WHAT CHINA WANTS

The AMERICAN INTEREST

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COOL NEW STUFF
...AND WHY WE NEED TO MAKE IT

BLACK PANTHER
POWER

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You Can't Fix Stupid?

As I hope is by now known to readers, *The American Interest* is embarked on an evaluation of the health of basic American institutions, notably those below the line of political sight where our nation's future mostly lies. We have already published seminal essays on medicine, labor, infrastructure, banking and finance, and other of the 13 "institutional" baskets. In this issue we feature an essay, by William Bonvillian and Peter Singer, on the promise of advanced manufacturing as a potential generator of good middle-class jobs—arguably the greatest challenge before us in an age of continuing if more diversified outsourcing and waxing automation. As the authors prove, part of the problem we have saddled ourselves with is intellectual confusion: namely, generic errors of mainstream economists as they have affected public policy for decades.

In some ways it is a familiar story: Institutions are by nature conservative. They are resistant to change, because change is a burden from a sociological point of view. This has always been true, and as a result *post hoc* embarrassment in the sciences has been prolific.

Thanks to Thomas Kuhn, everyone knows about the resistance of Ptolemaic astronomers to Copernicus. Everyone knows how many years, and how many unnecessary premature corpses, it took for the medical profession to accept the germ theory of disease. Many know that, until embarrassingly recently, most geneticists believed that there had been no change in the human genome over the past 10,000 years; though why a process underway for eons should come to a stop just for our emotional convenience never made any sense.

But here is the rub: None of these and hundreds of other embarrassments had much impact on public policy in days gone by for two reasons: The ambit of public policy was limited before the advent of welfare-state ambitions; and the technological extensions of basic science were relatively few and slow to develop, so also few and slow to affect social and political affairs. But the Industrial Revolution sharply accelerated the rate of innovation, in two phases: first the revolutionary harnessing of steam power to an array of applications, thanks initially to the Watts steam governor; and then the harnessing of innovation to basic science, which depended on no particular "thing" or gadget but rather on critical innovation in institutional design.

Ever since, the societies that have pioneered (or adapted) the scientific-technical revolution have been running a string of uncontrolled social science experiments on themselves, with decidedly mixed but hardly marginal results. The whirlwind of change, whether on balance positive, negative, or indeterminate, has rocked societies, and those societies have often found their political equipoise, such as it ever was, battered or even shattered as a consequence. The effects were not limited to national borders either. Three hegemonic wars—two hot, one cold— since the Industrial Revolution (Napoleonic, World, and Cold) in turn reshaped national politics in many ways. In the interstices of these wars the world recovered its social and political ballast only intermittently and, it now seems looking back from the current precipice, fleetingly.

Let's keep the point as simple as possible: The changes wrought by scientific-technical innovation are far outrunning the capacity of our temperamentally conservative social and political institutions to keep up with them. And the cybernetic revolution, like the harvesting of steam power before it, is not a simple innovation but a generative one that is affecting virtually everything humans do. The Industrial Revolution in its essence substituted machine power for human labor; the cybernetic revolution is substituting forms of machine power for human thought, as the justifiable contemporary anxiety about the implications of artificial intelligence illustrate. The difference is not trivial, and we frankly have no idea what it means.

In short, when it comes to effective public policymaking, the smart money is on the proposition that we are bound to look, and to actually get, stupider and stupider as time passes—at least for a good while longer. John Wayne is famous for the remark "you can't fix stupid." In a way, the question before us is, just how expansively right was he?

It would be risible to blame Donald Trump for any of this. His political ascendance is clearly a symptom of ambient distress in American society, not the cause of it. Maybe things need to get worse, possibly much worse, before the American political class will find the courage to confront the yawning obsolescence of our institutional order, whose ossification and decay are now plain to see.

In the meantime, *TAI* will continue its own special kind of long march through the institutions. Stick around, please; it promises to be a great journey.

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AMERICA'S INSTITUTIONAL HEALTH

What Economists Don't Know About Manufacturing

WILLIAM B. BONVILLIAN & PETER L. SINGER

The decline of manufacturing really is as disastrous as common sense suggests.

Robert Solow developed the field of growth economics by demonstrating that what he termed technological and related innovation was the dominant causative factor in economic growth.[1] He won the Nobel Prize in 1987 by finally identifying (only 211 years after the publication of the *Wealth of Nations*) the long-invisible behemoth in the classical economics parlor: a demonstrated theory of economic growth.

