International Benchmarking of Countries' Policies and Programs Supporting SME Manufacturers

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EXECUTIVE SUMMARY

This report builds on ITIF's recent report *The Case for a National Manufacturing Strategy* by identifying and analyzing manufacturing support programs and practices for small and medium sized enterprises (SMEs) that have been implemented in ten foreign countries, *Argentina, Australia, Austria, Canada, China, Germany, Japan, Korea, Spain, and the United Kingdom* (in addition to those of the United States). Specific emphasis is given in the report to Australia, Canada, Germany, Japan, Spain, and the United Kingdom, countries which have created formal agencies, institutions, or programs most like the United States' Manufacturing Extension Partnership (MEP) program to provide manufacturing extension services to their SME manufacturers (as illustrated in Table ES-1 below).

Country	Agency	# Centers/Regional Offices	Total Staff	Year Founded
United States	Manufacturing Extension Partnership (MEP)	60 State and Regional Centers	1,300+[1]	1988
Australia	Enterprise Connect	12 Centers	250	2008
Canada	Industrial Research Assistance Partnership (IRAP)	150 Offices in 90 Communities	220	1962
Germany	Fraunhofer Institutes	57 Fraunhofer Institutes	18,000	1949
Germany	Steinbeis Centers	750 Steinbeis Centers	4,600	1971
Japan	Public Industrial Technology Research Institutes (Kohsetsushi Centers)	262 Offices (182 Kohsetsushi Centers)	6,000+	1902
United Kingdom	Manufacturing Advisory Service (MAS)	9 Regional Centers	150	2002

Table ES-1: Countries' Manufacturing Support Agencies

The report examines program supports in a wide variety of ways, as Table ES-2 illustrates. In particular, the report focuses on the transition many programs have been making from continuous productivity improvements to innovation and growth. As Jayson Myers, President and CEO of Canadian Manufacturers and Exporters, (a national trade association), explains:

> Five years ago it was all about lean, quality, Six Sigma, and continuous improvement, but now it is all about innovation and new product development

> and finding new customers and new markets. A lot of small companies can understand process improvements, but performing research and development, retooling, understanding new customer sensing, designing products for new markets, and understanding standards requirements in global markets are the new challenges.[2]

As evidenced by Table ES-2, the report specifically focuses in on the broad areas of:

Technology acceleration programs and practices including but not limited to:

1. Promoting technology adoption by SMEs;
2. Conducting audits to identify opportunities for improvement in SMEs' manufacturing and operational processes;
3. Supporting technology transfer, diffusion, and commercialization;
4. Performing research and development (R&D) in direct partnership with SMEs, and/or providing access to research labs; and
5. Engaging SMEs in collaborative research and development and/or technology specific consortia.

For example, staff members at each Kohsetsushi Center in Japan spend up to half their time on research, mainly on applied projects focused toward and often undertaken in direct conjunction with local industries. Small manufacturers often send one or two of their staff members to actually work on Kohsetsushi Center projects, providing opportunities for company research personnel to gain research experience, develop new technical skills, and transfer technology back to their firms. The Kohsetsushi Centers are effectively partnering alongside SME manufacturers to help them research and develop new technologies and products.

Technology acceleration funding mechanisms including:

1. Providing direct research and development grants;
2. Providing loans to scale and grow the enterprise;
3. Providing innovation vouchers to assist SME manufacturers with new product development and innovation efforts; and
4. Funding joint pre-competitive research programs.

Many countries, including Austria, Canada, and Germany, provide innovation vouchers to help jumpstart innovation activities within firms and connect them with researchers at universities or other companies. Seventy percent of countries examined provide innovation-related funding directly to their SME manufacturers (with the United States being one of the few exceptions). Germany has three such models (beyond innovation vouchers) that provide funding for working in consortia, funding for network managers of firm consortia, and funding for single-firm innovation.

Next-generation manufacturing technical assistance including:

1. Providing export assistance and training;
2. Promoting energy-efficient manufacturing practices;

3. Promoting continuous productivity improvement including lean, Six Sigma, and other methods;
4. Providing information about and assistance with acquiring standards and certifications, and
5. Teaching SMEs about the role of design in manufacturing.

Category	Service \ Country	United States	Australia	Canada	Germany	Japan	United Kingdom	Argentina	Austria	China	Korea	Spain
Technology Acceleration Programs and Practice	**Promote Technology Adoption** by SMEs	√	√	√	√	√	√	√	√	√	√	√
	Provide Audits of SMEs' Lean Mfg. & Innovation Processes & Skills	√	√	√		√	√					
	Business Advisers Work Hands-on with SMEs to **Improve Manufacturing & Process Techniques**	√	√			√	√	√				√
	Support Tech Transfer & Commercialization	√	√	√	√	√	√	√	√	√	√	√
	Promote Tech/Knowledge Diffusion from Universities	√	√	√	√	√	√	√	√	√	√	√
	Perform R&D in Direct Partnership with SMEs					√						√
	Provide **Access to Research Labs**/Prototyping Facilities	√				√		√			√	√
	Get SMEs into **Mfg./ Technology Consortiums**				√			√	√			
Technology Acceleration: Funding Mechanisms	Provide SMEs **Direct R&D Funding Grants**		√	√	√	√			√	√	√	
	Provide SMEs **Loans to Scale/Grow Businesses**					√			√	√	√	
	Use Innovation Vouchers			√	√				√			
	Fund Joint Pre-Competitive Research Programs				√							
Next Generation Manufacturing Technical Assistance	**Teach Innovation & New Product Development** Skills	√		√		√	√	√			√	√
	Provide **SMEs Export Assistance and Training**[3]	*	√	*	√	*	√	√	*	√	√	√
	Promote **Energy-Efficient Manufacturing** Skills	√	√	√	√	√	√					
	Provide **Assistance with Standards**	√		√				√			√	√
	Teach Role of Design in Manufacturing			√			√					
Connect SMEs	**Act as Broker** to Other SME Support Services	√	√	√		√	√					
	Host Best Practice Events	√	√	√		√	√					√

Table ES-2: Range of Services Provided by Manufacturing Support Programs[4]
*** Export Assistance Provided by Countries' Manufacturing Extension Service**

For example, MEP in the United States has had a focus on providing formal mechanisms for coaching innovation skills and has also developed a Web portal called the *National*

Innovation Marketplace to facilitate relationships between those seeking innovations and those developing innovations.

Connections to and for SME manufacturers including:

1. use of multi-firm training and conference events so that firms can learn from and network with one another;
2. disseminating best practices to SMEs and intermediary organizations (such as local MEP centers); and
3. brokering products and services not directly delivered to other public (and/or private) resources that can help the firm increase its competitiveness.

For example, the Manufacturing Advisory Service (MAS) program in England brokers a number of services that it does not directly perform to other government service providers, such as providing SMEs support with regard to financial, human resources, marketing, legal, or environmental issues. In the United States, this brokerage can be to another government entity or even a private solutions provider. A common misconception of SME manufacturing support programs is that they duplicate services in the private sector, but in reality, far from supplanting private market advisory services, manufacturing support services tend to help SME manufacturers understand the value of those services and thus actually perform "market-making" for the private sector.[5]

The manufacturing support agencies and programs implemented by a number of countries have achieved unequivocal and substantial economic impact in boosting sales, employment, and growth of their SME manufacturers.

Other areas that are noteworthy but not easily comparable from country to country include the focus on regional competition. For example, the provision of the budget for Japan's Kohsetsushi Centers by Japan's regional governments encourages skills and capability-based competition among Japan's prefectures, incentivizing the prefectures to realize economic growth by helping locally situated businesses grow. Indeed, Japanese prefectures have the attitude that they cannot co-opt a firm from another prefecture; they can only grow their economy from within through superior technology development, transfer, and commercialization. This is in contrast to the "smokestack chasing" more common in the United States, a "race-to-the-bottom" in which states dangle incentives before businesses to induce them to relocate from one state to another. As Kenneth Thomas finds in his book, *Investment Incentives and the Global Competition for Capital*, U.S. states spend $60 billion a year on smokestack chasing, and only $2–$3 billion on technology development and transfer, an approach markedly different from Japan's.[6] The Japanese model invests state money in building firm competencies, not in inducing their relocation.

Also, while the report does not focus on the manufacturing and technology workforce at length, it is important to note a model that appears to be working well in different countries. Several German states, including Brandenburg, seek to facilitate the transfer of new knowledge from universities to SMEs by co-financing the placement of recent Ph.D. graduates with SME manufacturers. In Brandenburg's program, the state covers 50 percent of the cost for an SME manufacturer to employ a recent Ph.D. graduate for up to two years.[7] Australia's *Researchers in Business* grants allow businesses to bring a researcher from a university or public research agency into the business to help develop commercial ideas. Australian businesses selected to receive a *Researchers in Business* grant receive funding for up to 50 percent of salary costs, to a maximum of $53,000, for each placement for between

two and twelve months.[8] In a similar program, Canada's Industrial Research Assistance Program (IRAP) provides direct financial support for Youth Employment in Canadian SMEs, funding up to $30,500 in salary for six to twelve months for recent college or university graduates employed by SMEs. Productivity Alberta organizes mentoring programs in which local MBA students are assigned to local SMEs to identify and to help solve innovation, technical, and scientific challenges in the SMEs by connecting them to resources available at their graduate schools.[9] Likewise, Korea's Small and Medium Business Administration (SMBA) encourages the linkage of enterprises with technical high schools and junior colleges that produce graduates especially suited to SME requirements.

FUNDING AND IMPACTS

The report analyzes how robustly countries fund their manufacturing extension services and assesses the different models they use to fund their SME manufacturing support programs. Countries' funding models range from cost-share models, such as those in the United States and United Kingdom that balance the funding between federal government and businesses (plus local governments in the case of the United States), to the local government model in Japan where each Kohsetsushi Center receives funding from its local prefectural government. Much of Canada's model includes direct funding to SME manufacturers, and in Germany much of the funding goes to institutions such as universities.

