Skills and Innovation Strategies to Strengthen U.S. Manufacturing

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Lessons from Germany

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GLOBAL CITIES INITIATIVE A JOINT PROJECT OF BROOKINGS AND JPMORGAN CHASE

JOSEPH PARILLA, JESUS LEAL TRUJILLO, AND ALAN BERUBE



EXECUTIVE SUMMARY

BROOKINGS Metropolitan Policy Program aced with stagnating wages for most Americans, business, civic, and political leaders across the United States are rediscovering manufacturing as a source of good jobs and lasting economic growth. In an era of unrivaled global competition, however, revitalizing the U.S. manufacturing sector will require a renewed commitment to public-private-civic partnerships that deliver on the key driver of industrial competitiveness: a highly trained workforce that can use technology to translate basic and applied research and development (R&D) to large-scale commercial innovations. "Three key takeaways-regional collaboration between public, private, and civic actors; targeted institutional intermediaries that address market failures; and incentivebased investments to support small and medium sized businesses-should guide U.S. actors seeking to adapt German skills and innovation best practices to support manufacturing."

However, in both skills training and technological innovation, U.S. policies to support manufacturing have not matched the sector's evolution from one dominated by massive, vertically-integrated companies to a more distributed mix of small, medium, and large firms. In this new environment, research and development, particularly applied research, and skills training are underprovided in the market because individual firms fear they will not recoup their full investment if a competitor reaps the benefits of a new innovation or poaches a welltrained technician.

Other advanced nations have done a better job of addressing the market failures that inhibit industrial competitiveness. Germany is an oft-cited example of an advanced economy that has been able to sustain manufacturing as a relevant source of employment, growth, and exports. Manufacturing in Germany accounts for 20 percent of employment, nearly twice the share as in the United States, and generates 22 percent of national GDP and 82 percent of total goods exports. German manufacturing succeeds in the global marketplace even as the sector pays higher average wages than in the United States.

Germany's manufacturing sector benefits from a concerted federalist policy effort to support clusters of globally competitive manufacturers, particularly its small and mid-sized *Mittelstand* firms, through powerful **public-private collaborations on applied research to support innovation** and a **dual model of vocational education** to sustain a highly trained workforce. While recognized as global best practices, these models cannot be imported wholesale into the United States. Rather, three key takeaways-**regional** *collaboration* between public, private, and civic actors; *targeted institutional intermediaries* that address market and coordination failures; and *incentive-based investments* to support small and medium sized businesses-should guide U.S. practitioners and policymakers seeking to adapt German skills and innovation best practices to support manufacturing here at home.

In November 2014 the Global Cities Initiative, a joint project of Brookings and JPMorgan Chase, brought 40 U.S. business, civic, and government leaders to Munich and Nuremberg, Germany to learn more about the German model for manufacturing competitiveness. For U.S. practitioners and policymakers interested in applying German best practices in their own places, this paper serves to document the key discussion themes and potential lessons from that trip. It provides a brief overview of the current state of manufacturing in each country (Section I), the German systems for innovation (Section II) and vocational education and training (Section III), and concludes with examples of how U.S. leaders are applying the most successful elements of these German systems to the American context (Section IV).



THE STATE OF U.S. MANUFACTURING

U.S. manufacturing stands at a crossroads.

The first decade of this century saw one in 10 U.S. factories close, a one-third decline of the manufacturing workforce, and skyrocketing trade deficits. These setbacks, decades in the making, exposed serious weaknesses in U.S. industrial competitiveness.¹

Yet recent trends signal a tentative optimism. Manufacturing has rebounded in the post-recession period: Since 2009, the sector has grown faster than the economy as a whole, and since 2010 manufacturing has created nearly 800,000 new jobs.² And recent global dynamics–from rising labor costs abroad to new energy sources at lower prices and technologies at home–present new cost advantages over Asia and Europe and suggest that the sector's recovery may not simply be cyclical.³

For the country to seize on manufacturing's recent momentum, however, it must rebuild what Harvard Business School researchers Gary Pisano and Willy Shih call the "industrial commons"–the concentrations of research institutions, skilled workers, and suppliers that form the backbone of America's most competitive industrial hubs.⁴ Manufacturers thrive when they draw on the collective knowledge and spillovers from clusters of similar firms and deep pools of labor, which in turn are anchored by supportive institutions such as universities, research institutes, community colleges, and industry consortiums.⁵ These networks, which concentrate in regional economies, are together responsible for the key driver of industrial competitiveness: a highly trained workforce that can use technology to translate basic and applied research and development (R&D) to large-scale commercial innovations.⁶

BROOKINGS METROPOLITAN POLICY PROGRAM

Experts point to several factors to explain U.S. manufacturing's decline, including macro factors such as tax and trade policy, but insufficient investments in people and technology partly explain why the sector became

susceptible to global competition over the past several decades. The further opening of the global trading system; the effective doubling of the globally connected labor pool; and sustained advances in information, communication, and transportation technologies allowed companies to distribute different stages of production where they could be completed most efficiently and effectively.⁷ To remain profitable in this new environment. American companies needed to either cut costs or become more innovative. Many U.S.-based producers chose the former, offshoring their operations and outsourcing any responsibilities deemed non-essential to their supply chain.⁸ This phenomenon, coupled with automation, shrunk the average manufacturing establishment size from almost 70 employees in the late 1970s to 41 employees in 2006.9

The downsizing and offshoring of American manufacturing firms disrupted the longstanding model for innovation in manufacturing. Since the 1960s, the U.S. government has limited its involvement in innovation to the financing of basic research through universities, research institutions, and general research grants, while the private sector transformed these basic knowledge inputs into new products, technologies, services, and business models.¹⁰ This model worked well for American manufacturing because highly integrated companies developed R&D capabilities in-house that allowed them to translate pure scientific knowledge into new products (e.g. Bell Labs, PARC, etc.).11 Significantly, technological breakthroughs by large manufacturers also spilled over to small and medium-sized enterprises (SMEs), allowing them to participate in new industries or to innovate within existing supply chains.¹²

However, the offshoring of production to cheaper locales separated it from manufacturers' domestic R&D operations.¹³ These cost-cutting moves discounted the fact that innovation occurs most successfully when R&D and production are tightly linked, ideally co-located so engineers and production workers can make adaptations and bring products to market more quickly.¹⁴

The offshoring of different manufacturing industries not only affected the innovation capacity of firms within one industry, but also diminished "Revitalizing U.S. manufacturing will require renewed public-private-civic partnerships that deliver the workforce and technologies demanded by 21st century industry."

the positive spillover effects that many of these R&D activities had on other industries.¹⁵ In this way, offshoring diminished the competitiveness of multiple industries at once.¹⁶ Even when American researchers develop radical innovations, defined as the creation of a new industry due to technological or scientific breakthrough, U.S. manufacturers are often unable to bridge the "valley of death" between the basic research phase and industrial production due to lack of capital and other key resources.¹⁷

The valley of death widens without support for pre-competitive (applied) research, defined by Competence Centre for Materials Science and Technology as the "middle ground of focused cutting-edge research that lies between fundamental basic research conducted mainly in universities and proprietary research performed in corporate laboratories."18 For instance, U.S. companies developed the technology behind semiconductors, but more foreign manufacturers (at times buoyed by government support) attracted their production and have since improved on the original innovation, a process that helps them accrue significant benefits of the late technology cycle.¹⁹ The trade balance for semiconductors has fallen dramatically over the last decade, with the United States retaining a slim trade surplus of \$1.6 billion as of August 2014, as compared to a \$24 billion surplus in 2006.20 The United States' core innovative competencies-world-class universities, entrepreneurial dynamism, and a strong venture capital system, among others-have not been

enough to maintain its manufacturing market share in even the most high-tech industries.

