THE HAMILTON PROJECT

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Innovation Policies to Boost Productivity

John Van Reenen

MISSION STATEMENT

The Hamilton Project seeks to advance America's promise of opportunity, prosperity, and growth.

We believe that today's increasingly competitive global economy demands public policy ideas commensurate with the challenges of the 21st Century. The Project's economic strategy reflects a judgment that long-term prosperity is best achieved by fostering economic growth and broad participation in that growth, by enhancing individual economic security, and by embracing a role for effective government in making needed public investments.

Our strategy calls for combining public investment, a secure social safety net, and fiscal discipline. In that framework, the Project puts forward innovative proposals from leading economic thinkers — based on credible evidence and experience, not ideology or doctrine — to introduce new and effective policy options into the national debate.

The Project is named after Alexander Hamilton, the nation's first Treasury Secretary, who laid the foundation for the modern American economy. Hamilton stood for sound fiscal policy, believed that broad-based opportunity for advancement would drive American economic growth, and recognized that "prudent aids and encouragements on the part of government" are necessary to enhance and guide market forces. The guiding principles of the Project remain consistent with these views.

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Abstract

As a proportion of GDP, U.S. federal research and development (R&D) spending has fallen from almost 1.9 percent in the mid-1960s to below 0.7 percent today. Given that (i) the United States faces major innovation challenges from the environment, health-care, and defense sectors, and (ii) productivity growth has (with few exceptions) been lethargic since the mid-1970s, I propose a permanent Grand Innovation Fund. This would increase support for innovation by 0.5 percent of GDP—or about $100 billion a year. Both theory and empirical evidence show that the benefits to society from raising R&D would exceed the costs. I assess the evidence on alternative innovation policies over taxes, direct government grants, and human capital supply. I propose a distribution of the new fund across a portfolio of these innovation policies: 30 percent to direct R&D grants, 25 percent to tax credits, 20 percent to increase the STEM workforce, and 25 percent to exposure policies to improve the quality of a new generation of U.S. inventors. In addition, relaxing skilled immigration rules could also have a rapid and large positive effect on innovation at very low cost.

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Introduction

Since the 1970s U.S. total factor productivity (TFP) growth has slowed—from an average of 2.1 percent during 1948–1973 to an average of 0.7 percent during 1974–2015 (Fernald 2014; author's calculations). This slowdown has been reflected in falling total GDP growth, from 4 percent per annum in the postwar years, to less than 3 percent from the mid-1970s, and to under 2 percent since 2000. Prior to the current recession, the Congressional Budget Office (2020) projected growth of only 1.7 percent in the mid-2020s, with low productivity growth expected to continue. Furthermore, slow productivity growth has been accompanied by slow real wage growth for most U.S. workers, as well as rising wage inequality.

Productivity can grow through pushing outward the technological frontier (innovation) or by catching up to this frontier (diffusion). For less-developed economies, catch-up growth is a viable option, but there are limits to such a strategy for leading economies such as that in the United States. Certainly, many American firms are well behind the technological frontier and some indicators suggest this gap is widening as firm-level productivity dispersion has increased (Van Reenen 2018). Fostering faster diffusion of managerial and technological capabilities is valuable (e.g., Bloom, Sadun, and Van Reenen 2017; Bloom and Van Reenen 2007). Nonetheless, I believe that sensible innovation policy design, aimed at faster technological progress, is a key part of the solution for revitalizing the U.S. economy.

The challenges facing the United States and the world are severe and numerous. Environmental challenges, such as climate change, need large investments in innovation to shift us away from dependence on fossil fuels. Health challenges, such as the COVID-19 pandemic, require massive research efforts. These require directed technical change led by the government, adding to the urgency of improving innovation policy.

In this paper I first set out some background facts on U.S. productivity growth, research and development (R&D), and inequality. I then discuss the rationale for innovation subsidies in the section "The Challenge," and argue that the evidence suggests that additional investment in R&D would generate social benefits larger than the costs. In "Evaluating Innovation Policies" I discuss the evidence on alternative innovation policies: tax incentives for R&D, government research grants, human capital, competition, and trade policies for innovation. I also offer a summary assessment of these policies ("A Menu of Innovation Policies") to provide guidance to policymakers.

I then propose a Grand Innovation Fund of $100 billion per year and discuss its structure and allocation of resources (i.e., 30 percent to direct R&D grants, 25 percent to tax credits, 20 percent to increase the STEM workforce, and 25 percent to exposure policies to improve the quality of a new generation of U.S. inventors). In addition, as part of the package we should relax rules for skilled immigrants; these rules would have a rapid and large positive effect on innovation without additional taxpayer expense (any expenses could be recouped through visa fees, so this would be revenue neutral). Putting this innovation fund to work as a moon shot to tackle some of the most important missions of our age to do with environmental challenges (like climate change) and health threats (like pandemics) would make it both politically attractive as well as economically desirable.

Background: What Has Been Happening to Productivity, R&D, and Inequality in the United States?

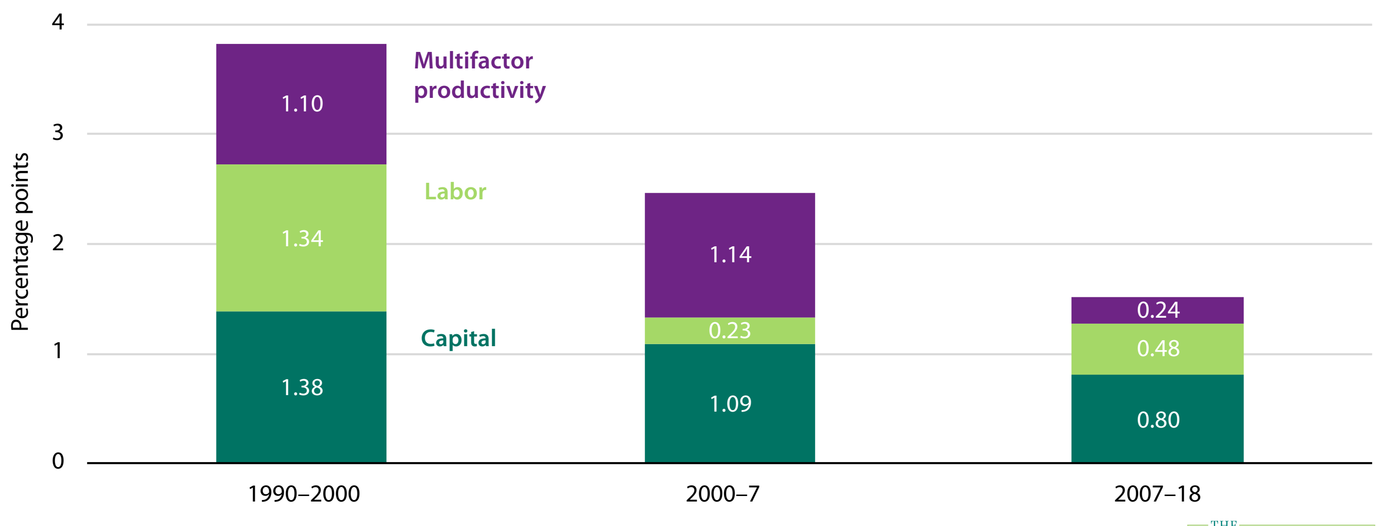
Output growth is driven by the growth of factors of production (e.g., labor and capital) and the efficiency with which these inputs are used (e.g., technical progress). An output growth slowdown could simply reflect demographic changes such as an ageing population and fewer workers entering the labor force, for example. Figure 1 reports a standard growth accounting exercise, decomposing private sector output growth into observable input growth (i.e., growth in the capital stock and the labor force) and productivity growth, understood as a residual multifactor productivity (MFP)—also known as total factor productivity (TFP)—term. (I refer to MFP and TFP interchangeably.) Clearly, the past decade has been particularly weak for MFP growth—it has been roughly zero compared to about 1 percent per annum in the earlier periods shown in figure 1.

