Why the U.S. Needs A New, Tech-Driven Growth Strategy

BY GREGORY TASSEY | FEBRUARY 2016

America needs an investment strategy designed to increase long-term productivity growth. This is the only way to achieve steady increases in the standard of living.

The most important impact of an economic growth policy is the long-term increase in workers' incomes. Achieving this requires an investment-driven process targeting several critical categories of economic assets that drive productivity growth and thereby wages. Unfortunately, what passes for U.S. growth policy is far from investment oriented. Instead, policymakers rely almost exclusively and myopically on macro stabilization tools, especially monetary policy, in large part because they continue to rely on simplistic and incomplete economic models that misrepresent modern technology-based growth. The result has been slow growth in real incomes since globalization has greatly increased worldwide competitiveness. America needs a four-point investment strategy designed to increase long-term productivity growth. This is the only way to achieve steady increases in the standard of living.

In spite of the United States' historically large application of monetary policy since the Great Recession in the form of unprecedented purchases of U.S. Treasury and mortgage-backed securities, coupled with interest rates near zero, acceptable rates of economic growth have not resumed. These gargantuan efforts have done nothing to boost productivity and little to increase real incomes for most Americans. Moreover, employment growth in the 36 months following the trough of the Great Recession has been the slowest of the 11 post-World War II recession recoveries.[1]

The major reason for such poor economic results is government's excessive and single-minded reliance by government on monetary policies. Americans have a near collective obsession with the day-to-day actions of the Federal Reserve Bank; however, its role is

limited and simple: stabilizing the business cycle and ensuring that actual growth is not too far from real growth potential. While providing a more stable general economic environment can have a positive effect on short-term investment and consumption, monetary and, in certain ways, fiscal stabilization tools cannot change long-term rates of economic growth—arguments by both liberals and conservatives to the contrary. In an intensely competitive global economy, sustained high rates of productivity and income growth require persistent investment, specifically in areas that drive productivity advances. In fact, virtually all U.S. economic growth problems can be traced to secular underinvestment in the four major categories of economic assets:

- Technology: the long-term driver of productivity growth;
- Physical and digital capital: in particular, hardware and software that embody most new technology and thereby enable its productive use;
- Human capital: skilled labor capable of using the new hardware and software and associated techniques; and
- Domestic industry structure and supporting technical and institutional infrastructure: necessary to efficiently develop and use modern complex technology systems.

The first category, technology, is the basis for long-term productivity growth, and the other three enable its development and delivery to markets where the resulting productivity advances have their impact on income growth. Unfortunately, multiple barriers within the U.S. economy prevent adequate rates of investment in these four asset categories; in fact, in a number of ways, U.S. policy harms, rather than enables, increases in investment in these four areas. It is time for economists and policymakers to recognize that America needs a new economic growth strategy, grounded not in fiscal and monetary policy, but in policies explicitly focused on spurring technological innovation.

U.S. ECONOMIC TRENDS

The McKinsey Global Institute estimates that declining U.S. population growth will require an 80 percent increase in the rate of productivity growth over the next 50 years to enable the same average rate of GDP growth of the past 50 years.[2] Here, the United States faces major challenges. A 2014 Bureau of Labor Statistics (BLS) study of postwar trends in labor productivity in the business sector found that the annualized rate of increase from 1947 to 1973 was 3.2 percent. But from 2008 to 2014, the growth was just 1.6 percent.[3]

Moreover, multifactor productivity (MFP)—a measure of the combined productivity of both labor and capital—has fallen from an average annual rate of 1.6 percent during the previous decade (1997–2007), a period of significant investment in information technology, to just 0.5 percent per year since the end of the recession. The flattening of MFP growth since 2007 is reflective of a poor rate of "private fixed investment" (plant, equipment, and software) through which most technology is utilized in economic activity.

The United States faces growing competitive challenges, which, in response, require greater productivity and income growth. U.S. competitiveness has been declining since the advent of meaningful globalization in the 1980s. Once the dominant technology-based economy

with significant trade surpluses and rising incomes, the U.S. has fallen behind, with a negative trade balance for the manufacturing sector since 1975. As Fig. 1 clearly shows, that trend has become increasingly pronounced—at least for manufacturing. Even the "advanced technology products" portion of manufacturing has been increasingly negative since 2002.

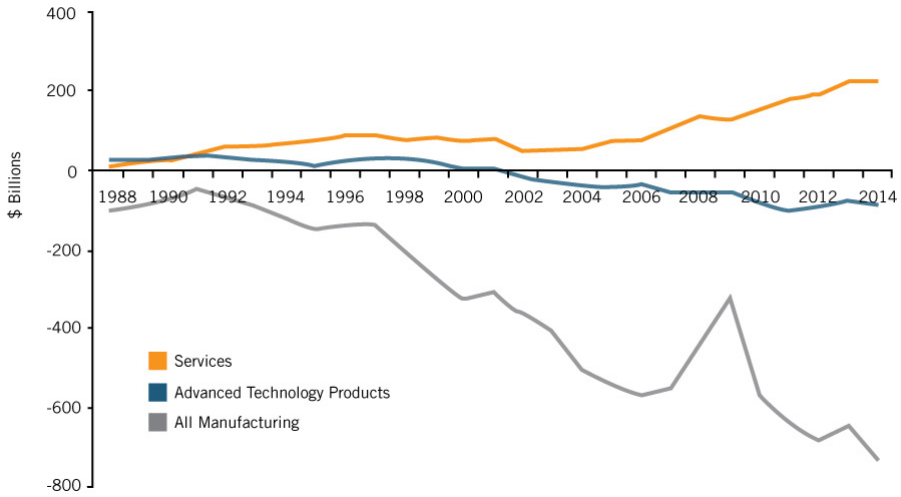

Figure 1: Trends in U.S. Trade Balances by Major Sector, 1988-2014[4]

This is why the U.S. economy is not growing, as measured by workers' real wages. Domestic industries still produce new technologies and employ skilled workers, but the quantity of new technology and the number of skilled workers are too small a share of the total economy. The remaining workers are still adjusting to the fact that they are underskilled for the wages and salaries paid. The resulting global labor wage arbitrage has been underway since the 1980s as the rest of the world's economies are increasing their technology development and utilization, while still paying their workers less than the wages for comparable jobs in the United States.

