Why U.S. Business R&D Is Not as Strong as It Appears

BY J. JOHN WU | JUNE 2018

If the United States is to continue expanding its innovation economy, it must enact stronger policies that support both business R&D and federal R&D.

Investment in research and development (R&D) lays the foundation for the successful evolution of the innovation economy. By investing in R&D, science is advanced, fresh ideas are generated, technologies are developed, and new products, services, and processes emerge. But while business R&D investment in the United States jumped by two-thirds on an inflation-adjusted basis from $328 billion in 2000 to $458 billion in 2016, the rate of R&D growth as a share of GDP over the same period has been anemic—inching up from 2.61 percent to 2.74 percent. Moreover, businesses are investing a much smaller share of their revenues in riskier early stage basic and applied research than in later-stage development, and the global share of business R&D performed in the United States has fallen significantly in the last decade. In order for the United States to continue expanding its innovation economy, it must enact stronger policies that support both business R&D—such as more-generous R&D-specific tax incentives and expansion of the science, technology, engineering, and math (STEM) workforce—and federal R&D, as every dollar of federal R&D spurs an additional 30 cents in business R&D.

This report briefly describes how business R&D leads to greater productivity, more employment, and increased competitiveness. It also explores the R&D landscape in the United States—both across the economy and by industry—and how U.S. businesses' R&D investments compare with those of their counterparts in other countries. The report concludes by offering a number of policy recommendations.

INVESTMENTS IN RESEARCH AND DEVELOPMENT DRIVE PRODUCTIVITY, JOB GROWTH, AND COMPETITIVENESS

Businesses invest in R&D to develop advantages over their competition and to maximize the returns on their investments. But R&D investments generate knowledge spillovers that can benefit competitors. Since private industry cannot capture the full social benefits of R&D investments, companies underinvest in R&D. In fact, actual private R&D investment is two to four times less than the amount needed to maximize U.S. economic welfare.[1]

Nonetheless, the private returns on R&D investments produce benefits for the economy by raising firm productivity and generating beneficial product and service innovations.

Economic research estimates that actual private R&D investment is two to four times less than what would maximize U.S. economic welfare.

Productivity

Through R&D, companies boost productivity by both enabling innovation in capital goods—machinery, equipment, and software—and developing new products and processes. In so doing, they gain market share while displacing less-productive firms and freeing up resources that can be put to better uses. A number of economic studies have concluded that when firms increase R&D investment by 1 percent, their productivity increases by 0.05 to 0.25 percent, which translates to a 20 to 30 percent return on investment.[2]

Employment

Firms that invest in R&D increase their chances of survival by developing new products and processes, which increase the likelihood they will be able to grow. This in turn creates the need for them to hire more workers.[3] For the average business, a 1 percent increase in its R&D stock increases employment by 0.8 to 0.9 percent.[4]

Competitiveness

In many industries, goods and services are traded internationally. As such, businesses that want to be competitive, especially businesses in high-cost nations, need to invest in R&D to develop superior products. Indeed, according to a review of 38 economic analyses, investment in R&D is a key determinant of a firm's success in international markets.[5] In an analysis of U.S. firm behavior, Foster, Grim, and Zolas found that approximately 50 to 60 percent of businesses that perform R&D engage in at least one international transaction per year. In contrast, only 7 to 8 percent of all U.S. firms do.[6]

OVERALL BUSINESS R&D

With the United States ceding so much of its less-innovative, commodity-based production to foreign nations, it has become imperative that it transform itself into a more R&D-intensive economy. And although business R&D has continued to grow, its pace in recent years has slowed.

Businesses R&D Investment Is Growing

At first glance, the picture of R&D investment in the United States looks positive. Investments in R&D have steadily increased, on an inflation-adjusted basis, since the

1980s (figure 1). In 1980, government and businesses in the United States invested $142 billion in R&D. That figure increased by more than 200 percent to $458 billion by 2016 (controlling for inflation). The pace of R&D investment has also exceeded that of the U.S. economy overall, which has expanded by only 160 percent since 1980. The most dramatic increases in R&D investment came between the early 1990s and the late 2000s. And while R&D investment did stagnate during the Great Recession, it has since picked up.

Figure 1: U.S. R&D Investment From 1980 to 2016 (Billions of 2009 Dollars)[7]

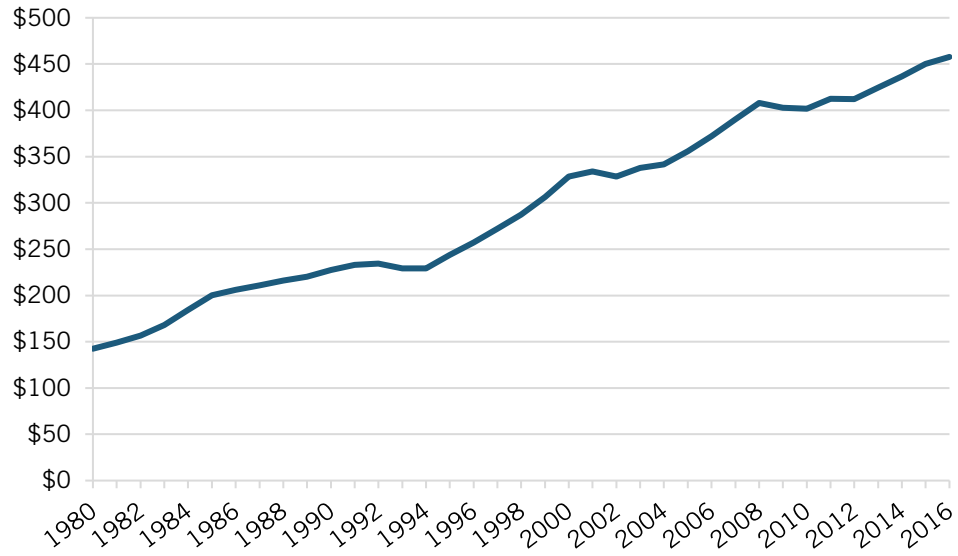
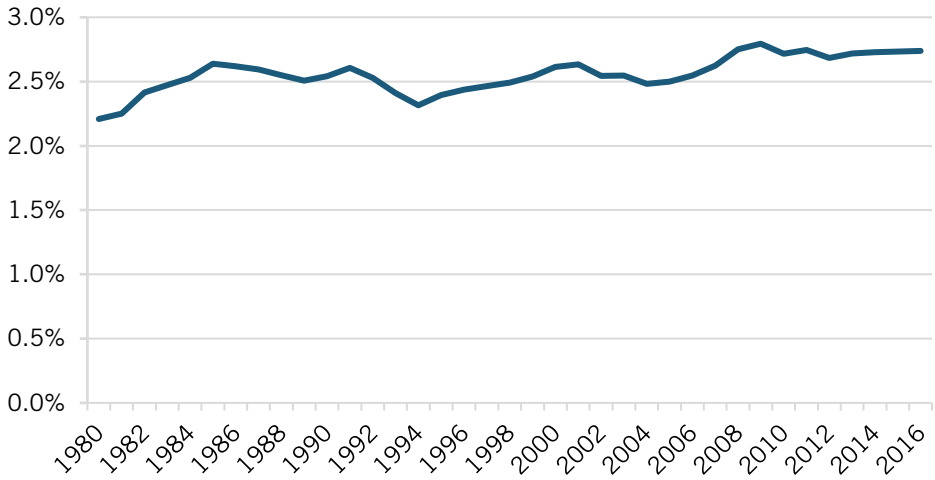