Figure 2 shows MFP growth over a longer historical sweep since World War II. From this graph it is clear that the postwar period had healthy MFP of about 2 percent per annum that then collapsed to 0.5 percent after the 1970s oil shocks. There was a brief recovery during 1996–2004 when MFP growth regained its postwar heights. This productivity miracle period was associated with the information and communication technology revolution and the widespread use of the internet (Bloom, Sadun, and Van Reenen 2012; Gordon 2016; Jorgenson 2001; Stiroh 2002). Unfortunately, since then, TFP has reverted to its disappointing growth rate of the 1974–95 period.

In 2017 spending on total R&D performed in the United States was just over $548 billion, or 2.8 percent of GDP. Figure 3 shows R&D spending as a share of GDP for major industrialized countries. In dollar terms, the United States spends more on R&D than any other country, accounting for roughly 28 percent of global R&D spending ($1.918 trillion; see National Science Board 2018).

FIGURE 1.

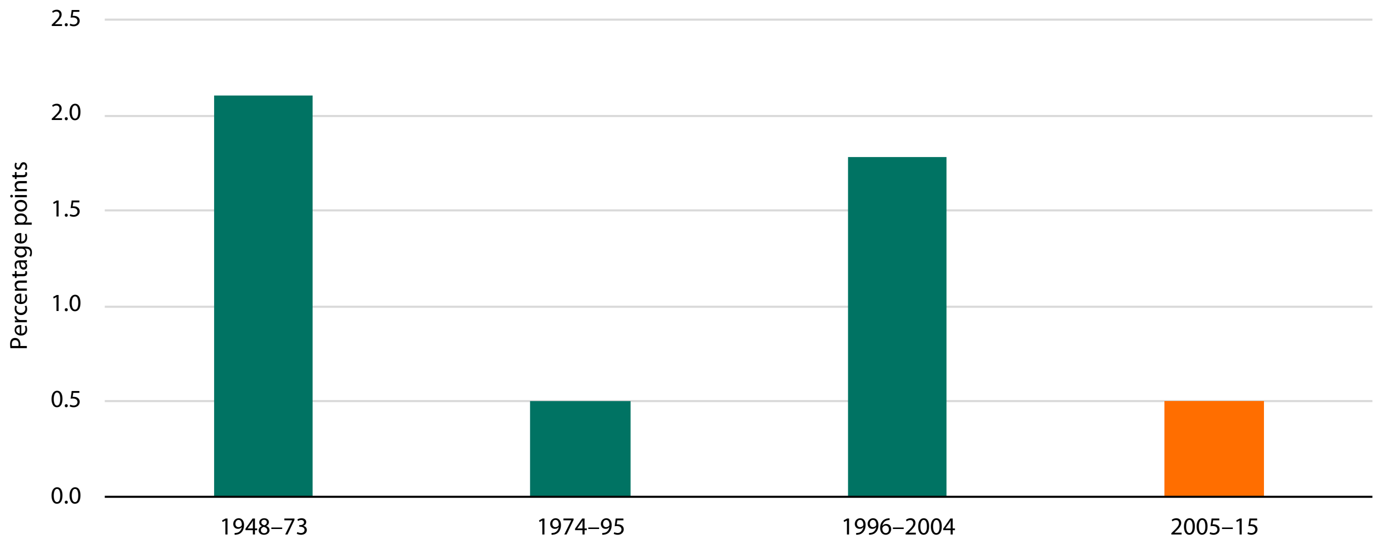
Contributions to Output Growth in Private Business, 1990–2018



Source: Bureau of Labor Statistics (BLS) 2020.

FIGURE 2.

Annual Total Factor Productivity Growth, 1948–2015



Source: Fernald 2014; author's calculations.

Note: Figure shows the average of the annual percent changes across years. A given year represents the percent change in annual total factor productivity from the previous year to the given year.

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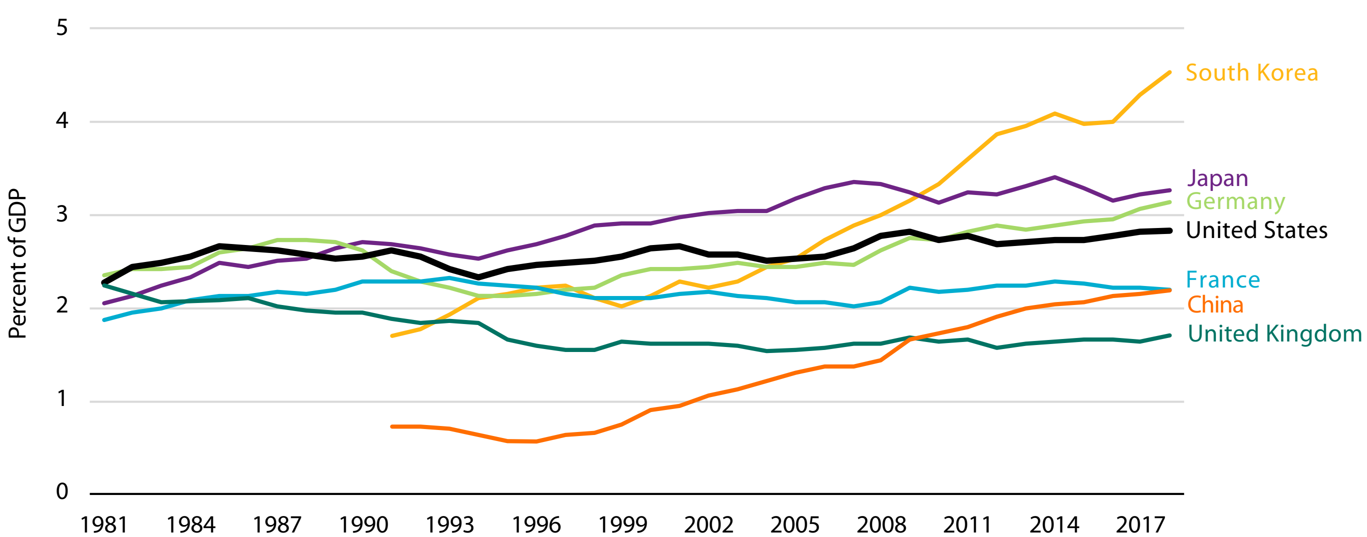
FIGURE 3.

R&D as a Share of GDP in Selected Countries, 1981–2017



Source: OECD 2019.

Note: R&D is defined by the OECD as the total expenditure (current and capital) on any research and/or development carried out by all resident companies, research institutions, university and government labs, etc., in a country. It includes R&D funded from abroad but excludes domestic funds on R&D performed outside of the domestic economy.

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Over time, however, U.S. predominance in R&D spending has diminished. The United States has maintained an R&D-to-GDP ratio of 2.5 to 2.7 percent since 1981. By contrast, other countries, particularly those in Asia (e.g., Japan, South Korea, and most recently and spectacularly, China), have been devoting increasing amounts of national income to R&D. China's growth in particular may raise concerns about the accuracy of what counts as R&D, but the data definition of R&D is consistent across countries using the *Frascati Manual* (2015)—an OECD manual of standards for defining R&D statistics. Even if China's growth is slower than figure 3 suggests, it is still likely to be impressive.

Although U.S. R&D (as a share of GDP) has been stable since the mid-1960s, the composition of U.S. R&D spending has changed dramatically. The proportion of total spending from government sources has declined substantially with private sector funding rising to compensate (see figure 4). In 2018 businesses spent more than twice as much as the federal government spent on R&D.

Private and government R&D are not interchangeable. Government R&D tends to fund higher-risk basic research that private investors are often reluctant to take on (see "The Challenge" below). Therefore, public R&D investment tends to produce higher value, as well as high spillover inventions over a longer period of time. It is concerning that federal R&D as a share of GDP fell from 1.86 percent in 1964 to 0.62 percent in 2018. In addition, despite this decline in government R&D funding, the private sector has invested *less* in basic research over time (e.g., Arora, Belenzon, and Patacconi 2018). This contraction in the share of basic R&D may be a factor contributing to the apparent decline in R&D productivity highlighted by Bloom et al. (2020).

