Investing in "Innovation Infrastructure" to Restore U.S. Growth

BY PETER L. SINGER | JANUARY 2017

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The recovery from the Great Recession has been painfully slow. Unemployment peaked in October 2009 at 10 percent, and it took until October 2015 to drop to 5 percent, although the labor force participation rate is still below 2000 levels.[1] Productivity growth has been the lowest since the federal government started tracking this in 1947.[2] And annual GDP growth has been averaging less than 2 percent for the past seven quarters.[3]

This poor economic performance has befuddled most economists and led to dusting off older theories such as "secular stagnation." One policy to address such stagnation that has gained traction from some economists and President-elect Trump is an infrastructure stimulus. When this was first proposed in 2013, the focus was on jobs; since then employment levels have recovered, but the underlying problems of investment and productivity growth remain. While support for traditional physical infrastructure could help increase employment if it is debt funded, we should not expect it to address the underlying structural problems of low investment and productivity stagnation that face the U.S. economy. Nor will it do much to revitalize the U.S. manufacturing sector, which suffered unprecedented output and job losses in the 2000s.[4] In addition, innovation-based growth seems to have stalled except in software. Filling potholes and repairing sewers will do nothing to address these deeper problems. Restoring an innovation- and investment-led economy depends in part on spurring growth through investments in America's "innovation infrastructure," including scientific and engineering research in the public, academic, and private sectors. As such, any stimulus program needs to focus more on "innovation infrastructure" than on traditional concrete and steel.

Secular Stagnation

As the recovery from the Great Depression inched along throughout the 1930s, the president of the American Economic Association, Alvin Hansen, proposed a new theory to describe this phenomenon: “secular stagnation.” In his 1938 address to the American Economic Association, Hansen described secular stagnation as “sick recoveries which die in their infancy and depressions which feed on themselves and leave a hard and seemingly immovable core of unemployment.”[5] A persistent shortage of investment opportunities ensures growth doesn’t accelerate. Hansen believed there were three outlets for driving investment to break out of the secular stagnation trap: population growth, new natural resources, and technological progress.[6] Within a decade, Hansen’s concern with secular stagnation was shown to be misplaced, as rapid technological progress achieved through federal funding of the war effort drove growth to unprecedented levels.

Since Hansen first proposed the theory, it has regularly resurfaced during serious economic downturns, as in the 1970s, with “stagflation” (high inflation and stagnant growth) and then again following the financial crisis of 2007 to 2009.[7] Economist Lawrence Summers used the term again in the policy debate in 2013.[8]

Lawrence Summers’ Demand-Side Perspective

Not surprisingly, given his Keynesian economic roots, the primary argument Summers put forward on secular stagnation was from a demand-side perspective. In Summers’ view, monetary policy had reached its limits. Given that Summers has never really embraced a theory of long-term growth grounded in innovation—what some term “innovation economics”[9]—the only thing left for him is fiscal policy. And to be sure, when the nominal interest rate is close to zero, central banks have little left with which to stimulate growth.[10]

With “innovation economics” off the table due to a lack of interest and understanding, fiscal policy has emerged as the only option, with government stepping in to increase spending, in this case through public investment. In addressing secular stagnation, Summers lists a number of factors hampering investment demand: decreasing population growth, retention of corporate savings, and an overall lack of “animal spirits.” On the savings side, Summers cites excessive reserve holdings among developing countries seeking to run trade surpluses, post-crisis financial regulations, growing economic inequality (which leads to excess savings by the rich) and increasing banking intermediation costs (the financial return to banks for matching lenders and borrowers).[11] His proposal to counter this litany of problems is fiscal stimulus in the form of physical infrastructure investment. While such spending could spur minimal productivity gains, the appeal for Summers is that it is a straightforward way for government to spend money and create new jobs quickly. Indeed, Summers would rather see the money go to “filling potholes” and other projects that "do not require extensive planning or regulatory approvals, so they can take place quickly.”[12] But these are precisely the physical infrastructure projects that would have the lowest impact on long-term productivity growth.

