as through their parents, social networks, and neighborhoods. Lack of exposure and role models also seems to be a factor behind the relatively low fraction of women and minorities becoming inventors. These barriers can be reduced through improving school quality in poor neighborhoods and greater exposure to role models and mentors, especially among children who show early signs of STEM skill potential. Bell et al. (2019b) suggest that such policies could quadruple long-run invention rates in the United States.

2.4 Policies That Don't Increase Innovation

There are large numbers of other policies that have been tried, but failed to significantly promote innovative activity. One example is patent boxes, which are special tax regimes that apply a lower tax rate to revenues linked to patents relative to other commercial revenues. By the end of 2015, patent boxes (or similarly structured intellectual property tax incentives) were used in 16 OECD countries (Guenther, 2017). Although patent box schemes purport to be a way of incentivizing R&D, in practice they induce tax competition by encouraging firms to shift their intellectual property royalties into different tax jurisdictions. In particular, multinational firms have considerable leeway in deciding where they will book their taxable income from intellectual property. Patent boxes provide a system through which they can manipulate stated revenues from patents to minimize their global tax burden (Griffith, Miller, & O'Connell, 2011). Although it may be attractive and effective (see Choi, 2019) for governments to use patent box policies to collect footloose tax revenues, such policies do not have much effect on the real location or the quantity of either

2 See also Kerr and Lincoln (2010); Bernstein, Diamond, McQuade, and Pousada (2018), Doran and Yoon (2018), Doran, Gelber, and Isen (2014), Borjas and Doran (2015); Moser, Voena, and Waldinger (2014).

research and development or innovation. Gaessler, Hall, and Harhoff (2018) find a small effect of the introduction of patent boxes in several countries in the European Union on transfers of patent ownership, but zero effect on real invention.

In recent years, cuts to the top rates of individual income tax have been suggested as an effective way to incentivize innovation. Bell et al. (2019b) argue that lower top tax rates are unlikely to generate substantially large numbers of new inventors. One reason is that Bell et al. (2019a) documented that exposure to the possibility of becoming an inventor at an early age is an important driving force behind the chances of growing up to be an inventor. Changing top tax rates does not change this. The fact that the Bush top tax cuts did not produce an innovation boom should also give one pause for thought over top-rate tax cuts as an innovation policy. Akcigit, Grigsby, Nicholas, and Stantcheva (2018) argue that lower income taxes across U.S. states raise innovation, but they cannot rule out that this increase may come from the movement of inventors around the United States (see Moretti & Wilson, 2017).

2.5 Summary of Innovation Policies

Today, U.S. federal spending on R&D is about 0.7% of economic output, compared to its peak in 1964 of about 2%. In today's dollars, the United States spends roughly $240 billion less per year on R&D than it did at its peak. Increasing R&D investment by $100 billion would represent one-half of 1% of GDP and would be transformative for the future of U.S. innovation.

These resources should be spent on the three policy areas identified above, although the timing and rate of return would vary across investments. In the near term, relaxing rules on skilled immigration would have an immediate and near-costless impact. Increasing the generosity of R&D tax credits could also produce quick wins in terms of total, private R&D investment. Directed R&D grants would have a medium-term impact, while human capital investments would have the longest and largest expected return.

3. Are There Lessons From East Asia on Industrial Policy?

3.1 Mission-Oriented Policies

Economists are traditionally skeptical about industrial policy. The conventional view is that markets are generally efficient and even when they are not, governments rarely have the nimbleness and foresight to effectively intervene. In addition, this assumes that bureaucrats are well intentioned and not are captured by vested interests. The experience of European and Latin American industrial policies in which governments threw money at "national champions" (such as the failed British Leyland in the U.K. auto industry) is not a promising model.

Two things have changed in recent years, however. First, there is more causal evidence on the positive effects of place-based, industrial policies (e.g. Criscuolo, Martin, Overman, & Van Reenen, 2019). Secondly, the slowdown of growth in Western countries and the perceived success of such policies in East Asia has caused some to re-evaluate the case for industrial policy (Rodrik, 2015). China looms large, and its success in science should not be underestimated. For example, Figure 3 showed that in the last decade alone, Chinese R&D grew from 0.5% of GDP in 1996 to 2.1% in 2017. In 1990, China produced only 1.2% of the world's scientific papers, whereas the United States produced 32%. By 2016, China had surpassed the United States, producing 426,000 compared to our 409,000. The average quality of research papers (as measured by citations) written by Chinese scientists quadrupled over the same period, whilst the quality of those written by American experts declined slightly (Tollefson, 2018).