The U.S. economy still accounts for 30 percent of global R&D. However, this means that more than twice as much R&D is now being spent by the rest of the world. Having achieved a high standard of living through investment in technology and the resulting productivity growth, the growing global competition has brought such growth in this country to a crawl. And, while 30 percent is still a significant share, it is only slightly larger than the U.S. share of world GDP (26 percent, which is about the same as Europe's and Asia's shares).

Moreover, despite rhetoric extolling a renaissance in U.S. manufacturing, the "recovery" in manufacturing employment since the end of the Great Recession is more a business cycle phenomenon than a renaissance in the intrinsic competitiveness (productivity) of domestic industries. In fact, the modest growth in employment does not come close to redressing the massive declines in domestic manufacturing jobs that occurred in the decade during and

prior to the recession. Growth in real value added by the manufacturing sector since the end of the recession has been nonexistent. It is true that efforts to improve manufacturing productivity have resulted in some previously offshored jobs being repatriated. But the level of repatriation has been underwhelming.

These trends are part of a process whereby other nations have aggressively focused on increasing their technology-based global competitiveness. For example, in the past 15 years, Chinese exports have grown by a factor of 10, and high-tech exports now account for about one-third of the total.[5] Such trends have created severe pressures on economic growth and incomes in leading industrialized nations across all sectors, including technology-based industries. For those who hold out hope that a convergence of domestic cost structures will be a panacea, it's important to note that as foreign costs rise, developing nations are investing ever more aggressively in productivity growth. Asian economies, which once relied on lower labor costs, are now investing aggressively in product R&D high-productivity process technologies, such as robots. So as their labor costs rise, so do their productivity rates. The critical point is that producing high rates of growth in incomes requires increased productivity by the majority of the domestic labor force.

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THE U.S. COMPETITIVENESS POLICY PROBLEM

Confronted with the increased pace of globalization, U.S. economic policy thinking, with its obsessive and narrow focus on macroeconomic stabilization models, has not caught up with the dramatic increases in the rate, scope, and especially the complexity of technological change occurring on a worldwide basis. Instead, a significant number of conservatives still argue that the marketplace will take care of increasing productivity through investments that respond to the price mechanism, while most liberals assume the productivity engine is on autopilot and the only role for government is to reengineer fairer income distributions. One side advocates for a federal government more fitting to the pre-WWII era, while the other refuses to accept that the postwar, Great Society welfare state is not sustainable. Both ignore and reject government's enterprise-supporting investment function.

And both liberals and conservatives see business-cycle management as the main way the government affects economic policy: through fiscal policy for most Democrats, and monetary policy for most Republicans. Indeed, the nation hangs on every word of the Federal Reserve Chair, believing that her actions actually have a meaningful impact on long-term growth. When the very health of the U.S. economy hinges on whether consumers binge on gifts on Black Friday or whether Fed chair Janet Yellen raises interest rates a quarter point, it is clear something is amiss.

Accommodative monetary policy can provide a modest short-term stimulus by lowering interest rates, but the required size and composition of investment in the assets needed for sustained productivity growth is beyond its reach. Basically, investment in new technologies has too long a time horizon and too much technical and market risk to be spurred by modestly lower interest rates on loans. The required investment stretches out over many years and exhibits risk and capture profiles that are beyond the capacity of low

interest rates or the private sector acting alone to address, the latter because of the presence of significant market failures that retard private investment.[6]

The bottom line is that across the political spectrum most influential thinkers largely fail to grasp the investment-growth nexus of needed new policy thrusts. Some, such as economist Paul Krugman, argue that the impact of technology may simply not be as great as we think. Incredibly, he states that "the whole digital era, spanning more than four decades, is looking like a disappointment. New technologies have yielded great headlines, but modest economic results."[7]

Radically new technologies affect productivity and the economy with a lag. This fact contributed to the skeptical or even negative views of information technology's impact 25 years ago when IT was in its infancy. For example, Robert Solow famously quipped in 1987 that "You can see the computer age everywhere but in the productivity statistics." Similar and even more detailed concerns were expressed six years later in 1993 by Eric Brynjolfsson.[8]

Today, this technology's mammoth impact on every aspect of society should be obvious, which leaves one incredulous at statements such as Krugman's. Current detractors seem oblivious to the many economic studies over several decades that demonstrate the dominant role of technology in driving productivity and output growth. U.S. Bureau of Labor Statistics data show that in the decade between 1997 and 2007, U.S. labor productivity grew at an average annual rate of 3.2 percent—faster than any other industrialized nation.[9] This was the payoff for the previous decades of information and computer technology (ICT) R&D spending.

But, then, fixed private investment (hardware and software) declined precipitously in the 2000s, and therefore so did productivity growth. Between 2007 and 2014, the average annual growth rate dropped to 1.7 percent—less than half the growth rate of the "IT decade," a clear illustration of the need for growth policies that encompass all four asset categories.