Overall funding for the United States' MEP program as a share of U.S. GDP has decreased since 1998. In fact, as a share of GDP, the federal government invested 1.28 times more in MEP in 1998 than it did in 2009. But not only has recent federal funding of the MEP program trailed the historical norm, it has begun to fall significantly behind the levels of funding that competitor countries provide their manufacturing extension services. Figure ES-1 shows countries' investment in their manufacturing extension service or programs as a percentage of GDP. As a share of GDP, Japan invests thirty times more than the United States, Germany invests over twenty times as much, and Canada almost ten times as much as the United States in their principal SME manufacturing support programs.

Despite the funding challenges, the MEP program continues to achieve very high level impacts. For instance, for every $1 of federal investment, MEP generates $32 of return in economic growth (see Figure ES-2), translating into $3.6 billion in total new sales annually for U.S. SME manufacturers.[10] (By comparison, the United Kingdom reports that, across their entire Manufacturing Advisory Service program, $1 of investment generates $6 in gross-value added, although specific MAS centers such as MAS Northeast are generating returns comparable to MEP levels). Moreover, client surveys indicate that MEP centers create or retain one manufacturing job for every $1,570 of federal investment, one of the highest job growth returns out of all federal funds.[11] In fact, 2009 impact data show that the MEP program created and retained over 70,000 jobs.

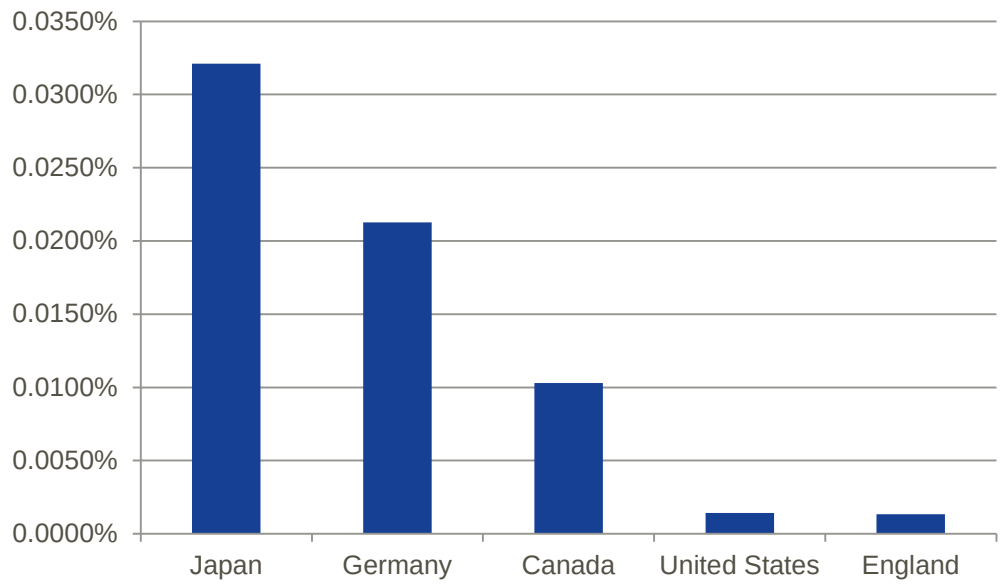

Figure ES-1: Country Investment in Manufacturing Extension Services/Programs as a Percentage of GDP[12]

Global best practices respond to where the majority of a nation's SME manufacturers stand with regard to their manufacturing process, technology adoption, R&D, and innovation capabilities; identifies the gaps; and seeks to take firms to the next level.

Overall, this study finds that global best practice in supporting SME manufacturers accomplishes two primary goals. These are:

1. Global best practices respond to where the majority of a nation's SME manufacturers stand with regard to their manufacturing process, technology adoption, R&D, and innovation capabilities; identifies the gaps; and seeks to take firms to the next level.

2. Global best practices have seen the manufacturing support agencies become the central hub, or delivery mechanism, for a comprehensive suite of services, some of it provided by the agency itself and some of it brokered by others, all designed to boost the competitiveness of SMEs.

Moreover, this study finds that the manufacturing support agencies and programs implemented by a number of countries have achieved unequivocal and substantial economic impact in boosting sales, employment, and growth of their SME manufacturers, and thus having a clear positive impact on broader economic and employment growth in their countries.

In summary, there are many insights that the United States can learn from successful and integrated programs such as those in Canada, Germany and Japan, or even in specific examples in any of the countries examined in this report. Perhaps the strongest of these is that the path of current SME manufacturing support programs towards growth and innovation is validated and substantiated by the fact that every other country has moved in a very similar direction, even if they have started from different points or are serving slightly different markets. Continuous productivity improvements serviced through single

organization, point-in-time solutions are necessary but no longer sufficient to the long-term competiveness of U.S. and world SME manufacturers.

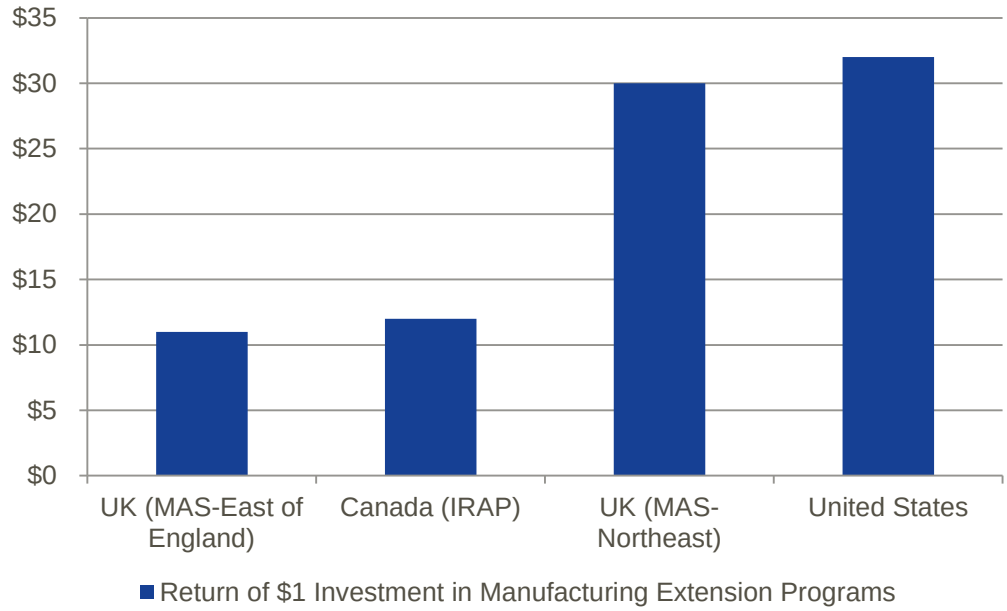

Figure ES-2: Return on $1 Investment in Manufacturing Extension Programs

INTRODUCTION

As ITIF documented in its report *The Case for a National Manufacturing Strategy*, manufacturing plays a vital role in helping nations achieve balanced terms of trade, providing large numbers of above-average paying jobs, driving research and development (R&D) and innovation, and ensuring national security. As they account for over 98 percent of manufacturing establishments in most countries, small medium sized enterprises (SMEs) form the backbone of nations' manufacturing sectors.[13] Accordingly, many nations have recognized that if they do not become partners in supporting their SME manufacturers, they are liable to lose not just their SMEs but also their largest original equipment manufacturers (OEMs), because SMEs play indispensible roles in sustaining healthy ecosystem value chains in almost all manufacturing industries. As this study explains, a number of countries have therefore introduced programs to support the competitiveness, innovation, and productivity of their SME manufacturers, in response both to market failures afflicting SMEs and to help sustain robust manufacturing value chains. In fact, supporting SME manufacturers' adoption of new technologies and manufacturing processes as well as their R&D, innovation, and new product development (NPD) and new product introduction activities has become essential to being an advanced industrial economy. Countries that do not have strategies in place to support their SME manufacturers are simply going to get left behind.

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The United States understood this well when it established the Manufacturing Extension Partnership (MEP) in 1988 to improve technology use and adoption by U.S. small and mid-sized manufacturers. At the time, the United States surveyed the world to understand how countries like Canada, Germany, and Japan were supporting their SME manufacturers, studying programs like Japan's Kohsetsushi Centers, Germany's Fraunhofer Institutes, and Canada's Industrial Research Assistance Program (IRAP). After its launch and steadily increased funding initially, the MEP program leveled off as a $100-$125 million dollar program. In adjusted dollars, MEP's budget in 2009, $110 million, was actually less than its 1998 budget of $113.5 million, meaning that, as a share of GDP, the United States invested 1.28 times more in supporting its SME manufacturers in 1998 as it did in 2009.[14]

Yet, in the meantime, competitor nations have substantially increased their investments in and the array of services provided by their SME manufacturing support programs. In fact, as a share of GDP, Japan invests thirty times more in its Kohsetsushi Centers than the United States does in MEP. Canada invests ten times more. And not only are other countries investing more, many have implemented a more comprehensive approach that is focused on a wider array of services related not just to lean manufacturing and technology adoption, but also to helping promote the R&D and innovation capacity of their SME manufacturers. For example, Japan's Kohsetsushi Centers support SMEs with technology adoption, lean manufacturing, advisory consulting, R&D funding and performance, test-bed facilities, etc. Unfortunately, the United States, and to some extent the United Kingdom, partly because of a lack of funding and partly because some fret that it constitutes industrial policy, have not provided full-throttled support to their manufacturing extension services in recent years. But as competitor nations do more to support their SME manufacturers, the United States needs not to cut but rather to sustain

and even to boost its investments in advancing the competitiveness of its SME manufacturers.

