MANUFACTURING POLICY INITIATIVE AT SPEA
INSIGHT INTO MANUFACTURING POLICY

Advanced Manufacturing Policy: Different Approaches, One Goal

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Since the beginning of the industrial revolution, nations have used public policy as a tool to foster domestic manufacturing, sometimes with considerable success. Although some may question *if* governments ought to intervene in this realm, there is little question as to *why*—because a strong manufacturing sector is a catalyst for increasing productivity, raising living standards, growing the economy, and enhancing national security.

According to economist Eric Reinert, poor countries have become wealthy by *emulating* the policies of rich countries—especially policies to promote industrialization. But what about developed economies that already possess world-class manufacturing? What do they do, if anything, to maintain or expand their global manufacturing leadership position?

Many aim to spur innovation in "advanced manufacturing"—leveraging high technology to produce goods with ever greater added value. And increasingly, they do this by employing *advanced manufacturing policy* (AMP), a deliberate attempt by governments to advantage their domestic industries in developing new technologies and processes to significantly improve production efficiency and competitiveness. A recent report from Stephen Ezell of the Information Technology and Innovation Foundation (ITIF) documented such policies across ten countries.

Advanced manufacturing is a high-stakes game and the payoff can be significant; therefore, the competition for global leadership is fierce. Consider the efforts by Germany, China, and the USA—arguably the leading manufacturing nations in the world. Table 1 provides a comparison of recent AMPs in each country.

Industrie 4.0

Industrie 4.0 is a German strategic initiative to maintain its position as a global leader in manufacturing through digitalization (i.e., the interconnection of products, value chains, and business models to enable real-time decisions through data analytics, the Internet of Things, and other information technologies). The promise of Industrie 4.0 lies in an orders-of-magnitude improvement in efficiency, such as reduced downtime,

reduced inventory, energy minimization, enhanced environmental and safety performance, faster response to customer needs, etc.

Table 1. Advanced Manufacturing Policy (AMP) in Three Countries.

AMP Element	***Germany***	***China***	***USA***
Name	Industrie 4.0	Made in China 2025	Manufacturing USA
Timeframe	2013-2020	2015-2025	2014-2022
Purpose	Maintain global leadership through digitalization across the value chain	Escape the middle income trap by leading the world in advanced manufactured products	Bolster the weakened Industrial Commons by bridging the "valley of death" in pre-competitive technology
Inspiration	High-Tech Strategy	Industrie 4.0	Fraunhofer Institutes
New institutional mechanisms	Plattform Industrie 4.0	40 new manufacturing institutes to advance pre-commercial technologies	14 manufacturing institutes to advance pre-commercial technologies
Government funding	$0.55B (over 7 years)	$1.5B (over 10 years), plus >$1.5B from provincial and local government	Roughly $0.9B (over 5 years)
Example of progress	Technical standards	Plug-in electric vehicles	Extensive R&D collaborations across industry, academia, and government
Challenges	Engaging small and medium firms	Indigenous innovation	Uncertainty over federal funding beyond initial 5-year commitments for manufacturing institutes

Managed under Plattform Industrie 4.0, this effort is led by the German government but includes manufacturing firms, trade associations, research institutions, labor organizations, and academia. Activities include the development and adoption of

technical standards, development of broadband infrastructure, enhanced cybersecurity, and accelerated workforce training. Government funding is estimated at $550 million for the first seven years. Implementation will be bolstered through Germany's network of over sixty Fraunhofer Institutes that are collaborations between industry, governments, and engineering schools in every region; these have a total annual ongoing budget of approximately $2B a year.

Inspiration for Industrie 4.0 comes from Germany's *High-Tech Strategy*, a national plan first issued in 2006 to promote research and innovation and revamped in 2010 as *High-Tech Strategy 2020*. The current version identifies ten "future" projects, including Industrie 4.0. The first details of the Industrie 4.0 program were revealed publicly in 2013.

Although broadly applicable to all of manufacturing, implementation has thus far focused on Germany's leading subsectors: autos and machine tools.

Germany is aggressively developing technical standards and pushing for their international adoption, starting within the EU. Plattform Industrie 4.0 supported development of the Reference Architectural Model for Industrie 4.0 (RAMI), which is a guide to standards and interoperability. According to a report from ITIF, Germany is aggressively pushing development of its standards, which are widely considered "rigorous, comprehensive, and inclusive."

Major challenges include (1) acceptance by the country's small and medium manufacturers, most of which have never heard of the initiative, according to one recent survey, and (2) fostering disruptive innovation. To date, much of the innovation under Industrie 4.0 has been incremental.

