technology review

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Why Manufacturing Matters

Manufacturing is not merely about giving people jobs. The next generation of technological innovations is intimately tied to production processes.

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Better battery: A123 Systems' new factory in Livonia, Michigan will make advanced batteries or hybrid and electric vehicles.
Credit: Roy Ritchie

Between 2000 and 2010, the number of manufacturing jobs in the United States declined by 34 percent—a loss of more than six million positions. For now America remains one of the world's greatest manufacturing powers—it makes 19.4 percent of the world's manufactured goods, a share that fell only slightly over the past 30 years and is right behind China's share of 19.8 percent. But hard questions remain about the future of production in an advanced industrial country like the U.S. The latest research suggests that the big recent decline in manufacturing jobs is due not only to increases in productivity, as we long thought, but also to large gains for Chinese imports. Do these global trends mean that manufacturing has a limited future in a high-wage country? Does the U.S. even need much domestic production when manufacturing has become a commodity that can easily and cheaply be purchased abroad? As the economy becomes more heavily dominated by services, why focus on manufacturing at all?

These questions have very old roots in American political economy. At the very beginning of the Republic, Alexander Hamilton was already arguing for industrial policies that would stimulate domestic production. More recently, in the 1980s, the rapid gains made by Japanese companies in industries like automobiles and consumer electronics stirred up huge political controversies over whether government should stave off this competition and try to sustain and revive U.S. manufacturing. The advocates for such policies argued that manufacturing plays a critical role in generating economic growth and employment opportunities and in assuring national security. The critics of industrial policies claimed that government was incapable of making good choices about industry—that it could not pick winners and losers. More fundamentally, the critics denied that there was anything special about manufacturing as distinct from other activities in the economy, or that any kind of manufacturing was more valuable than any other. As the director of the Office of Management and Budget in the first Bush administration put it: "Potato chips or silicon chips—who cares? They are both chips."

There is at least one great difference, however, between yesterday's concerns about manufacturing and today's. Over the past 25 years, a fundamental change in the structure of production has taken place, as digitization and modularity have made it possible to separate R&D and design from production in industries where these functions had previously been integrated within corporations. The experiences of successful firms over the past 30 years make it plausible to think that manufacturing can be outsourced and offshored without any damage to the engines of innovation. Once it was possible to codify the different stages of the journey from conception to final product and to break design apart from production, major new industries could arise around enterprises like Apple, Qualcomm, and Cisco. With the fragmentation of networked production, companies focused on specialized core competencies came to dominate the landscape, particularly in sectors linked to information technology. The great new U.S. companies of the past quarter-century have been ones with few if any manufacturing capabilities. Many of the vertically integrated giants, like Hewlett-Packard and Texas Instruments, also shed their manufacturing, outsourcing much of it to Asian contractors.

The IT industry came to provide the basic paradigm for thinking about industrial change. Given the spectacular success of companies like Apple and Dell, they were obvious models to emulate. Their example suggested that advanced industrial countries should focus on their comparative advantage in R&D, design, and distribution and leave manufacturing to less developed countries, with their large reserves of less educated, less demanding, low-wage labor. Research carried out by Dedrick, Kraemer, and Linden, with "tear-downs" on the composition of value in iconic products like the iPod and the iPhone, showed that the lion's share of the profits and high-paying jobs continued to accrue to companies and workers in the advanced industrial countries. In a $600 iPhone sold by Apple, assembly in China by subcontractors like Foxconn (Hon Hai) accounted for less than $7 of the cost, so why should Apple—or any other high-tech company—consider bringing production under its own roof? Collaboration between firms specializing in R&D and design in advanced industrial countries and those specializing in manufacturing in low-wage countries has greatly benefited both sides over the past quarter-century, but it seems clear which end of the bargain has been the better one. Indeed, as a matter of public policy it would be hard to see the rationale for bringing such jobs "back" to the United States.

The question for the future, however, is whether modularity and the separation of innovative activities from manufacturing will characterize the great new industries of the next decades, as they have characterized the IT industry of the recent past. Research being conducted by the MIT Production in the Innovation Economy Commission on companies in wind and solar, biotech, new materials, batteries, and other emerging technology sectors suggests a number of reasons to question whether the IT paradigm will be workable for them. It's yet too early to draw any firm conclusions from this research, but already it appears that the challenges in scaling up these activities from laboratories through startups into full production of new products and services are different from the issues that software or electronics companies face in their transition from product idea to market. One obvious difference is that scaling up requires much more capital in these new industries than it does in software. But equally critical, in today's emerging technology sectors R&D, design, and production appear to be harder to separate than they are in the IT industry. Indeed, much of the most promising R&D and innovation in solar power involves cheaper and more efficient ways of manufacturing photovoltaics, a relatively mature technology. Companies such as Suntech have become major players in solar power by leveraging advanced manufacturing technologies, while others, such as the startup 1366 Technologies, are developing new ways of making solar cells that could dramatically redefine the costs of the technology. In both cases, the innovation is in the manufacturing.

There is a close connection between R&D and manufacturing in many of the emerging sectors because modularization may just not work as well for these technologies as it has for IT. R&D engineers may have to stay close to manufacturing to develop new strategies for making processes more efficient. The tighter integration of innovation and production may also present opportunities to bring design closer to end users, as advanced manufacturing technologies make it possible to produce higher-value goods at lower volume.

If firms need to keep production closely connected to their front-end innovative activities in order to bring new products and processes to the market, it is that something we can do in the United States? The advances we see emerging in areas like energy, life sciences, transportation, environment, communication, construction, and security promise to transform our economy and society. But it may well be that only those countries that can build powerful links between laboratory research and new manufacturing will be able to derive full benefit from their innovative capabilities. New manufacturing may not mean a larger manufacturing sector with large numbers of added jobs, but it certainly would mean radical change in the technologies and business models we have now.

The case for optimism about a renewal of American production capabilities has two legs. First, the strong performance of manufacturing in some other advanced industrial countries suggests that manufacturing and blue-collar work are not doomed in high-wage environments. In Germany, where wages and social benefits for manufacturing jobs are higher than they are in the United States, the fraction of the workforce employed in manufacturing is about twice as high as it is here. Germany has a manufacturing trade surplus—even in its trade with China. New manufacturing is possible in countries with educated populations and high living standards. But realizing such possibilities in the United States will take a major transformation of aging industrial structures that are often less efficient than the large new plants and industrial complexes of Asia.

The second leg of the case for optimism is that radically new manufacturing technologies do appear to be within reach. The demand for new, cleaner energy sources, to name just one example, promises huge markets for technologies that can be manufactured cheaply enough to compete with fossil fuels. Some have called it a new industrial revolution that will have an impact comparable to that of the factory, new power sources, and new technologies in the 19th century. In addition to three-dimensional (additive) printing, there are strong new possibilities in biofabrication and nanomaterials. But for these ideas to be translated into advanced manufacturing and robust industries, we will require new policies—built on an understanding of why manufacturing really matters.

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