The changing structure of U.S. manufacturers also altered the hiring, training, and retention of industrial workers. As with R&D, the responsibility of training American manufacturing workers historically rested with a group of large, vertically integrated companies. In the post-war period, young people flocked to manufacturing with the realistic expectation that one firm could offer them a stable career with advancement potential. In turn, employers invested long-term in their employees with the realistic expectation that a more productive workforce would benefit the company's bottom line, not a competitor's.²¹

Facing new cost constraints, manufacturers had less capacity to train their workforce internally. At the same time, fewer young Americans viewed manufacturing as a promising career as automation and global pressures reduced job certainty and held back wage growth.²² In a world of short tenure, high turnover, and flat or declining real wages, workers hesitated to invest in their own skills, the education system moved decisively away from providing vocational pathways, and firms had less incentive to train their employees for the long term, choosing instead to search for experienced workers in the marketplace.²³

"Manufacturing in Germany accounts for 20 percent of employment, nearly twice the share as in the United States, and generates 22 percent of national GDP."

For several decades the supply of technical workers remained healthy due to the long-run decline in manufacturing employment demand and then the Great Recession's acute rise in layoffs.²⁴ Now, however, as manufacturers recover and ramp up hiring they are faced with an impending wave of baby boomer retirements, and are concerned they do not have a sufficient pipeline of talent in high-demand occupations that require significant levels of technical expertise.²⁵ As employers turn to the education system, there is a clear need for manufacturers and educators to work together to rebuild training pipelines, but existing policies and practices are ill-equipped to recreate such pipelines at scale.²⁶ At the same time, the U.S. youth unemployment rate stands at 14 percent, causing policymakers to question current approaches to helping young people transition from school to work.²⁷

WHY GERMANY?

Germany offers an example of an advanced economy that has been able to sustain manufacturing as a relevant source of employment, growth, and exports. Manufacturing in Germany accounts for 20 percent of employment, nearly twice the share as in the United States.²⁸ Manufacturing generates 22 percent of total German GDP and 82 percent of German goods exports.²⁹ In stark contrast to the United States' \$667 billion manufactured goods trade deficit, Germany's trade surplus in manufacturing is about \$425 billion.³⁰

These strong labor market, growth, and trade outcomes reflect Germany's ability to infuse technology into its manufacturing sector to remain globally competitive. Medium and high-technology industries account for a larger share of the sector's total output in Germany (58 percent) than in the United States (42 percent).³¹ Yet a cross-national comparison reveals that Germany invests only marginally more in public R&D as a share of its economy; U.S. universities exhibit much greater scientific impact; and entrepreneurship (as measured by new firm creation) is actually lower in Germany.

Three statistics may help explain Germany's advantage in manufacturing. First, 86 percent of private-sector R&D occurs in manufacturing, a much higher share than the 64 percent in the United States.³² Second, Germany translates research into

Table 1. Germany vs. the United States on Key Economic Indicators

	Germany	United States
Economic Output		
Share of GDP in Manufacturing	22%	12%
Share of Manufacturing GDP in Medium & High-Tech Manufacturing	58%	42%
Trade		
Total Exports as a Share of GDP	52%	14%
Share of Merchandise Exports in Manufacturing	82%	62%
Trade Balance in Manufactured Goods	\$425 billion	-\$668 billion
Innovation		
Total Researchers Per 1000 Workers	8.22	8.08
R&D Expenditures as a Share of GDP	2.98%	2.79%
Share of Corporate R&D in Manufacturing	86%	68%
Number of Top 50 Universities in Leiden Impact Rankings	0	39
Patents per 1000 Researchers	53.03	38.74
New Firm Entrants as a Share of Total Firms	7.90%	8.50%
Workforce		
Share of Employment in Manufacturing	20%	10%
Average Hourly Compensation in Manufacturing	\$45.79	\$35.67
Share of Graduates in STEM Fields (OECD Rank/36)	3	33
Youth Unemployment Rate	8%	14%

Source: World Bank and OECD national accounts data; OECD Science and Technology Indicators; CWTS Leiden Ranking; OECD Entrepreneurship at a Glance data; U.S. Bureau of Labor Statistics.

new products and technologies more effectively. In 2011, Germany produced 53 patents per 1,000 researchers, compared to 39 patents per 1,000 researchers in the United States. Finally, Germany's ability to translate research into new products derives from its rich base of graduates in STEM (science, technology, engineering, and mathematics) fields. In a ranking of 36 OECD countries on their share of graduates in STEM fields, Germany ranked third, well ahead of the United States at 33rd. In 2012, more than 800,000 German students participated in an apprenticeship program in the manufacturing sector.³⁴ Partly as a result of these apprenticeship programs, manufacturing companies do not suffer as dramatically from shortages in the supply of skilled technical workers, and employees receive valuable

qualifications that translate into high wages. The average compensation for a manufacturing worker in Germany is \$46 per hour, 28 percent more than in the United States.³⁵

In these ways Germany offers an illustrative model for industry growth. Many factors contribute to Germany's strong global position in manufacturing and trade, including a series of economy-improving federal reforms during the 2000s as well as an undervalued currency.³⁶ But Germany also benefits from its concerted federalist policy effort to support clusters of globally competitive manufacturers, particularly its *Mittelstand* firms, through powerful public-private collaborations on applied research to support innovation and a dual model of vocational education to sustain a highly-trained workforce.

II. GERMANY'S INNOVATION SYSTEM

nnovation-the act of taking an idea or technology and transforming it into a sellable product or process-remains the key to raising the living standards of any advanced economy.³⁷ Manufacturing's most important economic contribution, therefore, may be its role as a significant source of innovation. A two-year study found that manufacturing firms were more likely to create new products and processes than non-manufacturing firms.³⁸ In turn, innovation remains a critical input to manufacturing, especially as information and digital technologies such as robotics, advanced materials, and complex software systems increasingly pervade

the sector.39

German manufacturers have been particularly successful in translating research into new products and technologies due to a dense network of universities, public research organizations, state and federal governments, industrial research organizations, and foundations (Figure 1).⁴⁰ Organized by a highly-coordinated federal technology strategy, these institutions work collaboratively and across multiple levels of government to support manufacturing through basic scientific research, applied industrial research, innovation incentives, and targeted strategies to develop industry clusters and new technologies.