Made in China 2025

In 2011, China surpassed the US to become the leading manufacturing country in terms of total value added. This achievement is even more remarkable due to the speed of the country's ascent in this sector. Its rise coincided with China's admission to the WTO just ten years before. However, China believes the strategy that led it to this point is neither sustainable nor desirable. They recognize the threat posed by lower cost production in developing countries, particularly elsewhere in Asia. China lags some developed economies in producing goods with the highest value add. For China, it is imperative to avoid the "middle income trap" that has plagued so many other developing countries: industrialization raises GDP per capita, but only to a certain level.

Inspired by Germany's Industrie 4.0 in 2013, China went to work on its own AMP, which was revealed in 2015 as *Made in China 2025*. The plan is both broad in its coverage—much of its content would benefit all of manufacturing (e.g., through digitalization)—and also narrowly targeted to ten subsectors: information technology; CNC machine tools and industrial robotics; aerospace and aeronautical equipment; maritime equipment and high-tech maritime vessel manufacturing; advanced rail equipment; energy-saving and new-energy vehicles; electrical (power) equipment;

agricultural machinery and equipment; new materials; and biopharmaceuticals and high-performance medical devices. Its ambitious goal is to develop self-sufficiency and world leadership across these ten subsectors in a very short period of time.

The plan is supplemented by dozens of other policy documents, some of which are complementary (*Internet Plus Action Plan*, *MIC2025 Major Technical Road Map*) and others that are subsidiary (e.g., more than 70 provincial plans have been issued aligned with MIC2025).

The plan borrows elements of AMP from other countries. Aside from seeking leadership in the digitalization of manufacturing (like Germany's Industrie 4.0), China has committed to establishing 40 manufacturing innovation centers (like Manufacturing USA) at the national level by 2020; it currently has established just 5 (although 48 provincial innovation centers have reportedly been created).

Funding is significant. MIC2025 is expected to receive ($1.5B) from the national government and a greater amount ($1.6B) from provincial, city, or county governments. These initial figures likely represent a small portion of the total investment, with a much larger share coming from state-owned enterprises such as national banks. One recently established institute (on batteries) is reported to have received $400M in funding, and this is just one of 40 planned institutes. A study by the Mercator Institute (MERICS) identified large pools of state-directed funding: China's Advanced Manufacturing Fund is roughly $3 billion. The National Integrated Circuit Fund reportedly received 139 billion CNY ($22 billion). These financial resources are much larger than the German government has provided for research under Industrie 4.0.

MIC2025 implementation is moving forward rapidly and with noticeable results. For example, China has become, in just three years, the world's leading producer of plug-in electric vehicles (PEVs), a development attributable in part to policies that include subsidies, regulatory restrictions, and production quotas. (For more details, read the May 2018 issue of *Insight into Manufacturing Policy*).

China also faces serious challenges to realize the promise of MIC2025. Critically, it must promote indigenous innovation, a traditional weakness in the country's national system of innovation which has relied on a top-down governmental effort. Although China is spending heavily to promote innovation, critics contend its investment is inefficient. For example, China has a large amount of IP (e.g., patents), but that IP is considered relatively weak (i.e., not valuable).

Critics argue that implementation of MIC2025 will depend on mercantilism (to promote exports and limit imports) and autarky (becoming self-sufficient) at the expense of other nations. As evidence, they point to China's numeric targets—contained in *MIC2025* and the *Green Book*—that aim to increase its global share of manufacturing value add.

Manufacturing USA

In the first decade of this century, the US manufacturing sector lost 6 million jobs—one-third of its workforce. Observing the rapid exodus of US manufacturing capability through outsourcing, Harvard Business School professors Gary Pisano and Willy Shih argued that the US was losing its "Industrial Commons."

Influenced by a series of key academic reports and recommendations from two presidential task forces, Congress enacted legislation in 2014 to address the issue. The Reinventing American Manufacturing and Innovation (RAMI) Act ratified the creation of Manufacturing USA, a federal program to support government-industry-academic collaborations in new institutes to promote particular advanced technologies. The aim was to bridge the so-called "valley of death" in precompetitive manufacturing technologies.

Inspired by the success of Germany's famed Fraunhofer Institutes, the US program currently comprises 14 institutes that are geographically dispersed (see Figure 1). Each institute focuses on a particular set of related technologies, such as advanced composites, photonics, or biofabrication.

Manufacturing USA has four stated goals: (1) To increase the competitiveness of U.S. manufacturing; (2) facilitate the transition of innovative technologies into scalable, cost-effective, and high performing domestic manufacturing capabilities; (3) accelerate the development of an advanced manufacturing workforce; and (4) support business models that help institutes to become stable and sustainable after the initial federal startup funding period.