Robert Gordon's Supply-Side Perspective

Northwestern University economist Robert Gordon, on the other hand, has argued that the problem of secular stagnation lies on the supply side. Essentially Gordon views the problem as decreasing technological innovation: The supply of technological progress is in decline and is affecting growth. Total factor productivity (also termed multifactor productivity) is the most common economic measure of technology's impact on the economy. It is a variable, which accounts for effects in total output growth, related to the growth in traditionally measured inputs of labor and capital. It attempts to measure an economy's long-term technological change or technological dynamism, and therefore its ability to grow. A higher annual rate is generally indicative of new innovations being commercialized and widely used. Between 1948 and 1973, the average annual increase in multifactor productivity was 2.2 percent, but fell to 0.5 percent from 1973 to 1995. The impact of the IT Revolution was notable: Total factor productivity growth increased to about 1.5 percent between 1995 and 2007, but after the Great Recession fell again to 0.4 percent.[13] Gordon's pessimistic view is that the low-hanging fruit of technological innovation has already been picked and we should just consign ourselves to slow growth.[14] The issue hinges on whether Gordon is right about the potential for future innovation—his argument is obviously controversial and for many technologies, such as dramatic transformations now pending in transportation, Gordon simply overlooks their potential impact on the economy.[15] In contrast, a recent International Monetary Fund (IMF) report suggests that there hasn't been a slowdown in technological progress, but rather that efficiency problems arise in the use and implementation of these oncoming technologies.[16] Ultimately, it is very difficult to predict what innovations will make their way to market in the subsequent decades and even more so to estimate their economic impact, but there should be much stronger agreement that technological innovation is a key to growth and that current performance can be improved.

Fiscal Expansion

Whether secular stagnation is caused by insufficient demand, a slowdown in technological progress, or other factors, the question is what is the best way to address and restore robust growth. There are two mainstream policy tools: monetary and fiscal.

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Monetary policy appears to have reached the limits of its effectiveness.[17] While the effective federal funds rate was about 5.25 percent in July 2007, by the first half of December 2008 it had fallen below 0.25 percent.[18] Likewise, on December 31, 2007, the Federal Reserve had $918 billion in assets and $881 billion in liabilities on its books.[19] By May 27, 2009, the Fed's balance sheet more than doubled: The Fed had about $2.1 trillion in assets and about $2 trillion in liabilities.[20] Since 2009 both the Fed's assets and liabilities have more than doubled again.[21] And yet, while necessary, monetary expansion has not been enough.

In this situation, some have turned back to fiscal policy. During the Great Recession, fiscal stimulus reemerged as a policy tool, most notably in the American Recovery and Reinvestment Act of 2009. The revival was short-lived; countries throughout Europe promptly began to implement austerity programs. By 2012, however, the support for austerity was significantly diminished, and even the IMF reversed course in its October edition of *Fiscal Monitor*.[22] However, the United States, through its budget cutting "sequestration" program, began to focus more on budget deficits than stimulus.

It is worthwhile asking if there is any evidence that a fiscal expansion during a period of stagnating growth and high government debt is effective? The crux of the argument centers on the idea of the Keynesian multiplier, that any dollar spent by the government will cycle through the economy, increasing economic output by more than one dollar. While it is not possible to precisely identify the size of the multiplier, there is quite a bit of agreement that the multiplier is positive. Pedro Bom and Jenny Ligthart analyzed 578 different estimates and found, using a meta-regression analysis, that the multiplier is positive[23] An IMF study puts the multiplier around 0.6, during what they term normal times.[24] Olivier Blanchard and Daniel Leigh argue that the fiscal multiplier at the start of the Great Recession was likely significantly above one and that declining multipliers may suggest improvement in the economy.[25] There is a strong reason, based on data, to believe that fiscal stimulus during an economic downturn does not crowd out private investment but leads to growth. One question then is where the United States is currently on this cycle. Any multiplier now is surely considerably lower than it would have been in the depths of the recession. This reality has led many to argue for a productivity-focused stimulus, that not only spurs spending in the short run, but also productivity growth in the longer run. And to do that, many have turned to infrastructure.