BASIC RESEARCH-THE PLATFORM FOR INDUSTRIAL INNOVATION

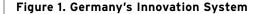
Germany employs a strong platform for basic scientific research that resembles the institutional structure in the United States. Basic scientific research occurs in a plethora of German institutions, including:

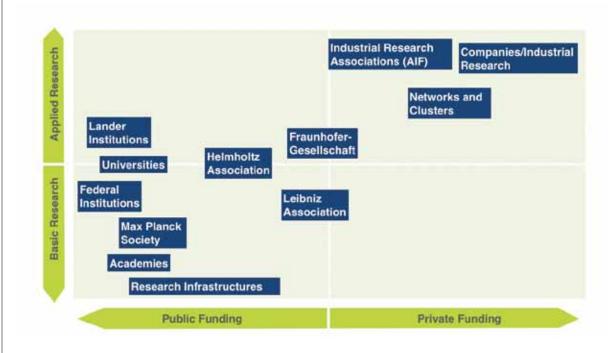
- A large network of universities and applied science universities;
- National laboratories such as the Helmholtz Association (the equivalent of the U.S. Department of Energy's National Laboratories). As Germany's largest research institution, the Helmholtz Association serves as the umbrella organization for different research entities in earth sciences, energy,

aeronautics, space and transport, health sciences, advanced materials, IT, and particle physics;⁴¹ and

Other research associations such as the Leibniz Association and the Max Planck Institutes. The Max Planck Institutes are one of the most prestigious research institutions in the world and focus on fields such as astronomy and astrophysics, complex systems, genetics, neuroscience, biosciences, chemistry, material science, computer science, particle and quantum physics, and microbiology.⁴²

Basic research matters for manufacturing in a couple of ways. First, as the main producers of pure scientific knowledge, basic research institutions provide the theoretical foundation for applied research and discover new research fields with potential application to industrial use.⁴³ Second, basic research laboratories are a vehicle for the federal government to shape the priorities of its broader industrial technology policy through grants and research bonuses.⁴⁴





Source: Brookings modification of graphic from "Research in Germany" portal, the central information platform of the initiative to "Promote Innovation and Research in Germany" by the Federal Ministry of Education and Research (BMBF).

APPLIED RESEARCH AND THE FRAUNHOFER SOCIETY

Where Germany's innovation system begins to differ from the United States' is in its network of applied research institutes. The Fraunhofer Society (Fraunhofer) is perhaps Germany's best known and most important applied research institution. Its purpose is to help translate basic research and nascent technologies into viable commercial products. Fraunhofer has 67 institutes and 23,000 employees in Germany as well as an international presence that includes seven U.S.-based centers.⁴⁵ Each institute cultivates a distinct specialization (e.g. applied polymer research, electric nanosystems, etc.) which fall under broader industries such as microelectronics, materials and components, production, surface technology and photonics, life sciences, information technology, and defense.⁴⁶ Approximately 70 percent of Fraunhofer's revenue is generated by contracts with industry and public institutions; state and federal governments contribute the remaining 30 percent.⁴⁷

BROOKINGS Metropolitan Policy Program

Put simply, Fraunhofer helps manufacturers bridge the valley of death, which often occurs at a stage of production development where the potential return

on investment is high but equally high levels of uncertainty prevent firms from investing significantly in R&D. This is especially true for small and mid-sized companies, where lower revenues at times prohibit R&D. Fraunhofer reduces firm uncertainty in a key way. Thanks to its vast network of researchers, which covers virtually all areas of science, Fraunhofer's scientists can interpret complicated experimental findings and their consequences in ways that lead to practical applications for the private sector.⁴⁸ The contracts they establish with firms, therefore, serve as a research subsidy: Fraunhofer charges companies to cover just the costs of developing a project, but do not include the historical costs Fraunhofer incurred to develop the institutional knowledge it uses in the project. Fraunhofer undertakes anywhere between 6,000 and 8,000 industry projects per year, including famous inventions like the MP3.49 The size of these projects varies significantly, ranging from less than €1,000 to several million euros.⁵⁰

Fraunhofer also offers flexibility to manufacturers. Firms may not have the in-house capabilities or resources to address a particular technical challenge so they contract with Fraunhofer to perform pre-production research or develop a prototype. At other times, Fraunhofer simply allows private sector researchers access to specialized machinery to test prototypes and conduct advanced research.⁵¹ Often Fraunhofer and industrial scientists work hand-in-hand on a project, promoting the mobility of scientists between universities and the industrial world.⁵² Research suggests that, through these myriad supports, Fraunhofer has been the most prominent actor in Germany's promotion of firm-level R&D.⁵³

In addition to supporting individual firms, Fraunhofer helps consolidate regional clusters by establishing industry or technological specializations within its individual institutes.⁵⁴ These specializations typically coincide with the industrial base of the region in which they reside and complement the research expertise of other research institutions and universities. Together, these networks form the backbone of a regional innovation ecosystem, but collaboration is not limited to only within the region. The Fraunhofer network has also facilitated "long distance" collaboration, which occurs when the closest Fraunhofer facility is not specialized in the technology of interest for a particular firm.

The German Federation of Industrial Research Associations are a less discussed but still relevant part of Germany's applied research ecosystem. They provide a series of services to support the advancement of R&D in SMEs by promoting, alongside the federal and state governments, relevant research areas for the industry.⁵⁵ They diffuse relevant information among SMEs, directing many firms to the right research institutions, and serve as project managers for joint research projects. They also facilitate the pooling of resources to avoid the problems of funding shortfalls, personnel or training gaps, and technology and equipment inadequacies.⁵⁶

INNOVATION INCENTIVES

The collection of organizations involved in supporting innovation in manufacturing-research centers, universities, firms, and research consortiums-benefit from a robust offering of incentives from Germany's federal and state governments. The system has multiple tools to foster innovation, which translate into multiple options for companies to access and implement R&D, thus maximizing the likelihood they will adopt new technologies.

The federal government, via the Federal Ministry for Economic Affairs and Energy (BMWi), provides direct funding for SMEs through the Central SME Innovation Program (*ZIM-Solo*). Companies that have fewer than 250 employees can apply for a non-refundable research subsidy to cover expenses associated with the development of R&D projects, either in-house or by a research institution, as well as consulting services for the implementation of new processes and technologies. The funds, up to € 350,000, can cover up to 55 percent of R&D activities and up to 50 percent of the consulting services.⁵⁷

State governments also have a wide range of tools to promote innovation. State-level funding facilitates collaboration between universities, other research institutions and firms. In Bavaria, the Ministry of Economic Affairs, Infrastructure, Transport and Technology provides funds for joint research through programs such as the New Materials Development Program, Microsystem Technologies Program, and Information and Communication Technologies Program.⁵⁸

State governments also provide innovation vouchers to SMEs to support their R&D activities. Innovation vouchers allow firms to conduct additional research themselves or redeem the voucher at a research institution of their choosing. The effect of the innovation vouchers is twofold. First, they promote the participation of SMEs in R&D activities that, due to high financial cost and uncertainty on the return of the investment, would not have occurred otherwise. Second, the vouchers also provide additional funding for research institutions, particularly for applied research organizations, to conduct risky research at a lower cost.⁵⁹ The state of Bavaria offers innovation vouchers through its Program for the Introduction of Technologies (BayTP), while also offering loans and capital for recently created start-ups in high-tech industries.⁶⁰

SMART FEDERALISM ORGANIZED Around technologies and Regional clusters

Germany organizes basic research, applied research, and firm-level incentives around a concerted federalist strategy that sets general policies and research guidelines, establishes funding levels, decentralizes administrative tasks, and defines priority technologies, regions, and clusters.