Federal funds are approved for a five-year period for each institute. The federal funding level is typically $70-110M per institute, matched or exceeded by funding from private industry and other non-federal sources, with a minimum 1:1 cost share. To date, the federal-nonfederal ratio exceeds 1:2.

Each institute has a federal agency sponsor and is managed by a third-party, often a non-profit entity set up through a university. A Deloitte study sponsored by the US Department of Commerce concluded that the program has fostered a high degree of collaboration in its first year, and that institute members "have made substantial joint investments in collaborative approaches to R&D and commercialization of cutting-edge advanced manufacturing technologies." Subsequent GAO and National Academies reports reached similar conclusions.

The program has several challenges. Perhaps the most critical is uncertainty as to whether the federal government will extend the initial five year startup funding for the manufacturing institutes, which may be necessary for the program to meet its long-term goals.

Figure 1. The 14 Manufacturing USA institutes. Source: NIST, 2018.

Observations

Although emulation played a role in shaping AMP in these countries, it was not determinative—each country developed a unique approach. Given the common goal of spurring innovation, national plans can be expected to diverge for several reasons:

- Circumstances differ. China wishes to escape the middle-income trap and to do so, it needs to leapfrog its technological development. The US wants to avoid further erosion of its Industrial Commons by becoming more efficient in commercializing its massive basic research enterprise which requires a strong manufacturing sector. Germany wants to become a player in IT-derived innovation by leveraging its leading position in certain kinds of manufacturing (e.g., machine tools).
- Systems of innovation differ. Each country has a unique national system of innovation shaped by established institutions with particular strengths and weaknesses. An AMP strategy that leverages the set of institutions in one country (e.g., centralized planning) may not be suited to a different set of institutions (e.g., market-driven innovation). And AMP continuously evolves; for example, the Trump Administration is planning new policies to spur innovation in its industrial defense base.

- Capabilities in manufacturing differ. For example, China's biopharmaceutical sector is at a very different stage of development than that of the United States and therefore requires a different set of policy incentives.
- Politics. The political environment that shapes the content of policy differs across countries. A nation that simply wants to mimic the policy of a rival will need to change that policy to garner the necessary political support or utilize a different set of tools (e.g., leverage SOEs) to achieve the same aim.

The presence of AMPs across several leading industrial nations disproves three persistent myths: that manufacturing is not so important in advanced economies (it is), that countries with robust capabilities in manufacturing have no worries (they do), and that governments should not give special treatment to manufacturing (they will). The big question is not whether AMP is warranted, but how to craft it to best suit a particular national innovation system. A nation that can rise to the challenge will improve the competitive position of its domestic manufacturing sector.

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For Further Reading:

Bonvillian, William B. and Peter L. Singer. 2018. *Advanced Manufacturing: The New American Innovation Policies*. MIT Press: Boston.

Deloitte. 2017. *Manufacturing USA: A Third-Party Evaluation of Program Design and Progress*. January.

Ezell, Stephen. 2018. *Why Manufacturing Digitalization Matters and How Countries Are Supporting It*. Information Technology and Innovation Foundation. April.

Government Accountability Office. 2017. *U.S. Manufacturing: Federal Programs Reported Providing Support and Addressing Trends*. GAO-17-240. Washington DC: Government Accountability Office.

Graham, 2018. "China, through Electrification, Takes Aim at the Global Auto Sector." *Insight in Manufacturing Policy*. May.

Kennedy, Scott. 2017. *The Fat Tech Dragon: Benchmarking China's Innovation Drive*. Center for Strategic and International Studies: Washington, DC.

Public Law 113-235. 2014. "Revitalize American Manufacturing and Innovation Act" (RAMI Act).

National Academies, STEP Board, *Securing Advanced Manufacturing in the United States The Role of Manufacturing USA*: Proceedings of a Workshop (National Academies of Science Press 2017) - https://www.nap.edu/read/24875/chapter/1

Presidential Council of Advisors on Science and Technology. 2011. *Report to the President on Ensuring Manufacturing Leadership in Advanced Manufacturing*. Executive Office of the President, Office of Science and Technology.

Reinert, Eric S. 2007. *How Rich Countries Got Rich and Why Poor Countries Stay Poor*. Public Affairs: New York.

Thoben, K.-D.; S. Weisner, and T. Wuest. 2017. "'Industrie 4.0' and Smart Manufacturing: A Review of Research Issues and Applications, *Int. J. of Automation Technology*, *11*(1), 4-16.

Wubbeke, Jost, Mirjam Meissner, Max J. Zenglein, Jaqueline Ives, and Bjorn Conrad. 2016. *Made in China 2025: The Making of a High-Tech Superpower and the Consequences for Industrial Countries*. Mercator Institute for China Studies (MERICS): Berlin.