In fact, virtually all technologies driving the world's economy today had their origins in U.S. government funding, not only for the underlying basic science but the early phases of technology development as well.[10] Even a cursory survey of world's economy shows increasing and successful government-industry cooperation in the development and deployment of new technologies. Yet some, including a few in innovation hot spots such as Silicon Valley, argue that federal R&D funding is no longer a useful policy tool. The British libertarian writer, Matt Ridley, asserts that government funding is actually detrimental to innovation.[11]

More broadly, the lack of understanding by U.S. policymakers of the critical importance of investments in productivity growth is evidenced by a failure to provide policy-analysis expertise to inform decisionmakers. The Federal Reserve Bank employs a very large number of economists to analyze reams of data in order to manage monetary policy and predict when to raise or lower interest rates, but neither they nor any other part of the federal government has institutionalized innovation policy analysis capability.

This situation leads to errors in managing a wide range of innovation-policy indicators and tools. For example, the media only rarely report summary productivity trends, and when they do it is with almost no analysis of these trends. They also only report labor productivity, not "multifactor productivity," which measures the combined impact of labor and capital on output. The latter metric more accurately represents the way the economy actually works but seems beyond our collective capacity to understand.

It is easy for U.S. economic thought leaders to ignore structural factors because they subscribe to conventional trade theory, which holds that the scope of competitiveness for a particular economy will be determined by the law of comparative advantage. This theory largely assumes the existence of relatively fixed sets of assets across the world's economies. The single most important adjustment that is needed to this theory is an explicit recognition of the fact that in today's technology-based global economy, most comparative advantages are created through enlightened growth policies.

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In larger economies, a sensible long-term productivity growth strategy would encompass both product and process innovation applied to a large number of industries. Doing so would promote competitiveness over the entire technology lifecycle, thereby maximizing and perpetuating domestic economic gains. The implication is the need for a comprehensive growth policy that relies on sustained investment over time in the four asset categories. This is not happening.

Indeed, as a nation, America does not seem capable of having an intelligent conversation about productivity growth and its sources. A large number on both sides of the political aisle cling to the historical and inaccurate fear that increasing productivity through automation will eliminate jobs, and they therefore oppose new growth policies that support process technology development.

The exact opposite is the case. Automation lowers the cost of producing existing products. If cost-reducing investments in automation are not made in U.S. traded sectors, the entire industry will lose global market share, which will reduce employment. In contrast, the cost-reducing impact of automation allows domestic companies in these industries to lower prices and take market share from foreign competitors. The resulting expansion in domestic output creates additional jobs and thereby counteracts the negative effect on employment of the reduction in labor content per unit of output. Thus, automation actually preserves some jobs in traded industries.

As the U.S. Bureau of Labor Statistics has shown, companies that increase productivity either raise wages or cut prices, both of which lead to additional spending by their workers and customers. Historically, that has always been the dynamic. In the 19th century, almost one-half of total employment in the U.S. economy was in agriculture; in 1950, the sector's share was 13 percent; today, it is about 2 percent. Yet, over this extended period, millions of new higher paying jobs have been created in manufacturing and service industries to replace those lost to automation in agriculture. Further, as food prices have dropped, the savings are spent on other things.

THE WRONG POLICY TOOLS AND TARGETS

Six years after the Great Recession ended, the U.S. economy has recovered to a greater extent than other industrialized nations, due largely to a huge stimulus from fiscal and monetary policy. In this context, much is made of the Fed's "dual mandate": control inflation and promote full employment. But, even the Fed's own economists doubt monetary policy's ability to affect employment growth. The reality is that it cannot do so for any significant length of time, at least without creating distortions that ultimately have negative effects on growth.[12] Most important, what it really has no control over is the relative wages and salaries of American workers. As Jim Grant, editor of *Grant's Interest Rate Observer*, put it, "The Federal Reserve can change how things look but not how they are."[13]

Conventional fiscal policy is equally constrained. In an economy with underutilization of factors of production, aggressive fiscal spending can make sense as a business-cycle tool. But running budget deficits for a long time is unsustainable and, unless directed at growth targets, deficits can't drive growth.

Unfortunately, from a policy perspective, the vast majority of national discussions characterize government spending and tax cuts in the aggregate, in effect as part of the business-cycle stabilization debate. Liberals argue for more spending to help the economy by stimulating aggregate demand; conservatives insist on tax cuts and smaller government to avoid "crowding out" and, in general, free the private sector to achieve allocative efficiency.

Critical for economic growth objectives is the fact that, in contrast to monetary policy, fiscal policy instruments (spending and taxation) can have a long-term growth component—if government spending or tax incentives are directed toward investment in productivity-enhancing assets. For example, government funding for the early development of a range of new technologies drove productivity in the first three decades after World War II. But steadily expanding global investment in R&D and subsequent increased innovation capabilities in other economies have resulted in higher rates of productivity growth outside the United States and hence more competition for shares of higher value-added global markets. Likewise, tax policies such as the investment tax credit and the R&D tax credit historically have spurred productivity-driving investments. Here, too, the United States was the first to implement a tax incentive for R&D, but it now has one of the weaker ones—27th out of 42 industrialized nations, according to a 2012 Information Technology and Innovation Foundation (ITIF) report, and Congress eliminated the investment tax credit in 1986.[14]

In the face of the most serious global recession since the Great Depression, the United States made only a modest and short-lived attempt to use fiscal policy as a true economic growth instrument. The "centerpiece" of this limited fiscal stimulation was the American Recovery and Reinvestment Act (ARRA) of 2009, funded at $787 billion. While ARRA was certainly a major stimulus program, only a modest share of the total funding was directed at investment. Specifically, $105.3 billion was allocated to traditional economic infrastructure projects (highways, bridges, public transportation, etc.). An additional $48.7

billion was directed at energy infrastructure and energy efficiency, including a small amount for energy research and manufacturing scale-up; and $19.2 billion was allocated to support scientific research, including $5.9 billion given to universities. Thus, ARRA was an aggressive short-term fiscal stimulus strategy with at best a modest investment component. But there was no follow through.