Germany's federalist strategy begins with its national innovation policy, the High-Tech Strategy 2020 (HTS). The HTS provides incentives to increase collaboration between science and industry and, in doing so, sets the framework for basic and applied research. The strategy provides €15 billion for research related to cross-cutting technologies that have broad applicability across multiple manufacturing industries, dispensing the funding in a competitive process that requires collaboration among public, private, and civic institutions.⁶¹ Similarly, the Federal Ministry for Economic Affairs and Energy's ZIM-Coop scheme provides funding for R&D projects undertaken by several companies or between a firm and research institutes.⁶²

Germany's strategy also recognizes that innovation typically occurs amid regional clusters of research institutions, firms, and universities. In 2007 the Federal Ministry of Education and Research launched the Leading-Edge Cluster Competition, a research contest that provides funds of up to \in 40 million to five clusters, selected every 18 months, to develop key technologies that have the potential to impact an entire supply chain.⁶³ The initiative asks for joint proposals by the private sector, research institutions, and universities to develop new technologies, products, and processes. These programs are not "top-down" in the traditional sense. Rather, they decentralize administrative and managerial tasks to project management institutions well-versed in the innovation needs of firms; a structure that reduces duplicity of efforts, minimizes bureaucracy costs, and improves project management.⁶⁴ As of 2014, three different cohorts of five clusters each have been selected, all revolving around one key technology and involving a regional component. Preliminary results show that participating SMEs were more likely to conduct R&D.65

BROOKINGS METROPOLITAN POLICY PROGRAM In many occasions federal funds complement state-led innovation initiatives. For example, two clusters selected as part of the Leading-Edge Cluster Competition also received support from the Bavarian Ministry of Economic Affairs, Infrastructure, Transport and Technology's Cluster Offensive. The funds provided by the state government were utilized to cover expenses not included or sufficiently funded in the Leading-Edge Cluster Competition funds.⁶⁶

The main takeaway: Germany's innovation system offers several types of resources and

"Germany's comprehensive innovation strategy helps firms engage in R&D, fosters collaboration between researchers and the private sector, and enhances the competitiveness of manufacturers and the regional economies in which they reside."

incentives for different actors with a significant role in the innovation process. This multi-targeted and multilevel approach increases the likelihood that firms will engage in R&D, fosters collaboration between researchers and the private sector, and promotes accumulation of research and technical knowledge within manufacturers and the regional economies in which they reside. Thanks to this organized effort, a wide variety of firms, particularly Germany's *Mittelstand*, have been able to reap the benefits of public and private research to outperform international competitors.⁶⁷

STUDY TOUR: EXAMINING GERMANY'S INNOVATION MODEL AT ESG⁶⁸

he Global Cities Initiative study tour examined Germany's multi-faceted innovation system through a visit to the mid-sized industrial software house ESG in Munich and a workshop between leading U.S. and German practitioners and policymakers. Following a tour of ESG's software simulators, a series of executives at ESG and public officials described the purposeful German approach to technology innovation. Participants were impressed by the rigor of ESG's internal "road-mapping" of the direction of the global systems software business and its self-funded research programs, which allow employees to apply for three-week mini sojourns to try out new ideas in preparation for more substantial investigations.

Buttressing ESG's company-level efforts are a multi-dimensional set of supportive institutions and activities. Jurgen Niehaus, the CEO of the German "competence cluster" SafeTrans, noted how his industry association supports R&D activities in ESG's embedded systems industry through a variety of workshops,

exchanges, and outlook exercises. Florian Holzapfel, the chairman of the Department at Flight Dynamics at the nearby Technical University of Munich, described a university heavily oriented toward applied technical work on avionics and the dynamics of aerial platforms. And Manfred Wolter from the state of Bavaria's technology ministry detailed a carefully structured suite of sub-national programs aimed at strengthening the region's research infrastructure, providing R&D funding, and encouraging tech transfer, especially to small and medium-sized businesses.

The American participants were



impressed by the deliberateness of a fully worked-out system aimed at surrounding firms with everything they might need to innovate. And yet, German workshop attendees also reflected on the possible shortcomings of their system, which prompted a frank dialogue about the strengths and weaknesses of two contrasting, but highly successful, innovation systems. While the Americans were struck by the strong embrace of regional collaboration and the sophistication of government's engagement in technology development, the Germans remained envious of American-style business dynamism.

Along those lines, participants heard from American experts from Clemson University's International Center for Automotive Research (CU-ICAR) and TechShop, a national network of maker spaces that provides entrepreneurs access to tools, software, and workspace. Several university-based former ESG employees applauded American entrepreneurship and worried about the inertia of the highly procedural German system. Others perceived a weakness in Germany on the production of "radical new ideas" and worried about a lack of attention to start-ups and small companies, latter of which is a specific focus of the TechShop model. The encounter played out as a balanced weighing of two successful, but imperfect, national innovation systems with each having much to learn from the other. Representatives from ESG demonstrate the simulators they use to test the information technology systems that will be embedded in automobiles and aircraft.



III. GERMANY'S WORKFORCE TRAINING SYSTEM

f innovation continues to be the key to raising living standards, human capital remains a critical determinant of innovation.⁶⁹ While the term innovation may invoke radical breakthroughs such as the internet or the iPhone, research suggests that most firm-level innovation is actually incremental in nature, and therefore relies on a broad swath of the workforce.⁷⁰ Manufacturing epitomizes this phenomenon: The complex, capital-intensive systems that increasingly define manufacturing demand qualified production workers who possess the practical knowledge, creativity and adaptability to implement and improve new processes and technologies.⁷¹ And it is workers' ability to complement machines that increasingly determine their productivity, and therefore the wages they can command.⁷²

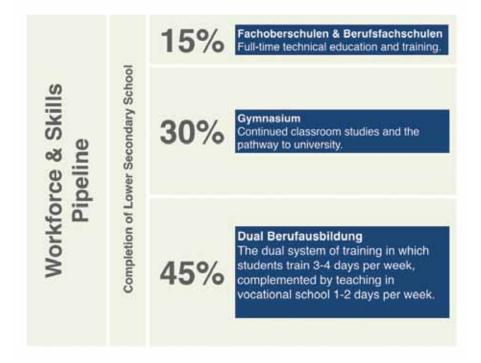
THE DUAL SYSTEM: EDUCATION AND WORK

The German education and training system has been particularly adept at preparing its manufacturing workforce to complement new technology.⁷³ This preparation begins relatively early in the education pursued the university track.⁷⁷ Germany is actively promoting greater participation in university-based higher education. This emphasis has led to recent reforms that aim to ease the transition from the dual system to university, which according to an OECD review has not historically been a common pathway.⁷⁸

system as compared to other countries. German students are tracked at an early age.⁷⁴ The school system closely follows the performance of primary school pupils to assess their ideal educational path. When students finish primary school (at the age of 10-12), parents, students, and educators together decide on one of three common lower secondary schools: general secondary school (Hauptschule), Intermediate School (Realschule), and Grammar School (Gymnasium).75 Upon completion of lower secondary school three pathways to employment emerge-45 percent of students enter the dual system (Dual Berufsausbildung), 15 percent pursue full-time vocational education and training (Fachoberschulen and Berufsfachschulen), and 30 percent continue Gymnasium en route to university.76

The most common pathway to a job is the dual system, through which students obtain field-specific

workplace skills in one of 349 occupations (as of 2013) that cover all aspects of the economy. Training occurs mainly through a two- to three-year apprenticeship at a firm, where students train three or four days a week. Students spend the remaining one or two days per week at a part-time vocational school (*Berufsschule*) where they receive more theoretical training. According to the most recent statistics, 1.46 million young people participated in apprenticeships in 2011. While this is still the dominant pathway to the labor force, participation in the dual system declined 3.2 percent between 2010 and 2011, as more young people



Source: Brookings Institution with information from the Federal Institute for Vocational Education and Training (BIBB).