But there was a problem. Solow found that economic growth was "exogenous" to the approaches of his still-dominant school of neoclassical economics. The variables behind innovation were simply too complex to fit within 20th-century metrics-driven neoclassical theories. While mainstream economics focused on markets because they can be modeled, it was unable to model the complex of factors behind economic growth that lay outside the market system as such. The central concept of mainstream economics is dynamic equilibrium: Market signals drive meeting points between supply and demand, such that even as change is constant the net consequence remains equilibrium. Innovation-based growth, however, is a dynamic system that is not, *cannot be*, in equilibrium. Features like the organization of innovation systems simply did not fit with supply and demand curves.

Of course, an economics school without a functioning theory of growth appeared entirely unacceptable to many, and a group of "New Growth Theory" economists, initially led by Paul Romer,[2] worked to make growth theory "endogenous"; in other words, to somehow put it into an analytical, neoclassical box. But this has proven to be such a hard problem that many economists have sought more manageable and measurable projects like those of behavioral economics.

Its inability to grapple with innovation systems has left economics in a particularly difficult situation when it comes to analyzing the American manufacturing sector. Manufacturing, and especially the initial production of new technologies, must be seen as part of the innovation system. It is an autonomously creative stage in which a new product must evolve through prototyping, product definition, and production design from an idea into both a marketable and produce-able good. This often requires a re-examination of the underlying science behind the innovation. While the innovation leaders of other nations, including Germany, Japan, Korea, Taiwan, and now China, have focused on "manufacturing-led" innovation,[3] those in the United States still mostly think that R&D is the only key to innovation, and that all the rest somehow takes care of itself.

It used to, at least relatively speaking, but over time the delinking of innovation from production has put the United States increasingly at a competitive disadvantage. Many other better-known factors play into the problems of the American economy, but the drag that comes from ignoring the innovative power of manufacturing technique has been hugely important, too. Whatever the reasons for the oversight—the biases of classical economics, the path-dependency effects of the post-World War II "pipeline" model that emphasized

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federally funded research universities and basic research—if we want to recoup our leadership and ensure social comity and peace, we must stop ignoring this critical connection.

Manufacturing's Lost Decade

The U.S. manufacturing sector experienced a devastating decade between 2000 and 2010, from which it has only partially recovered. The decline is illustrated by five measures: employment, investment, output, productivity, and trade.

Employment: Over the past 50 years manufacturing's share of gross domestic product (GDP) shrank from 27 percent to 12 percent. For most of this period (1965-2000), manufacturing employment remained constant at about 17 million; in the decade from 2000 to 2010 it fell by almost a third, to under 12 million, recovering by 2015 to only 12.3 million.[4] All manufacturing sectors saw job losses between 2000 and 2010, with sectors most prone to globalization displacement, led by textiles and furniture, suffering massive losses.[5]

Investment: The fixed capital investment of manufacturing (plant, equipment, information technology, and so on), actually declined 1.8 percent in the 2000s when adjusted for cost—the first time this has occurred since data collection began in 1947. It declined in 15 of 19 industrial sectors and continues at low levels.[6]

Output: U.S. manufacturing output grew only 0.5 percent per year between 2000 and 2007, and during the Great Recession of 2007-09 fell by a dramatic 10.3 percent. Even as GDP began to slowly grow again (in what has been the slowest economic recovery in total GDP in 60 years), manufacturing output remained flat and has only recently returned to pre-recession levels.[7]

Productivity: Recent analysis shows that although the productivity growth rate in manufacturing ran at 3-4 percent per year between 1989 and 2000 while the sector was absorbing the gains of the IT revolution, it fell to only 1.7 percent per year between 2007 and 2014.[8] Because productivity and output are tied together, the decline and stagnation in output tracks with the decline in productivity in this period. Assuming that our metrics are appropriate for a changing economic environment, compared with 19 other leading manufacturing nations, the United States was 10th in productivity growth and 17th in net output growth.[9] Though still increasing, U.S. productivity growth remains at historically low levels; so productivity increases alone cannot account for the decline in manufacturing employment.

Trade: The decline of the U.S. manufacturing sector is made clear by its manufacturing trade deficit. In 2015 the United States ran a trade deficit of $832 billion in manufactured goods. In 2017 the total included a $110 billion deficit in advanced technology products, a deficit that has been growing since 2002.[10]

Trading Places: China moved from 5.7 percent of global manufacturing output in 2000 to 19.8 percent in 2011, passing the United States as the world's largest manufacturing power. Since then, the gap has widened further. Manufacturing value-added in China totaled $2.56 trillion in 2012 compared with $1.99 trillion for the United States.[11] The U.S. share of world manufacturing value-added declined from 18.1 percent in 2010 to 17.4 percent in 2012, and the decline was primarily against China's growing share. In the first half of 2016, China's global exports in manufactured goods totaled $935 billion, 68 percent more than the $555 billion of U.S. exports; this is striking because in 2000, U.S. manufactured exports were three times larger than Chinese exports.[12]

The median income for men without high school diplomas fell by 20 percent between 1990 and 2013.