Another appeal of government spending-focused fiscal policy is that since the start of the recession, interest rates have remained low. Following the worst of the financial crisis, yields on 10-year Treasury notes increased to 3.85 percent in April 2010; with the onset of the Eurozone crisis, yields on U.S. notes fell, signifying increased demand. Since 2010, demand for U.S. Treasuries has remained strong but yields dropped to 1.6 percent in September 2016.[26] This is in line with the "safe assets shortage" theory; in essence, investors' tolerance for risk falls, making fixed-income securities more appealing. Another indicator of strong demand is that the trade-weighted dollar appreciated by about 21 percent between 2010 and 2015 as well.[27] This combination of a strong dollar and low interest rates is ideal for government borrowing. However, the recent selloff of treasuries, resulting in yields increasing up to 2.29 percent in November 2016, may signify the end of this trend. The government appears to still be in a position, despite its growing entitlement obligations, to make a longer-term investment in national assets that would boost productivity, and hence government revenues in out years.

Infrastructure as the Fiscal Stimulus

Infrastructure spending has become the consensus focus for two reasons. First, as Auerbach, Gale, and Harris find, fiscal policies with the highest multiplier are government purchases of goods and services, and infrastructure spending, compared with tax cuts, which rank sixth out of nine types of spending.[28]

Second, in contrast to spurring consumer spending with tax cuts, infrastructure spending, depending on its focus, will also spur longer term growth. One reason for this is the poor state of U.S. physical infrastructure. The American Society of Civil Engineers (ASCE) gave U.S. infrastructure a grade of D+, arguing that the United States needs $3.6 trillion in investment by 2020.[29] Of course, the ASCE has a vested interest in more infrastructure investment, but even the World Economic Forum ranks U.S. infrastructure behind a number of countries and territories, including Hong Kong, Singapore, and the United Arab Emirates.[30]

Another appeal of infrastructure is that the unemployment rate for people with less than a high school diploma is 7.9 percent, compared with 2.3 percent for college graduates, and infrastructure construction could employ more of the former.[31] Additionally, the labor-force participation rate has been of growing concern. This rate for working age males, 25 to 54, was 91.7 percent in 1994 but fell to 88.7 percent by 2014. This is part of a broader trend: All age groups 55 and over have had increasing workforce participation, while all groups between 16 to 54 have had falling participation.[32] The appeal of infrastructure is that the jobs that are created tend to favor men and generally require less education, which is the same group that appears to be struggling the most.

The Limits of Traditional Infrastructure Spending

Because of the poor conditions and performance of U.S. physical infrastructure, there is a case to be made for spending on infrastructure maintenance.[33] However, the case for economic growth is a weak one. One issue that arises is separating investments in new infrastructure from maintenance of existing infrastructure. A study by Kalyvitis and Vella attempts to fill this gap in the literature. Using 2007 data from the Office of Management and Budget, they calculate the different effects of spending on maintenance by the federal government and state and local governments. They find that federal spending on transportation infrastructure maintenance does not result in multifactor productivity increases and, in some cases, may lead to decreased productivity. However, spending at the state and local level does appear to increase productivity.[34] A later study from Kalyvitis and Vella found that cross-state spillovers have resulted in the underfunding of maintenance and may signal a need for federal aid to states.[35] The conclusion from the limited analysis of maintenance funding is that direct federal expenditure is not likely to have significant productivity benefits.

Some evidence shows that new infrastructure funded by the federal government yields larger productivity gains, but these have declined over time as infrastructure has been built out, and the remaining projects will have less benefit (e.g., rural interstate extensions) or higher costs (e.g., urban freeways). In a meta-analysis of 33 studies, Melo, Graham, and Brage-Ardao found that a 10 percent increase in funding transportation infrastructure only raises output by 0.5 percent.[36] Another study by Chandra and Thompson, covering 24 years, found new interstates in rural areas led to close to no growth in the regional economy.[37] Duranton and Turner's analysis of interstate highways in urban areas found a "10% increase in a city's stock of (interstate) highways causes about a 1.5% increase in its employment over 20 years."[38] Fraumeni estimates that between 1959 and 2005 the average rate of growth of highway gross output was 2.17 percent, and the contribution to growth of highways is small.[39] Infrastructure is vital for any advanced country, but once it is largely built out, additional spending is not a panacea for growth.