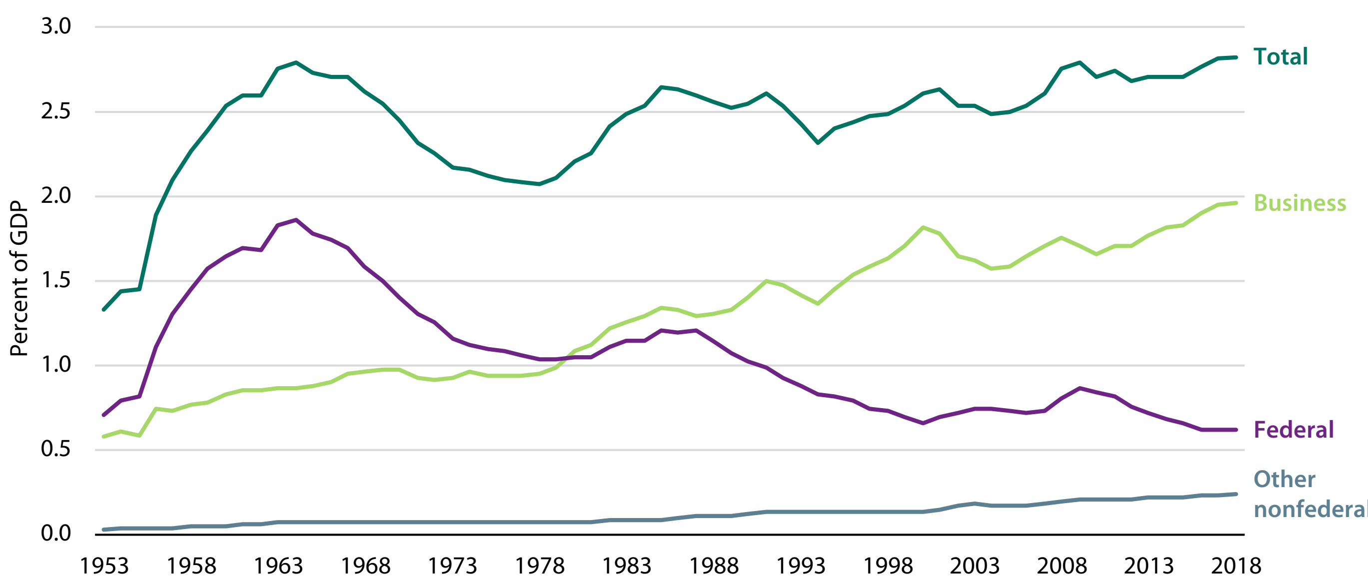
These general trends in R&D investment and productivity growth may be related to labor market trends over the same period. Figures 5a and 5b show real (i.e., inflation-adjusted) earnings (indexed to 1963) over time, broken down by gender and education group. As is well known, inequality between educational attainment groups (and between workers in general) has increased dramatically since the mid-1970s. It is striking that men with less than a four-year college degree have experienced an actual *fall* in their real wages since the mid-1970s, an extraordinarily poor performance for the most powerful country in the world.

Weak growth in average wages is partly due to poor productivity growth, but it is also due to the falling share of labor in GDP (see Autor et al. 2020) and the increasing share of nonwage costs in total compensation (in particular, health-care costs; see Case and Deaton 2020).

Increased inequality between people has been accompanied by increased inequality between places. Wages have always been higher in large cities than in smaller cities and rural areas, but the gap between so-called superstar cities and smaller places appears to have grown over time. High-density areas have bigger concentrations of high-skilled workers, and the lower-skilled individuals who work there seem to be getting much less of a premium for location than they did in the past (Autor 2019). Altogether, this has engendered a triple element of feeling left behind for the unskilled—worse outcomes relative to the skilled, often lower wages than their

FIGURE 4.

U.S. R&D by Source of Funds, 1953–2018



Source: National Science Board 2018.

Note: R&D spending is categorized by funder rather than performer. Other nonfederal funders include, but are not limited to, higher education, nonfederal government, and other nonprofit organizations.

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parents enjoyed, and, when living in smaller towns, worse outcomes compared to the average person in larger cities (e.g., Guvenen 2018).

In summary, productivity growth has been disappointing in the United States over the past 45 years compared to the postwar period. This has been reflected in slow real wage growth. Combined with growing inequality, this has put downward pressure on the wages of typical workers. Total R&D as a fraction of GDP has held stable over this period, although the share of government R&D has fallen and R&D has grown as a share of output in many other leading countries, particularly in East Asia.

FIGURE 5A.

Real Mean Weekly Earnings for Men by Educational Attainment, 1963–2017

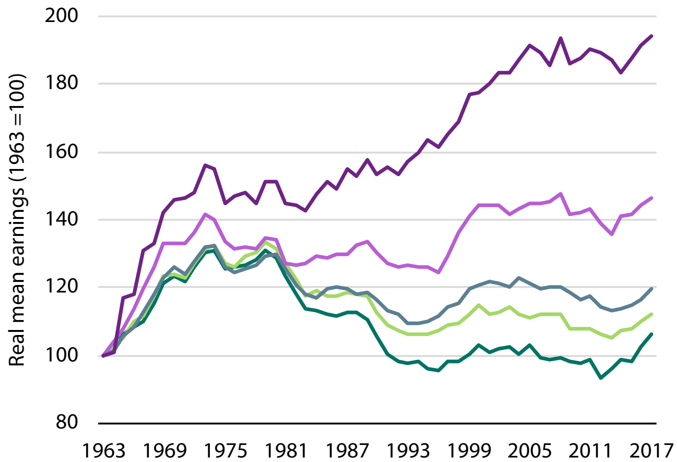
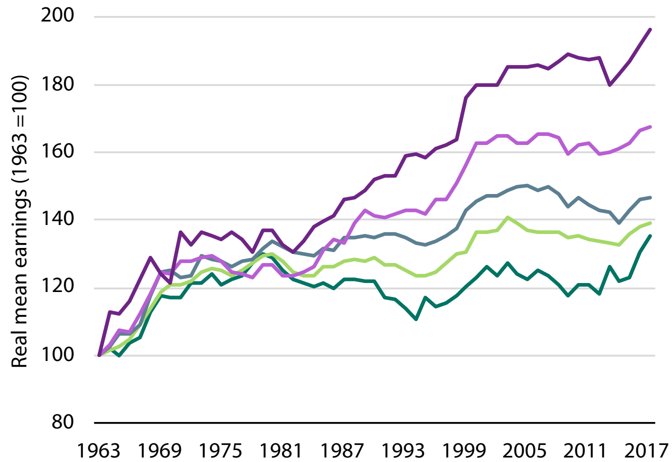


FIGURE 5B.

Real Mean Weekly Earnings for Women by Educational Attainment, 1963–2017



High school dropout — High school graduate — Some college — Bachelor's degree — Graduate degree

Source: Autor 2019.

Note: Figure shows the estimated composition-adjusted mean weekly earnings for full-time, full-year workers ages 16 to 64. For more details on estimation method, see Autor 2019. Real weekly earnings are indexed to 100 in 1963.

The Challenge: Why Should Governments Promote Innovation?

What are the market failures that justify government intervention in innovation markets? There are many examples of government failures—e.g., the Anglo-French supersonic jet, the Concorde (see Lerner 2005 for more discussion). On the other hand, there have been many success stories of inventions built on publicly funded R&D, such as nuclear power, jet engines, radar, and the internet (Janeway 2012; Mazzucato 2013).[1]

The first central market failure that justifies government intervention is knowledge spillovers. If one firm creates something truly innovative, this knowledge may spill over to other firms through copying or by learning from the original research—without other firms having to pay the full R&D costs. It is difficult to keep ideas fully protected even with a strong intellectual property system. There is a great deal of academic literature documenting the existence of these positive spillovers from innovations, from the wheel to hybrid corn to modern drugs (see Bloom, Van Reenen, and Williams 2019).[2]

Research evidence on spillovers has consistently indicated that social returns to R&D are much higher than private returns, implying that government-supported innovation policy has a role to play in boosting innovation. One recent example of such evidence from the United States, based on three decades of firm-level data and a production function–based approach, finds evidence of substantial positive net knowledge spillovers (Lucking, Bloom, and Van Reenen 2019). Although there is evidence of business-stealing effects of R&D (i.e., investments that help one firm get ahead of another without improving productivity), they are much smaller in magnitude than knowledge spillovers. The authors estimate that social returns to R&D are three to four times as large as private returns, suggesting the need for a substantial increase in public research subsidies.