Figure 2: U.S. R&D Investment From 1980 to 2016 (as a Share of GDP)[8]



Since 1980, most R&D growth has come from business, with government R&D largely stagnant since 1986 (figure 3). Business R&D increased from $70 billion in 1980 to $300 billion in 2016, a 340 percent rise. Overall growth was robust, with slight declines during recessions—because businesses had fewer resources to invest in R&D due to reduced consumer demand. In contrast, government investments in R&D have remained relatively steady, having fluctuated by around $100 billion since 1986 (peaking at $126 billion in

2009 due to the R&D spending associated with the American Recovery Act). Other sources of R&D investment (universities, nonprofits, and state governments) have increased by almost 700 percent, from $5 billion in 1980 to $39 billion in 2016. Expressing these figures as a share of GDP, business R&D accounted for 1.84 percent in 2016, up from 1.08 percent in 1980; government R&D amounted to 0.66 percent in 2016, down from 1.05 percent in 1980; and other sources of R&D constituted 0.23 percent in 2016, up from 0.08 percent in 1980.

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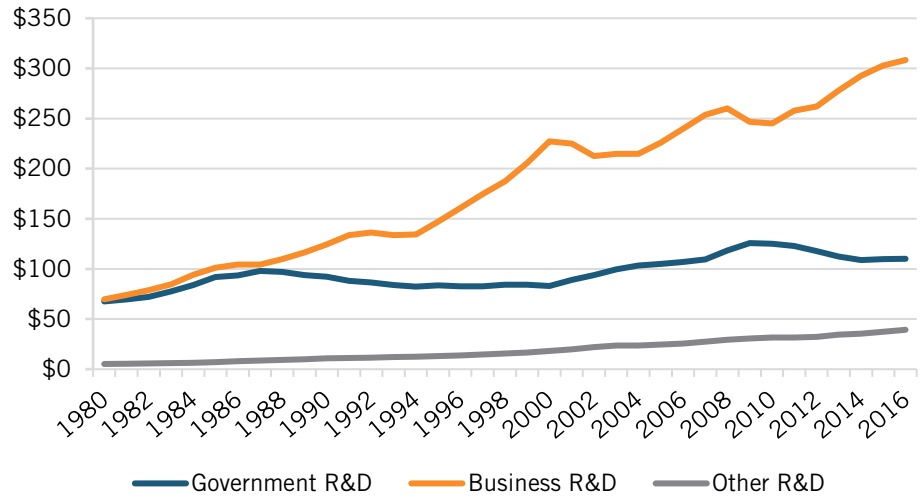
Figure 3: U.S. R&D Investment by Sector From 1980 to 2016 (Billions of 2009 Dollars)[9]

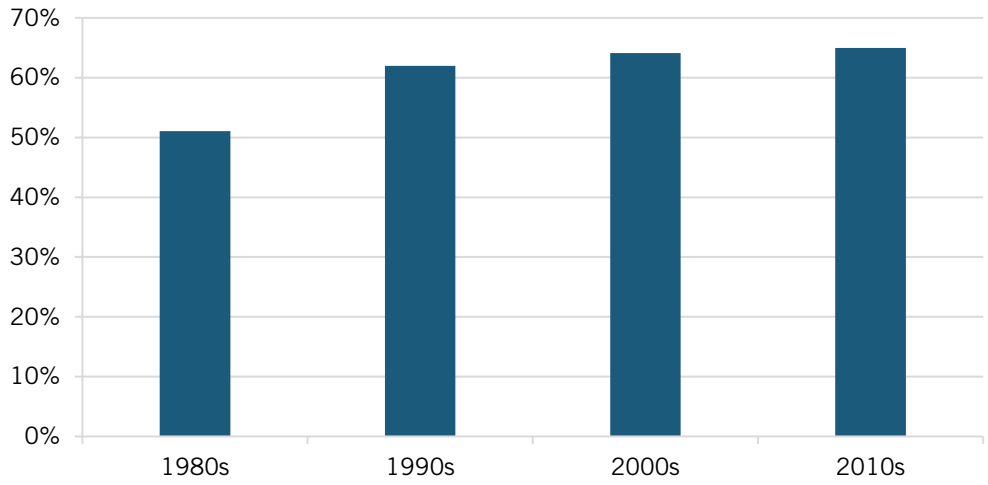


Thanks to steady growth in business R&D, and the stagnation of government R&D, businesses fund 65 percent of all U.S. R&D today—compared with a nearly equal split between government and the private sector in the 1980s (figure 4).