Unfortunately, U.S. policymakers have not recognized the fundamental characteristic of long-term investment in technological change—its public-private character. One side wants to get rid of "big government"—whatever that means. The other wants to rein in "big business"—whatever that means. Such inconsistent and poorly conceived growth policies exemplify the central problem, which is that the poor economic growth performance by the U.S. economy over the past 15 years is due to one overarching policy error: failure to adapt to globalization. The bottom-line reason is that, although the U.S. economy continues to develop new technologies, the rest of the world is rapidly acquiring the same capability. These other economies are increasingly both developing new technology and combining existing technologies with lower cost labor or more productive production processes to take market shares from U.S. industries. They are using new policy tools and more aggressively applying existing ones.

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Supporters of traditional economic philosophies point to the success of the U.S. economy for several decades after World War II and argue that the private sector was the dominant engine of growth. While a true statement, it is also a fact that virtually every major technology driving global economic growth originated in the United States over the post-War period. The initial driver was actually fiscal policy in the form of R&D support for "public missions" such as defense, space exploration, clean and efficient energy, health, etc. Unfortunately, most federal R&D spending and continues to be on R&D that supports these "mission" agencies. When the United States had little competition for technology-based markets from the rest of the world's economies, there was enough time for spinoffs from mission agency R&D to seep—in an unstructured and piecemeal way—into the broader domestic economy, eventually starting new industries (electronics, advanced materials, network communications, etc.) that have been the major sources of productivity growth for decades.

The persistence of this "growth policy" framework is an example of how intransigent existing growth philosophies can be, constrained as they are by past investment practices and behavior. The investment component is the victim of an "installed base" effect, which is especially pronounced for high-performance economies whose past high rates of growth were built on a range of investments in a set of technologies, related capital and labor assets, and infrastructures that supported their development and use. The combination of past success and the substantial cost of retiring obsolete existing assets breeds resistance to change.

Most macroeconomists, who populate most U.S. economic policy advisory positions, have argued since the last recession that the growth problem is primarily one of inadequate demand, ignoring the fact that much of existing economic asset structures (public and private) are obsolete to varying degrees. It's as if, in their model of the economy as a steam

boiler, there are rapidly decaying pistons, but the only thing they can do is keep the valve closed (low interest rates) even longer to futilely try to build up needed pressure.

Associated with the installed-base effect is the "installed-wisdom" effect, under which learned behavior associated with past investment decision-making and managing of resulting investments becomes entrenched. The success of the entrepreneurial culture and the emphasis on competition among firms as a necessary and sufficient method for achieving allocative efficiency have acted as barriers to the needed new forms of public-private cooperation in a number of areas where the public-good content of various economic assets has grown.

This private-sector only philosophy, derived from simpler economic times, continues to block changes in the growth strategies needed to achieve adaptive efficiency—the structural and behavioral changes that enable sustained productivity growth over time in response to the dynamics of global competition.[15] The "apostles of denial" find numerous ways to avoid dealing with the productivity issue. Some have declared victory, based on the recession's end and the ensuing modest growth. Others continue to recommend additional monetary and/or fiscal stimulus. Still others on the left decry productivity growth (specifically, automation) for its supposed disruptive impact on workers.

Yet another group contends that removing our trade deficit will go a long way toward restoring adequate domestic output. It is true that the global economy is replete with exchange rate manipulation, tariffs, intellectual property theft, and non-tariff barriers, such as arbitrary restrictions on specific designs through domestic content laws. Removing these distortions would certainly go a long way to restoring U.S. growth, but they would not be enough. An economy still has to have competitive products and services to sell in global markets.

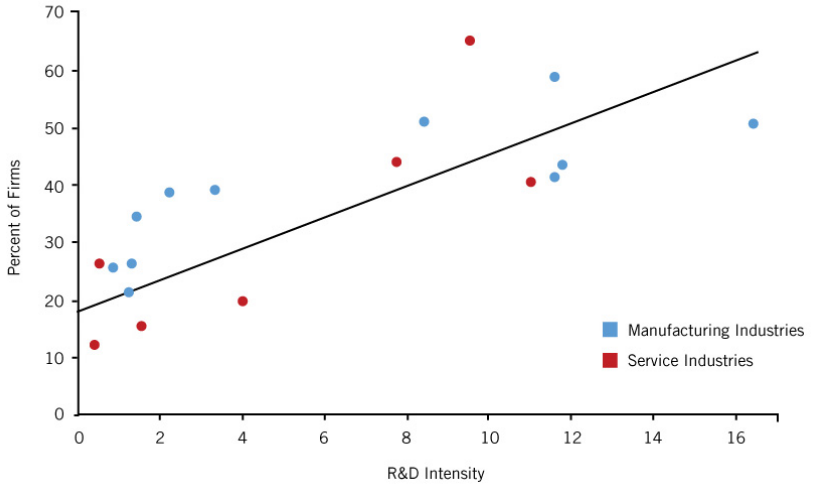

Figure 2: The Payoff from Private R&D Investment: Percent of Firms in Manufacturing and Service Industries Reporting Innovations Relative to R&D Intensity[16]

Over time, competitive products come from investment in R&D, which produces the innovations that leverage productivity growth. A little over a decade ago, the National Science Foundation (NSF) began to collect data on company innovation rates. Using these data, Fig. 2 shows a strong correlation between R&D intensity (industry R&D as a percent of net sales) and the rate of innovation. This impact is seen in both manufacturing and services.