Indeed, given the central role that SME manufacturers play in the manufacturing sectors of nations around the world, it should come as little surprise that an increasing number of countries have introduced and robustly funded a broad array of agencies, programs, and policy instruments to support the competitiveness, productivity, and innovation capacity of their SME manufacturers. These efforts range from programs that seek to:

1. Mentor and train SME manufacturers in continuously improving their processes and operational performance by adopting lean or quality manufacturing principles and new manufacturing process technologies;
2. Promote the diffusion of new technologies and knowledge from universities, national laboratories, or public research institutes to SME manufacturers;
3. Help SME manufacturers innovate new products and services by supporting their R&D and new product development efforts; or
4. Address gaps in SME manufacturers' access to financing for their R&D and innovation activities.

Some countries, such as Canada, Japan, Spain, the United Kingdom, and the United States, have formal government agencies dedicated to providing manufacturing extension services to SME manufacturers. These manufacturing extension services (MES) can be defined as "the deployment of outreach mechanisms in the field to stimulate companies to acquire or to improve their use of technology and to stimulate innovation."[15] Other countries do not have formally dedicated agencies but still provide similar manufacturing support services through other government or innovation promotion agencies, public research institutes, or public-private partnerships.

This report examines the SME manufacturing support approaches, agencies, and programs of eleven countries, including *Argentina, Australia, Austria, Canada, China, Germany, Japan, Korea, Spain, the United Kingdom, and the United States.* It finds nations using a multitude of approaches and institutions, each aligned with the national innovation system of their countries. The U.S. and UK approach—spearheaded by the U.S. Manufacturing Extension Partnership (MEP) and England's Manufacturing Advisory Service (MAS)—has traditionally been aligned around intervening at the firm level to enhance SME manufacturers' productivity and efficiency by encouraging new technology adoption (especially with regard to manufacturing process technologies) and boosting manufacturers' skills and capabilities in applying lean manufacturing and organizational management techniques not just on the shop floor, but also throughout their business and that of their supply chain. While this has traditionally been their focus, in recent years both countries have expanded to include coaching SME manufacturers on new innovation methodologies, assisting their new product development and new product introduction efforts related to the commercialization of new technologies, and promoting principles of sustainable and energy-efficient manufacturing. In both the United States and the United Kingdom, manufacturing extension services include the engagement of business experts who help SMEs improve manufacturing techniques and learn technology commercialization skills.

The continental European approach, typified by Austria and Germany, is much more focused on directly supporting SME manufacturers' R&D activities—that is, supporting their efforts to innovate new or improve upon existing products—in large part by including them in technology or sector-specific research consortia. In slight contrast to the continental European approach, the Scandinavian approach (e.g. Finland and Sweden) appears to be building competence centers in specific technologies that support all manufacturers in a given sector. While these countries have programs in place to support SMEs in general, they have fewer mechanisms specifically targeted to SME manufacturers.

The Japanese and Canadian approaches borrow elements from both the Anglo-American and continental European models. Japan combines firm-level intervention to improve SME manufacturers' process capability, but also works alongside SMEs to perform research relevant to SME manufacturers in specific technologies or sectors. Canada's approach includes less of the firm level intervention of the U.S. and UK style, but does also feature expert advisors who not only advise SMEs on lean manufacturing practices but also act as conduits to help move technology and knowledge from Canada's universities and laboratories to its SMEs. Canada also provides more direct funding to support SME manufacturers' R&D and innovation activities than the United Kingdom or the United States does.

A number of countries have made the provision of financial assistance to SME manufacturers a key component of their SME manufacturing support policies.

Indeed, a number of countries, including Austria, Canada, China, Germany, Hong Kong, Korea, and Singapore have made the provision of financial assistance to SME manufacturers—for both their innovation-oriented and general growth (expansion) activities—a key component of their SME manufacturing support policies. Such financing instruments span the gamut from direct R&D grants, to loan (credit) guarantees to third parties investing in SME manufacturers, to loan interest repayments, to—in China—even paying SMEs for each job they create. However, it is important to distinguish between financial support programs designed to support mature, established SMEs and those designed to spur the creation of new high-tech SMEs (whether in manufacturing or high-tech services).

This report provides a cross-national comparison of countries' SME manufacturing support approaches and programs across five categories, including: 1) existence of formal SME manufacturing support agencies or programs; 2) the range of services provided by SME manufacturing support agencies and programs; 3) funding levels and business (fee) models for these agencies or programs; 4) best practices observed across countries' SME manufacturing support programs; 5) measures of impact and return on investment from these programs; and 6) overall lessons and insights from these programs.

RATIONALE FOR GOVERNMENT INITIATIVES TO SUPPORT SME MANUFACTURERS

A robust and competitive manufacturing sector is a vital component of a healthy economy. As ITIF documented in its report *The Case for a National Manufacturing Strategy*, manufacturing plays a critical role in economies for five key reasons:[16]

1. It is extremely difficult for any country to balance its trade account without a healthy manufacturing sector.

2. Manufacturing is a key driver of overall job growth and an important source of middle-class jobs for individuals at many skill levels.
3. Manufacturing is vital to a country's national security.
4. Manufacturing is the principal source of R&D and innovation activity.
5. Manufacturing and services sectors are inseparable and complementary.

Manufacturing is critical to the health of a nation's economy—and SMEs form the backbone of all nations' manufacturing sectors. SMEs account for upwards of 98 percent of business establishments in most economies. In the United States, there were about 245,500 SMEs in manufacturing in 2009; these firms comprised 98.5 percent of all U.S. manufacturing firms and employed some 5.3 million workers, or about 41 percent of all U.S. manufacturing jobs.[17] Similar numbers hold in other economies. 99.8 percent of Korean manufacturers, 98.6 percent of English and Japanese manufacturers, and 97.8 percent of German manufacturers are SMEs.[18] These SMEs, both in the broader economy and within manufacturing, are key sources of job creation across all countries. For example, Canada's SMEs account for 80 percent of new jobs and 82 percent of new technologies created in the country.[19] Likewise in the United States, SMEs have generated about 60 percent to 80 percent of the new jobs created annually over the past decade.[20]

Governments pursue several goals through their SME manufacturing support programs, for they are not just about boosting the competitiveness, productivity, and efficiency of SME manufacturers, but also about safeguarding and even increasing local employment, improving the competitiveness of economic regions, and preserving supply chains and ecosystems in vital national manufacturing sectors in which SMEs play a critical role. (In Austria, for instance, every third manufacturing workplace is associated with the automotive manufacturing sector.)[21] Yet despite the importance of manufacturing—and SME manufacturers—to a nation's economic vitality, a number of systemic market failures and externalities affect manufacturing activity in general, and SME manufacturers in particular, which justify government intervention. First, SME manufacturers underinvest in R&D and innovation relative to societally optimal levels. Second, smaller manufacturers are less likely than larger ones to implement new technology, to adopt modern manufacturing processes, to invest in worker training, to adopt new forms of work organization, and to deploy improved business practices.[22] That is, SMEs lag in adopting new technologies that would make them more productive. Third, specific market failures exist around the provision of information and advisory services for SMEs. Finally, since SME manufacturers play a key role in most manufacturing supply chains, their competitiveness (or lack thereof) has an impact on the competitiveness of other firms in those supply chains and on the broader economy as a whole.

SME manufacturers (like all companies) underinvest in R&D and capital equipment relative to societally optimal levels because they cannot capture all the benefits of their investments.[23] Indeed, a plethora of studies have found that the rate of return to society from corporate R&D is at least twice the estimated returns that the company itself receives.[24] In addition to spillovers from R&D performed to create new products, there are also significant spillovers from process R&D, which is the R&D conducted to help organizations produce things better. But the inability of firms to capture all the benefits of

their own investments in R&D and new capital equipment means that, left on their own, they will produce much less innovation and productivity than is optimal for society. This is the key rationale for policies such as the R&D tax credit and accelerated depreciation of new equipment investments.[25] It is also why so many countries are directly supporting their SME manufacturers' investments in R&D and innovation activities.

Despite their importance, SME manufacturers often lack the information networks, technical skills, and resources available to larger firms. Largely because of this, a substantial productivity gap exists between large and small manufacturers. This gap is seen in virtually all countries, and has been growing over time. For example, on average in the United States, value-added per employee in SMEs was about 80 percent of that of large establishments in the 1960s, but by the late 1990s, value-added per employee in SMEs was on average less than 60 percent of large establishments (Figure 1).[26] Professor Brian Lee of Korea's Kwangwoon University also observes a "widening gap between large firms and SMEs in Korea in their productivity and competitiveness."[27] Indeed, data from South Korea's Ministry of Science and Technology shows that while large Korean manufacturers produced twice as much value-added per capita as Korean SME manufacturers in 1990, by 2002 they produced more than three times as much. Likewise, "UK manufacturing SMEs are comparatively weak performers in important areas such as productivity and market winning dimensions."[28] These productivity gaps occur in part because SMEs tend to invest less in equipment and are less likely to adopt new business and manufacturing practices than large firms.[29] But they also occur because small manufacturers often simply lack the resources, scale, experience, or wherewithal to stay abreast of the latest emerging technologies, manufacturing processes, or business management practices. Thus, a critical role countries' manufacturing extension services play is to close this knowledge and best practices gap between small and large manufacturers.

SMEs tend to invest less in equipment and are less likely to adopt new business and manufacturing practices than large firms.