The lack of growth in government R&D investment is especially problematic because it tends to "crowd in" private R&D investment. In other words, the more the government invests in R&D, the more businesses tend to invest in R&D. As an Organization for Economic Co-operation and Development study found, "Direct government funding of R&D performed by firms (either grants or procurement) has a positive effect on business financed R&D (one dollar given to firms results in 1.70 dollars of research on average)."[10] And one additional dollar of public contract research added to the stock of government R&D has the effect of inducing an additional 27 cents of private R&D investment.[11] For the life sciences industry, one dollar of support for National Institutes of Health research leads to an even greater increase in private medical research of roughly 32 cents.[12] A survey of over 60 academic articles on whether public-sector R&D crowds out private-sector investments concluded, "There are a number of econometric studies that, while imperfect and undoubtedly subject to improvement and revision, between them make a quite convincing case for a high rate of return to public science in this [life science] industry. It is worth noting that there are, so far as we are aware, no systematic quantitative studies that have found a negative impact of public science."[13]

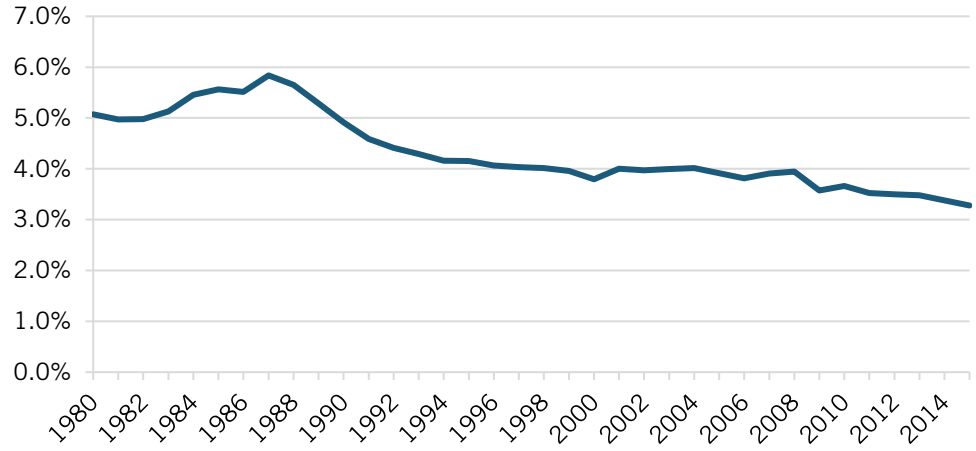
The reasoning behind the complementarity between private and public R&D is two-fold. First, public R&D investment corrects the market failure of private markets underinvesting in R&D (because businesses cannot capture the social benefits of R&D). Second, businesses that receive federal R&D investments can attract further private R&D investments, as federal R&D grants have strict evaluation processes that private investors can use as good indicators of a company's potential. For example, according to economist Sabrina Howell, companies that receive Small Business Innovation Research awards doubled their chances of receiving venture capital later.[14]

Figure 4: U.S. Business R&D as a Share of Total U.S. R&D[15]



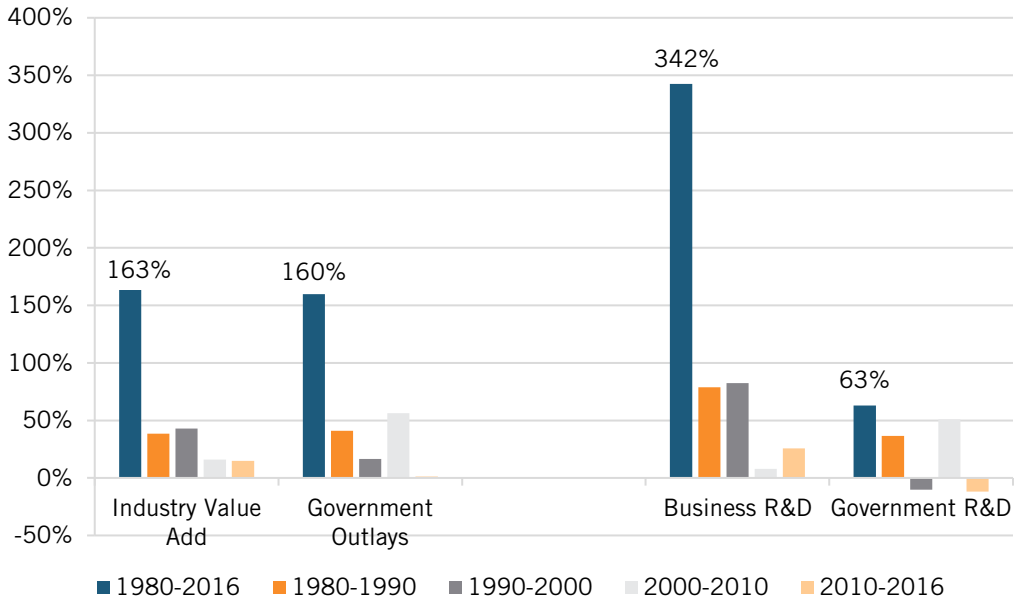
Expressing government support for R&D as a share of government outlays demonstrates just how much government priorities have shifted away from R&D. In the 1980s, R&D investments comprised 5 to 6 percent of government outlays (figure 5). Then, as the Cold War ended and entitlements to retirees were on the rise, the government began allocating less of its budget to R&D. Government R&D as a share of outlays then decreased by almost half, to a historic low of 3.3 percent in 2015. Although federal R&D investments have fallen as a share of GDP, they have been consistently allocated between defense and nondefense functions. Since the 1980s, nondefense-related federal R&D investments ranged from 40 to 50 percent of total government R&D investments.[16]

Figure 5: Government R&D as a Share of Government Outlays From 1980 to 2015[17]



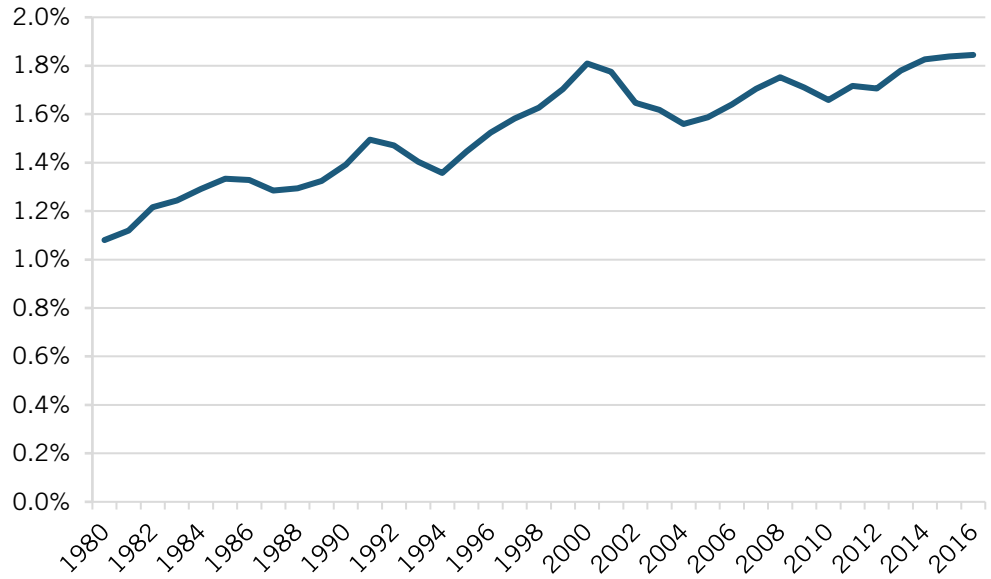
From 1980 to 2016, industry value-added and government outlays each grew by about 160 percent. However, while businesses used that additional revenue to increase R&D investment by 340 percent during that period, government spent most of it on entitlements, and increased R&D investment by only 60 percent (figure 6).