Intellectual property rights—a temporary right to exclude others from selling the protected invention—are a way of incentivizing innovation by seeking to (temporarily) prevent spillovers through copying. The higher prices that can be charged due to this temporary market power lead to some static welfare loss, but this loss could be outweighed by the dynamic gains associated with more R&D. Of course, the length or breadth of patents could be inefficiently long or short and get the trade-off between static and dynamic efficiency wrong.

The patent system works better on paper than it does in practice. Firms can invent around a patent. The empirical evidence noted above shows substantial knowledge spillovers in countries like the United States that have strong intellectual property rights. Moreover, companies can use large numbers of overlapping patents to create thickets that create strong barriers to entry for potential competitors. Finally, the information on patents is often insufficient to allow future inventors to build on the findings. Ouellette and Williams (2020) have some practical suggestions on reforms.

The second main market failure is financial constraints. The nature of knowledge is that there is a deep informational asymmetry between the potential innovator and the supplier of finance. Trying to convince a funder will mean at least partially revealing what the innovation is, thus reducing its value. Since most R&D investment is in people, it cannot be used as collateral, since the human capital assets can simply exit the enterprise. Financial constraints do often hold back innovation (see Hall and Lerner 2010 for a discussion of the evidence).

In summary, there is strong theoretical and empirical evidence that the private sector will fail to deliver enough R&D. The degree of support for innovation by the U.S. government appears to be below the socially optimal level.

Evaluating Innovation Policies

I now discuss several innovation policies: tax incentives for R&D, government research grants, human capital policies for innovation, and competition and trade policies. Not all of these policies are equally valuable, and each has different strengths and weaknesses.

TAX INCENTIVES FOR R&D

The U.S. tax system treats R&D expenditures by firms more generously than it treats tangible capital investment. In the United States, as in most other countries, most R&D expenses are current costs—like scientists' wages and lab materials—and are directly deductible expenses. In contrast, fixed investment in equipment and structures are written off over several years, meaning that tax liabilities are deducted only in the future. This aspect of the tax system therefore discourages firms from making long-lived investments but has little or no effect on R&D investments.

The United States introduced its first Research and Experimentation Tax Credit in 1981. The policy design has changed in many ways since then, but in essence it allows a further proportion of R&D expenses to be deducted from corporate tax liabilities. Federal and state R&D tax credits cost about $13 billion a year in lost tax revenue (National Science Board 2018).

In 2018, 83 percent of OECD countries had some R&D tax incentives (OECD 2019). The U.S. federal R&D tax credit is relatively ungenerous, falling in the bottom third of OECD nations. This is primarily because the U.S. tax credit is based on the incremental increase in a firm's R&D above a historically defined base level, as opposed to a subsidy paid for the total amount of R&D spending.

The quantity of R&D does seem to increase when it receives more-favorable tax treatment. Surveys in OECD (2019) and Becker (2015) cover a wide range of studies examining the effects of changes in R&D tax credits. These include using cross-country data (e.g., Bloom, Griffith, and Van Reenen 2002) or cross-state data (e.g., Wilson 2009) relating changes in R&D to changes in tax rules. Work that is more recent focuses on firm-level data and uses the differential effects of tax laws before and after a policy change. Rao (2016), for example, uses administrative IRS data to show that changes in the federal tax rules change the after-tax R&D price faced by different firms in heterogeneous ways. The firms facing the largest falls in the after-tax price increased their R&D by the most.

In 2015 President Obama signed the Protecting Americans from Tax Hikes (PATH) Act that permanently extended the R&D tax credit, which gave enhanced tax breaks for smaller businesses. In many countries smaller firms get more-generous tax incentives than larger firms, so researchers can compare companies at either side of the threshold that determines which tax regime a firm falls in.[3] Overall, the literature concludes that a 1 percent fall in the after-tax price of R&D results in at least a 1 percent increase in R&D.[4]

Are the effects of the tax credit exaggerated because firms may relabel existing expenditures as R&D to exploit the tax system? Studying Chinese firms, Chen et al. (2018) found 30 percent of new "R&D" was just relabeled administrative expenses. Auditing studies in Western countries have not found wide-scale abuse, however (e.g., Hall and Van Reenen 2000). Nonetheless, one can assess whether R&D tax credits really matter beyond relabeling by looking directly at non-R&D outcomes such as patenting, productivity, or jobs. These also increase (with a lag) following tax changes; see Akcigit et al. (2018) and Lucking (2018) for the United States; Dechezlepretre et al. (2016) for the United Kingdom; Chen et al. (2018) for China; and Bøler, Moxnes, and Ulltveit-Moe (2015) for Norway.

To what extent do R&D tax credits simply shift R&D toward geographic areas that introduce them rather than raising aggregate R&D? If the benefits of innovation are local, policymakers may not care if the tax subsidies shift activity from another country to their own. However, federal policymakers should care if state-specific credits simply shift around activity from one state to another without raising total U.S. activity. This kind of beggar-thy-neighbor policy may simply compound distortions in the allocation of R&D investment, since those areas who bid the most are not always the places where the research will be most socially valuable.

Although there is evidence of relocation in response to tax incentives (Akcigit, Baslandze, and Stantcheva 2017; Bloom and Griffith 2005; Moretti and Wilson 2017; Wilson 2009) it does not account for all of the increase in R&D. For example, Akcigit et al. (2018) account for relocation and estimate effects of tax incentive changes on nonrelocating incumbents, finding significant positive effects of tax cuts on innovation.

In summary, the literature suggests important aggregate effects of R&D tax credits on R&D inputs and innovative outputs.

GOVERNMENT RESEARCH GRANTS

Tax credits are poorly equipped to target the types of R&D that generate the highest spillovers. For example, companies doing high-spillover basic research are not privileged over those conducting near-market research with high private returns. Direct government R&D grants can in principle focus on high-spillover R&D that creates benefits that are more public. Many government programs subsidize both academic researchers (e.g., through the U.S. National Institutes of Health, or NIH) and researchers with private firms (e.g., through the U.S. Department of Energy's Small Business Innovation Research [SBIR]). I now turn to analyzing the effectiveness of these direct grants.

Effects on Academic Research

Evaluating the effectiveness of grant funding for R&D is challenging and the evidence is less plentiful than it is for the effectiveness of tax credits. The targeting of such grants makes the receipt highly selective, so it is difficult to find a comparison group of nonrecipients to determine what would have happened if the R&D grant had not been received.

One research approach is to compare applicants that were narrowly approved or rejected for grants. Jacob and Lefgren (2011) do this for large "R1" NIH grants. A typical grant is worth $1.7 million and produces positive but small effects, such as one additional publication over five years (an increase of 7 percent). These modest effects are probably because the groups that just failed to get an NIH grant often obtain other sources of funding.

Effects on Firms

There are many ways public R&D affects private firms. First, and as noted above, academic research can spill over to private firms. For example, NIH funding is also used by Azoulay, Zivin, et al. (2019), who use the somewhat random variation in funding across research areas to show that a $10 million increase in NIH funding to academics led to 2.7 additional private-firm patents.

Second, private firms themselves sometimes conduct publicly funded R&D. Howell (2017) examines outcomes for SBIR grant applicants, comparing applicants who had been just marginally accepted or rejected.[5] Early-stage SBIR grants roughly double the probability that a firm receives venture capital funding; receipt of an SBIR grant also has positive impacts on firm revenue, venture capital funding, and patenting. The success of the program seems to come primarily from the wisdom of the SBIR examiners: they do not disproportionately select the grants that most need supporting. Rather, Howell (2017) believes it is the examiners' focus on financially-constrained, small, high-tech firms that makes the program successful.