THE ROLE OF EMPLOYERS, GOVERNMENT, AND OTHER SOCIAL PARTNERS IN THE DUAL SYSTEM

From the very beginning of the journey from school to work, dual system participants establish close relationships with employers.⁷⁹ Companies sign contracts with young people under private law and provide them an hourly wage just below that of an entry-level worker. On-the-job training typically comprises two-thirds of the curriculum in the dual system and the contents of the curriculum as well

LESSONS FROM GERMANY

Figure 2. Germany's Workforce and Skills Pipeline

as supervision are the responsibility of the hiring company, with active monitoring by the industrial chambers of commerce and state government to ensure training is in accordance with national occupational standards. Firms also contribute about two-thirds of the overall costs (approximately €5.6 billion in 2010) of the dual system through on-the-job training (states cover the remaining costs).⁸⁰ Twenty-two percent of German companies offered on-the-job training in 2011.⁸¹

Employers participate in the dual system for several reasons. Evidence suggests that German manufacturers do not recoup the cost of training apprentices during the apprenticeship.⁸² Rather, they are viewed as a human capital investment that will pay off as apprentices become more skilled full-time workers upon completion of their training.⁸³ Skills investments are justified because access to gualified labor provides firms a productivity advantage over their competitors, given that many technical skills remain relatively scarce.⁸⁴ Additionally, solid worker protections from the country's powerful labor unions make firing workers more difficult than in countries like the United States. Apprenticeships allow German manufacturers to evaluate young workers before hiring them full-time, and significant investments in skills are more attractive to companies when they know workers will be in their factories long-term.

Manufacturers in Germany are better able to participate in the education and workforce system because they are organized by a network of supporting chambers of commerce, government, and labor organizations.

The dual system relies heavily on the national network of 80 regional chambers of industry and commerce (IHK), which employers are required by law to join and serve two critical functions. First, the IHKs are the organizing voice for industry in the workforce system. Instead of an individual employer having to spend the time and resources to establish a specific, one-off collaboration with a vocational school, it can engage the system under the umbrella of the IHKs. Further, IHKs represent firms during training regulation negotiations with the federal government, state government, and trade unions. Second, the IHKs provide institutional support to ensure that firms comply with the standards of the Vocational Training Act of 1969 (updated in 2005). IHK experts assist companies with vocational training, register the training contracts, help conceive occupational examinations, examine trainees and instructors, and withdraw training permission in case companies violate training standards.⁸⁵ There is no equivalent American organization that provides the scope and depth of firm-level support provided by the IHKs in the German workforce system.

On the public sector side, the federal government, through the Federal Ministry of Education and Research (BMBF), the Federal Ministry of Economics and Technology (BMWi), and the Federal Employment Agency (BA), supervises the implementation of the general guidelines established in the Vocational Training Act. The nationally-organized advisory committee for the Federal Institute for Vocational Education and Training (BIBB) facilitates dialogue between the private sector, state government, unions, and local officials to establish occupational credentials.⁸⁶

The Länder (state) governments, represented by their ministries of education and economic affairs, are responsible for vocational schools, overseeing the IHKs, and promoting cooperation between the school-based and work-based aspects of the dual system. State governments contribute about onethird of the costs of the dual system (approximately € 3.1 billion).⁸⁷ Individual state governments are advised by Länder vocational training committees that include representatives from relevant state ministries, employer associations and chambers, and workers. And the Conference of State Ministers of Education (KMK) decides on common approaches and national recognition of the types of school, curriculum standards, and qualifications.⁸⁸

Workers, typically via the country's powerful labor unions, participate in various stages of the dual system–advising state and national vocational education and training committees, negotiating occupational credentials, and sitting on works councils.⁸⁹

THE ROLE OF OCCUPATIONAL CERTIFICATIONS IN THE DUAL SYSTEM

The high degree of collaboration between government, labor, and employees reflects itself in the dual system's establishment of nationally-defined, industry-recognized occupational certifications, around which the social partners and government organize training. Upon completing an apprenticeship or full-time vocational degree, German students are accredited by the BIBB, based on their performance on examinations administered by the country's chambers of commerce in areas such as industry, health, agriculture, and commerce. Approximately 60 percent of Germans receive a relevant occupational certification by the age of 20, either through the dual system or a full-time vocational school.⁹⁰

As of 2013 there were 349 different federallyrecognized certifications, which are quite stringent by international standards and remain a requirement for employability.⁹¹ For certifications to have lasting significance they must be continuously updated and new occupations must be added to keep pace with technological and economic change.⁹² The process of upgrading training requirements and certifications begins with industry. Employers notify their chamber of commerce, who then pass along the request to the BIBB, where experts study it and, if deemed necessary, upgrade the training regulations. BIBB decisions receive input from an advisory committee with members from the private sector, state government, unions, and municipalities. For occupational upgrades, the entire process takes about a year while a new occupation definition typically takes two years.93 Almost one-third of existing occupations have been created in the last 15 years to respond to the rapid technological change occurring in many industries.94

A national credentialing system contributes to labor market transparency and certainty. Credentials jointly determined by employers and educators provide certainty for: 1) students, who have reasonable confidence that their education investment will be recognized and rewarded by employers; 2) educators, who better ensure that the education they are providing is economically relevant; and 3) employers, who more clearly understand how prospective employees' education, competencies, and skills match the needs of their open positions. Credentials also ensure portability across states: a company in Bavaria operates under the same certification system as a company in Baden-Württemberg. This regime differs markedly from the highly decentralized, opaque system of occupational credentialing in the United States.

Centralized certifications are not without drawbacks, however. They may limit labor market flexibility: The barrier to entry for occupations can be unnecessarily high for professions that do not actually need formal training, or transitioning to a new occupation may be overly difficult because workers must restart the training process to gain a new certification. In response to these critiques, policies have been put in place that count qualifications obtained through the dual system or full-time vocational education towards other occupational credentialing or the further pursuit of higher education.⁹⁵

The main takeaway: The German education and training system significantly aids innovation within the manufacturing sector.⁹⁶ First, the system endows manufacturing workers with general skills in different clusters of industries, providing a basic foundation so they can accrue very specialized on-the-job skills.⁹⁷ Second, the occupational profiles take into consideration best practices in human capital development, with a strong emphasis on active learning and adaptability. This approach favors early-career apprenticeships in addition to lifelong training, often supported by companies, so technical workers can improve production processes and effectively implement innovations along the value chain as technologies change.⁹⁸ And third, the entire training system nimbly responds to industrial and occupational changes due to close cooperation between companies, industrial chambers, research institutions, and government agencies.⁹⁹ Drawing on this collaborative system to train their workers has helped Germany's world-renowned *Mittelstand* keep their products at the cutting edge of global markets.¹⁰⁰

STUDY TOUR: OBSERVING THE DUAL SYSTEM ON THE FACTORY FLOOR AT SIEMENS AND SEIDENADER¹⁰¹

• he Global Cities Initiative delegation visited two Bavarian companies–Siemens and Seidenader– to understand the German approach to work-based education and training from the perspective of a major multinational firm and a Mittelstand company, respectively. After touring Siemens' Nuremberg factory floor, participants heard from executive Jürgen Siebel about why the company invests significantly in its apprenticeship program. For starters, youth unemployment rates are still unacceptably high in most of the world-14 percent in the United States and well above 25 percent in parts of Southern Europe-a threat to both economic competitiveness and societal stability. He argued that a skilled and flexible labor market is critical to sustaining a full and lasting recovery, preserving a strong industrial base, and

The U.S. delegation heard firsthand from more



An apprentice at Siemens demonstrates his final project-a model smart grid-to Amy Liu of Brookings and Karin Norington-Reaves of the Chicago-Cook Workforce Partnership.

BROOKINGS METROPOLITAN POLICY PROGRAM

complete their apprenticeship. American participants remarked that beyond the first-class technical skills apprentices displayed, these young people's soft skills-their ability to work in teams, their confident presentation, and their full command of English-were perhaps even more impressive. Siemens, one of Germany's largest and most prestigious companies, has the luxury of selecting the most talented apprentices from a highly competitive application process.