Figure 6: Growth in Industry Value Added, Government Outlays, Business R&D, and Government R&D, by Decade[18]



While business R&D in the United States continues to increase, its share of GDP has only grown very slowly, from around 1.80 percent in 2000 to 1.82 percent in 2016 (figure 7). And with success in the global economy contingent on the U.S. economy becoming more R&D- and innovation-intensive, this stagnation is troubling.

Figure 7: U.S. Business R&D From 1980 to 2016 (as a Share of GDP)



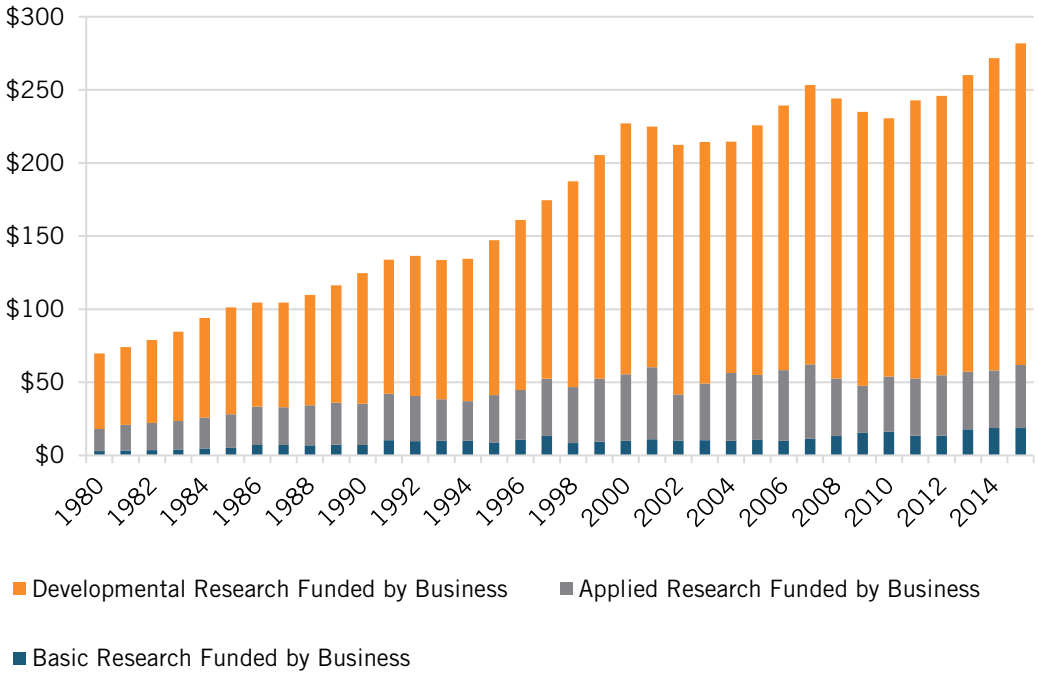
Adjusted for inflation, businesses in 2014 invested just as much in basic and applied research as they did in 2000.

Businesses R&D Investment is Shifting to Later-Stage Activities

Business R&D has increased more than threefold since 1980, an unusually large portion of which has gone to development, rather than to longer-term and riskier basic and applied research. Basic research is mainly exploratory, and concerns pushing the known bounds of basic scientific concepts and understanding. Applied research involves using known basic scientific concepts to solve a particular problem. Developmental research refers to developing available scientific knowledge into a commercial product or process. In other words, basic and applied research are the building blocks, while developmental research is the process of turning those blocks into "buildings." Thus, the more building blocks are developed now, the more potential innovation in the future.

From 1980 to 2014, basic and applied research increased by 244 percent, while developmental research increased by 325 percent (figure 8). Over the past 15 years, private investment in basic and applied research has stagnated. In 1980, 30 percent of the private sector's R&D budget went to basic and applied research, but by the 2010s, this share had dropped to 22 percent (figure 10). Adjusted for inflation, businesses in 2014 invested as much in basic and applied research as they did in 2000. When looking at basic and applied research as a share of business value added, investments peaked in 1991 (0.55 percent of industry value added) and declined to 0.43 percent by 2014 (figure 9).

Figure 8: Business R&D Breakdown 1980 to 2015 (Billions of 2009 Dollars)[19]



Although businesses have substantially increased investments in R&D since the 1980s, recent economic studies and aggregated metrics suggest the productivity of R&D investments has gone down in recent years.

Figure 9: Breakdown of U.S. Business R&D Investment as a Share of Industry Value Added from 1980 to 2015[20]