Yet, some will argue, if the provision of such advisory services are so important, why should governments provide them; shouldn't the private market be willing to do so? But as the European Commission's *Study of Business Support Services and Market Failure* found, there are a number of market failures associated with the provision of public information and advisory services to SMEs.[30] First, there are adverse selection issues including inefficiencies and discrepancies that arise via and during the exchange of information. These arise when "inappropriate take-up of business support services occurs" because SMEs do not have the scale to know the range of available business support to them or the experience or knowledge necessary to adequately assess the value of those services or the quality of particular service providers. A second form of business support market failure arises when information services are not provided because no or only insufficient financial return can be made by private sector firms. These market imperfections give rise to economic inefficiencies that justify public intervention.[31]

Britain's Manufacturing Advisory Service justifies its role precisely based on information irregularities affecting SME manufacturers, meaning they lack the information required to make optimal purchasing decisions. As a 2010 review of the MAS program found, "[UK] SMEs are not accessing business advice that would help them achieve productivity growth, for two reasons. First, SMEs underestimate the benefits of external advice because they

have limited or no knowledge of or access to best practice and therefore do not seek advice. Second, they may have limited or no access to affordable best practice information and advice."[32]

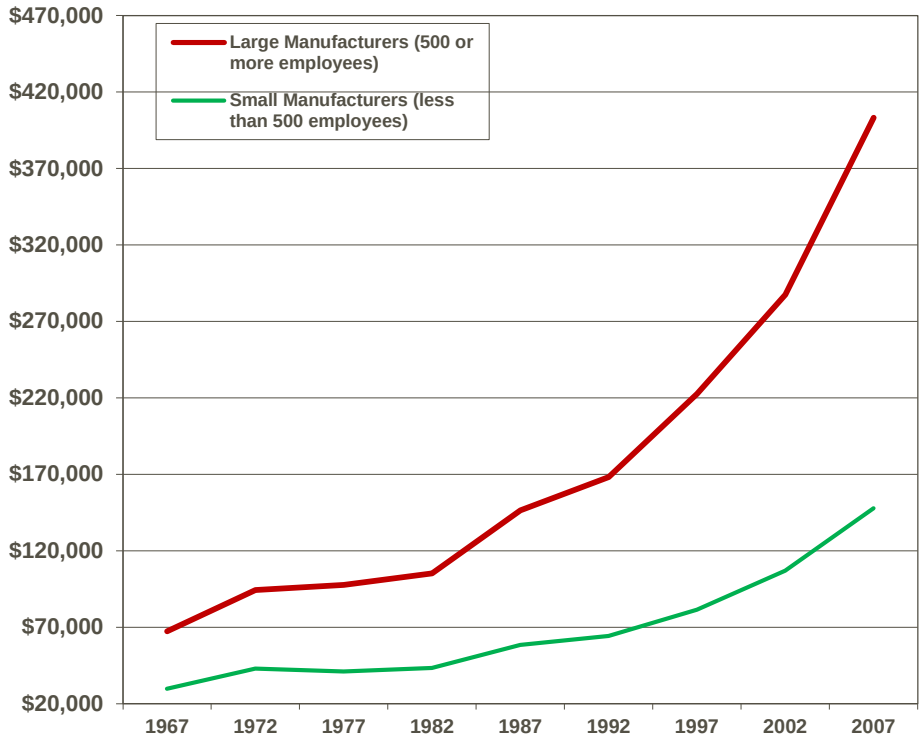

Figure 1: The Productivity Gap between Small and Large Manufacturing Establishments is Growing, 1967-2002[33]

Thus, a central goal of many countries' SME manufacturing support programs is to expose their SME manufacturers to and to help them understand the value of private consulting services that can assist them with productivity improvements such as lean manufacturing, Six Sigma and other quality control and continuous improvement processes; technology uptake; and innovation, design, and new product development methodologies. The belief is that demonstration projects will help SMEs see the value in these services and will encourage them to procure such services on their own in the future. As Petar Stojic, the former Director of Business Support Policy for Britain's Department for Business, Innovation and Skills (BIS), which oversees the Manufacturing Advisory Service, comments:

> The market failure we are trying to address is the information asymmetry market failure. SMEs do not always know what they do not know, and they do not know how useful business expertise can be. And even when the SME manufacturer knows it has a problem, it does not always know how to procure the right solution. After they have worked with MAS, they

> understand the value of lean principles and/or better innovation practices and the value of external expertise in general, so when they have to pay the full rate in the future, they now know what to look for and have greater confidence in approaching the market.[34]

In reality, far from supplanting private market advisory services, countries' manufacturing extension services tend to help SME manufacturers understand the value of those services and thus actually perform a "market-making" function for the private sector.[35]

Finally, governments support SME manufacturers because they play critical roles in supporting healthy manufacturing ecosystems and supply chains, for if their SMEs are not competitive, the entire supply chain, local regions, and the broader national economy suffer. As the U.S. MEP's 2008 annual report explained, "The relationship between large and small firms is becoming more complementary and cooperative rather than competitive. As large firms increase their dependence on suppliers for parts and services, the performance and capabilities of small manufacturers is even more important to the competitiveness of all manufacturers. Further, large manufacturers are requiring small firms within their supply chains to meet increasingly rigorous quality standards, to reduce costs, and to become sources of innovation."[36] Likewise, Piore and Sabel find that the combination of small firms with regions that support flexibility and inter-firm linkages encourages innovation and promotes competitive advantage.[37] Thus, SME manufacturers are critical components of regional economies and broader industrial value chains, so their health generates positive spillovers and externalities to the rest of the economy, providing yet another justification for governments' SME manufacturing support programs.

MEP places technologies and innovations developed through research at federal laboratories, educational institutions, and corporations directly in the hands of U.S. manufacturers.

SME MANUFACTURING SUPPORT AGENCIES AND PROGRAMS OF COMPARISON COUNTRIES

Argentina, Australia, Canada, Germany, Japan, Spain, the United Kingdom, and the United States have each created formal agencies, institutions, or programs to provide manufacturing extension services to their SME manufacturers, as Table 1 illustrates.

United States

The National Institute of Standards and Technology's Hollings Manufacturing Extension Partnership (MEP) works with small and mid-sized U.S. manufacturers to help them create and retain jobs, increase profits, and save time and money. The nationwide network provides a variety of services, from innovation strategies to process improvements to green manufacturing. MEP also works with partners at the state and federal levels on programs that put manufacturers in position to develop new customers, expand into new markets, and create new products.

MEP's field staff features over 1,300 technical experts—located in every state—serving as trusted business advisors focused on solving manufacturers' challenges and identifying opportunities for growth. As a program of the U.S. Department of Commerce, MEP offers its clients a wealth of unique and effective resources centered on five critical areas: technology acceleration, supplier development, sustainability, workforce, and continuous improvement.

Country	Agency	# Centers/Regional Offices	Total Staff	Year Founded
United States	Manufacturing Extension Partnership (MEP)	60 State and Regional Centers	1,300+[38]	1988
Australia	Enterprise Connect	12 Centers	250	2008
Canada	Industrial Research Assistance Partnership (IRAP)	150 Offices in 90 Communities	220	1962
Germany	Fraunhofer Institutes	57 Fraunhofer Institutes	18,000	1949
Germany	Steinbeis Centers	750 Steinbeis Centers	4,600	1971
Japan	Public Industrial Technology Research Institutes (Kohsetsushi Centers)	262 Offices (182 Kohsetsushi Centers)	6,000+	1902
United Kingdom	Manufacturing Advisory Service (MAS)	9 Regional Centers	150	2002

Table 1: Countries' Manufacturing Support Agencies (in alphabetical order)

Innovation is at the core of what MEP does. Manufacturers that accelerate innovation are far more successful than those that do not. By placing technologies and innovations developed through research at federal laboratories, educational institutions, and corporations directly in the hands of U.S. manufacturers, MEP serves an essential role in sustaining and growing America's manufacturing base. The program assists manufacturers in achieving new sales, leading to higher tax receipts and new sustainable jobs in the high-paying advanced manufacturing sector.

MEP has introduced a new training program, the Innovation Engineering Management System (IEMS), which includes a digital toolset, online collaborative workspace, and formal curriculum to help U.S. manufacturers innovate and grow. The Innovation Engineering Management System has been designed to help U.S. SME manufacturers develop skills and confidence in commercializing new technologies. MEP is also helping SMEs connect to broader innovation networks. A key tool in facilitating this has become the USA National Innovation Marketplace (Figure 2), which allows SMEs to post their innovative products and technologies online in a concise, easily comprehensible format so the SME can: (a) highlight and promote its capabilities to make supply chain connections; (b) reach a wider audience of potential buyers or investors; (c) search for expert help or assistance; and (d) search for innovation-driven business opportunities. To date, one in five SMEs that have used the National Innovation Marketplace report successful connections with an investor, buyer, or partner.[39]

Figure 2: USA National Innovation Marketplace

United Kingdom

The United Kingdom's Manufacturing Advisory Service (MAS) provides technical information and specialist support to British SME manufacturers through a network of nine regional centers. (Scotland and Wales operate similar but independent centers.) MAS helps English SME manufacturers increase their competitiveness by boosting productivity and efficiency through the adoption of best practice manufacturing solutions, particularly around lean manufacturing. Eighty-five percent of MAS's work with English SME manufacturers focuses on lean principles. This includes lean on the shop floor, throughout the organization, and throughout the value or supply chain.[40]

In 2011, the United Kingdom streamlined the country's array of business support services, which at one point had numbered over 3,000, down to just 13 "Solutions for Business," of which MAS is a prominent one.

MAS offers five levels of support services to SMEs.[41]

- Level 1 is a free helpline inquiry service, through which manufacturing and business experts are available to answer questions on a range of technical issues.
- Level 2 is a free, one-day, on-site manufacturing review whereby MAS manufacturing practitioners assess the firm's manufacturing operations and highlight opportunities to improve operational performance. Those Level 2 diagnostics often lead to additional services at higher levels.

- Level 3 includes provision of general awareness training and networking events, including best-practice factory visits.

- Level 4 is MAS's capstone subsidized consultancy support, referred to as "workouts." During workouts, a MAS practitioner spends up to two weeks on-site with the SME instilling competitive manufacturing processes in the firm, including implementing lean manufacturing processes, co-developing value stream and process maps, teaching innovation methodologies, improving shop floor layouts and space utilization, and introducing sustainable and energy-efficient manufacturing principles.