The labor profile derangement caused by this economic shift has resulted in growing social disruption.[13] While most Americans once assumed we were becoming one big middle class—defined socially in the popular imagination as opposed to economically—instead a working class that has been facing declining incomes is now in clear, angry view. For example, full-year employment of men with high school but not college degrees went from 76 percent in 1990 to 68 percent in 2013.[14] The share of these men who did not work at all went from 11 percent in 1990 to 18 percent in 2013. Importantly, the median income for men without high school diplomas fell by 20 percent between 1990 and 2013; for men with high school diplomas or some college, it fell by 13 percent.[15]

Because men dominated the production workforce, the decline of American manufacturing in the 2000s hit them particularly hard. Overall, real household income, measured both at the median and the mean, declined between 1999 and 2014.[16] Importantly, there is a growing gap between *median* household income—the statistical center of the middle class—and *average* household income, which includes the higher gains going to the upper-middle and upper classes.[17] This spells middle-class decline.

It also spells growing income inequality. As labor economist Richard Freeman put it, "inequality is now at Third World levels."[18] It can be traced to the stagnation in college graduation rates since the mid-1970s: Workforce skill requirements kept growing but educational output, as state support of higher education waned, failed to keep up.[19] Those who had the education captured a wage premium, those without it, the opposite. Meanwhile, the one-third decline in better-paying manufacturing jobs in the 2000s exacerbated the inequality split as the definition of the middle class shifted over time: In other words, employment in manufacturing has proven for many to be a downward way out of the middle class. The manufacturing decline curtailed what had been a critical pathway to the middle class for working-class families. This wasn't just a white working-class problem: African-Americans make up 10 percent of the manufacturing workforce and Hispanics 16 percent; the decline restricted a pivotal middle-class route for those sub-communities.[20]

The massive trade imbalance in manufacturing hit many industrial communities especially hard.[21] Those areas that faced direct impacts from Chinese imports sustained an average income loss per adult per year of $549 between 1990 and 2007. This was offset by per capita Federal adjustment assistance of only $58. Job loss to trade with China was 2.4 million between 1999 and 2011. As Nobel economist Michael Spence has found, "Globalization hurts some subgroups within some countries, including in advanced economies. . . . The result is growing disparities in income and employment across the U.S. economy, with highly educated workers enjoying more opportunities and workers with less education facing declining employment prospects and stagnant incomes."[22]

The Significance of Manufacturing Employment

Employment in the manufacturing sector can be viewed as an hourglass.[23] At the center, the narrow point of the hourglass, is the production moment. But manufacturing employment is not subsumed by that moment. Pouring into the production moment is a much larger employment base that includes those working in resources, those employed by a range of suppliers and component makers, and the innovation workforce—the roughly 60 percent of scientists and engineers employed by industrial firms. Flowing out of the production moment is another, larger host of jobs, in distribution systems, retail and sales, and maintenance of the product over its life cycle both within and beyond the main production company. The employment base at the top and bottom of the hourglass is far larger than the production moment itself.

Arranged throughout the hourglass are lengthy and complex value chains of firms involved in the production of the goods—from resources to suppliers of components to innovation, production, and finally distribution, retail, and life cycle—a great array of skills and firms, much of which we count as services. But these services are tied inextricably to manufacturing; if we removed the production element,

the value chains of connected companies snap. While the lower base of the hourglass, the output end, may be partially restored if a foreign good is substituted for a domestic one, the firms involved will still be disrupted. The upper part of the hourglass, the input end, with its firms and employees, doesn't get restored by import substitution. One major study of manufacturing value-added indicates that when the full hourglass effects are considered, manufacturing may amount to a third of the economy.[24]

When these complex value chains are disrupted, it is hard to put them back together. That's why, historically, once the U.S. economy loses an economic sector it tends not to come back. It also loses the potential to innovate in the sector. This is a key reason why manufacturing decline is so consequential.

Produce There, Innovate There?

Following World War II, the U.S. economy was organized around world leadership in technology.[25] It developed a comparative advantage over other nations in innovation and, as a result, led nearly all the significant innovation waves for the rest of the 20th century.[26] The operating assumption was that U.S. industry would innovate and translate those innovations into products. By innovating here and producing here, it realized the full spectrum of economic gains at all stages, from research and development through production at scale, and in the follow-on life cycle of the product. It worked—the United States became the world's richest economy.