We see that with the history of highway spending. As more towns and cities were connected by interstates, we would expect to see economic growth, but after every city is connected, the economic benefits of additional roads and improvements fade. Some evidence shows that the construction of the interstate system under Eisenhower led to significant productivity gains, tied to automotive and truck transport improvements, but as construction continued into the 1960s and 1970s, those gains diminished significantly.[40] The same is likely to hold true for ports, dams, and water and sewage systems. Expansions and repairs are likely only to lead to small productivity gains because the system has largely been built out to meet the market need. This should in no way diminish the necessity of infrastructure investment but only suggests that physical infrastructure funding is unlikely to do much to restore U.S. growth in the medium and long term.

Physical infrastructure funding by itself is unlikely to do much to restore U.S. growth in the medium and long term.

The other major issue that has prompted widespread support for infrastructure is job creation. The Federal Highway Administration, analyzing data from 2007, found that for each $1 billion invested, 27,800 jobs would be supported.[41] As noted earlier, these are likely to be jobs for less educated working-age males, who have been struggling. Perhaps the largest concern about a one-time infrastructure stimulus is that it will provide only short-term jobs. The concern is that the recent decrease in employment is not a post-crisis phenomenon, but an underlying structural problem. The housing bubble provides an example of a temporary fix. Construction employment increased from a low in 1993 of around 4.6 million to 7.7 million at the start of 2007.[42] Charles, Hurst, and Notowidigdo have argued that this increase in construction employment hid the decline of manufacturing in the 2000s, masking the underlying problem.[43] So, much like construction jobs during a housing bubble, traditional infrastructure spending does little to address the underlying structural problem in the U.S. economy, including in manufacturing and other areas where innovation is needed.

Investing in Innovation Infrastructure

If the structural problems the U.S. economy faces concern issues of innovation underinvestment and lagging productivity growth, are there other areas of public investment that might be more effective? Shouldn't we consider investment in kinds of "infrastructure" that could be linked to innovations that would enable technological advance and therefore higher productivity and growth levels? This kind of "new" infrastructure, tied to a basic factor in growth—innovation—potentially could create a much higher economic yield than more traditional infrastructure.

Increasing Research Funding

Another promising area is investment in research and development as part of the new "innovation infrastructure." Full employment is not a sufficient condition for long-term growth; technological and related innovation is now accepted as the critical factor in economic growth. Since Robert Solow's 1957 paper "Technical Change and the Aggregate Production Function," there is a widely shared understanding in economics on innovation's vital role for growth. As was noted earlier, since 1973, multifactor productivity, which approximates innovation, has fallen, except during the IT boom during the 1990s. It is difficult to overstate the U.S. government's role in supporting the IT Revolution in the decades following World War II; government R&D support was behind nearly all of the foundational technology advances that led to the IT innovation wave.[44]

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Studies of patents resulting from research sponsored by the National Institutes of Health (NIH) indicate that, overall, a dollar invested in research funding results in approximately two dollars in follow-on economic activity, an impressive yield.[45] However, when a scientific advance starts to scale into a societal technology advance, the returns can be far higher. One study estimated that the $14.5 billion spent on the Human Genome Project translated, between 1998 and 2012, into over $1 trillion in cumulative economic impacts, and more than 4 million job-years of employment.[46] This study did not even attempt to include the economic benefits and cost savings from improved health that genomics is now starting to yield. The major technology advances in our society derived from basic research advances in recent decades include: in information technology, the search engine, GPS, supercomputing, speech recognition software, assistive robotics, the Internet, and the core technologies behind the smartphone; in energy, the shale gas revolution, seismic imaging, battery advances, and LED lighting; in health, MRIs, advanced prosthetics, and AIDs advances, to name only a few in just three fields.[47] Funding of basic research by the National Science Foundation (NSF), the Department of Defense (DOD), and NIH had spillovers leading to hundreds of thousands of jobs in companies such as Google, Sun Microsystems, Pfizer, and Cisco. The economic impact from federal support for basic research is so extensive that it is impossible to fully quantify. [48]