Looking more widely across the OECD, Moretti, Steinwender, and Van Reenen (2019) use changes in defense-related R&D spending. Since these changes are generally driven by noneconomic considerations, big changes in this spending are like natural experiments in public R&D spending. Their work suggests that a 1 percent increase in publicly funded R&D generates a 0.4 percent crowd-in of private R&D and a subsequent jump in productivity growth. We can use the Moretti, Steinwender, and Van Reenen (2019) estimates to compare the cost effectiveness of tax credits with direct grants. If the $11.3 billion spent on tax credits were reallocated to direct federal grants, Moretti, Steinwender, and Van Reenen estimate that this would raise total R&D by about $25.2 billion (the $11.3 billion from public spending plus another $13.9 billion from private sector crowd in). By contrast, the tax credit system generates about $14.2 to $28 billion in extra private R&D.[6] On the basis of these calculations; the two instruments seem comparably effective, with perhaps a slight advantage to direct federal funding.

HUMAN CAPITAL POLICIES FOR INNOVATION

The attraction of human capital policies for innovation is that they act directly on the supply side to increase the number of potential and actual innovators (Romer 2001). Demand-side policies such as tax credits and direct government R&D grants can be effective in increasing firms' incentives to do more R&D, as discussed above. However, if the supply of R&D workers does not respond readily to demand increases, then the risk is that those demand increases merely drive up wages (and the cost of R&D) without increasing the quantity of R&D. This is what Goolsbee (1998) found in aggregate U.S. data—scientists' wages rose substantially with increased federal R&D spending.[7] Furthermore, since R&D workers are above median-pay employees, this type of demand-side policy could increase inequality while providing little in the way of aggregate innovation.

The responsiveness of R&D worker supply—i.e., the elasticity of supply—is unlikely to be zero (especially when we consider immigration into the United States—see "Immigration" below). In the short run, however, supply could be relatively unresponsive, so these concerns are real.

An increase in the supply of R&D workers does not carry such a risk. Unless the new workers are dramatically less productive than current workers, we would expect a direct increase in innovation. Furthermore, the increase in supply should reduce the cost of R&D by reducing R&D worker wage growth; a successful supply-side policy provides a further indirect boost to the amount of innovation, as firms face lower R&D costs. Of course, a counterargument is that increasing the STEM supply is leaky: trained graduates might move to Wall Street rather than research labs, capturing private returns instead of generating positive spillovers to society, as we discuss in the subsections that follow.

Undergraduates and Postgraduates

The most commonly discussed policy change that would boost R&D worker supply is to increase the number of individuals with training in science, technology, engineering, and mathematics, commonly known as STEM. The direct way to do this would be to subsidize doctoral and postdoctoral study in these subjects, and to increase the generosity of support for training in these fields. Training and subsequent careers in these fields could also be made more attractive through an indirect route by subsidizing more grants and support, especially for research in labs.

More generally, one can imagine support for raising educational attainment at an even younger age (undergraduates and even K–12). There is a great deal of evidence that human capital and new technologies are complementary (referred to by economists as skill-biased technical change), so increasing human capital could have a positive effect on technical change (e.g., Autor, Goldin, and Katz 2020; Van Reenen 2011). However, this literature is usually focused on the diffusion of technologies (e.g., firms adopting information and communication technology) rather than pushing forward the technological frontier. For the latter, it is likely that postgraduate qualifications are much more important.

There has been much macroeconomic analysis of the impact of human capital on growth (e.g., see Sianesi and Van Reenen 2003 for a survey). However, the evidence is rather inconclusive because of the difficulty of determining whether increased human capital actually causes growth at the level of the economy (or industry). The large number of other confounding factors at the macroeconomic level makes it difficult to infer causality. There is a vast literature looking at the impact of schooling on wages but a paucity of work looking at more-specific interventions that affect the STEM workforce.

University Expansion

Universities are key suppliers of STEM workers. Toivanen and Väänänen (2016) looked at whether people grew up near a newly established technical university and found that such individuals were more likely to become engineers and to create patents.[8] Establishing three technical universities caused on average a 20 percent increase in U.S. Patent and Trademark Office (USPTO) patents by Finnish inventors. In a similar vein, Carneiro, Liu, and Salvanes (2018) compare municipalities in Norway where there was an upsurge in government college start-ups in the 1970s to comparable areas where the expansion did not take place. They provide evidence that the founding of STEM-focused colleges eventually led to more R&D and a speedup in the rate and direction of technological progress.

Other researchers have analyzed national labs, which are often managed by universities, and document evidence of positive spillovers (e.g., Jaffe and Lerner 2001). Similarly, Andrews (2020) and Hausman (2019) find positive effects of universities on U.S. innovation. Valero and Van Reenen (2019) also offer a generally positive assessment of the impact of universities on productivity overall and innovation specifically, looking at 50 years of subnational data from more than 100 countries.

A major implication of these papers is that university founding or expansion increases the supply of workers with STEM qualifications, and that these STEM workers increase innovation. However, universities may also have other more-direct effects. First, research and innovation by university faculty (possibly collaborating with local firms) could also directly increase innovation. Research on innovation clustering (e.g., Silicon Valley and Stanford, or Greater Boston and MIT) explores this mechanism.[9] Second, universities may influence local democratic participation and institutions, which may also have an effect on innovation.[10]

Bianchi and Giorcelli (2019) present the most direct test of the role of universities increasing STEM. They exploit a change in the enrollment requirements for Italian STEM majors, which had a major effect of expanding the number of graduates. This increase in STEM boosted innovation in medicine, IT, and chemistry, although there was leakage—some STEM-trained graduates worked in sectors that are not especially focused on R&D or innovation, such as finance.

Immigration

Migration affects innovation by changing the quantity and composition of human capital. Immigrants make up 18 percent of the U.S. labor force aged 25 or older, but 26 percent of the STEM workforce. Immigrants account for about a quarter of all U.S. startups and patents each year (Kerr and Kerr 2020). The literature suggests U.S. immigrants, especially high-skilled immigrants, have increased innovation. For example, using state-level data from 1940 to 2000, Hunt and Gauthier-Loiselle (2010) find that a 1 percentage–point increase in the population share of immigrant college graduates increases patents per capita by 9 to 18 percent. Exploring policy changes that affect the number of H1-B visas, Kerr and Lincoln (2010) argue that the positive effects of skilled immigration on innovation are due to the new migrants' own innovation. Bernstein et al. (2019) look at what happens after the death of an inventor and find large positive spillover effects of immigrants on innovation of native-born Americans. Hunt and Gauthier-Loiselle (2010) also estimate large spillovers.

Another source of evidence on how immigration affects innovation comes from history. In the early 1920s the United States introduced stricter quotas against some countries than others. For example, immigration from Italy was more strongly affected than immigration from Sweden. Moser and San (2019) show that these quotas lowered immigration of Eastern and Southern European scientists to the United States, which reduced aggregate innovation. Negative effects of limiting immigration on innovation are also discussed in Doran and Yoon (2020). By contrast, U.S. chemistry innovation was increased by the arrival of Jewish scientists who had been expelled by the Nazi regime in the 1930s (see Moser, Voena, and Waldinger 2014).

Not all evidence confirms this generally positive view of the impact of immigration on innovation. Using H1-B visa lotteries, Doran, Gelber, and Isen (2015) find smaller effects than Kerr and Lincoln (2010). In addition, Borjas and Doran (2012) find negative effects of the fall of the Soviet Union on academic publications by Americans in mathematics journals. However, they do not convincingly show negative aggregate effects (combining immigrants and native-born authors) and note that their findings may be specific to academic publishing, a context in which there are short-run constraints on the size of academic journals and departments. In addition, Moser, Voena, and Waldinger (2014) estimate that most of the effect of immigration comes from new entry into the innovation sector, rather than changes in incumbents' productivity.

In summary, my reading of the literature is that there is good evidence that immigration, especially skilled immigration, raises innovation. It is a particularly attractive policy because the cost of educating immigrants has been borne by other countries rather than by American taxpayer subsidies; unlike many other supply-side policies, the increase in human capital can occur very quickly. The problem with relaxing immigration policy appears to be more political than economic (see Tabellini 2020).