The United States since 1940, then, has been playing out Solow's economic growth theory—that the predominant factor in economic growth is technological and related innovation—and demonstrating that it works, with its model increasingly emulated abroad. But in recent years, with the advent of a more interconnected global economy, the *innovate here/produce here* model has broken down. In some industrial sectors, firms can now sever R&D and design from production. Codeable information-technology-based specifications for goods that can be sent to software-controlled production equipment have enabled "distributed" manufacturing.[27]

The *innovate here/produce there* model appears to work well for many IT and commodity products. However, the distributed model does not work for all sectors, particularly those that still require a close connection between research, design, and production—for example, capital goods, aerospace products, energy equipment, and complex pharmaceuticals. Here, the production infrastructure provides constant feedback to the R&D and design phases. Product innovation is most efficient when tied to a close understanding of and linkage to manufacturing processes.

However, if R&D/design and production are tightly linked, these innovation stages *may have to follow production offshore* if it indeed goes offshore. To the extent this is happening it is disastrous. The *produce there/innovate there* approach brings the very foundations of U.S. innovation-based economic success into question. If this approach grows in importance, the historic U.S. comparative advantage in innovation could be jeopardized, further hindering growth and stimulating social disruption.

What Mainstream Economics Got Wrong

Understanding how manufacturing is related to the economy as a whole is critical to all related policy processes concerning the economy. Alas, our understanding is fragile. Few U.S. leaders took the developments in manufacturing described above seriously in recent decades partly because a series of well-established economic views assured us that declines in manufacturing would be more than offset by gains elsewhere in the economy.[28]

Economics has held an elevated position in national policymaking—the President has a Council of Economic Advisors, not a Council of Sociological Advisors. Mainstream economists have long told us a reassuring story about economic change and the role of manufacturing in it:

- The nation was losing manufacturing jobs because of major productivity gains;
- The production economy would in the natural course of economics be replaced by a services economy;
- Low-wage, low-cost producer nations must inevitably displace higher-cost ones;
- Don't worry about the loss of commodity production, since the country will retain a lead in producing high-value advanced technologies;
- The benefits of free trade always greatly outweigh any short-term adverse effects;
- Innovation is distinct from production, so innovation capacity remains even if production is distributed worldwide; and
- A governmental role in the production system would constitute a dangerous "industrial policy."

Alas, each of these arguments has proved incorrect.

Productivity and job loss: Political economist Suzanne Berger has noted that mainstream economists thought manufacturing was like agriculture, where relentless productivity gains allowed an ever-smaller workforce to achieve ever-greater output. She found that the agriculture analogy was simply incorrect.[29] This finding means that it is necessary to look at the overall decline in the sector itself for reasons why manufacturing lost nearly one-third of its workforce in a decade. The U.S. productivity growth rate is now at historic lows, again assuming that we are counting the right things; low productivity growth and related low investment levels signal that automation-driven productivity gains have *not* been the cause of manufacturing job decline. Instead, global competition, led by China's entry as the leading manufacturing power, has been the largest factor—at least so far.[30] Mainstream economists proffered a false dream about productivity gains while output fell; they diverted us from the reality of tough international competition with nations following mercantilist policies.

A service economy supersedes a production economy: Success in a highly competitive world rewards nations and regions that produce complex, value-added goods and sell them in international trade. Although world trade in services is growing, world trade in goods is four times as strong. Complex, high-value goods such as energy, communication, and medical technologies make up more than 80 percent of U.S. exports and a significant majority of imports. The currency of world trade is in such high-value goods and will remain so indefinitely. Gradual growth in the services trade surplus ($227 billion in 2015) is dwarfed by the size and continuing growth of the deficit in goods; the former will not offset the latter anytime in the foreseeable future.

In addition, the production sector leads other sectors in the introduction of productivity gains, which lead to real gains in an economy, providing new wealth that can be distributed. Services are generally slow productivity adaptors. Production is also the most scalable factor in an economy, able to scale growth much more rapidly than services sectors that remain more face-to-face in nature. In other words, manufacturing appears to be indispensable to a modern economy and will not be superseded anytime soon by a services-only economy. Economists should stop pretending otherwise.

Mainstream economists proffered a false dream about productivity gains while output fell.

Manufacturing in low-wage, low-cost nations must surpass high-wage, high-cost ones: The American public, reflecting mainstream economic views, has long assumed that the U.S. economy must inevitably lose manufacturing to lower-wage nations in Asia and elsewhere. American economists forgot to send that memo to Germany, however. German companies pay much higher manufacturing wages than do U.S. companies, yet have lately been running the largest manufacturing trade surplus in history. The German experience demonstrates that there is no inherent and inevitable manufacturing employment or sectoral decline in advanced economies in competing with lower-wage ones. An advanced economy can keep climbing the value-added ladder in both capital input and

human-capital input if its public policies are designed properly.