The following day the delegation visited Seidenader, a 400-employee manufacturer of visual inspection machines for pharmaceutical products located just outside Munich. Even though it is much smaller than Siemens, Seidenader maintains a similarly robust apprenticeship program. Each year, the firm's leadership visits local schools, provides weeklong internships to high school students, and selects apprentice candidates based on interest and aptitude. The firm's strong recent growth has allowed it to bring in dozens of apprentices a year, training them for two to three years in technical and commercial occupations while they also attend school. Unlike at Siemens, where apprentices are educated in a separate training facility, Seidenader's apprentices work right alongside other employees on the production line, in machine installation and maintenance, and in sales and marketing. Management reports that the firm has hired about 90 percent of apprentices upon their completion of the program. Two-thirds of Seidenader's workers end up pursuing more education with support from the company-to gain new skills with hopes of a higher income and more responsibility at the factory.

Note: Siemens AG provides financial support to Brookings

PHOTO BY DARREN JACKLIN



n both skills training and technological innovation, U.S. policies to support manufacturing have not matched the sector's evolution from one dominated by massive, vertically-integrated companies to a more distributed mix of small, medium, and large firms. Research and development, particularly applied research, and training are underprovided in the market as individual firms are fearful they will not recoup their full investment. Each suffers from a market failure which business, civic, and policy leaders must together address to curb the country's long-term decline in manufacturing.

Meanwhile, Germany's public-private collaborations around technology and its dual model for vocational education are widely considered global best practices. But can they be transferred to the United States?

Notwithstanding the two countries' similarly devolved federalist systems, there are important differences that may impede full adoption. First, government plays a more significant role in shaping the economy in Germany than in the United States. Government spending as a share of GDP in Germany (45.3 percent) exceeds that of the United States (41.7 percent) and the federal government has historically intervened more in businesses and labor markets.¹⁰²

Second, the relationship between business and labor differs markedly across the two countries. Firm membership in industrial chambers of commerce is mandatory in Germany. German law requires workers to have a seat on a company-level works council to bargain with management on changes to company practices.¹⁰³ Union coverage rates are also dramatically higher: Approximately 61 percent of eligible German workers were covered by a collective bargaining agreement in 2011 versus 13 percent of American workers.¹⁰⁴ Third, both the vocational education system and collaborations on technology development have a long history in Germany, with the former rooted in the country's medieval guilds, raising questions about whether they can be quickly adopted by other countries.¹⁰⁵

These political and cultural differences suggest that the German model cannot and should not be imported whole cloth. Rather its most successful elements can be drawn out, documented, and then tailored to our unique political economy and federalist system. Three key takeaways-regional collaboration between public, private, and civic actors; targeted institutional intermediaries that address market and coordination failures; and incentive-based investments to support SMEs-should guide U.S. practitioners and policymakers seeking to adapt German skills and innovation best practices to support manufacturing. As with most policy advancements in the United States, especially given continued paralysis in Washington, early adoption will occur in the country's cities, regions, and states. Indeed, several U.S. regions and states have already adopted at least one of these three "elements of success" to guide their workforce and innovation strategies.

REGIONAL COLLABORATION

Germany's regions display distinct levels of collaboration between government, educational institutions, employer associations, and firms to support the skills and technology innovation demands of key manufacturing industries. Similarly impressive levels of coordination are occurring across leading U.S. regions:

In San Diego, CA a dense network of universities, research institutions, economic development organizations, talented workers, and innovative firms have collaborated for decades to build and nurture its worldbeating clusters in life sciences and information technology (IT).

INNOVATION | NETWORKS, CLUSTERS, AND TALENT FURTHER INNOVATION IN SAN DIEGO

An Diego exemplifies how a metro area can leverage its regional resources to foster innovation and promote the creation of high-tech clusters. Over the past 40 years, San Diego has transformed from a defense, real estate development, and tourism dependent economy to a world-leading hub of biotechnology and information and communication technology companies. Its economic transformation can be explained by three critical elements that helped the metro area leverage its regional resources effectively: a dense network of institutions and universities that perform cutting edge research; the existence of organizations that aid the creation of technology-oriented companies; and a steady supply of highly qualified workers to foster innovation.¹⁰⁶

First, a dense network of research institutions, including six universities and more than 80 research institutes, provide the scientific knowledge and resources to San Diego companies to develop new products. The San Diego innovation network promotes joint research projects that diffuse relevant knowledge across firms, a critical process in the formation of high-tech clusters, and fosters the development of a network of entrepreneurs and researchers.¹⁰⁷

Second, San Diego's manufacturers have also benefited from cluster-focused organizations like CONNECT. Focused on life science and technology products, CONNECT helps organize entrepreneurs, scientists, business services providers, and venture capitalists. Firms are able to tap into the ideas, managerial expertise, capital, and business services necessary for their early growth. CONNECT's \$3.7 million budget is sustained through membership fees and has helped in the creation of more than 3,000 companies in the region.¹⁰⁸

Third, a constant supply of qualified workers has allowed San Diego to sustain and expand innovative products. Universities such as UC-San Diego, the University of San Diego, and San Diego State University, and research institutions like the Salk Institute for Biological Studies and the Scripps Research Institute, are the main suppliers of technically trained workers. These researchers and the industry clusters to which they belong have higher average wages compared to other industries both in San Diego and nationally, and have registered higher growth in wages than other industries.¹⁰⁹

Finally, San Diego has developed into a high-tech cluster by making effective use of local, state, and federal resources. State and federal funding to universities and other research institutions was critical for the development of the underlying science behind many of the firms located in San Diego. Furthermore, the existence of a research network is a necessary condition for the emergence of innovation but not a sufficient one. The active involvement of different stakeholders through organizations like CONNECT and the provision of the right incentives to promote joint research and collaborative networks are equally important.

BROOKINGS METROPOLITAN POLICY PROGRAM

BEST PRACTICES: CONNECT, NorTech, SEMATECH

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Led by Toyota, manufacturers in the Louisville-Lexington region have created an industry-led consortium in partnership with a local community college to strengthen the region's supply of young technical workers.

SKILLS | KENTUCKY FAME BUILDS REGIONAL TALENT SUPPLY

entucky's automotive industry, the state's largest manufacturing industry, employs 65,000 workers at over 400 facilities.¹¹⁰ None hosts more jobs than Toyota's Georgetown plant-where 7,000 workers support the manufacture of the Camry, Avalon and Venza models-the company's largest outside Japan.¹¹¹

Yet beginning in 2009, Toyota executives began to register concern that the region's workforce would not be able to replace the pending wave of front-line worker retirements. In response, the company partnered with the Bluegrass Community and Technical College (BCTC) to create the Advanced Manufacturing Technician (AMT) program–a multi-disciplinary degree focused on electricity, fluid power, mechanics, and fabrication–to strengthen the supply of young manufacturing workers in the Lexington region.¹¹² Since then, the AMT program has expanded to upwards of 15 additional companies and now operates under a regional consortium called the Kentucky Federation of Advanced Manufacturing Education (KY FAME).

In many ways the AMT program resembles the German approach to dual-track training. Participating companies recruit from a pool of high school students that must meet a stringent set of requirements to be considered: 1) graduated from a Project Lead The Way high school (Project Lead The Way is a K-12 STEM program operating in 6,500 elementary, middle, and high schools nationwide); 2) scored at least a 25 on their ACT; and 3) maintained at least a 3.0 GPA.¹¹³ Once sponsored by a company, AMT trainees undertake a two-year apprenticeship through which they attend classes at BCTC two days a week and earn a wage between \$12 and \$16 working for the sponsor company for the remaining three days.¹¹⁴ Most students complete the program debt-free.¹¹⁵

The region's educational institutions engage closely with employers. BCTC has a campus on Toyota's grounds so that selected students can get first-hand training with robots, computers and other equipment. In the fall of 2014, new construction began on a \$24 million advanced manufacturing training center associated with BCTC.¹¹⁷ And four-year programs at Northwood University and the University of Kentucky are available for those students seeking an engineering degree upon completion of AMT.