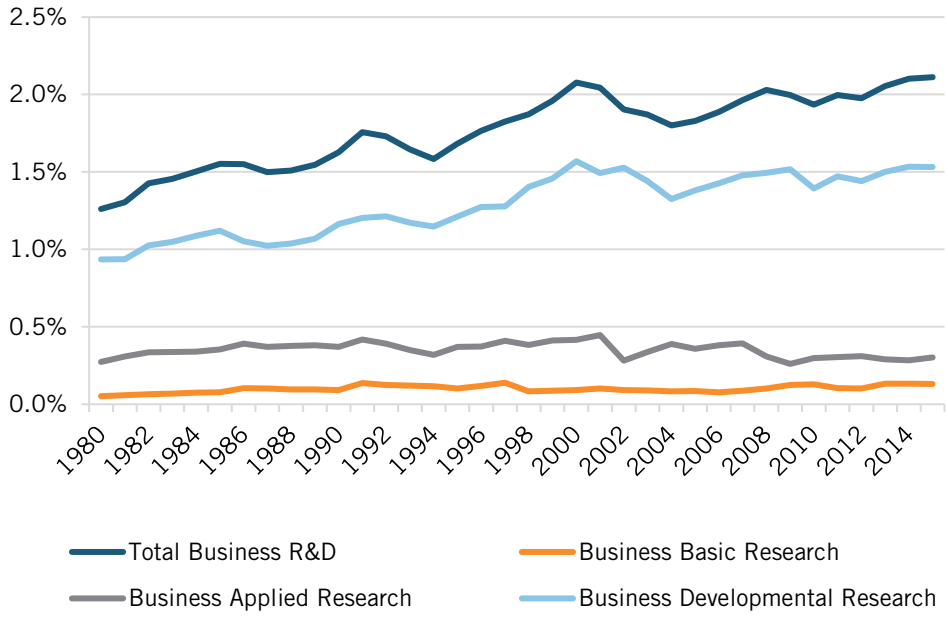
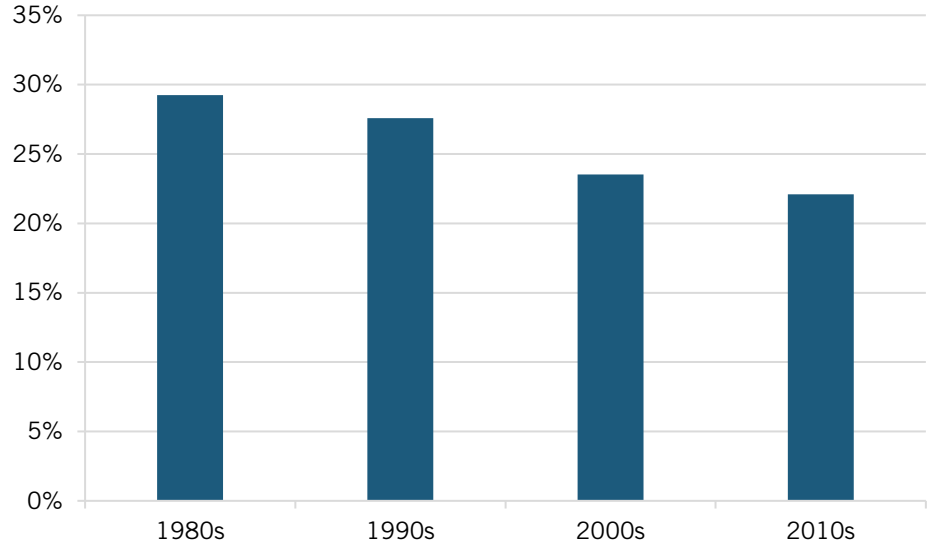


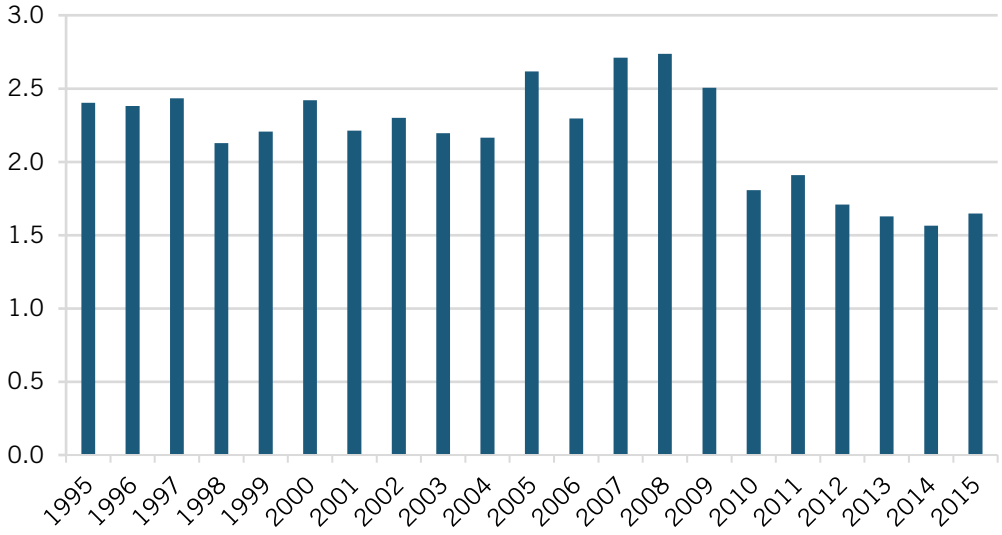
Figure 10: Basic and Applied Business R&D as Share of Total Business R&D, by Decade[21]



Although businesses have substantially increased investments in R&D since the 1980s, economic studies and aggregated metrics suggest the productivity of R&D investments has gone down in recent years. An example of one such metric reflecting this trend is the number of corporate patents granted per million dollars invested in developmental research (figure 11). From 1995 to 2009, every million dollars in developmental research invested by U.S. companies resulted in approximately 2.5 patents; since 2009, this figure has decreased to 1.5.

In a 2017 analysis of the declining productivity of R&D investments, economists at the National Bureau of Economic Research examined a wide range of evidence from various industries, products, and firms and reached the startling conclusion that "research effort is rising substantially while research productivity is declining sharply."[22] They analyzed research that covered economic data from the 1970s to the 2010s within the agricultural, pharmaceutical, and manufacturing industries, among both privately and publicly owned companies. They further suggested that research productivity falls in half every 13 years as ideas are getting harder and harder to find.[23] Another recent economic study avers that one reason for the decreased effectiveness of R&D investments is the reduced growth of the available "pool of ideas" from which researchers can develop new innovations.[24] Its analysis of U.S. patent data from 1926 to 2009 produced two key findings: One, the "pool of ideas" had stopped growing since the 1980s. Two, newer patents are less likely to induce further patenting.[25] In summary, for the average U.S. business, innovation is getting harder and more expensive.