Developed nations can cede lower-end production and make it up in advanced technologies: Clayton Christensen has argued that established production firms, faced with disruptive innovation, typically cede low-margin production and work to retain leadership through incremental ("sustaining") advances in high-margin production. But they end up ceding those as well, as the disruptive advances that allow capture of the low end (aided by lower costs and expanded customer bases) mature and enable the capture of the high end.[31]

This also resembles what entire nations go through. As noted above, Chinese industry is not simply pursuing its low-cost production advantage but is innovating in rapid production scale-up. Chinese process advances are integrated across regional firms and accelerate production tempo and volume, which are tied to cost savings.[32] In other words, Chinese leaders are pursuing an innovative production strategy using "manufacturing-led" innovation for competitive advantage. At the same time, U.S. industry has allowed its historic production leadership to slip, endangering its innovative capacity—again, because production cannot really be delinked from innovation—in important areas of technology. As noted, the U.S. economy, far from leading in advanced technologies, ran a $110 billion trade deficit in advanced technology goods in 2017—a deficit that has been growing.[33] Developed nations aren't necessarily assured of leading in advanced technologies when they cede commodity technologies.

Free trade advantages always outweigh any short-term adverse effects: The data cited above concerning social disruption and manufacturing decline is illustrative of the reality of adverse trade effects. As noted, trade was the leading cause of manufacturing decline in the 2000s.[34] Manufacturing decline can be readily mapped; it tends to be regional with significant effects on particular industrial communities. As Amy Goldstein's *Janesville* shows, most sectors in communities that lose a major industrial employer tend to contract, from suppliers to indirectly related services firms.[35] The decline affects the community's tax base as real estate values drop, affecting community services like education and health care.

The U.S. economy ran a $110 billion trade deficit in advanced technology goods in 2017.

Homes are typically a family's greatest asset; if their homes are devalued it is difficult financially for families to leave. Middle-aged workers often have extended families and generations of ties in these localities, with accompanying responsibilities that make it hard for them to bail out, even if they can acquire the skills to find other work. These market frictions exacerbate social disruption; it is very difficult for affected communities and individuals to climb back, so that decline is lasting rather than short term. The effects can be dramatic. Gains from increased trade are often offset, as David Autor and his colleagues have shown, by "deadweight losses" to the economy in affected regions, particularly through the rise in transfer payments for unemployment, health and disability insurance, and food stamps that are required to cope with declines in employment and real wages. These payments are compensatory; they do not reflect economically productive investments and indeed they make such investments harder to finance.

Back in 2004 Paul Samuelson took on mainstream economics by asking how the United States could be an economic loser with a low-cost, low-wage competitor like China, despite the longstanding Ricardo-based economic theory of "comparative advantage" in trade.[36] He noted that if Chinese industry begins to make productivity-enhancing gains, coupled with a low-wage advantage, it could capture some of the comparative advantage that previously belonged to the United States through its productivity dominance. Then, in a Ricardian analysis, he added that unemployment caused by trade never lasts forever, "so it is not that U.S. jobs are ever lost in the long run; it is that the new labor-market clearing real wages has been lowered by this vision of dynamic fair trade." In other words, U.S. wages would fall to a point where China's production price advantage is offset.

That is correct: Wage stagnation in the United States is a growing problem below the upper-middle class, and growing numbers of the working class are moving from middle-class incomes to lower-end, lower-paying services jobs. The U.S. economy still benefits from lower-priced imported goods, but there are now "new net harmful U.S. terms of trade."

Dani Rodrik's new work, *Straight Talk on Trade*, attacks the economics mainstream for its failure to alert the public that global trade was creating gaps in developed nations between the well-educated, who do well in global trade, and the less-educated, who tend to do badly.[37] The academic mainstream, he suggests, continues to articulate a theory of free trade where the benefits are pervasive even when it is not reciprocal (where one side allows open trade and the other does not). He found that,

> [E]conomists can be counted on to parrot the wonders of comparative advantage and free trade whenever trade agreements come up. They have consistently minimalized distributional concerns. . . . [Yet] the standard models of trade . . . typically yield sharp distributional effects: income losses by certain groups of producers or workers are the flip side of the "gains from trade."[38]

By holding to perspectives that assumed away such things as trade-related unemployment and income inequality, Rodrik argues, the mainstream favored theory over known realities, misled the public, and blocked a focus on more realistic policies for adapting to a global economy.

Samuelson had warned years earlier that responding to trade disruption by imposing tariffs could result in economic "arterial sclerosis." His alarm is reasonable; the economy, including the production supply chain, is now thoroughly globalized and retrenchment from trade (as opposed to pushing back against mercantile practices) would be very problematic. But we should stop systematically underesti-

We should stop systematically underestimating adverse trade effects and refusing to consider improved trade strategies and worker support.

mating adverse trade effects and refusing to consider improved overall trade strategies and worker support.