But over the last decade there has been a sustained attack on the very notion that firms in R&D-intensive industries should make enough profits to reinvest in risky R&D to develop next generation products. Indeed, liberal politicians have proposed copying other nations by imposing stringent price controls on drugs. This advice focuses on short-term consumer welfare rather than long-term productivity and innovation stemming from adequate revenues that can be reinvested in innovation.

While increased R&D and capital investment intensity is necessary, they are not enough. Companies that compete against each other in established markets increasingly need to cooperate in early-phase R&D and with universities and government laboratories in order to advance new technologies to the point at which decisions can be made about private-sector investment in the considerable cost of developing specific market applications (innovations). Many Asian and especially European economies are ahead of us in implementing growth strategies that bring public and private groups together by applying so-called "innovation-cluster" or "innovation-sector" models. Such research infrastructure must be applied to as many emerging technologies as necessary to expand the domestic technology-based economy and thereby raise overall productivity growth.

The victims of out-of-date or at least incomplete U.S. economic growth philosophies have been government policies supporting the emerging global public-private asset investment model.

The victims of out-of-date or at least incomplete U.S. economic growth philosophies have been government policies supporting the emerging global public-private asset investment model (the asset categories listed at the beginning of this discussion). When the United States dominated the high-income portion of the world's economy, speed and overall efficiency in the development and utilization of new technologies were not critical. Growth policies focused almost entirely on stabilizing the business cycle to enable an environment conducive to private investment. This implementation of neoclassical economics was based on the premise that under conditions of a stable economic environment (damped swings in the business cycle and sufficient competition), private markets would allocate resources efficiently in response to relative prices. Government's sole responsibility with respect to economic growth policy, therefore, was to ensure the allocative efficiency of the marketplace by maintaining a competitive industry structure and muted business cycles. But when policies in other nations enable foreign companies to gain a first-mover advantage, no amount of U.S. consumer demand will enable competitive advantage.

Finally, the focus of what meager policy analysis has been undertaken to understand issues and formulate accurate policy options has been largely on manufacturing. This sector is clearly more important than its 12 percent share of GDP, as it funds and conducts a disproportionately large share of industry R&D, creates a large number of supporting services jobs, and enables co-location synergies with the much larger service sector (increasingly important, given the latter's growing dependency on technology). It is also

true that the "knowledge-intensive" (KI) service industries are much larger than the "high-technology" (HT) manufacturing industries and will continue to grow at a faster rate.

INNOVATION-BASED PRODUCTIVITY POLICY

As stated above, productivity is advanced by investment in a set of four asset categories. For a successful growth policy, each of these categories of the "public-private technology growth model" requires accurate characterization of underinvestment phenomena and selection of appropriate policy support mechanisms:

Technology

The most important reason for more and the right kind of federal R&D spending is that investments in (1) technology, especially in its early phases of development, and (2) supporting technical infrastructure ("infratechnologies" and associated standards) have significant degrees of public content.

Early-phase technology research is designed to prove technological concepts, often referred to as technology platforms. Although critical for the efficiency of subsequent applied R&D, such concepts are a long way from achieving commercially viable products and services. Companies therefore apply a large time-discounting factor to this research, making it less likely that they invest in it. Further, such proof-of-concept technology research exhibits significant spillovers, meaning companies don't get anywhere near all the intellectual property benefits from their investments. Finally, the resulting technology platforms exhibit significant economies of scope with respect to potential markets, the set of which is usually broader than the strategic scope of even large firms. The combined impact of these market failures is inadequate expected rates of return on private investment and therefore substantial underinvestment by the private sector. And with the increasing pressure from equity markets for short-term returns, this underinvestment is even more severe today.

A major explanation for such underinvestment is the degree and nature of the public-good character of each class of technology assets. This fact explains why industrialized nations promote various forms of cooperative research to pool risk, capture economies of scope, and speed up access to technological advances. Co-location of entire supply chains has become essential, especially for emerging advanced technologies, as suppliers and customers must be closely involved with each other in the development and commercialization of individual components and ultimately their integration into the final product technology system.

Similarly, infratechnologies, consisting of measurement and test methods, science and engineering data, and the technical specifications for the physical and especially the functional interfaces between components of modern technology systems become the basis for industry standards and therefore similarly exhibit public-good infrastructure characteristics. For example, in the modern technology system, a large number of hardware and software components must work seamlessly together; that is, functional interfaces must be developed and in put in place. Further, commonly accepted test methods for monitoring and adjusting manufacturing processes (e.g., sensors specifications and equipment calibration standards) must be available to enable quality and process control.

Finally, executing market transactions requires product acceptance test standards to reduce transaction costs and thereby lower the effective price of a new product. These multiple functions constitute a ubiquitous role for standards. For example, the semiconductor industry has over 1,000 standards associated with the above functions, without which that industry could not function.

The expanding technology-based global economy and the increasing complexity of emerging technologies require government roles at both the federal and state levels to increase the efficiency of the development and deployment of new technologies. In effect, governments around the world now compete against each other as much as do their domestic industries, as they attempt to apply this emerging public-private asset model of economic growth. Under such a model, governments and groups of firms are increasingly co-funding the early phases of a technology's development and the research that provides the range of technical infrastructures needed by high-tech industries. How efficiently they do this will greatly influence their economies' overall competitiveness.