KY FAME is a unique example of regional collaboration because it is entirely employer-generated. After developing AMT, Toyota helped organize other regional manufacturers with similar talent needs, including those in their supply chain, growing the program from four companies sponsoring 15 students in 2013 to 15 companies sponsoring 50 students by the fall of 2014. In 2013 Toyota's AMT was recognized as the nation's top Career Pathway program by the National Career Pathways Network and its early success is now being replicated in other parts of the state, including as a key element of Louisville-Lexington's Bluegrass Economic Advancement Movement (BEAM) manufacturing strategy. A central challenge, however, is resources. Currently, KY FAME has no devoted staff, but rather relies on staff at participating companies to fundraise, market, and organize the collaborative. Private and public leaders alike recognize the need to hire full-time staff and are exploring different models, from state and federal grants to company membership dues, to finance KY FAME's next phase.

BEST PRACTICES: KY FAME, Centers of Excellence, Partners for a Competitive Workforce

TARGETED INSTITUTIONAL INTERMEDIARIES

A second German element of success is its institutions, which in turn support regional collaboration. German manufacturers receive support from tailored intermediaries designed to correct for the market's underprovision of pre-competitive research (Fraunhofer Institutes) and job training (regional chambers of commerce). Similar institutions, albeit at a smaller scale, provide similar benefits in U.S. regions:

In Detroit, MI a reinvigorated manufacturing base draws on the institutional knowledge, capabilities, and space from one of Fraunhofer USA's seven American locations to help cultivate a new specialization in battery technology.

INNOVATION | FRAUNHOFER USA HELPS POWER DETROIT'S BATTERY INDUSTRY

s Detroit's manufacturing base emerges from the Great Recession, the region is providing resources to companies to engage in research and development and drawing on a deep network of research institutions to cultivate new specializations in advanced technologies. Detroit's efforts to become an innovation hub are exemplified by Inmatech, a startup manufacturing company that fabricates efficient, low cost lead-acid batteries that are used in the automotive industry, electrical grids, and other defense-related systems.¹²⁰

Founded in 2010, Inmatech's emergence is the product of many institutions and actors. The technology behind its prototype is the result of basic research conducted by Levi Thompson, professor of chemical engineering at the University of Michigan and director of the school's Hydrogen Energy Technology Laboratory, which is part of a broader research effort involving Wayne University and Michigan State University to promote technologies that impact advanced manufacturing.¹²¹

In addition to their collaboration with the University of Michigan, Inmatech has worked closely with the Fraunhofer Center for Coatings and Laser Applications (CCL).¹²² Their joint work allowed Inmatech to develop a supercapacitor, a class of electrochemical energy-storage device that complements batteries for uninterruptible power supply applications. This component was necessary for their final prototype, and was successfully developed thanks to the ample technical and commercial expertise of researchers at Fraunhofer.

Finally, local and federal governments as well as local stakeholders provided critical support to Inmatech. The company's battery prototype was funded by \$610,000 in small-business innovation grants from the National Science Foundation.¹²³ Inmatech has also received funds from local and regional grants and awards, including the Lakes Entrepreneur's Quest and the Michigan Clean Energy Prize.

Inmatech is now poised to impact multiple industries, like electricity generation, defense, and aeronautics, thanks to the ecosystem that facilitated the development of its technology.

BEST PRACTICES: Fraunhofer USA, EWI, CU-ICAR, Commonwealth Center for Advanced Manufacturing, TechShop

A sector-based workforce intermediary in Southeast Michigan has effectively overcome significant coordination challenges to create an advanced technician training program in conjunction with area manufacturers and community colleges.

SKILLS | MICHIGAN ADVANCED TECHNICIAN TRAINING PROGRAM (MAT²)

etroit's post-recession recovery has been one of the nation's strongest, ranking fourth among the nation's 100 largest metropolitan areas, bolstered by a 29 percent increase in manufacturing jobs.¹²⁴ Yet as the region's manufacturers increased production, they discovered an insufficient pipeline of workers with competencies in mechatronics, a design process that requires knowledge of mechanical engineering, electronics, and computer programming. It was at about this same time that Michigan Governor Rick Snyder participated in a trade mission to Germany, where he became convinced that a statewide initiative resembling the dual system could help Michigan's manufacturing skills shortage.¹²⁵

Upon returning from his trip, Governor Snyder asked the Michigan Economic Development Corporation (MEDC) to help overcome the collective action problems that so often plague pilot workforce development initiatives. Community colleges needed to be convinced that they would enroll at least 15 students to make a capital-intensive mechatronics program cost-effective. Employers needed to be convinced that the program would be worth the approximately \$20,000 annual cost to cover apprentices' tuition and wages. And students and parents, with the job losses of the Great Recession fresh in their minds, needed to be convinced that a manufacturing training program offered a viable pathway to well-paid career with advancement opportunities.

In 2013, MEDC launched the Michigan Advanced Technician Training Program, or MAT², along with Henry Ford Community College and Oakland Community College and 11 Southeast Michigan manufacturers. The first cohort contained 31 students and focused only on mechatronics, but by September 2014 MAT² had expanded to include 29 employers, 98 students, four community colleges and now offers additional programs in Information Technology and Technical Product Design.¹²⁶ Each program costs about \$300,000 to launch and MAT² maintains an annual budget of \$1 million, which is supported by the state of Michigan.¹²⁷

MEDC, a quasi-public agency, has been the coordinating body during the program's ramp up, with support from an advisory committee that includes representatives from industry, community colleges, the Department of Labor, and the German-American Chamber of Commerce.¹²⁸ German and American manufacturing firms work with the participating community colleges to design the curriculum and core competencies, cover their trainees' tuition, and pay them between \$9 and \$12 per hour over the course of the program.¹²⁹ Graduating high school seniors that prefer an alternative route to a four-year university can gain theory, practice, and work experience over the course of the three-year program. MAT² markets the program at college and career fairs and Metro Detroit school districts.¹³⁰ Successful graduates of the three-year training program receive an associate's degree, a nationally-recognized credential from the Department of Labor and/or a national-recognized credential by the German IHK, and a company certificate (when applicable). Most importantly, they have an entry-level technician job waiting for them.¹³¹

BEST PRACTICES: MAT², Apprenticeship 2000, Wisconsin Regional Training Partnership

INVESTMENT

Finally, manufacturers in Germany receive a diversity of public investments to incentivize companies, particularly SMEs, to invest in technology and train workers. Several forward-looking U.S. states are making these types of strategic investments:

While most funding for basic and applied research occurs at the federal level, states are also supporting companies with targeted investments. In **Pennsylvania**, Ben Franklin Technology Partners spurs economic growth by investing in technology commercialization.

INNOVATION | INVESTMENTS IN INNOVATION: BEN FRANKLIN TECHNOLOGY PARTNERS

hree decades ago Pennsylvania's political leadership founded the Ben Franklin Technology Partners (BFTP) to catalyze technology-led economic growth. Through its four regional headquarters, BFTP provides companies with capital, technical assistance, and connections to a broad network of firms, universities, and experts.