Figure 11: Number of Business Patents Granted per Million Dollars in Developmental Research[26]

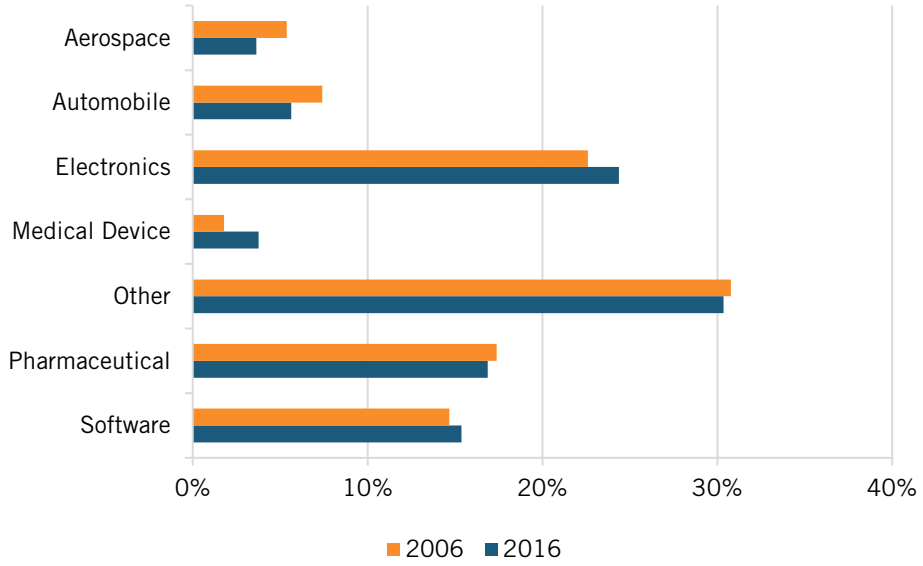


If U.S. and Chinese business R&D investments continue to grow at the same rate as over the past ten years, Chinese business R&D will overtake that of the United States within the next decade.

Industry and Firm Size in U.S. R&D Investments

Most industries in the United States spend very little on R&D. Seven industries—aerospace, automobiles, electronics, medical device, pharmaceutical, and software—support 70 percent of U.S. business R&D (figure 12). In 2016, the electronics sector accounted for almost a quarter of private R&D investments, followed by the pharmaceutical and software industries, each investing a sixth of total business investments. Compared with 2006, three industries (electronics, medical device, and software) accounted for a larger share of business R&D in 2016, while the remaining four accounted for a relatively smaller share.

Figure 12: Industry Breakdown of U.S. Business R&D Investment 2006, 2016[27]



As of 2016, large firms (500 or more employees) accounted for 87 percent of R&D spending in the United States. This share has increased from 2006 because gross R&D investment by small firms (under 500 employees) only increased by 3 percent as compared to the 49 percent increase by large firms[28] Moreover, while small firms currently account for 49 percent of U.S. employment, they represent a mere 13 percent of business spending on R&D, while firms of more than 25,000 workers account for 36 percent.[29] Likewise, small firms account for 18.8 percent of patents issued, while the largest firms account for 37.4 percent.[30] Average R&D spending per worker decreases with company size (not controlling for industry), as firms with five to 99 workers spend around $790 per worker, while large firms with 500 or more workers spend around $3,370 per worker.[31]

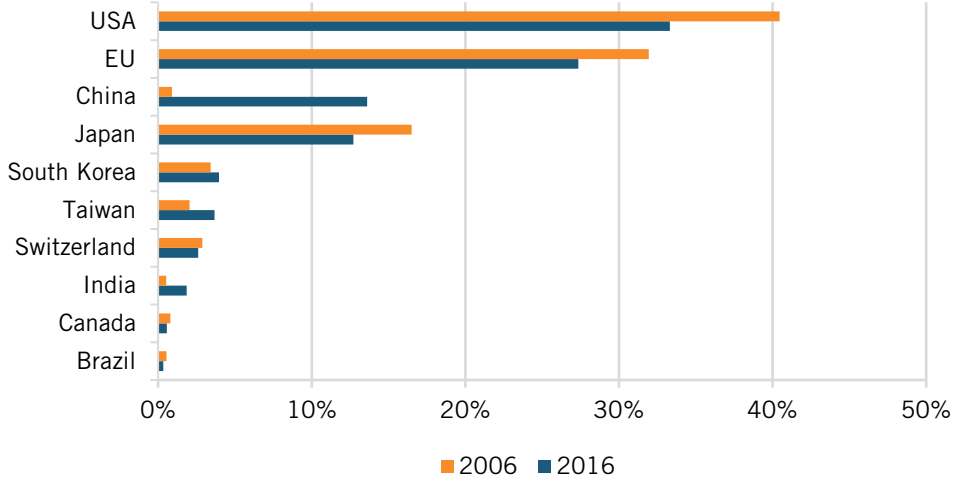
U.S. Business R&D in the Global Context

In 2016, businesses around the world invested slightly more than $700 billion in R&D, up 40 percent from a decade prior. Among companies from the 10 countries that invested the most in business R&D in 2006 (adjusted for purchasing price parity), U.S. businesses accounted for 40 percent of global business R&D—which decreased to 33 percent by 2016 (figure 13). EU businesses accounted for 32 percent in 2006 and 27 percent by 2016. The global share for Japan, Switzerland, Canada, and Brazil each also decreased—conversely, those for China, South Korea, Taiwan, and India each increased.

Economic data from the world's 2,500 largest R&D-spending companies provide additional global trends in R&D investment. U.S. businesses still lead the world in R&D investment, with 22 of the top 50 companies globally in terms of R&D investment headquartered in the United States, including Alphabet, Microsoft, Intel, Apple, Johnson and Johnson, and General Motors.[32] Of those 2,500 global companies, nearly a third (823) were based in the United States. They funded 33 percent of global private-sector R&D in 2016 but the United States accounted for only a quarter of global GDP—a decrease in business R&D share from 40 percent in 2006.[33] Even if current growth rates for U.S. business R&D remain constant, their share will continue to decline because R&D investment is growing faster outside the United States.[34]

Much of this decline for the United States can be attributed to the rapid growth of Chinese business R&D investment. In 2006, they accounted for just as much R&D investment as Canadian businesses (the then seventh largest investor in R&D). By 2016, they were the world's third-largest private investors in R&D, accounting for 14 percent of global business R&D investment. In fact, China currently has 375 firms among the 2,500 largest R&D-performing firms in the world. However, their R&D intensity (the share of company sales reinvested in R&D anywhere in the world) is less than half of U.S. firms' (2.8 percent versus 6.2 percent), yet their profitability is almost half that of U.S. firms (6.9 percent versus 12.7 percent). If U.S. and Chinese business R&D investments continue to grow at the same rate as over the past ten years, Chinese business R&D will overtake that of the United States within the next decade.[35]