Without systematic and substantive government support for corporate investment, companies yield to the pressures from Wall Street to deliver short-term benefits.

In terms of specific indicators of policy adequacy, the R&D intensity of an economy indicates the relative amount of an economy's output of goods and services that are being invested in technology development for future competition. From the 1980s, when the competitive effects of globalization first became apparent, until about 10 years ago, total U.S. national R&D intensity (government and business R&D spending divided by GDP) remained flat, averaging about 2.6 percent. Since 2006, this indicator has risen modestly to about 2.8 percent. Other economies have increased their R&D intensities faster, so that the U.S. ranking has continued to slip to its current 9th place among industrialized nations.

With respect to the federal government's critical role in funding emerging technology development, its spending on R&D exploded in the 1950s and 1960s due to dramatic increases in the areas of aeronautics (defense and space exploration) and a general realization that much more science was needed for the society of the future. But the federal government's share of national R&D then declined 47 percent between 1970 and 2014. The critical nondefense portion declined by exactly the same percentage. More recently, and therefore more alarming, federal R&D budget authority has declined 16 percent in real terms between 2010 and 2015. Most of this decline was in defense spending (which has considerable spillovers into civilian technology development), but nondefense federal budget authority also declined by 2.8 percent in real terms over this period.

Such investment is absolutely essential to leverage productivity growth in the U.S. economy. The long-term decline in federal R&D funding intensity, as well as its share of national R&D, is a critically important problem because, as discussed above, global competitive pressures and growing technological complexity have increased investment risk and extended R&D asset requirements well beyond the capabilities of even the largest R&D-intensive companies. Particularly acute is the need for government funding support in the early phases of a technology's development and in the increasingly complex set of infratechnologies and associated standards that are required to efficiently execute modern R&D projects and then rapidly gear up for production and commercialization.

Without systematic and substantive government support for corporate investment, companies yield to the pressures from Wall Street to deliver short-term benefits. For example, in the period 2009 to 2014, U.S. domestic corporate R&D spending totaled roughly $1.5 trillion, with a growing share on development, rather than basic and long-term technology research. However, during this same period, S&P 500 companies were estimated to have spent $2.1 trillion on stock buybacks.[17]

Such huge purchases have been enabled by increasingly liquid corporate balance sheets, thanks to the Fed's largesse. The average corporate debt-to-equity ratio for S&P 500 firms dropped dramatically from its average level in the last decade (1999–2009) of approximately 225 percent to a little over 100 percent in 2015.[18] With such pristine balance sheets, companies could have easily financed increased investment. A *Harvard Review* article estimated that over the period 2003 to 2012, stock buybacks absorbed 54 percent of corporate earnings and attributed the primary motivation to the fact that a majority of corporate managers' income is stock-based.[19] Consequently, while such buybacks provide short-term benefits to corporate managers and shareholders, they contributed significantly to a decline in the average annual growth rate of corporate investment. Likewise, over the last 20 years the share of dividends to capital expenditures has grown steadily, especially after dividend tax rates for individuals were cut significantly in the early 2000s.

On the government's side, the same denial that has led to extreme underinvestment in traditional economic infrastructure prevents adequate investment (through direct spending or tax incentives) in the increasingly critical set of technical infrastructures that are essential for competitive innovation and productivity growth in the global economy.

Skilled Labor

There were, on average, 1.8 unemployed workers for every open job in January 2015. That is typical of a healthy economy and is down from a record high of 6.7 in July 2009, just after the recession officially ended. But so far, the improving job market has yet to lift wages. Although skill levels are strongly correlated with incomes, a number of economists reject the argument that a skills gap exists and that shortcomings in our educational system are a major cause of stagnant income growth and consequent income inequality.

This argument is derived from the belief that such gaps cannot realistically exist because corporations can easily acquire needed skills by simply offering premium wages. What these economists overlook is the fact that education is a public good and therefore not directly responsive to traditional market forces. College degrees cover skills in areas as disparate as science, art, and management. Thus, if the right skilled workers are not being produced by the educational system, no salary offer is high enough, at least in the moderate term. Moreover, with other nations making much more strategic and sizable investments in human capital, U.S. companies do not need to bid up wages to get the talent they need; they can buy it overseas.

Virtually every survey and testimonial by corporate executives confirms that community colleges and universities are not turning out the right mix of skilled workers. In a 2014 survey by the Business Roundtable, 97 percent of the responding CEOs said the skills gap

threatens their businesses. A significant number of CEOs said they are having difficulty finding workers with computer and IT skills, advanced quantitative knowledge, and even basic STEM literacy.[20] A 2015 Deloitte study estimates that over the next 10 years, 3.5 million new manufacturing jobs will be created, but the skills gap will prevent 2 million of them from being filled.

One can expect that the supply will eventually adjust to meet shifts in demand. In fact, some community colleges, with help from grants from the Labor Department, have revamped curricula in consultation with local industries to adjust the skill mix of the local labor pool; however, this is not being done close to the level needed. The problem is that we live in an increasingly competitive global economy. Companies that cannot find the skilled labor needed can increasingly do so elsewhere in the world and often at lower wage rates. Ironically, one partial solution, increasing H1B visas, has been met with strong resistance on the grounds that an increased supply of foreign workers will replace domestic workers. The reverse is actually the case because companies faced with skilled labor shortages often will not only look to other economies for those specific skills but will offshore the entire operation to preserve synergies.

A stronger U.S. advanced technology sector will enable the U.S. dollar to be stronger, which in turn will enable all U.S. wages, not just in export-oriented sectors, to be higher in real terms.