The dangers of industrial policy: A debate over industrial policy has been going on for years, and for nearly all the time it has been going on the terms of the debate have been excessively simplified and distorted. Thus, when Japan's innovations in quality manufacturing harmed U.S. auto and consumer electronic sectors in the 1980s, some in Congress proposed rescuing industrial losers through an industrial bank. Economist Charles Schultz, in a well-known attack on industrial policy, argued in response that the inevitable political forces driving government led it to be ill suited to carefully fashioned industrial interventions.[39]

The same debate cropped up again in 2012 when Christina Romer, Chair of President Obama's Council of Economic Advisors in 2009-10, wrote a *New York Times* op-ed titled "Do Manufacturers Need Special Treatment?" Although the Obama Administration had been studying responses to the manufacturing decline of 2000-10, she suggested that Americans valued services like haircuts as much as manufactured goods, arguing that goods are not inherently more important than services. She insisted that "public policy needs to go beyond sentiment," denigrating a policy focus on manufacturing. She was directly attacking her recent boss's proposals in his State of the Union speech, ten days before, proposing advanced manufacturing institutes modeled on Germany's Fraunhofer Institutes to nurture

new advanced production technologies. In an economy in distress (unemployment was still at 8.3 percent), her comments attracted the manufacturing sector's ire.

Rightly so. Romer's argument that manufacturing jobs are economically equivalent to services jobs was and remains simply wrong. Manufacturing jobs have the highest job multiplier effect; that is, they lead to more jobs throughout the economy than do jobs in other sectors. Manufacturing is also an innovation driver, so it is critical to U.S. research and development and follow-on technological innovation—and therefore to growth. Stephen Ezell pointed out, as well, that manufacturing should be a preferred sector because it is still America's largest "traded sector"—that is, much of its sales occur abroad, so it spurs exports and accompanying positive trade gains and national wealth. Since goods far outweigh services in trade, Ezell notes, manufacturing will be the leading traded sector "for a long time, and it is simply impossible to have a vibrant economy without a healthy traded sector."[40]

What to make of this eternal debate? The innovation system should certainly be spared the political pork barrel but, *pace* market fundamentalist dogma, many important governmental interventions can stop far short of that. As growth economist Richard Nelson states:

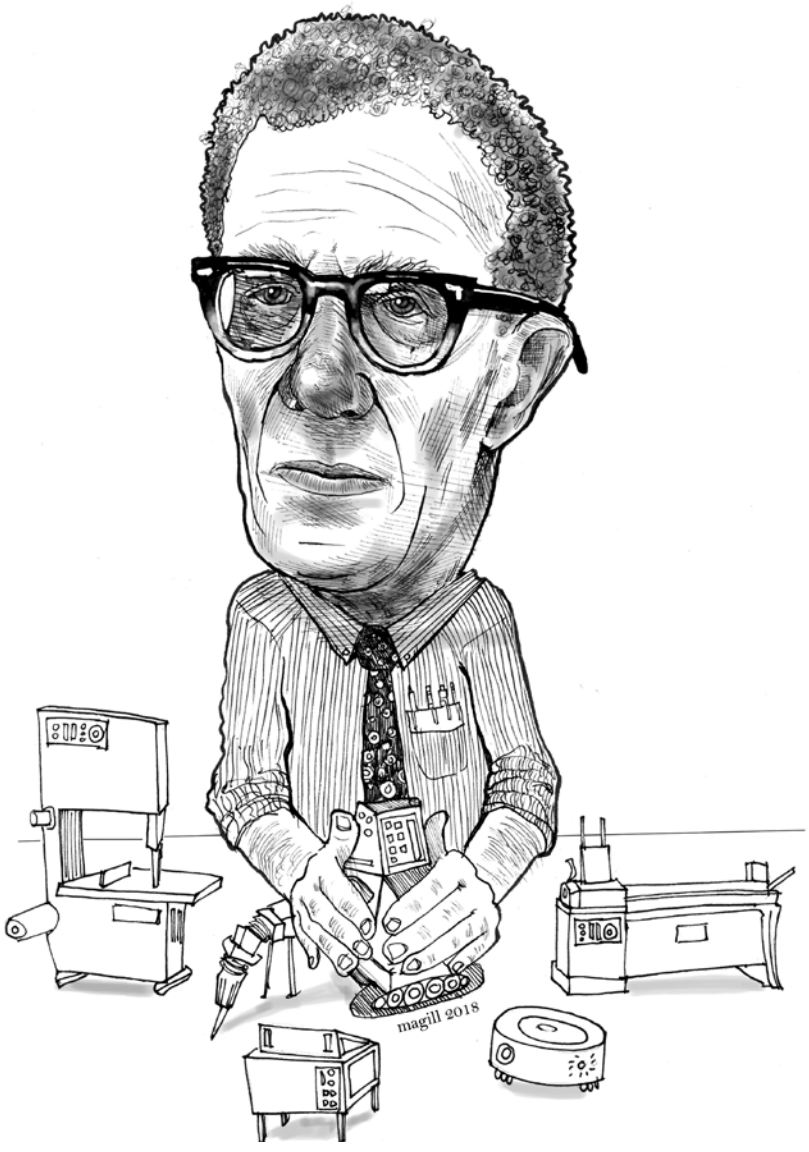
> The conditions for a pure market organization to result in a "Pareto optimal" equilibrium never are fully met. This is recognized, implicitly, in serious policy discussion, where the argument about policy almost never is about whether the situation actually is "optimal," but rather about whether the problems with the existing regime are sufficiently severe to warrant active new policy measures.[41]