There are many ways the government can support nascent technologies: certainly, through the funding of university science and engineering, but also through initial procurement for advanced technologies, as DOD has long done effectively.[49]

However, federal R&D investment is in decline. The level of a society's investment in innovation is indicated by "R&D intensity," the ratio of R&D to GDP; it is the key benchmark for comparing national innovation systems. The federal commitment to R&D—its R&D intensity—has slipped from a high point of 1.8 percent in the 1960s by over half, to 0.78 percent in 2014.[50] From 1973 until today, federal support for research and development has fallen from 6.9 percent of government spending to just 3.4 percent in 2016.[51]

While industry is keeping up its support of development, the federal government is the predominant funder of basic and applied research; federal investment in basic and applied research—the foundational stages of research, on which all the rest depends—is shrinking, both in absolute terms and as a percentage of GDP.[52] Between 2010 and 2014, federal spending on research and development of all kinds decreased an inflation-adjusted 17 percent.[53] As a result, federally funded R&D has now declined to its lowest point as a share of GDP since record-keeping began in 1953. Alvin Hansen's underlying argument about addressing "secular stagnation" is that as population growth slows, other sources of investment are needed to maintain economic growth, primarily technology. Any stimulus that will help long-term growth, not just short term, needs to make provisions for innovation investment—and R&D is at the core of innovation investment: It represents new infrastructure.

Increasing Advanced-Technology Development Funding

There are a wide range of investments that have the potential to substantially impact the U.S. economy. To cite one example, exascale computing is the next step forward in supercomputing. This is critical to the emerging field of big data and analytics, which will undergird future advances in fields from health to manufacturing. The United States faces stiff competition from China, which currently has the two fastest supercomputers in the world.[54] The applications for exascale computing are numerous, from weather to multiscale modeling of materials to artificial intelligence to epidemiology to genetic data analysis. Current high-performance computers are unable to meet the requirements for this type of analysis.[55] The administration's FY2017 budget request for the National Strategic Computing Initiative called for $285 million for the Department of Energy (DOE) and $33 million for NSF; this would be an increase of more than $32 million.[56] Computing has proven to be a general-purpose technology, suggesting that a new generation of supercomputers could have a widespread impact on productivity.[57]

There are numerous other examples where support for this kind of advanced-technology "new infrastructure" could yield significant gains, including brain and precision-medicine initiatives, the "materials genome" project, robotics, quantum computing, advanced batteries, modular and inherently safer nuclear reactors, thin-film solar technologies, and nanotechnology. For example, ITIF has estimated that spurring biopharmaceutical innovation to understand and cure brain diseases and disorders could increase U.S. GDP by $1.5 trillion or more.[58] New technologies like these and others have the potential to raise productivity across the country in sectors ranging from manufacturing and construction to higher education and even government.[59]

Infrastructure for Scientific Research

A third major area for investment is research infrastructure. An important program at NSF is the major research instrumentation program (MRI). The aim of the program is to make major scientific and engineering instruments available to universities but also museums, science centers, and research organization. The cost of this type of instrumentation generally falls outside the range that most research organizations can afford, generally ranging from $100,000 to $4 million. Cost-sharing from research universities is 30 percent. Without NSF's program, access to major instrumentation is curtailed for millions of students and researchers, limiting both current and future innovation. Yet, the program is significantly oversubscribed, and a doubling of the program to $400 million per year would undoubtedly be money well spent.

"Smart" Infrastructure

As the Information Technology and Innovation Foundation (ITIF) has written, smart infrastructure is likely to have bigger productivity payoffs than simply pouring more concrete or laying pipe.[60] This new "hybrid infrastructure," which integrates both physical and digital aspects, moving IT technology advances into traditional infrastructure to significantly improve its performance, is important to delivering the next wave of innovation and economic growth. For example, water mains embedded with Internet-connected sensors can detect and transmit information on leaks. Smart traffic lights that sense ebbs and flows and adjust accordingly can reduce travel time in cities by 25 percent. Overall, studies find that investments in IT-enabled infrastructure can have 60 percent greater productivity impacts than investments in roads alone. One reason these investments are likely to have a larger payoff is because, just like the initial investments in the interstate system where the big benefits were from the creation of a network, rather than construction of individual links, making physical infrastructure smart will enable similar network effects, enabling smart vehicles, smart logistics, and other related improvements.