- Level 5 includes referrals of SMEs' "non-manufacturing queries, such as financial, human resources, marketing, legal, or environmental issues," to other providers and programs within the UK's suite of Solutions for Business. Indeed, MAS's role is kept primarily to supporting manufacturing operations (and to a lesser extent teaching innovation methods); other programs help these firms discover new markets, export globally, learn design principles, or secure financing for R&D activity. In these cases, MAS acts as a broker, serving as the central hub for connecting English SME manufacturers to the array of SME support services offered by the UK government.

Japan

Japan's Public Industrial Technology Research Institutes, or Kohsetsushi Centers, were established in the first decade of the 20th century, modeled after the U.S. agricultural extension and engineering experimentation stations. Kohsetsushi Centers provide Japanese SME manufacturers with a range of services including technology guidance; technical assistance and training; networking; testing, analysis, and instrumentation; and access to open laboratories and test beds. They even undertake applied research and R&D projects in conjunction with SMEs. They also provide facilities for prototyping and trial industrial production using new machines and technologies, with the centers making their specialized equipment available for research, prototyping, and training. The Kohsetsushi Centers have established most Japanese regions as viable production locations, and they have proven especially effective in quality, testing, "catch-up" research, and acting as a bridge for SMEs. The Kohsetsushi Centers are managed by local prefectures, although they are operated under the guidance of the Ministry of Economy, Trade, and Industry ("METI"). Each of Japan's forty-seven prefectures has at least one Kohsetsushi Center, and there is usually a combination of general centers alongside sector-oriented centers targeted to upgrading particular industries through the adaptation of emerging technologies. Kohsetsushi Centers support Japanese SME manufacturers' adoption of a range of emerging technologies, including sensor-enabled (e.g. smart) devices; embedded intelligence; advanced machining; nanotechnology; robotics; automation; MEMS (microelectromechanical systems); and computer numerically controlled machines.

Staff at each Kohsetsushi Center spends up to half their time on research, mainly on applied projects focused toward and often undertaken in direct conjunction with local industries.[42] Small manufacturers often send one or two of their staff members to actually

work on Kohsetsushi Center projects, providing opportunities for company research personnel to gain research experience, develop new technical skills, and transfer technology back to their firms. The Kohsetsushi Centers are uniquely and effectively partnering alongside SME manufacturers to help them research and develop new technologies and products.

Canada

Canada's Industrial Research Assistance Program (IRAP), administered by the National Research Council (NRC), is Canada's main technology support program for SME manufacturers, whose mission is to "stimulate wealth creation for Canada through technological innovation."[43] IRAP provides technology advice, assistance, and services to SMEs to help them build their innovation capacity. However, IRAP works with SMEs in any industry sector, including both manufacturing and high-tech services SMEs. IRAP delivers its services through a network of 220 Industrial Technology Advisors (ITAs) located in 150 regional offices in 90 communities throughout Canada. The Industrial Technology Advisors focus primarily on assisting Canadian SMEs with technology development, innovation, and new product development activities (as opposed to mostly lean manufacturing principles, although they do that as well) and play a special role in connecting technologies and knowledge emerging from Canadian universities and national laboratories with SMEs. The ITAs provide advisory services to SMEs, but unlike the U.S. MEP and UK MAS programs, do not engage as much in deep firm-level interventions to transform SMEs' manufacturing practices. (The ITAs would be more likely to connect the SME to a private sector provider for such workouts.) However, unlike MEP and MAS, IRAP directly provides funds for SMEs' R&D and innovation activities. At Canada's provincial level, Productivity Alberta has a staff of industrial engineers who perform in-depth interventions to improve SME manufacturers' capabilities (similar to MEP or MAS workouts), although Alberta's program is unique among Canadian provinces.[44]

Australia

Australia's Enterprise Connect program is a national network of twelve manufacturing centers run by the Department of Innovation, Industry, Science and Research and is the country's primary vehicle for delivering firm-level support. Enterprise Connect's twelve centers work with SMEs in a range of industries, including not just manufacturing but also clean technology, natural resources, defense, and the creative sector, and provide a multitude of business improvement services including advice on lean manufacturing, business opportunity development, and coaching at growth, innovation, and new product development skills. Like MAS and MEP, Enterprise Connect provides SMEs with a business review (e.g. audit) and then works side-by-side with an SME to help it transform and reach its full potential.[45] Enterprise Connect promotes innovation and enterprise improvement among smaller Australian firms in part by reducing the cost of finding, acquiring, and adapting information, and by strengthening links between small firms and other actors in the innovation system.[46] A particular focus of Enterprise Connect is developing connections with universities and public research agencies that will help unlock their knowledge for wider application by Australian businesses. Enterprise Connect has provided over 1,600 business reviews and supports over 500 tailored advisory services to help drive innovation and change. In addition to providing hands-on support from

business advisors, Enterprise Connect may also award discretionary grants to fund specific R&D projects considered worthy of support.[47]

Germany

Germany's closest analogues to the U.S. Manufacturing Extension Partnership are its Fraunhofer Institutes and Steinbeis Centers of Management and Technology. However, Germany does not have a true equivalent to the U.S. MEP. Germany's approach is much more focused on collaborative industry research and solving common industry technological challenges; it does not focus exclusively on SME manufacturers, as opposed to the U.S. and UK approach of intervening at the firm level to teach manufacturers best practices to boost their productivity, efficiency, and innovative capacity. Germany's fifty-seven Fraunhofer Institutes undertake applied research of direct utility to private and public enterprise and of wide benefit to society. In effect, they perform applied research that translates technologies into commercializable products.[48] Specifically, Fraunhofer Institutes provide joint pre-competitive research, bilateral applied research with individual firms, prototype manufacturing, and pre-production and cooperative technology transfer arrangements with companies.[49] In essence, they bring together cutting-edge research in an industrially relevant way across a number of sectors and technology platforms, including advanced machining, optics, photonics, microelectromechanical systems, robotics, nanotechnology, advanced materials and surfaces, wireless technologies, and many others.[50] All firms within the country can avail themselves of these shared ecosystem support networks, participating in research programs to develop their capabilities/expertise in these functions and sectors.

Germany's federal government provides grants of up to 100 percent for research projects orchestrated by research associations, with the projects industry-selected, and again the research results open for use by all interested companies.

Similar to Germany's Fraunhofer Institutes is the lesser-known Industrielle Gemeinschaftsforschung program, operated by the Allianz Industrie Forschung, a separate program supporting sector-oriented pre-competitive research projects undertaken by manufacturing consortia themselves.[51] Germany has about twenty-five of these research associations, typically in "old industry" sectors such as textiles or steel (whereas Fraunhofer Institutes are generally focused more on advanced technologies like adaptronics, mechatronics, nanotechnology, etc.). Germany's federal government provides grants of up to 100 percent for research projects orchestrated by research associations, with the projects industry-selected, and again the research results open for use by all interested companies.

Germany's Steinbeis Centers, predominantly located in the state of Baden-Württemburg, represent a technology extension program that seeks to transfer existing know-how in education and industry and that helps SMEs to access expertise and new technology through cooperative projects, consulting and technical assistance, and training.[52] Technical services are delivered through semi-autonomous technology centers located primarily at polytechnic universities of applied sciences.[53] The Steinbeis Foundation, which operates as a private center under state sponsorship, sponsors 750 organizational units, including transfer centers, research centers, consulting centers, and a university.[54]

Spain

Spain's Federación Española de Entitades de Innovación (Spanish Federation of Technology Centers, or FEDIT) is a membership organization comprised of Spain's sixty-

seven regional technology centers, with a total staff of over 5,500.[55] The services these centers provide SMEs include R&D project assistance; technical assessment and advice; technology diffusion; standards and quality certification; training; and international cooperation. Essentially, FEDIT is an intermediary organization leveraged to build a national program through networking and linking existing organizations that provide manufacturing extension services.[56]

Argentina

Argentina's INTI, Instituto Nacional de Tecnología Industrial (National Institute of Industrial Technology), is an autonomous entity operating under the jurisdiction of Argentina's Secretary of Industry, Trade, and Small and Medium Enterprise. INTI promotes technology development and transfer to industry, offering a range of services including: technical assistance, research and development, training, product quality and certification, environmental protection, tests, analyses, and calibrations.[57] As a centrally chartered technology development and transfer institute, INTI operates a variety of business and technology services, including a technology extension division, and supports a system of R&D centers and laboratories in about half of Argentina's provinces.[58]

Korea

Korea's Small and Medium Business Administration (SMBA) is not a manufacturing extension service per se, but it is Korea's main government SME promotion agency (including but not limited to SME manufacturers). SMBA provides a variety of technology and innovation support programs, including support for: start-up technology development; SME technology transfer; joint utilization of research equipment; production-environment innovation technology; joint development of industry-academia-research institutes; and establishment of research institutes attached to SMEs. SMBA also provides indirect SME financing support programs focused on helping innovative entrepreneurs set up or expand operations, develop new products, and invest in new staff or production facilities. In particular, SMBA helps companies with excellent technologies, especially in next-generation growth fields such as green energy technology and information technology. SMBA further offers Korean SMEs a credit guarantee system and new growth and technology commercialization funds.[59]