Precisely in that spirit, the 2011 report issued by the President's Council of Advisors on Science and Technology (PCAST)[42] outlined manufacturing policies focused on R&D and workforce education, where government has long played a key role, not on an interventionist government picking industrial winners and losers.[43] The advanced manufacturing institutes subsequently set up by the Defense, Energy, and Commerce Departments, which were led and cost-shared in most cases at a 2-to-1 ratio by industry, focused on R&D and training in technologies to increase productivity gains.

Mainstream economics has long seen the production function in terms of measurable inputs yielding measurable outputs; it has much more difficulty evaluating, to borrow a term from chemistry, significant phase changes in the production function. New technological-economic paradigms—innovation waves—are infrequent, but when they arrive they spite input/output formulations. Horses are not analogous to railroads just because both are transportation modes; printed books are not analogous to the internet either. Such phase changes have occurred in manufacturing, too: Interchangeable machine-made parts and mass production, along with quality manufacturing, are leading examples.

Some new technologies, like 3D printing, have the potential to re-localize supply chains, generating even more jobs.

Classical economics is not good at understanding these phase changes because they don't fit equilibrium-biased input/output models. This is particularly important because these new paradigms are usually not implemented by the private sector alone: Railroad development was heavily supported and subsidized by state and Federal governments; the internet was developed through DARPA; interchangeable machine-made parts were nurtured by the War Department in the mid-19th century; and quality production was strongly backed in Japan by the Ministry of International Trade and Industry in the 1970s and 1980s.[44] Such paradigm changes cannot often be undertaken in the private sector alone because it cannot manage the high level of risk and lengthy development cycles. Advanced manufacturing technologies, and a corresponding phase change to the new production paradigms they could allow, fall squarely into this category.



Advanced Manufacturing

The beginning of wisdom when it comes to understanding advanced manufacturing is the simple but somehow elusive point that not all industries are created equal in generating growth. Regrettably, mainstream economists have typically been unable to differentiate between the potential of different sectors. The stories of Christina Romer's equation of haircuts with manufacturing and Michael Boskin's inability to differentiate between the production of potato chips and computer chips are embarrassing cases in point.[45] These experts and others fail to understand that factors such as technological capacity and its ability to generate increasing returns make a real difference. Manufacturing is the classic sector for increasing returns, and, because it dominates technological development in the economy, it is at the core of technological capacity. Creating phase changes using new manufacturing paradigms, arguably then, carries major potential growth benefits.

New production paradigms can transform the production sector.[46] As noted, we have seen

new production paradigms before, and we will doubtless see them again. We can, arguably, *make them happen*, too. So U.S. industry is competing with low-wage, low-cost producers, particularly in Asia: Could it develop new production paradigms to drive up efficiency and drive down costs so it could better compete? We can if we try, if in so doing we take pains to make sure that, as was once the case by accident more than by design, the relevant institutions that need to be involved cohere with one another.

Innovation carries its own rewards; *production* innovation is no exception. It can enable better products, create new markets, and, just as important, generate good jobs. Scientists and engineers now tell of breakthroughs—new phase changes and paradigms—in a series of technology fields that could significantly enhance the way we produce complex, high-value technologies and goods. These include digital production technologies (new systems of sensors and controls, big data and analytics, robotics, artificial intelligence, new simulation and modeling, and so on); advanced materials and composites; biofabrication; mass customization (the ability to produce small customized lots at mass-production costs, through 3D printing and computerized controls); nanofabrication; photonics; and new distribution efficiencies. These new advances, in turn, require new processes and business models to implement them. Hardware must be matched to "software," so to speak, for the paradigm to work. Not only are new jobs inherent in these new "hourglasses" (not necessarily at the production moment), but some of the technologies, like 3D printing, have the potential to re-localize supply chains, generating additional jobs.