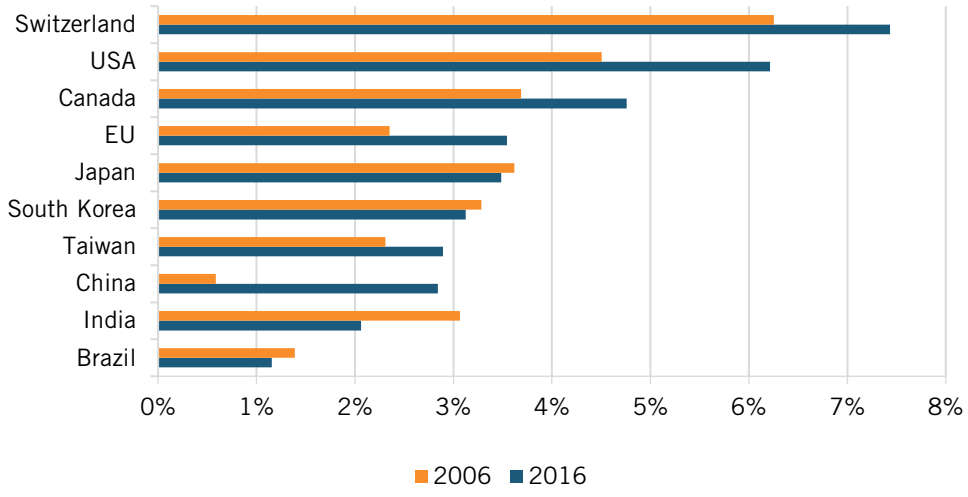
Figure 13: Global Business R&D Shares Among Selected Countries, 2006 and 2016 (Adjusted for PPP)[36]



But over the years, as countries have continued to develop their own innovation capabilities, so too have their R&D investments—thereby increasing competition within many of the industries the United States has traditionally been the leading innovator.

Business R&D intensity is another way to compare nations. Global R&D intensity of the 2,500 largest international firms increased from 3.2 percent to 5 percent from 2006 to 2016.[37] Of the ten largest economies in terms of business R&D, six (China, Canada, the EU, Switzerland, Taiwan, and the United States) increased their business R&D intensity between 2006 and 2016 (figure 14). Swiss businesses were the most R&D intensive, investing 7.4 percent of their sales into R&D in 2016, up 1.2 percent from 2006. (The main driver was Switzerland's pharmaceutical companies, which are in the most R&D-intensive industry in the world.) U.S. businesses ranked second, investing 6.2 percent of sales into R&D, up from 4.5 percent in 2006. Chinese businesses raised R&D intensity fourfold, from 0.6 percent to 2.8 percent. Despite their share of global R&D expanding, India and South Korea became less R&D intensive because their overall economies experienced high growth. Japan and Brazil became less R&D intensive as their share of global R&D shrank.

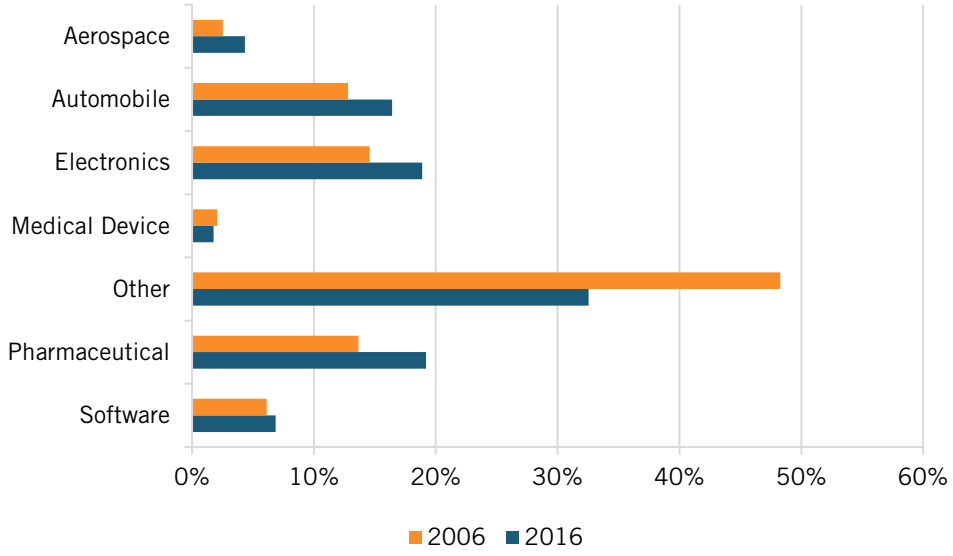
Figure 14: Business R&D Intensity, 2006 and 2016[38]



R&D has become more globalized, with a greater number of businesses in more nations investing in industries that have provided the highest rates of return. Global business R&D trends split between various industries have started to mirror those within the United States. In 2006, seven industries—aerospace, automobile, electronics, medical device, pharmaceutical, and software—accounted for half of the total worldwide business R&D. By 2016, this share had increased to just under 70 percent—similar to the breakdown of business R&D by industry in the United States (figure 15).

In terms of industry composition, there are some slight differences in where R&D dollars are being allocated, both in the United States and globally, with U.S. industries that invest the most in R&D facing increased global competition. For instance, the automobile industry outside the United States receives a much larger share of global R&D business investment than it does in the United States (due to the highly competitive nature of automobile manufacturers in Europe and East Asia). Over the years, as countries have continued to develop their own innovation capabilities, so too have their R&D investments—thereby increasing competition within many of the industries the United States has traditionally been the leading innovator.