INCREASING THE QUALITY OF INVENTORS: LOST EINSTEINS

Recent research has explored different characteristics of inventors, emphasizing that many groups—including women, minorities, and those born into low-income families—are highly underrepresented (Bell et al. 2019a; Cook and Kongcharoen 2010). For example, U.S. children born into the top 1 percent of the parental income distribution are 10 times more likely to grow up to be inventors (named as such on patent documents, though not necessarily the holders of the intellectual property) than are those born in the bottom half of the distribution. In principle, these differences in likelihood of a person being an inventor could be due to innate differences in ability or preferences. Only a minority of this difference is related to early ability indicators such as childhood test scores in math (Bell et al. 2019a).

Evidence suggests these patterns represent a misallocation of talent. Recent research suggests that large amounts of productivity are lost due to such misallocation (e.g., Celik 2018; Hsieh et al. 2019; Hsieh and Klenow 2009). Under this view, if disadvantaged groups were given the same opportunities as their similarly talented but more privileged peers, many more of them would pursue a career as an inventor and increase the quality and quantity of aggregate human capital. For example, Bell et al. (2019b) estimate a potential quadrupling of aggregate U.S. innovation from reducing such barriers.

Bell et al. (2019a) find that exposure rates to inventors in childhood are an important cause of the lower invention rate of disadvantaged groups. They measure exposure by family environment, proxies for the work network of parents and innovation rates in the commuting zones where kids grew up. They find a strong association between the probability of growing up to be an inventor and measures of childhood exposure to inventors. The relationship appears to be causal. For example, it is not simply the fact that kids who grow up in Silicon Valley are more likely to be inventors: they are more likely to invent in the detailed technology classes (relative to other classes) that Silicon Valley specializes in. Furthermore, kids who move to high-innovation areas at an earlier age are more likely to become inventors than kids who move at a later age, again suggesting a causal impact of place.

Note that this exposure-based view of invention could suggest much larger welfare losses from barriers to equal participation than in the standard talent misallocation models. In Hsieh et al. (2019), for example, barriers to entry into occupations (the R&D sector in this case) means a loss of talent. However, Hsieh et al. assume that only the marginal inventors are discouraged from becoming inventors. Great inventors—like Albert Einstein or Marie Curie—will never be put off by obstacles. In the exposure-based model, by contrast, even a very talented person from (say) a poor family may end up not becoming an inventor because they are never exposed to the possibility. Bell et al. (2019a) show evidence in favor of this point and argue for large welfare losses.

If we took seriously the idea that much talent is being lost because of a lack of exposure to the possibility of becoming an inventor, what are the appropriate policy responses? Several options are discussed below, and a related set of policy proposals are made by Lisa Cook in a separate Hamilton Project proposal (2020).

A classic set of responses would focus on improving conditions in disadvantaged neighborhoods, particularly in schools. These are justified on their own terms, but the lost innovation adds an additional compelling justification. It would make sense to target resources on those most likely to benefit: disadvantaged kids who show some early promise. Bell et al. 2019a find that quantitative skills, such as scoring in the top 5 percent of third-grade math, were strong predictors of future inventor status. This suggests focusing on expansions of programs for gifted and talented students. There is a growing body of evidence on these programs, with some randomized control trial evidence suggesting particularly strong effects on disadvantaged children. For example, Card and Giuliano (2016) report evidence from a gifted-and-talented randomized control trial in Florida. They find that, although these programs do not work well for the typical student, those from minority backgrounds appear to particularly benefit. Changes to such policies have almost a zero financial cost in Card and Giuliano (2016). This suggests that expanding such policies to bring in more disadvantaged kids could have very large benefits in terms of growth as well as equity.

Another set of targeted policies relate to mentorship. The Lemelson Foundation, for example, runs inventor education programs targeted at disadvantaged children in K–12. An important part of these programs is hands-on experience of problem solving in the local community, with students meeting inventors who look like them (e.g., girls meeting female scientists). Such interventions are rarely subject to rigorous evaluation, unfortunately, so an immediate priority should be resources for researching their impact (see Gabriel, Ollard, and Wilkinson 2018 for a survey of available evidence). In addition, internship and work exchange programs can be targeted at young people who would not normally be exposed to high innovation environments. Such programs would also help to enhance student exposure to innovation.

Finally, Congress could create a Department of Education "SMART Students Everywhere Grant" to fund up to 50,000 annual scholarships, each worth up to $10,000 (up to $500 million a year) over the course of their study for underrepresented minority and financially disadvantaged students studying STEM in undergraduate, graduate, or certificate programs. This proposal revives, focuses, and improves now-defunct SMART grants, which were a smaller scholarship program for students studying STEM that ceased to be funded after 2010.

PRODUCT MARKET COMPETITION AND INTERNATIONAL TRADE

As a matter of economic theory, it is not clear whether the impact of competition on innovation is positive or negative. On the negative side, Schumpeter (1942) argued that innovation is rewarded with temporary monopoly profits, so increasing competition reduces these rewards and hence reduces incentives to innovate. In addition, he mentions the benefits of scale economies in R&D labs (e.g., through access to finance) that give large firms an advantage. Enhanced competition could therefore be expected to reduce innovation. 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). Scale has disadvantages—for example excessive bureaucracy may suffocate innovators, which is why many radical innovations come from so-called garage start-ups.[11] These considerations suggest that enhanced competition would increase innovation.

The available empirical evidence suggests that competition typically increases innovation, especially if competition is initially low (see Van Reenen 2011 for a survey). Much of the research considers the impact of trade with China on innovation over the past 20 years. China's growth as an export market is a clear benefit for innovation since it increases market size, which helps spreads the fixed cost of R&D over a larger market (e.g., Bloom et al. 2019; Grossman and Helpman 1991). There is a lot of work looking at Chinese import shocks, especially following China's accession to the World Trade Organization in 2001. Shu and Steinwender (2018) summarize more than 40 papers on trade and competition, arguing that in Asia, Europe, and South America import competition mostly increases innovation (e.g., Atkin, Khandelwal, and Osman 2017; Bloom et al. 2014; Blundell, Griffith, and Van Reenen 1999). In North America the impact of import competition is more mixed; for example, Autor et al. (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. This conclusion means that industrial policies should be designed to encourage rather than chill trade competition (e.g., avoid protecting industries with high import tariffs).

A MENU OF INNOVATION POLICIES, WITH RECOMMENDATIONS

My judgments on the literature—building on those stated in Bloom, Van Reenen, and Williams (2019)—are summarized in table 1, as a menu for innovation policymakers. Column (2) summarizes my reading of the quality of the currently available empirical evidence in terms of both quantity of papers and credibility of the evidence provided by those studies. Column (3) summarizes the conclusiveness of the evidence—for example, although there are some credible approaches for estimating the impact of intellectual property, the policy implications of the available findings are unclear (see Ouellette and Williams 2020).

Column (4) has my suggested budget allocation for the policy. This represents a composite of the strength of the evidence as well as the magnitude of average effects.

I have chosen to put the highest share of resources, 30 percent, into direct R&D grants. I allocate an additional 25 percent to innovation tax credits. The evidence is positive both for this policy and for R&D tax credits, although the quality of the evidence is stronger for tax credits than direct grants. However, direct R&D grants have two advantages: First, they seem to be slightly more cost effective. Second, if policymakers choose to implement a mission-oriented policy, it is easier to direct technical change with direct grants than it is with fiscal policies.

Although these demand-based policies are the most effective in the short run, policies that increase the supply of human capital are more effective in the long run. I have put another 25 percent into exposure policies and 20 percent into universities for increasing the STEM supply. I believe that in the long run, exposure policies have huge promise, although the downside is that we have much less concrete evidence on what would be the most effective policies. I would put significant resources into education policies targeted on underrepresented groups and into evaluating a multitude of exposure policies. The latter would take relatively few resources; as more data come in on what works, significant resources can be reallocated into the most-effective policies.

Policy reforms to increase skilled immigration would be valuable but not costly, and administrative costs could be paid with additional visa fees. My view is that relaxing the rules for high-skilled immigrants would be very effective, resulting in a quick increase in STEM workers to stimulate innovation. Reforming trade and competition policy is also low cost, so worth supporting. However, the conclusiveness of the evidence with regard to innovation is less compelling here than it is in other areas.