BLS data show that in all but one of 71 technology-oriented occupations, the median income exceeds the median for all occupations. In 57 of these occupations, the median income is 50 percent or more above the overall industry median. So, a policy imperative is to increase domestic worker skills to levels that are not easily accessible elsewhere in the global economy, thereby forcing companies all over the world to choose the U.S. economy as the preferred investment location. A stronger U.S. advanced technology sector will enable the U.S. dollar to be stronger, which in turn will enable all U.S. wages, not just in export-oriented sectors, to be higher in real terms.

Capital Formation

Investment in plant and equipment is essential for deploying new technologies and thereby achieving productivity growth. Like R&D, capital formation policy suffers from a weak and poorly conceived structure.

Most technology is directly embodied in hardware and software. Unfortunately, Fig. 3 shows the trend in fixed private investment (hardware and software) over the past 55 years. The rate of investment declined in each decade from 1960 through 1990. The 1990s experienced a dramatic but temporary reversal, but in the following decade (2000s), investment in hardware and software was negligible. This severe drop was due to the bursting of the dot.com bubble in the first part of the decade and the Great Recession in the last part. The trend since 2010 shows only a modest revival.

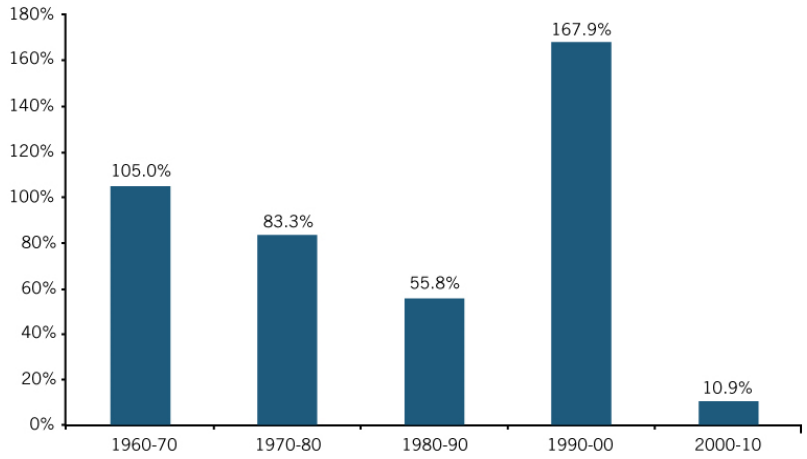

Figure 3: Fixed Private Investment (Hardware and Software): Percent Real Growth by Decade[21]

Like R&D, capital formation also suffers from significant market failures, as ITIF has shown.[22] Moreover, the pressure placed on U.S. corporations for quick returns means that investments in long-lived capital assets are reduced. But the investment lifecycles of new technologies can last for 10 years or longer. Thus, sustained investment is essential to maintain productivity advances over time. Periodic and inconsistent tax incentives are not effective. As argued in a 2015 ITIF report, the two major types of tax incentives, the R&D tax credit and bonus depreciation, "encourage the kind of investment and innovation that creates high-paying jobs." Yet, such "tax extenders" are historically temporary (requiring periodic renewal with occasional gaps in their availability). The result is weak and inconsistent investment incentives.[23]

INDUSTRY STRUCTURE AND SUPPORTING INFRASTRUCTURE

For most of modern economic history, to the extent non-macro factors have been the focus of economic growth policies, the focus was on "industry." However, today's complex technology systems are derived from both horizontally and vertically integrated domestic supply chains.

Vertical integration of suppliers and their customers (the next tier forward in the supply chain) is required to make sure performance specifications are adequately developed and the interfaces between components of a technology system are fully and efficiently functional. Horizontal integration has until recently been frowned upon by policymakers steeped in neoclassical economics due to the purported negative implications for competition. However, the market failures identified above make a strong case for cooperation in the development of technology platforms and infratechnologies. Thus, competing companies (in the same industry), while conducting their own proprietary R&D as in the past, increasingly participate in joint (precompetitive) research through industry consortia to conduct early phase proof-of-concept technology research.

This complexity of modern technology-based industry structures is the result of the fact that the scope of technology systems and hence the number of supplier industries have grown as technological complexity has expanded, creating major information and

coordination market failures that lead to poorly functioning product or service systems. The scope and depth of the imperative for economies of scope and system integration exist not just in terms of technology but also in terms of the supplier structure and infrastructure. This trend is evidenced globally by co-location of suppliers and their customers in order to improve information flows among them. The supply chain (also called the value chain) is therefore a critical policy focus.

Such efforts are especially critical in a technology's development because new technology platforms must be in place to leverage the efficiency of subsequent proprietary applied R&D that leads to commercial market applications (innovations). In economic terms, these new research infrastructures are essential to address the fact that the public-private nature of modern technologies requires partnerships between industry and government to pool research assets and the considerable risk of early-phase research. Advanced manufacturing, nanotechnologies, biopharmaceuticals, and other emerging technologies—which will provide the high-paying jobs of the future—all require such an approach.

The best we seem to be able to do is place all our economic hopes and dreams onto the Fed and wait with baited breath to see whether it will tighten or loosen the economic "valve"—as if this had anything to do with real long-term growth.

Passage of the Revitalize American Manufacturing and Innovation Act of 2014 and support (through reprogrammed funds) by the Obama Administration for its National Network for Manufacturing Innovation (NNMI) are a beginning. Under this program, nine Manufacturing Innovation Institutes (MIIs) have been established, with seven more planned for 2016. The MIIs have the potential to evolve into complete innovation clusters, which have substantial ability to leverage regional high-income economic growth.