Drawing on this work, an industrial policy could focus on innovation. There have been many such "mission-oriented" policies in the United States around defense (e.g. the Defense Advanced Research Projects Agency, or DARPA), space (e.g. the National Aeronautics and Space Administration), and health (e.g. NIH) that have led to important inventions such as jet engines, radar, nuclear power, digital computers, the Global Positioning System (GPS), the Human Genome Project, and perhaps most significantly, the Internet (Janeway, 2012; Mazzucato, 2013; Gruber & Johnson, 2019). Successful examples of these require decentralization, active project selection (and a tolerance for failure), and organizational flexibility (e.g., Azoulay et al. 2018).

Climate change is a leading example of an area in which more innovation is needed to avoid environmental catastrophe, but where decentralized markets are unlikely to provide sufficient technology within the necessary timeline. It is important to remember that when the rate and direction of technological change is endogenous, horizontal policies like a carbon tax can be doubly effective because they reduce consumption of fossil fuels directly while also indirectly stimulating the development of clean technology. (Acemoglu, Aghion, Bursztyn, & Hemous, 2012; Aghion, Dechezleprêtre, Hemous, Martin, & Van Reenen, 2016). Despite this, it is clear that there are strong political obstacles to a carbon tax (or its equivalent, like "cap and trade") that would be large enough to effectively combat global warming. The United States clearly needs to develop a portfolio of technologies to address climate change, and it needs a strategy to effectively deliver it.

3.2 Product Market Competition and Trade Policies

Industrial policy has earned a bad reputation because it has often involved heavy restrictions on competition, such as tariffs to protect infant industries from foreign competition and relaxed antitrust policy to allow for more mergers to create national champions. The impact of competition on innovation is theoretically ambiguous. On the negative side, Schumpeter (1942) argued that the ex-post reward of innovation is monopoly profits, so increasing competition reduces incentives to innovate. On the positive side, monopolists have little incentive to innovate and replace the stream of rents they already enjoy, while new entrants are not similarly burdened (known as the "replacement effect" in Arrow, 1962). Existing empirical evidence suggests that competition typically increases innovation; especially if competition is initially low (see Van Reenen, 2011b for a survey).

There has been a great deal of research on the impact of trade with China on innovation over the last 20 years. China's growth as an export market is a clear benefit for innovation as it increases market size, which helps spread the fixed cost of R&D over a larger market (e.g., Grossman & Helpman, 1991; Bloom, Romer, Terry and Van Reenen, 2019). Much of this literature focuses on import shocks that increase competition, such as China's integration in the global market following its accession to the World Trade Organization in 2001. Shu and Steinwender (2018) summarize over 40 papers on trade and competition, arguing that in South America, Asia, and Europe, import competition mostly increases innovation (e.g., Blundell, Griffith, & Van Reenen, 1999; Bloom et al., 2016; Atkin, Khandelwal, & Osman, 2017). In North America, the impact of import competition is more mixed; for example, Autor, Dorn, Hanson, Pisano, and Shu (2017) find negative effects, whereas Gong and Xu (2017) find a zero effect.

In my view, the balance of the evidence suggests that greater trade competition typically increases innovation, and thus, current trade wars will be a detriment to growth. This conclusion means that industrial policies should be designed to encourage rather than chill trade competition (e.g., avoid protecting industries through high import tariffs). A better way is to encourage many entrants in areas of policy emphasis (e.g., environment) and award support that is based on merit. Moreover, policymakers must be prepared to allow many failures, which are inherent to experimentation, rather than assuming ex-ante that the government is capable of selecting winning approaches. The most successful industrial policies are based on this principle and include South Korean motor vehicles (Cherif & Hasanov, 2019) and the Taiwanese semiconductor industry that arose from Hsinchu Science Park (Chen, 2008).

4. Conclusion

Economic theory—and common sense—tells us that market economies will fail to provide a socially optimal amount of innovation. Reinvigorating technological leadership is not just a matter of national pride, it is necessary in order to sustain a robust middle class with good jobs at decent wages.

I have drawn on the most recent evidence to suggest three major areas where a largescale investment would have the greatest pay-offs: R&D tax credits, direct innovation grants, and expanding the supply of inventors (e.g., by relaxing skilled immigration rules). In my opinion, the largest, long-term effects would be through improving the opportunities of the many "Lost Marie Curies" and "Lost Einsteins," talented, potential inventors who are held back by being born into disadvantaged backgrounds. Such a policy would reduce long-run inequality and increase growth, but would take many decades to have an effect. Therefore, a shorter-term program should also feature R&D taxes and subsidies.

Traditional approaches to industrial policy, which pick winners, are not desirable. However, the United States could learn from recent successes in East Asia and consider a mission-driven, industrial strategy in which the government creates a massive pool of R&D resources that are invested in the areas where market failures are the most substantial, such as climate change.

I propose the United States create a 10-year, $1 trillion Grand Innovation Challenge to reinvigorate R&D investment. At $100 billion per year (half of 1% of GDP), this program would still be less than half of the difference between federal R&D support today and that of 1964. If we are serious about building technological muscle back to the levels of the postwar period, we must make long-term investments that generate good, high-wage jobs.

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