The effects of these policies differ in additional respects, including time frame and impacts on inequality. Skilled immigration has large effects even in the short run. Competition and trade policies probably have innovation benefits that are more modest but also inexpensive in financial terms, and so also score high. R&D subsidies and trade policies are both likely to increase inequality, partly through increasing the demand for high-skilled labor and partly, in the case of trade, because some communities will endure the pain of trade adjustment and job loss. By contrast, increasing the supply of high-skilled labor is likely to reduce inequality by easing competition for scarce human capital. Combining these policies has the advantage that increases in supply of innovation workers can help ensure that policies aimed at the demand for innovation do not simply raise wages of current scientists instead of producing more innovation.

Columns (5) and (6) of table 1 summarize the time frame and inequality implications of a given policy. Different policymakers (and citizens) will assign different weights to criteria summarized in table 1.

TABLE 1.

Innovation Policy Menu

(1)	(2)	(3)	(4)	(5)	(6)
Policy	Quality of evidence	Conclusiveness of evidence	Suggested budget allocation	Time frame	Effect on inequality
Direct R&D grants	Medium	Medium	30%	Medium run	↑
R&D tax credits	High	High	25%	Medium run	↑
Skilled immigration	High	High	–	Short run	↓
Universities: STEM supply	Medium	Medium	20%	Long run	↓
Exposure policies	Medium	Low	25%	Long run	↓
Trade and competition	Medium	Low	0%	Medium run	↑

Source: Adapted from Bloom, Van Reenen, and Williams 2019.

Note: This is my (highly subjective) reading of the evidence. Column (2) is a mixture of the number of studies and the quality of the research design. Column (3) is whether the existing evidence delivers any firm policy conclusions. Column (4) is my recommendation for the fraction of the budget that should be spent on the policy. Column (5) is whether the main benefits are likely to be seen (if there are any) in the short run (roughly, the next three to four years) or longer. Column (6) is the likely effect on inequality.

THE HAMILTON PROJECT
BROOKINGS

The Proposal: The Grand Innovation Fund

The approach so far has assessed the evidence for different tools of innovation policies that could, in principle, be used with any given level of budget and without necessarily specifying a particular direction of technical change. In my view there are many advantages to an ambitious mission-oriented approach, such as the Apollo Moon Shot in 1969, which delivered a man on the moon. Economists are traditionally skeptical about this industrial policy style approach. 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, an effective industrial policy requires that bureaucrats be well intentioned and not captured by vested interests. The experience of European industrial policies in which governments threw money at national champions, such as the failed Leyland Motors in the UK 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 industrial policies (e.g., Criscuolo et al. 2019). Second, the slowdown of growth in Western countries and the perceived success of such policies in East Asia has caused some to reevaluate the case for industrial policy (Rodrik 2015). China looms large, and its scientific success should not be underestimated. For example, figure 3 showed that, in the last decade alone, Chinese R&D grew from 1.3 percent of GDP to 2.1 percent. In 1990 China produced only 1.2 percent of the world's scientific papers while the United States produced 32 percent. By 2016 China had surpassed the United States, producing 426,000 papers compared to our 409,000. The average quality (as measured by citations) of research papers written by Chinese scientists quadrupled over the same period while the quality of those written by American scientists declined slightly (Tollefson 2018). In some areas, such as artificial intelligence (e.g., visual recognition), China seems to have surpassed the United States (Yuchtman 2019).

Drawing on this work, an industrial policy could focus on innovation in some particular area or areas. As noted above, there have been many such mission-oriented policies in the United States around defense (e.g., DARPA), space (e.g., NASA) and health (e.g., NIH) that have led to important inventions such as jet engines, radar, nuclear power, digital computers, GPS, the Human Genome Project, and, perhaps most significantly, the internet (Janeway 2012; Mazzucato 2013). Successful examples of these require decentralization, active project selection (as well as a tolerance for failure), and organizational flexibility (see, e.g., Azoulay, Fuchs, et al. 2019).

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 technological improvement within the necessary timeline. It is important to remember that when the rate and direction of technological change depend on prices and incentives, horizontal policies like a carbon tax can be doubly effective because such policies reduce consumption of fossil fuels directly while also indirectly stimulating the development of clean technology (Acemoglu et al. 2012; Aghion et al. 2016). Despite this, it is clear that there are strong political obstacles to a carbon tax (or its equivalent, such as cap and trade) that would be large enough to effectively combat global warming. The United States clearly needs to develop a portfolio of, and strategy to deliver, technologies to address climate change. A recent Hamilton Project policy proposal by David Popp (2019) describes implications of the research literature on clean energy that inform optimal policy design in that area.

There are many other possible mission-oriented objectives. Other environmental challenges such as safe disposal of plastics, clean water and air, and biodiversity loom large. There are many health challenges, from dealing with global pandemics such as COVID-19, to cancer, to endemic diseases in developing countries. There are also military challenges such as dealing with artificial intelligence–enabled drones and cybersecurity threats. The challenge of space exploration also remains a possible mission-oriented objective.

SCALE

I propose we restore some of the decline in federal R&D support, which has fallen from 1.87 percent of GDP in 1964 to 0.62 percent of GDP in 2017. For example, aiming to increase innovation spending by 0.5 percent of GDP would still get us less than halfway to the levels of the mid-1960s. This would be an increase of $100 billion per annum, roughly doubling federal R&D expenditures from its current level. I suggest gradually ramping up spending to this level rather than trying to do so immediately. It would be much better to spend five years reaching this goal and maintaining it for two decades than to go from famine to feast and back to famine again. The lessons from the doubling of NIH spending between 1998 to 2003 point to the importance of a gradual increase (Freeman and Van Reenen 2009).

The allocation of this fund would follow the advice of table 1, reflecting the current state-of-the-art empirical evidence over what works and what does not.

PRINCIPLES

The funds should be used for breakthrough science and some part should be focused on areas where there is a well-identified national mission—such as health care and climate change. There are at least five principles that are important in this program.

First, the agency deciding how to disperse funding needs to be politically independent and run by experts. Congress can set the priorities such as climate change, but the allocation of funds needs to be determined by a body similar to the Base Realignment and Closure commission that decided where and how to close military bases toward the end of the Cold War. That commission shows that such bipartisan approaches are possible, as well as highly desirable.[12] Many different types of research activity could be supported.[13]

Second, the agency must be prepared to allow many failures, which are inherent to experimentation, rather than assuming that the government is capable of selecting (exclusively) winning approaches. The most successful industrial policies are based on this principle and include South Korean motor vehicles (Cherif and Hasanov 2019) and the Taiwanese semiconductor industry that arose from Hsinchu Science Park (Chen 2008). One approach is a prize-based competition where the objective is specified, but not how to achieve it.

Third, different coalitions in different geographical areas can collaborate on competitive bids for these funds. Consortia across universities, corporations, and local governments could all come together to put forward such bids. Similar to the Amazon HQ2, such collaborations could unleash a wave of creative thinking about how to make the best use of the new innovation hubs. However, unlike HQ2, a for-profit company will not capture the benefits of the competition. For example, this competition could result in 30 new innovation hubs created by the end of the 10-year program. Some of the funds would be directly sent to the hubs, but (as an example) a third of the overall budget could be allocated through a competitive process to existing institutions such as the National Science Foundation, U.S. Department of Energy, and NIH.

Fourth, a variety of incentives and rewards could be used. Direct grants, tax incentives, and training subsidies have been discussed above and could all be part of the policy mix. Prizes and advance market commitments may also be appropriate in some circumstances, especially for mission-oriented R&D (see Kalil 2006 for a discussion).

Fifth (and most controversially perhaps), there should be an explicit set of criteria to make sure the resources are allocated geographically in a way that is both cost effective and productive. Cost effectiveness could be measured in terms of house prices. This will mean that the new facilities are not all located in existing high-cost innovation hubs such as Cambridge, Massachusetts, or Palo Alto, California. Nor, however, will they be located in places where there is no real research capacity. Candidate locations would need to have an existing skill base as indicated by a minimum amount of average education, for example. Cities including Pittsburgh, Pennsylvania, and Rochester, New York, which have substantial research capacity, would be prime candidates and would help address the issue of left-behind cities. Such a fund could generate local spillovers and, by alleviating spatial inequality (a source of rising populism), be more politically sustainable.