BFTP makes direct investments to both start-ups and established companies seeking to commercialize new technologies. Through a rigorous vetting process, BFTP has made over 3,500 investments in Pennsylvania companies since its founding in 1983. Often BFTP has been one of the first institutional investors in a company, helping solidify commercialization efforts and spurring additional capital injections from other investors.¹³² For instance, BFTP seeded the first capital investment to a young researcher from Johns Hopkins Medical School to commercialize his research on cancer and infectious disease treatments. That researcher went on to found Morphotek, which today employs 200 workers and is one of the leading life sciences companies in Pennsylvania.¹³³

BFTP's experts also deliver technical assistance. The organization's experts help young companies with product development, marketing, fundraising, accounting, operations, and human resources. This aspect of BFTP's work helps companies chart a growth path that takes them from their initial idea to full commercialization.¹³⁴

Finally, and perhaps most importantly, BFTP serves as the hub of a deep institutional network that can be tapped to support companies. This network stretches across the investor community, universities and research labs, state and regional economic development organizations, business incubators, and other entrepreneurs. Since 1987, East Penn Manufacturing, one of the world's largest battery manufacturers, has drawn on BFTP's networking capabilities to partner with Lehigh University, Enterprise Systems Partners, Penn College of Technology's Plastics Innovation and Resource Center, and Northampton Community College's Emerging Technology Applications Center.¹³⁵

Together, these services have yielded real economic benefit. An evaluation of BFTP by Pennsylvania Economy League and KLIOS Consulting estimated that since 1989 BFTP has contributed over \$23 billion to the state economy, helped create 51,000 jobs in its firms, and generated a 3.6-to-1 return on investment in terms of state tax revenue.¹³⁶ Strong economic outcomes from its relatively modest budget (around \$14 million as of 2011) continue to position BFTP as a leading state-level best practice.¹³⁷

BEST PRACTICES: Ben Franklin Technology Partners, CTNext, Advanced Industry Accelerator Program

- States are taking the lead in making investments to connect young people with employment opportunities. South Carolina has utilized an employer tax credit to create one of the country's largest and fastest growing apprenticeship programs.
- *

SKILLS | APPRENTICESHIP CAROLINA: CREATING NEW PATHWAYS TO MANUFACTURING EMPLOYMENT

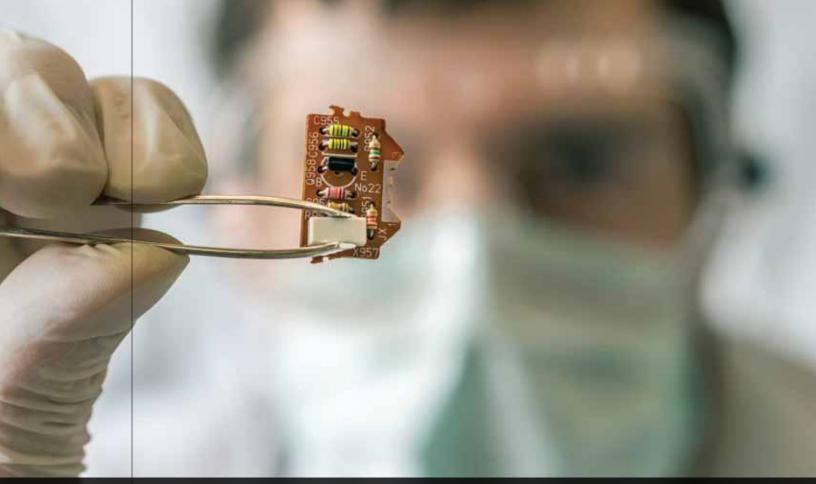
outh Carolina has long been a destination for German companies–from BMW to ZF to Bosch. The state has now become an early adopter of incentivizing apprenticeships through its statewide program, Apprenticeship Carolina.

Apprenticeship Carolina operates in 46 counties across South Carolina to expand junior and adult apprenticeship programs in manufacturing, technology, healthcare, and other industries. Initiated under a special grant from the state legislature and housed within the South Carolina Technical College system, Apprenticeship Carolina provides companies with free apprenticeship consultants to guide them through the registered apprenticeship development process, from initial information to full recognition in the national Registered Apprenticeship System.¹³⁸ Consultants identify occupational training gaps, solicit proper supervisors for apprentices, link to providers for related technical instruction (often at one of the state's 16 technical colleges), and recruit a supervisor to maintain training standards.¹³⁹ The program costs about \$1 million a year, which is covered through state funding and includes an annual employer tax credit of \$1,000 per apprentice.¹⁴⁰

The apprenticeship typically consists of two main components: 1) on-the-job training at the workplace; and 2) a job-related technical instruction at a local community or technical college. As the apprentice's skills progress, so does their pay through a set formula. It is also a way for an employer, who sets the wage levels, to offset costs when investing in employees who are not immediately fully productive and to retain employers when investing in their training.¹⁴¹ For instance, the BMW Scholars program offers full-time students at three local community colleges the opportunity to work up to 20 hours per week at BMW's Spartanburg auto plant while they complete their two-year degree.¹⁴²

Apprenticeship Carolina has achieved remarkable growth. Begun in 2007 with just 777 trainees and 90 companies, it has since served over 10,000 students and more than 650 companies.¹⁴³ Yet the program is not without its challenges. First, an underlying concern for participating companies is that other companies that do not invest in the apprenticeship program can still profit by poaching or hiring workers who have been trained by other companies. Second, the program can still improve collaboration between businesses and educational institutions and better connect apprenticeship skills and credentials to the university credit system. Nevertheless, Apprenticeship Carolina serves as an attractive state-level model to expand pathways to manufacturing.

BEST PRACTICES: Apprenticeship Carolina, Connecticut Department of Labor, Tennessee Promise



V. CONCLUSION

ermany's leading manufacturing regions can serve as exemplars for U.S. leaders seeking to build and sustain their own manufacturing sectors. As the Global Cities Initiative investigated in Munich and Nuremberg, three elements of success-regional collaboration

between public, private, and civic actors; targeted institutional intermediaries that address market and coordination failures; and incentive-based investments to support SMEs-should guide U.S. practitioners and policymakers seeking to adapt German skills and innovation best practices to support manufacturing here at home.

U.S. jurisdictions as diverse as Detroit, San Diego, Pennsylvania, and South Carolina are adopting these methods because they recognize manufacturing remains an important contributor to growth, job creation, trade, and innovation. And while Germany maintains a different culture and political economy than the United States, the country's best practices represent powerful tools for American efforts to strengthen manufacturing through skills and innovation.

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The Global Cities Initiative aims to equip metropolitan leaders with the information, policy ideas, and global connections they need to bolster their position within the global economy. Combining Brookings' deep expertise in fact-based, metropolitan-focused research and JPMorgan Chase's longstanding commitment to investing in cities, this initiative aims to:

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- Provide metropolitan area leaders with proven, actionable ideas for how to expand the global reach of their economies, building on best practices and policy innovations from across the nation and around the world.
- Create a network of leaders from global cities intent upon deepening global trade relationships.

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- Indianapolis, IN
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Metropolitan Policy Program at Brookings 1775 Massachusetts Avenue, NW Washington, D.C. 20036-2188 Telephone: 202.797.6000 Fax: 202.797.6004 Website: **www.brookings.edu**

Joseph Parilla Research Analyst Metropolitan Policy Program at Brookings **jparilla@brookings.edu**

Jesus Leal Trujillo Research Assistant Metropolitan Policy Program at Brookings **jtrujillo®brookings.edu**

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