In addition to the NNMI, a number of programs have been initiated in recent years to increase advanced technology research efficiency. For example, the Material Genome Initiative (MGI), launched in 2011, seeks to promote a systems-level approach to materials design, optimization, and implementation. But compared with other nations, U.S. investment in such cooperative research endeavors is quite limited.

However, even economies that have been maligned for decades, such as England, have begun to generate more rapid productivity advances using these new institutional strategies. For example, *The Economist* points to Rolls-Royce, which has halved the time required to design and produce fan disks and turbine discs used in jet engines. The methods were developed at the Advanced Manufacturing Research Centre (AMRC) at Sheffield University. The AMRC is part of a network of well-funded, government-backed "catapult centers"—an implementation of the innovation-cluster model linking university and industrial researchers in knowledge and risk-pooling efforts to more efficiently advance early-phase R&D (the result was a prototype). Such initiatives are appearing all over the industrialized world to the advantage of national and local economies.

Another reason for promoting regional and sectoral clusters is the reality that modern technologies are complex systems. This means that multiple component technologies must be developed based on the underlying science and engineering. Single companies, even the largest ones, cannot develop all the components. Further, all components must advance at some minimum rate for system productivity to be realized in a time frame driven by competition.

For example, automobiles used to be a modestly complex set of hardware components: engine, drive train, suspension, and the like. However, for at least a decade, cars have contained numerous subsystems for which electronics is a central element. These subsystems are controlled and connected to each other by as many as 100 microprocessors in some models and a mile of wiring.[24] Efficiently developing such technological systems requires coordination and efficient interfaces among a large number of companies making up the automotive supply chain, who are necessarily undertaking progressively larger shares of automotive R&D. Such complexity means co-location synergies among component suppliers and system integrators are significant.

Finally, overall economic efficiency is increased by the fact that regional clusters offer a large and diversified pool of skilled labor to draw upon. Workers can move among companies much more efficiently as labor needs shift. Toyota recently announced that it would invest $1 billion over the next five years in the development of artificial intelligence and robotics. The company chose the mother of innovation clusters, Silicon Valley, as the location for this research because of the unparalleled availability of the needed research talent.

Companies who compete against each other in established markets increasingly need to cooperate in early-phase R&D with themselves and with universities and government laboratories in order to pool risk and research assets, as well as gain quick access to research results. This is the economic rationale behind the NNMI Program. However, most other industrialized nations are pursuing the same investment strategies, and many have been doing it longer and much more aggressively. In addition, many nations now offer more generous tax incentives for such collaborative R&D.[25]

CONCLUSION

Two fundamental growth policy options are available to the United States: (1) accept lower wages (or a lower value to the dollar) to enable lower prices and thereby expand global market shares, which will lead to a lower standard of living; or, (2) support faster wage growth through more aggressive policies to support investment in the set of productivity-enhancing assets identified in this paper, which will increase long-term economic efficiency and competitiveness and thereby raise the standard of living over time. Given the current economic situation—no significant real income growth, 45 million Americans on food stamps, high levels of income inequality, and low labor force participation—it should be easy to see that option 1 has been the de facto growth policy.

Resistance in the United States to option 2 comes from the outdated private-good-only mentality that results in the "black-box" view of technology investment. This perpetuates the dominant view of economic growth policy, held by macroeconomists, the Fed, and a significant portion of economists on the left and right, that government can't influence long-term growth. Indeed, as a nation, the best we seem to be able to do is place all our economic hopes and dreams onto the Fed and wait with baited breath to see whether they will tighten or loosen the economic "valve"—as if this had anything to do with real long-term growth.

We ignore the kind of tax and expenditure policies needed to drive investment. The result is underinvestment in the factors that drive productivity growth. Politically, this outdated belief is manifested in both conservatives' and liberals' simplistic views of how the modern economy operates, with one side saying there's no role for government to spur investment, even though targeted tax incentives like the R&D tax credit or investment incentives can have significant impact on capital formation, and the other side simply giving up on growth in favor of redistribution of incomes from the wealthy and corporations. The result has been not just stalemate, but ineffective policy.

In economic terms, the adoption of an adaptive and dynamic policy mindset is being thwarted by the installed-base and installed-wisdom effects. In fact, the critical long-run competitiveness issues discussed here are barely on the radar screen of the broader economic growth policy establishment. When Yellen gives a speech in which she hints about whether she will open the "valve" a tad, it is national news. When the Bureau of Labor Statistics reports on quarterly productivity numbers, media respond with hardly a yawn.

In the final analysis, the high-income economy must be the high-tech economy.

The long run is not a problem until one gets there; then, it becomes a crisis, which is not easily or quickly solved. For the U.S. economy, the long-run has arrived in the form of annual GDP growth in the 2 to 3 percent range, with no real wage growth in spite of enormous monetary stimulus. And, such stimulus obviously cannot continue indefinitely. The response is either to believe that good times are just around the corner, or to resign in desperation to the "new normal." In neither case is there the broad-based recognition of the requirement for a structural growth strategy grounded in reviving investment.

In the final analysis, the high-income economy must be the high-tech economy. Unfortunately, denial of structural problems is inhibiting adaptation to the rapid growth of global technology-based competition and consequently constraining growth in real incomes for a majority of American workers.

The result is not only no growth in living standards, but also increasing social and political unrest. The frustration and anger so evident among voters in the 2016 presidential election campaign reflects the spreading discontent over people's deteriorating quality of life, which is attributable largely to a lack of growth in real incomes. As long as politicians of both political parties remain largely uninformed or uncommitted to the major elements of modern economic growth policy, the prospects for successfully addressing this problem are bleak indeed.

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