Category	Service	United States	Australia	Canada	Germany	Japan	United Kingdom	Argentina	Austria	China	Korea	Spain
Technology Acceleration Programs and Practice	**Promote Technology Adoption** by SMEs	√	√	√	√	√	√	√	√	√	√	√
	Provide Audits of SMEs' Lean Mfg. & Innovation Processes & Skills	√	√	√		√	√					
	Business Advisers Work Hands-on with SMEs to **Improve Manufacturing & Process Techniques**	√	√			√	√	√				√
	Support Tech Transfer & Commercialization	√	√	√	√	√	√	√	√	√	√	√
	Promote Tech/Knowledge Diffusion from Universities	√	√	√	√	√	√	√	√	√	√	√
	Perform R&D in Direct Partnership with SMEs					√						√
	Provide **Access to Research Labs**/Prototyping Facilities	√				√		√			√	√
	Get SMEs into **Mfg./ Technology Consortiums**				√			√	√			
Technology Acceleration: Funding Mechanisms	Provide SMEs **Direct R&D Funding Grants**		√	√	√	√			√	√	√	
	Provide SMEs **Loans to Scale/Grow Businesses**					√			√	√	√	
	Use Innovation Vouchers			√	√				√			
	Fund Joint Pre-Competitive Research Programs				√							
Next Generation Manufacturing Technical Assistance	**Teach Innovation & New Product Development** Skills	√		√		√	√	√			√	√
	Provide **SMEs Export Assistance and Training**[60]	*	√	*	√	*	√	√	*	√	√	√
	Promote **Energy-Efficient Manufacturing** Skills	√	√	√	√	√	√					
	Provide **Assistance with Standards**	√		√				√			√	√
	Teach Role of Design in Manufacturing			√			√					
Connect SMEs	**Act as Broker** to Other SME Support Services	√	√	√		√	√					
	Host Best Practice Events	√	√	√		√	√					√

Table 2: Range of Services Provided by Manufacturing Support Programs[61]
*** Export Assistance Provided by Countries' Manufacturing Extension Service**

RANGE OF SERVICES PROVIDED BY SME MANUFACTURING SUPPORT PROGRAMS

Assisting SME manufacturers with identifying and adopting new technologies, learning about and implementing lean manufacturing practices, and exposing them to new manufacturing process technologies remain the indispensible and core activities of most manufacturing extension services. However, many countries' manufacturing extension services have been expanding their range of activities, particularly to assist SME manufacturers with their innovation, R&D, and new product development activities,

notably through a range of new financing instruments. As Jayson Myers, President & CEO of the Canadian Manufacturers and Exporters trade association, which partners extensively with IRAP to deliver knowledge and training programs to Canadian SME manufacturers, explains:

> Five years ago it was all about lean, quality, Six Sigma, and continuous improvement, but now it is all about innovation and new product development and finding new customers and new markets. A lot of small companies can understand process improvements, but performing R&D, retooling, understanding new customer sensing, designing products for new markets, and understanding standards requirements in global markets are the new challenges.[62]

Likewise, in Japan, there is a sense that SME manufacturers are already automated, so the next step is to develop new fields through innovation. Indeed, Japanese SME manufacturers have a sense that, though productivity improvements are still very important, an ability to successfully innovate is just as important.[63]

This section examines some of the new services and approaches countries are implementing to support their SME manufacturers, as well as some new techniques for fulfilling classic MES roles, such as promoting technology transfer. Table 2 summarizes the range of services provided by manufacturing extension services in various countries.

Techniques to Promote Technology and Knowledge Transfer from Universities/Labs to SMEs

Techniques to promote technology and knowledge transfer and diffusion from universities to SMEs are a particularly important focus of countries' manufacturing extension services. In Japan, Kohsetsushi Center research staff attend annual meetings of scientific societies in order to exchange technical information with professors at universities or scientists at national laboratories. Kohsetsushi Center staff then provide knowledge learned to SME manufacturers through technical consultations, seminars, and joint research efforts.[64]

Several German states, including Brandenburg, seek to facilitate the transfer of new knowledge from universities to SMEs by co-financing the placement of recent Ph.D. graduates with SME manufacturers. In Brandenburg's program, the state covers 50 percent of the cost for an SME manufacturer to employ a recent Ph.D. graduate for up to two years.[65] Australia's *Researchers in Business* grants allows businesses to bring a researcher from a university or public research agency into the business to help develop commercial ideas. Australian businesses selected to receive a *Researchers in Business* grant receive funding for up to 50 percent of salary costs, to a maximum of $53,000, for each placement for between two and twelve months.[66] In a similar program, Canada's IRAP provides direct financial support for Youth Employment in Canadian SMEs, funding up to $30,500 in salary for six to twelve months for recent college or university graduates employed by SMEs. Productivity Alberta organizes mentoring programs in which local MBA students are assigned to local SMEs to identify and to help solve innovation, technical, and scientific challenges in the SMEs by connecting them to resources available at their graduate

schools.[67] Korea's SMBA encourages the linkage of enterprises with technical high schools and junior colleges that produce graduates especially suited to SME requirements.

Promoting R&D Activities in Direct Partnership with SMEs

Japan's Kohsetsushi Centers appear to be unique among manufacturing extension services in terms of participating in undertaking R&D research projects in partnership with and in service of local SMEs. The Kohsetsushi Centers perform R&D related to technologies of specific interest to regional manufacturing SMEs. Of course, Germany's Fraunhofer Institutes play a similar role, although they are not specifically for SMEs, as Japan's Kohsetsushi Centers are. To a lesser extent, Argentina's INTI also provides research assistance to Argentinian SMEs.

Engaging SMEs in Collaborative Research & Development Consortia

As noted, unlike the Anglo-American approach to intervening at the firm level to boost SME manufacturer productivity, efficiency, and innovative capacity, the focal point of Austria's and Germany's SME manufacturer support programs is to support SMEs' R&D (e.g. innovation) efforts, in largest part by enrolling them in collaborative R&D consortia. As Rainer Jäkel, Deputy Director General of Technology and Innovation Policies for Germany's Federal Ministry of Economics and Technology, elaborates regarding Germany's SME manufacturing support programs, "The main focus is on giving incentives for cooperation between SMEs and universities and research organizations."[68] Germany supports its SMEs' R&D projects in four ways: through its Central Innovation Program, through its ERP-Innovation program, through collective research, and by providing innovation vouchers to SMEs.

Germany's Central Innovation Programme (ZIM) SME has three components: ZIM-KOOP, ZIM-SOLO, and ZIM-NEMO. ZIM-KOOP supports R&D cooperation projects among SMEs or between SMEs in conjunction with universities or research organizations—such as the Fraunhofer Institutes or Helmholtz Institutes (Germany's largest scientific research organization)—by providing research project subsidies. This is specifically the means by which Germany gets its manufacturing SMEs into collaborative research efforts with larger companies, universities, and research institutes. ZIM-SOLO supports single-company R&D projects with research subsidies. ZIM-NEMO supports networking projects between innovative SMEs by providing a subsidy for the network manager. These programs are open to all technologies and support both manufacturing and services SMEs, though predominantly manufacturing SMEs.

The Central Innovation Programme provides grants of up to 50 percent for the SME and up to 100 percent per participating research institute, with a maximum of $245,000 per project. The ZIM program, launched in July 2008, has supported an average of 6,000 projects annually with a total of 19,500 applications received and 13,000 awards granted. However, the program is heavily oriented toward collaborative research projects, with almost 70 percent of the awards and 73 percent of the funding going toward collaborative research efforts. The funds are also skewed toward the smallest SMEs, with 73 percent of the funds going to SMEs with less than 50 employees, 23 percent to those with 50-249 employees, and just 4 percent to firms with more than 250 employees.[69] The 2011 ZIM

budget totaled $545 million, but it received an added $1.26 billion boost (over 2010 and 2011) as part of Germany's economic stimulus package.[70] By 2015, the ZIM budget is expected to grow to $735 million annually, all for SMEs.

The ZIM program turned out to have some unanticipated ancillary benefits for manufacturing SMEs during Germany's recession, allowing companies to retain qualified scientific and research personnel they might otherwise have had to let go by paying them through ZIM projects, which were financed 35 to 40 percent by the government.[71] Like the U.S. Small Business Innovation Research (SBIR) program, ZIM has also helped to validate German SMEs in the eyes of potential creditors and investors. However, an important difference between the SBIR and ZIM programs is that ZIM is heavily focused toward supporting collaborative research efforts, whereas U.S. SBIR funding usually goes to individual firms.

Like Germany, Austria focuses on getting its SMEs into collaborative R&D relationships with larger companies, universities, and research institutes. The Austrian Research Promotion Agency (FFG) is dedicated to strengthening the technological competitiveness of Austrian companies, including its manufacturing SMEs. One of FFG's main SME support instruments is the BRIDGE Program, which has the goal of intensifying research cooperation between science and industry. The collaborative research program funds 75 percent of the cost of selected technology-based research projects that include at least one SME and one scientific partner for a period of up to three years.[72] Seventy-five percent of the payments go to the company and 25 percent to the research organization. Of the 3,000 research projects the FFG supported in 2009, 75 percent to 80 percent involved SMEs (although the BRIDGE Program is for all businesses and not exclusively targeted to SMEs), and in total 5,220 partners participated in the research.[73] In 2008 and 2009, 46 percent and 39 percent, respectively, of applicants for FFG's research promotion loans were first time applicants, meaning FFG is succeeding at enrolling new participants in its research promotion efforts.

Similar to Germany's fifty-seven Fraunhofer Institutes, Austria also supports thirty-five Kompetenzzentren (Competence Centers for Excellent Technologies). The Kompetenzzentren are organized by industrial technological application or industry, with various centers focusing on technologies such as advanced materials, mechatronics, electromechanical systems, metallurgy, information and communications technology (ICT), or sectors such as medical research, mobile communications, or forestry. The Centers are owned by the companies and universities themselves. They convene to form a common pre-competitive research agenda and to chart technological roadmaps for these technologies or industries, generally operating on a seven to ten year timeframe. Funding for the Kompetenzzentren centers comes 50-60 percent from the government (through FFG), 35-40 percent from companies, and 5 percent from the universities.[74] Many SME manufacturers participate in Kompetenzzentren research programs.

Finally, FFG sponsors a smaller program, COIN, dedicated to improving innovation performance in Austria. COIN focuses on stimulating SME research and innovation activities by fostering cooperation between companies (especially SMEs) and research

institutions for a more efficient implementation of know-how in innovative products, processes, and services.[75]

Provision of Credit/Financing Support for SME Manufacturers

The provision of financing or credit support for SME manufacturers has become an increasingly popular and important component of nations' SME manufacturing support strategies in recent years, with many countries introducing new instruments. Such programs can generally be categorized into two types of programs: those that assist with the R&D, innovation, and new product development activities of SME manufacturers, and those that provide credit or financing support for general SME growth or business expansion.