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Support for Pre-Competitive Cooperative Advanced-Manufacturing Research Institutes

Advanced and "smart" manufacturing is particularly interesting in this "new infrastructure" context because it addresses both the need for greater capital investment and productivity levels, but also the social disruption that stemmed in significant part from manufacturing's employment decline in the decade of the 2000s.[61] This is not to say it's possible for the country to return to the level of manufacturing employment in 1979 of 19.5 million, but it is possible to reduce trade deficits in manufacturing. If the United States reduced its 2015 trade deficit of $745 billion in goods by $200 billion, the Economic Policy Institute has estimated that 2.3 million jobs could be created.[62] And these jobs would not just be shop-floor production jobs, but in the value chains of firms spread through the hourglass that provide inputs (from resources to components to R&D) and outputs (from distribution to retail to product life-cycle support).[63]

A substantial investment in advanced-manufacturing institutes focusing on such areas as advanced materials (including lightweight metals and composites), 3D printing, "smart" manufacturing (including new controls and sensors throughout the production process), power electronics, photonics, and revolutionary fibers, offers an opportunity to directly address the underlying trends driving low productivity levels and working-class unemployment. It will not be a short-term stimulus—there is implementation time required. In addition, unlike a traditional infrastructure approach discussed above, which is not tied to a technology-driven new innovation wave that can significantly grow the economy, advanced manufacturing is by design tied to a major set of technology advances that can scale into the economy. The past manufacturing technology advances that led to mass production and quality manufacturing innovation waves illustrate this. By tying support for the infrastructure around advanced manufacturing to what could be technology advances of significant impact we get a "two-fer" of economic gains—new productive infrastructure, plus technology innovation—so the potential productivity gains could be significant.

This process began in 2012 with the announcement of America Makes, the National Additive Manufacturing Institute. Since then, a total of 15 existing and planned Manufacturing USA institutes have created consortia of large and small manufacturers, two- and four-year colleges and universities for research and workforce education, as well as government-funded R&D, in order to provide concrete paths for manufacturing-technology advances as well as for workers in the value chains of firms that manufacturing enables. The institutes are granted a federal award for a five-year period or an annual federal budget of about $225 million across the institutes. R&D for advanced-technology development, shared testing facilities for new technologies, and workforce education support at these collaborative, pre-competitive private-public institutes could be significantly increased beyond a five-year period, as well as expanding the number of institutes to meet the country's needs.

Support for advanced manufacturing is not a traditional infrastructure "public good" approach. Manufacturing infrastructure is held by the private sector. Economists have long cautioned against "industrial policy" as an inefficient governmental intervention in the marketplace.[64] However, the new advanced-manufacturing institutes are designed so that they will be industry-, not government-led, including major industry cost-sharing (which typically significantly exceeds the federal match), with the federal government itself contributing traditional "public goods" through its historic R&D and education roles, both long recognized in economics as necessary because of market failures.

Conclusion

One key reason Donald Trump was elected president is because he stressed the importance of growth and getting the U.S. economy out of its structural stagnation, low-growth rut. We believe that such a goal is not only desirable, but possible to achieve. But if the major policy tool is spending money to repair roads, bridges, and water pipes, robust growth will not be restored. To do that requires much more innovation and the private sector investment that comes when companies want to significantly ramp up their investment because the new products and tools are sensible investments. And that will not happen at the pace we need without significant increases in investment in innovation infrastructure. Making expansion of "innovation infrastructure"—the new infrastructure around such areas as R&D investment, advanced-technology development, scientific infrastructure, and advanced manufacturing—needs to play a key role in any Trump administration policy attacking the structural problems of low productivity and investment, which in turn affect GDP growth and quality job creation.

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ACKNOWLEDGMENTS

The author wishes to thank the following individuals for providing input to this report: William B. Bonvillian. Any errors or omissions are the author's alone.

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