Figure 15: Industry Breakdown of Global Business R&D Investment 2006, 2016[39]

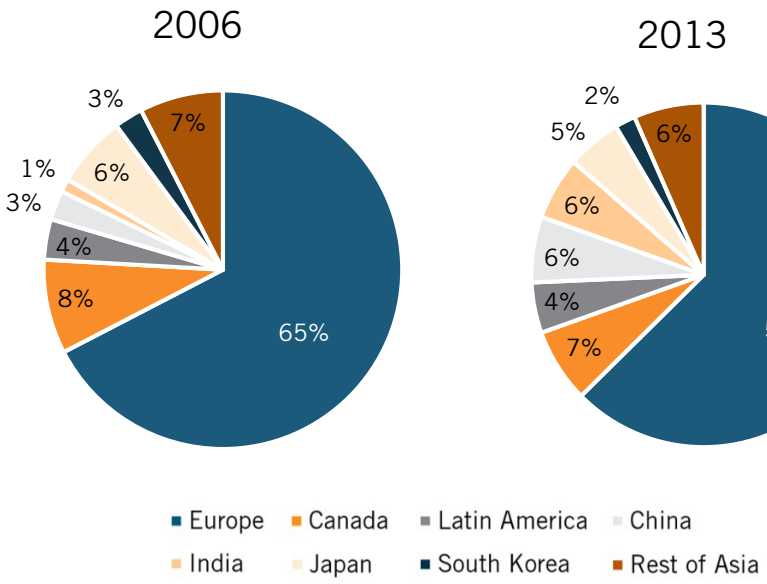


Just as businesses in other countries are investing more in R&D, U.S. companies are doing likewise outside of the United States. In 2006, U.S. businesses invested $31 billion in overseas R&D. By 2013, such investments had more than doubled to $68 billion (adjusting for inflation).[40] U.S. businesses invest the lion's share of their foreign R&D investments in Europe. But while gross investment in this region is growing, its overall share relative to other regions is decreasing (figure 16). In 2006, U.S. businesses invested $20 billion in R&D in Europe (65 percent of all U.S. business overseas R&D), and increased to $40 billion by 2013 (59 percent of all U.S. business overseas R&D). China and India have been the major beneficiaries of increased U.S. business foreign R&D

investments. In 2006, they received 4 percent of all U.S. business foreign R&D investments, which increased to 12 percent by 2013.

One reason for U.S. businesses investing more into R&D in foreign countries is the generous R&D-investment incentives offered by other countries. In a 2017 report, ITIF found that the United States ranked 25th out of a sample of 41 countries for R&D tax incentives.[41] In the OECD's "Science, Technology, and Innovation 2017 Indicators," the United States ranked 32nd out of 38 in terms of its generosity of R&D tax incentives.[42]

Figure 16: Breakdown of U.S. Business Foreign R&D Investments by Region, 2006 and 2013[43]



While U.S. business R&D investments show some signs of improvement, challenges remain. In particular, the relative stagnation of basic and applied research, coupled with the declining share of global business R&D, suggests the U.S. business R&D performance has much room for improvement.

POLICIES TO SPUR U.S. BUSINESS R&D

Although business R&D has increased significantly, relative to other advanced economies, policies to incentivize businesses to invest in R&D are weak. While U.S. business R&D investments show some signs of improvement, challenges remain. In particular, the relative stagnation of basic and applied research, coupled with the declining share of global business R&D, suggests the U.S. business R&D performance has much room for improvement. There are several key areas for policy makers to focus on.

Stronger Tax Incentives for Business R&D

While Congress passed tax reform in 2017, there is significantly more it could do to encourage private investment in R&D. The recent tax reform achieved several important things, such as lowering the statutory rate and moving toward a territorial system. However, the combination of a lower statutory tax rate and the requirement that companies begin amortizing R&D expenses as of 2023 reduces the tax incentives for conducting more research.[44] And although Congress did not amend the R&D tax credit within the recent tax reform, it should nevertheless expand R&D tax incentives:

- Expand the rate of the Alternative Simplified Credit from 14 percent to at least 25 percent. ITIF has calculated that expanding the R&D tax credit would pay for itself from the additional revenue growth after 15 years.[45]
- Institute an "innovation box"—a tax policy already present in many advanced economies—that provides favorable tax treatment for revenues generated from newly developed intellectual property.[46]

Expand STEM Skills

As businesses continue to increase their investments in R&D, so too will their need for talented scientists and engineers to translate those investments into productivity-driving innovations.

- More-generous immigration rules regarding STEM workers intending to move to the United States should be enacted, such as by shifting more permanent-resident slots away from family-based and other related programs to workers with advanced STEM skills.[47]
- Expand National Science Foundation (NSF) funding for Ph.D. STEM fellowships each year, as they are key factors in producing more Ph.D. degrees in STEM fields. Compared with the number of science and engineering graduates, NSF now awards fewer than half as many research fellowships as it did in the 1960s.[48]
- Congress should establish cash prizes for colleges and universities that succeed in graduating more STEM students.
- Congress should appropriate funding to the NSF to award prizes to colleges and universities that dramatically increase—and then sustain—the rate at which freshman STEM students graduate with STEM degrees. Awards could be tiered for small, mid-sized, and large universities. Alternatively, Congress could require NSF to consider an institution's record on STEM "switch-outs" and dropouts, especially among women and minority students, and in fields such as engineering and computer science, as a factor in awarding research grants.[49]

Increase Federal R&D Spending

Because greater support for federal R&D investments will crowd in greater levels of business R&D, policymakers should commit more resources to innovation-based federal programs that have a proven track record of raising U.S. innovation.

- Commit to restoring federal R&D to 1980s levels as a share of GDP. This would require approximately $65 billion in additional federal R&D investments per year.[50]
- Increase funding for industry-university partnerships to at least $50 million annually (up from $8 million). In the United States, there are two kinds of industry-university partnerships: Engineering Research Centers (ERCs) and Industry/University Cooperative Research Centers (I/UCRCs). The 19 ERCs focus on collaborative research among universities in advanced engineering systems, while the 75 I/UCRCs bring in the industry component of advanced engineering systems research in collaboration with universities. Current estimates show each dollar invested by I/UCRC generates $64.70 in economic impact.[51]

CONCLUSION

At first glance, U.S. businesses appear to be making robust investments in R&D, because they are allocating increasing shares of their revenue for that purpose. But three key challenges lie under the surface. First, businesses are steering more of their R&D investments toward product development that has the potential to generate returns in the near term and allocating less for basic and applied research that takes longer to bear fruit. Second, the federal government has deprioritized funding for R&D, which reduces the pool of new discoveries that private industry can capitalize on by making additional R&D investments of their own. Third, as other countries increase their public and private investments in R&D, they are increasingly competing in high-value-added industries in which the United States historically has had an advantage stemming from its leadership in innovation. The clear implication of these trends is that the United States cannot afford to rest on its laurels. Policymakers should provide stronger tax incentives for business R&D while increasing support for federal R&D.

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ACKNOWLEDGMENTS

The author wishes to thank the following individuals for providing input to this report: Rob Atkinson and Alex Key. Any errors or omissions are the author's alone.

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