Programs Providing Funds for SME Manufacturers' R&D and Innovation Activities

Germany's ZIM-SOLO program, discussed previously, represents a good example of the first type of program. Canada's IRAP likewise provides financial contributions to firms to conduct R&D in the interest of developing new technologies and products. IRAP provides direct "Innovation Support" through a non-repayable contribution that averages about $110,000-$115,000 (but that can be as large as $1–$2 million in exceptional cases) for innovation activities including R&D, technical feasibility studies, prototype and process development, and developing/exploiting licensed technology.[76] From 2010-2011, IRAP will provide a total of $238.9 million in such direct support to Canadian SME manufacturers.

The provision of financing or credit support for SME manufacturers has become an increasingly popular and important component of nations' SME manufacturing support strategies in recent years, with many countries introducing new instruments.

Separately, Canadian Manufacturers and Exporters (CME), Canada's manufacturing trade association, provides support when small manufacturers need additional financial assistance with productivity enhancement projects, such as implementing lean processes, adopting energy-efficient manufacturing practices, or integrating IT systems. As CME President Myers explains, "If IRAP focuses on the "R" in R&D, we focus on the "D," particularly with regard to lean, Six Sigma, and process technologies on the shop floor."[77] SME manufacturers can receive up to $50,700 for such productivity improvement projects. The program has run since 2006 and has provided $42.6 million in financial support for over 600 companies, although it is currently only available to SME manufacturers in Ontario.[78]

Austria's PROTRANS is a program that funds R&D transfer directed toward SMEs. It is run by Austria's Wirtschaftsservice (AWS), a public sector entity in charge of promoting the development of innovative companies and the commercialization of new technologies.[79] As program director Norbert Knoll explains, "PROTRANS projects must include some form of technology or innovation transfer from a third party. Thus, it is not simply a project done by the firm, but it must have a partner/cooperation with a university, research institute, or larger institute co-performing the research or co-developing the technology."[80] (AWS's PROTRANS is distinguished from FFG's previously described BRIDGE program because it is specifically targeted at SMEs.) Funding is provided in two phases: 1) conception or design of the R&D project, and 2) the implementation phase (if the proposed concept passes an evaluation). The concept phase lasts six months, with the government providing a grant for half the cost of the concept evaluation. The average size of the grant is about $56,000, or 50 percent of the expense, as the cost of the

concept/design phase for the average project is $120,000. In the implementation phase of the R&D project, the average project size is $500,000, and AWS provides a grant, on average, of $175,000, or about 35 percent. In 2009-2010, AWS funded forty-one projects totaling $22.9 million in funding.[81] As discussed in the subsequent impact analysis section, Austrian SMEs regard PROTRANS as a hugely successful support program.

The United Kingdom's Grant for Research and Development is a national grant mechanism that helps SMEs carry out R&D work on technologically innovative products and processes. The grants are available to both manufacturing and high-tech services SMEs. Offered by the UK's Technology Strategy Board, these discretionary grants allow SMEs to test the commercial potential of a new idea; investigate the technical and commercial feasibility of innovative technological products or processes; or develop pre-production prototypes of innovative technological products or processes. This mechanism provides small grants ranging from $16,000 to $800,000, and intends to provide these funds at "a critical stage of development."[82] The program seeks to increase SME involvement "in a range of R&D activity, helping overcome barriers where there is high risk and uncertainty around the expected results."[83]

Germany's *ERP Innovation Programme* promotes "close-to-market research and development of new products and processes." The ERP Innovation Programme provides low-interest, long-term loans (with a maximum $7 million loan), with the Federal Ministry of Economics and Technology a co-investor in cases where the firm already has a private lead investor but is still unable to secure sufficient private capital for the early phase of its innovations. German SMEs with sales of up to $175 million are eligible to participate in the Ministry's ERP Innovation Programme.[84]

Japan's Ministry of Economy, Trade, and Industry provides R&D grants of $100,000 to $200,000 to SMEs, typically for three year projects, and has allocated $15 billion in total. METI also operates a fund solely for manufacturing start-ups that are leveraging specific technologies, such as molding or stamping. At least eighty firms have received a minimum of $10,000 as part of this program, with $2.3 million invested in the effort.[85] Financial support for Japanese SMEs have a history of more than forty years. These financial supports, especially through direct loan programs and guarantee programs for innovation in SMEs are quite substantial: governmental direct loans to SMEs consist of more than ten percent of total outstanding lending to SMEs in Japan. Further, the value of financial guarantees the Japanese government provides for SMEs' liabilities is more than ten times the value of the direct loan programs.[86]

Korea's government (across all levels) invests $141.3 million annually in an SME technology innovation development program, $2 million in a technology innovation-driven SME promotion program, $14.3 million in SME informatization programs, $3.5 million in SME process innovation support, and $41.1 million in an industry-academia-research institute joint technology development consortium.[87]

China does not have a government agency akin to the United States' Manufacturing Extension Partnership or the United Kingdom's Manufacturing Advisory Service that supports the process and innovation capabilities of Chinese SME manufacturers. However,

this does not mean that the country has not moved aggressively to support its SME manufacturers. Rather, China's approach has focused on providing funds (and in many cases, subsidies) to its manufacturing SMEs. China's government provides direct funds, loan guarantees, loan interest repayments, and even equity investments to manufacturing SMEs.

China's Innovation Fund for Small Technology-based Firms (InnoFund), founded in 2002, is an innovation fund for small-technology based firms (STFs) that, "facilitates and encourages the innovation activities of STFs and the transformation of research achievements by way of financing." A special government fund set up on approval of the state council, it supports technological innovations of STFs, thereby "facilitating transformations of scientific discoveries." China's Innovation Funds takes three forms: appropriations, loan interest subsidies, or direct equity investments. Appropriations are start-up capital provided to small firms founded by research personnel bearing their own scientific achievements, or to existing STFs for new product development and pilot production. These appropriations typically do not exceed $155,000.[88] Loan interest subsidies provide interest repayments for STFs requiring loans from commercial banks to expand the production scale of an innovation project. Again, loan interest subsidies typically max out at $155,000. Finally, InnoFund equity investments are targeted toward a small number of technology-intense projects with market potential in emerging industries, with the investment not exceeding 20 percent of the registered capital of the investee company. The Chinese government stipulates that firms receiving these funds must "comply with the national industrial technology policies."[89] Beyond the InnoFund, the Chinese government generally follows a cluster-based SME innovation promotion strategy.[90]

Programs Providing Funds for SME Manufacturers' Business Growth and Expansion

Separate from programs funding SME manufacturers' R&D and innovation activities, a number of countries have established credit or equity instruments to bolster their general growth. For example, through its Finance for Business program, the British government provides SMEs with fewer than 250 employees loans of up to $400,000 and equity investments up to $3.2 million (two-thirds public money supplemented by a one-third private investment). The SME finance body of Britain's Department of Business, Innovation, and Skills, named Capital for Enterprise Limited, connects fund managers investing through Enterprise Capital Funds as the primary national instrument for SME equity investment.[91]

Austria, through AWS, provides $700 million annually in financial assistance to SME manufacturers, usually in the form of loan guarantees. This assistance provides guarantees to investors in SME companies, particularly for investments that underpin Austrian SMEs' internationalization projects, often when the company is investing in China or Eastern Europe. AWS also provides loan guarantee support for SMEs' immaterial or intangible investments, such as in intellectual property or skills development.[92]

Hong Kong supports its SMEs (both manufacturing and services) through an SME Loan Guarantee Scheme, operated by the Trade and Industry Department, which as of February

2011 has an upper authorization limit of $3.9 billion.[93] The program guarantees up to 50 percent of any loan to an SME up to a maximum of $771,000, with the program supporting a total of $4.2 billion worth of loans to more than 12,000 SMEs since 2001.

Aside from China's InnoFund, China's 2006 SME Growth Project promulgated a series of promotions and regulations in further support of Chinese SMEs. These included the establishment of a credit guarantee system for Chinese SMEs and the development of a state-allocated budget for SME financing.[94] The government also required financial institutions to improve the financing environment for SMEs and strengthen their support to SMEs in terms of enhanced credit and direct financing channels. However, China's finance and credit supports for SMEs are not like those of other countries, for they are closely aligned with the country's industrial policy and practices.[95] For example, SMEs receiving these supports "are enjoined to conscientiously implement the nation's industrial policies and industrial planning regulations, especially those on market access."[96] Moreover, China's government operates a "pay-for-performance system," as incentives, including tax reduction and income tax waivers, are "given to SMEs that meet a state-stipulated number of jobs that are expected to be generated each year."[97]

Like Austria's program, Holland's enables SMEs to "buy" expertise from public research institutions, universities, or large corporations, with the intent of stimulating knowledge transfer to SMEs.