Developing such new integrative paradigms is the core concept behind advanced manufacturing. Advanced manufacturing institutes have been devised as a means to nurture such paradigms. They are young and few Americans know they exist, but they represent a major policy change for, as already noted, the disconnect in the United States between R&D and production has limited such thinking. Previously, the policy issues in manufacturing concerned tax, trade, currency, and regulatory policy; innovation was not on the table. Although these other policy areas remain important, improvements in them tend to be incremental and marginal. Gains from innovation can be more dynamic, as the advent of mass production and quality manufacturing indicate. This is the first time—at least since Sematech (Semiconductor Manufacturing Technology), a public-private DARPA-supported collaboration dating from 1986-87—that an *innovation system* approach to manufacturing has been considered.

Neither of the two major U.S. political parties seems to get the basics of growth economics.

Based on recommendations from the industry-university Advanced Manufacturing Partnership collaboration,[47] an effort began in 2012 to use new manufacturing institutes to create new production paradigms in 14 production areas, shared across the supply chains of large and small firms and across industry sectors. The costs of the institutes are shared among Federal agencies, industry, and state governments.

Why institutes? One key reason is that the majority of the U.S. manufacturing sector consists of small and midsize firms that are risk-averse and thinly capitalized; they are not in a position to perform research or adopt new technologies and processes unless the costs and efficiency gains are demonstrated and understood. Although larger firms once assisted their supply chains in this role, providing a vertical integration function, in an era of intense global competition they have often cut back to their core competencies. They are therefore less able to assist suppliers and have their own competitive problems in adapting. As Suzanne Berger puts it, manufacturing firms are increasingly "home alone."[48]

Larger firms, too, need to collaborate to share the risks and costs of changing to new production paradigms. Taking a page from Germany's Fraunhofer system, institutes act as test beds, providing a range of industries and firms with opportunities to collaborate on, test, and prove prototypes for advanced production technologies and processes.

Another gap institutes can fill is talent. Technical workers must be trained to work with the advanced technologies and develop processes and routines necessary for introducing them into production systems. Otherwise they simply will go nowhere.

Advanced manufacturing policies are now hanging in the balance. Germany and China, as well as other competitors, are now making much larger investments than the United States has considered. But now manufacturing has had its "Sputnik moment": the 2016 presidential election and the working-class backlash it illuminated. Yet the current Administration, although it embraced manufacturing during the campaign, appears to be merely tolerating the manufacturing institutes and related innovation policies rather than advancing them.

Outside of government, much will depend on whether mainstream economists accept these ideas. While some—Rodrik, Autor, Samuelson, Spence, Freeman, and others—advocate a "rethink" of the labor market and trade aspects of these issues, this view is by no means pervasive.

Meanwhile, neither of the two major U.S. political parties seems to get the basics of the growth economics that lies behind this new innovation focus on manufacturing. How did the parties miss growth economics? Simple: As John Maynard Keynes famously wrote, "Practical men who believe themselves to be quite exempt from any intellectual influence, are usually the slaves of some defunct economist."

Our political parties appear to have locked in long ago on classical economics. The politics of each is organized around one of the two dominant factors that classical economics thought was responsible for growth: capital supply and labor supply. Republicans have focused on capital supply, with its leaders returning again and again to the popular political well of lowering marginal tax rates. Democrats focus on labor supply—improving education, health, and income in labor markets. Both matter and remain significant, although Solow demonstrated many years ago that these factors are responsible for only some 20 percent of growth. But the American political class has missed almost entirely the critical role of technological innovation and its power to spur innovation-driven growth. Advanced manufacturing is now a key asset in such innovation.

Unless growth agendas like advanced manufacturing policies are supported adequately, we are in for a difficult time ahead.

Economist Benjamin Friedman's noted 2005 book, *The Moral Consequences of Economic Growth,*[49] showed that periods of higher economic growth tend to be accompanied historically by more tolerance, optimism, and egalitarian perspectives; declining economic growth periods are typically characterized by pessimism, nostalgia, xenophobia, and violence. While the American upper-middle class is doing fine, much of the remainder of the population has been less than fine. Productivity growth and related investment are at low levels despite their demonstrated role in driving growth. Unless growth agendas like advanced manufacturing policies are supported adequately and consistently, we are in for a difficult time ahead.

We now are seeing what may prove to be an advanced wave of social externalities accompanying the economic decline affecting the American working class. If automation piles on new labor profile dislocations in the years ahead, things may get considerably worse unless we plan to offset its effects. Economists and the political system they influence need to get with the program.

Endnotes

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