BENEFITS AND COSTS

This proposal would certainly come with costs. First, the scale is large: a decade of annual $100 billion R&D spending is a $1 trillion proposal. Is this worth it? I would argue it is. The evidence summarized above shows that the positive impact on GDP over the long run will more than pay for the costs of investment in R&D. This is exactly the kind of short-run spending for a long-run benefit that can be financed by government bonds. Nevertheless, there is no compelling reason to set total spending at $100 billion, and the amount could certainly be scaled down (or, indeed, scaled up).

Second, the proposed preference for lower-cost areas is based in part on goals other than maximizing R&D returns. There is probably some inefficiency associated with skewing the allocation of resources away from the high-tech clusters of (for example) Silicon Valley and Cambridge. It is important that the resources go to places that have a credible education base, which is why I recommend (following Gruber and Johnson 2019) that the twin criteria of house prices and education fraction be used.

Questions and Concerns

1. Would an incremental change to existing policies be easier to achieve than a directed moon-shot initiative?

Adjustments to the existing policy mix—even with a very large increase in funding—are certainly more straightforward than a directed, industrial-style policy. In the first option, markets are given more scope to determine the types of innovation that would result from the additional funds.

However, there may be a compelling argument for moon shots related to raw politics. In order to generate significant extra resources for R&D, a politically sustainable vision needs to be created. It is easier to create excitement around such a mission than around the more mundane cost-benefit exercise of incremental policy adjustment. In addition, there are clear global challenges over the environment and health we need to address and innovation has to be part of the solution to these challenges.

2. Where would the money for the Grand Innovation Fund come from?

Congress passed a $2 trillion COVID-19 stimulus package in early 2020, so although $100 billion is substantial, it is only 5 percent of $2 trillion. This expenditure is on investment, not consumption, so it is exactly the kind of public spending that should be bond financed. Given the social returns to R&D, it will more than pay for itself in the future.

Conclusion

America faces an innovation challenge. There are pressing missions that need addressing: environmental challenges such as climate change, military challenges such as AI-based drones, and health challenges such as the COVID-19 pandemic. Moreover, the United States has generally suffered slow productivity growth since the mid-1970s, which has contributed to slow real wage growth. The social and political problems associated with lackluster average earnings growth have been exacerbated by a growth of inequality between people and across places. Increasing productivity growth for a leading country like the United States requires more frontier innovation, not just swifter diffusion of existing technologies. Federal funding for R&D has declined as a proportion of GDP by about 1 percentage point between the mid-1960s and today, or about $200 billion per year in today's money. Both theory and empirical evidence suggest that the United States is not investing enough in innovation.

I have evaluated the evidence on a wide range of innovation policies. In the short run, R&D tax credit policies and government direct grants appear more effective, but stimulating the demand side may also lead to increases in the cost of R&D. In the long run, increasing human capital is probably the most effective way of increasing innovation, but our evidence on policies that will likely work here is weak. The one exception is skilled migration, which is both inexpensive, quick, and likely to reduce inequality (see Kerr and Kerr 2020 for a series of concrete proposals). Unfortunately, it is also the most politically contentious.

Given the scale of the problem, I propose an ambitious mission-oriented innovation policy. This should scale up to be a permanent $100 billion per year Grand Innovation Fund to set up new technology hubs across the United States. Based on my menu I propose a distribution of these funds as well as an independent agency to administer them. If we are serious about rebuilding America's technological muscle to the postwar level, we must make long-term investments that generate both technological advances and good, high-wage jobs.

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Van Reenen has published widely on the economics of innovation, labor markets and productivity. He has been a senior policy advisor to the Secretary of State for Health, Downing Street, and for many international organizations. He has also been a Visiting Professor at the University of California at Berkeley, Stanford and at Harvard University, a Research Fellow at the Institute for Fiscal Studies, a Professor at University College London, a partner in Lexecon Ltd. (now CRAI), and Chief Technology Officer of a software start-up.

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Endnotes

1. These examples and the conceptual framework for this section draw from Bloom, Van Reenen, and Williams (2019), which discusses similar challenges.
2. In theory, private sector R&D could be either too high if much of innovation investments are less about expanding the market and more about stealing market share from other firms. One example from pharmaceuticals, is when a firm invests in a "me-too" drug that is only incrementally better than a drug produced by a rival firm. The small improvement in therapeutic value may allow the firm to capture nearly the entire market. This R&D investment generates large private benefits for pharmaceutical firms more than patients.
3. Dechezlepretre et al. (2016) use a regression discontinuity design to show large effects.
4. That is, the absolute elasticity of R&D capital with respect to its tax-adjusted user cost is unity or greater. Importantly, these are long-run estimates; the initial response may be sluggish due to adjustment costs.
5. There are a large number of qualitative evaluations of the SBIR (e.g., National Academies of Sciences, Engineering, Medicine n.d.), but Howell (2017) is the best quantitative evaluation with the strongest claim to identify the causal impact of SBIR grants.
6. The estimate depends on whether a user cost elasticity of 1 or 2 is used.
7. Microeconomic analysis might miss this: the wage increase is a general equilibrium effect, absorbed away by the time dummies typically included in the evaluations.
8. Those institutions rapidly expanded in the 1960s and 1970s in Finland and offered postgraduate engineering.
9. A classic research paper finds that proximity to universities raised patenting (Jaffe 1989).
10. If universities have an effect on innovation (or growth) over and above the impact on human capital, then they are not valid instruments for human capital, since this effect violates the assumption that universities affect innovation only through human capital supply (i.e., the exclusion restriction). The effect of universities on innovation may still be causal, but the mechanism may not be solely (or even at all) through the human capital channel.
11. This may also be why increasing concentration is not obviously beneficial for innovation (see Autor et al. 2020 for a discussion).
12. Possible areas include artificial intelligence; computer hardware, including data storage; cybersecurity; advanced manufacturing; advanced communications, including 5G telecommunications; biotechnology and synthetic biology; medical technologies, from devices to drugs; material science, including fibers and polymers; advanced energy technologies, including batteries; other climate-related technologies, including agricultural and water-related innovations; and explorations of new frontiers from the deep ocean to outer space.
13. For example, university facilities and faculty endowment; data infrastructure; other science-supporting infrastructure and technical facilities; acquisition of land; primary and secondary school improvements in STEM; support for postsecondary training in STEM; and career technical education in STEM, including apprenticeships.

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Highlights

Productivity growth is flat, government research and development (R&D) spending has fallen, and wage inequality has risen. Meanwhile, the United States and the world face severe and numerous challenges. John Van Reenen of MIT and the Sloan School of Management proposes an ambitious Grand Innovation Challenge Fund that would increase U.S. spending on R&D. The fund will give a much-needed boost to innovation and productivity by tackling some of the world's most critical challenges.

The Proposal

Implement a permanent Grand Innovation Challenge Fund to support breakthrough science. A portion of the Fund will focus on well-identified national missions—such as health care and climate change. The agency tasked with distributing funding must be prepared to take risks and tolerate failures in order to find the next moonshot.

Independent experts will allocate funds to different, evidence-based innovation policies. Out of the fund, 30 percent will go to direct R&D grants, 25 percent to tax policies credits, 20 percent to increase the STEM workforce, and 25 percent to policies that would promote innovation among underrepresented groups. In addition, relaxing skilled immigration rules could also have a rapid and large positive effect on innovation at very low cost.

Increase support for innovation by half a percent of GDP—or about $100 billion a year. In order to get closer to the historical federal R&D spending peak, the fund will roughly double the federal government's spending on R&D. Funding would scale up gradually to sustainably reach the proposed increase.

Benefits

Increased spending on R&D investments is costly, but the evidence shows the positive impact on GDP over the long run would make such an investment worthwhile. The Grand Innovation Challenge Fund would tackle some of the most important problems, like climate change and public health threats, thereby boosting sluggish productivity growth and improving society.

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