Providing Innovation Vouchers to Assist SME Manufacturers with New Product Development/Innovation Efforts

Several countries, including Austria, Canada, Belgium, Denmark, Germany, the Netherlands, Ireland, and Sweden have begun using Innovation Vouchers to support manufacturing SMEs. For example, Austria's Innovationsscheck (Innovation Voucher) is designed to help SMEs start with continuous research and innovation activities. SMEs receive a $7,000 voucher for a cooperation project with a research institution for preparatory studies, analysis of technology transfer, analysis of the innovation potential of a new technology, etc. Austria has allocated $11.1 million towards the Innovationsscheck program.[98] The German program was introduced by several German states, including North Rhine Westphalia and Baden-Württemberg, in the late 2000s; was then expanded to cover all East German states; and has now been made available nationwide.[99] Germany offers vouchers at the $7,000 and $16,800 levels (for firms with fewer than 50 and between 50-250 employees, respectively), although "firms can get up to $42,000 if they follow all the steps."[100] The German program is seen as mostly for training and improving innovation systems in SMEs; that is, as a first step for companies to learn how to innovate. The Canadian province of Alberta recently introduced a similar innovation voucher program. NUTEK, the Swedish Development Agency, also provides funding to small businesses for the purchase of external services that help develop new products or services.[101]

The Netherlands' innovation agency, Senter Novem, was the first to create an Innovation Voucher program, in the early-2000s. Like Austria's program, Holland's enables SMEs to "buy" expertise from public research institutions, universities, or large corporations, with the intent of stimulating knowledge transfer to SMEs. Senter Novem has found that the program substantially stimulates innovation—eight out of ten vouchers issued resulted in an innovation that would not have otherwise come to fruition and 80 percent of new R&D jobs created in Holland since 2005 are attributable to the vouchers.[102]

Helping SME Manufacturers Understand the Importance and Role of Design Methods

Several countries have introduced programs to help SME manufacturers understand the importance and role of design methods and principles. The UK's Designing Demand program is a mentoring and support service helping businesses make strategic design decisions and set up and manage design projects.[103] The program gives high-growth-potential SMEs up to ten days of design and innovation focused mentoring over 6-18 months. Designing Demand helps SMEs gain a deeper understanding of design processes and how to specify demand projects and issue design tenders. Companies taking part in the program benefit from government support of up to 80 percent of the cost of services provided by the Design Associate, with SMEs incurring average expenses of $8,000 to $22,500 on design engagements. For the most part, the Designing Demand service is not delivered as part of MAS (although at least two MAS Centers provide this service), but rather by the UK Design Council.

Likewise, Ontario's Design Industry Advisory Committee (DIAC) has launched the Design Advisory Service, a design support program to help manufacturers and other growth-oriented SMEs improve their innovation outcomes.[104] The program aims to expand Ontarian SMEs' use of strategic design in every stage of the product development process. The effort includes a series of design seminars to introduce Canada's IRAP ITAs and SME client participants to the value of integrating design with business strategy and adopting an integrated design process in product development and commercialization. Companies receive a one-day Design Audit that shows how design principles can be used in the development of the SMEs' products, environment, and communications. Following the design audit, DIAC supports a one-week design project that introduces the SME to the strategic design process and how to leverage design opportunities.[105]

Helping SME Manufacturers Understand the Role of International Standards

Korea assists its SMEs in improving their reliability and boosting their exports by bearing a portion of the costs related to acquiring international standards certificates. Canada's Canadian and Manufacturing Exporters association likewise helps SME manufacturers understand the role of standards on international markets, and how to make their products compatible with global standards. Argentina and Spain both also help their SME manufacturers understand international standards and design their products according to international standards specifications. Located within the U.S. National Institute of Standards and Technology, the U.S. MEP program is well-positioned to assist U.S. SME manufacturers in understanding how evolving global standards requirements for certain technologies impact their businesses.

FUNDING AND BUSINESS (FEE) MODELS OF SME MANUFACTURING SUPPORT AGENCIES

The funding models for countries' manufacturing extension services vary considerably. While national governments often provide a portion of funding, with matched funding coming from states and recipient firms, in Japan funding of the Kohsetsushi Centers comes entirely from the provincial level government. Likewise, while most countries expect recipient firms to participate in at least a portion of the cost, Japan strives to offer free- or

low-cost services to SME manufacturers through its Kohsetsushi Centers. There, consultations with Japanese SME manufacturers are free, although the use of facilities is cost-shared.

As a cost share program, MEP centers are required to match the federal investment with non-federal sources such as state investments and fees for services delivered on a 1:2 basis. (That is, every federal $1 must be met by $2 from either state or local resources or the firm itself.) In recent years, total federal funding for MEP has come to about $110 million annually, meaning that the MEP program in total is supporting over $300 million in investment for increasing the capabilities of U.S. manufacturers.

However, overall funding for the United States' MEP program as a share of U.S. GDP has decreased since 1998. In fact, as a share of GDP, the federal government invested 1.28 times more in MEP in 1998 than it did in 2009. But not only has recent federal funding of the MEP program trailed the historical norm, it has begun to fall significantly behind the levels of funding that competitor countries provide their manufacturing extension services. Figure 3 shows countries' investment in their manufacturing extension service or programs as a percentage of GDP. As a share of GDP, Japan invests thirty times more than the United States, Germany invests approximately twenty times as much, and Canada almost ten times as much as the United States in their principal SME manufacturing support programs.

As a share of GDP, the federal government invested 1.28 times more in MEP in 1998 than it did in 2009.

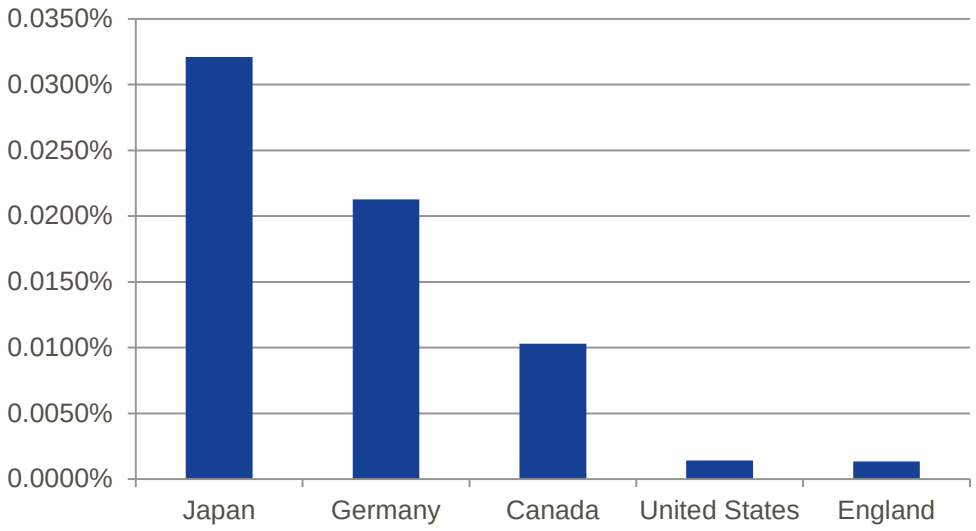

Figure 3: Country Investment in Manufacturing Extension Services/Programs as a Percentage of GDP[106]

The Manufacturing Advisory Service model for its Level 4 subsidized consultancy service is somewhat similar to MEP's model. On average, MAS provides approximately fifty percent of the cost for experts trained to help English SME manufacturers improve their businesses.[107] [Technically, there are two levels of consultancy rate available. Very small companies (those with fewer than 50 employees) pay $530 per man-day, while those with 50-250 employees pay $880 per man-day. Non-SMEs acquiring MAS-like services on the

private market pay up to $1,600 per man-day, so the UK subsidy for the service is about two-thirds the cost for very small firms and 45 percent the cost for medium-sized enterprises.] In 2011, the British government allocated $91 million to the Manufacturing Advisory Service for the ensuing three-year period.[108]

Japan's Kohsetsushi Centers received $1.67 billion in funding in FY 2009, almost all of it provided by local prefectural governments, with hardly any operating budget provided by the federal government.[109] (Though Tokyo's Metropolitan Industrial Technology Research Institute, TIRI, does receive 5 percent of its funding from the federal government.)[110] Japan's level of investment in SME manufacturing support far outstrips that of all competitor nations except Germany, as Figure 3 shows.

The provision of budget for the Kohsetsushi Centers by Japan's regional governments encourages skills and capability-based competition among Japan's prefectures, incenting the prefectures to realize economic growth by helping locally situated businesses grow. Indeed, Japanese prefectures have the attitude that they cannot coopt a firm from another prefecture; they can only grow their economy from within through superior technology development, transfer, and commercialization. This is in contrast to the "smokestack chasing" more common in the United States, a "race-to-the-bottom" in which states dangle incentives before businesses to induce them to relocate from one state to another. As Kenneth Thomas finds in his book, *Investment Incentives and the Global Competition for Capital*, U.S. states spend $60 billion a year on smokestack chasing, and only $2-$3 billion on technology development and transfer, an approach markedly different from Japan's.[111] The Japanese model invests state money in building firm competencies, not towards inducing their relocation.

Canada will provide $236.1 million in direct client support to Canadian SME manufacturers in 2010-2011, and an additional $28.8 million in Information Technology Advisor (ITA) direct service. At those levels, per-GDP, Canada invests almost ten times as much on SME support through the Industrial Research Assistance Program than the United States does through MEP. However, that high level of funding resulted because IRAP received an extra $100 million ($90M for contributions to firms and $10M for Youth projects) in 2009-2010 as part of Canada's economic stimulus package.[112] On an ongoing basis, Canada's annual funding for IRAP will revert to an about $88 million baseline annually. ($73.7 million for contributions to firms, $9.4 million for contributions to non-profit organizations that benefit SMEs, and $5 million for Youth projects.)[113] IRAP's ITAs are not doing the deep interventions that MAS and MAP advisors are. Rather, IRAP is much more active at providing direct R&D contributions to SMEs. From 2009-2010, NRC-IRAP worked with 8,578 SMEs, of which 2,871, or 33 percent, received some form of funding.[114] The average size of the R&D contribution IRAP provides SMEs is $85,000-102,000 (based on data from 2007/08-2010/11), although it can provide support for projects as large as $1–$2 million in exceptional cases.[115]

Canada's IRAP promotes as a strength of its model the ability of its information technology advisors to work closely with SME manufacturers and to make funding decisions in the field. At the regional level, ITA Directors are empowered to authorize up to $355,000 in

grants to SMEs. Executive Directors can make grant decisions up to $507,000 and the National Director can sign off on projects up to 760,000. That kind of distributed decision-making allows IRAP ITAs to work very closely with SME manufacturers.[116]

Germany's Fraunhofer Institutes have an annual research budget totaling $2.35 billion. Of that sum, almost 30 percent, or just over $700 million, is contributed by the German federal and Länder governments in the form of institutional funding.[117] $1.96 billion of the total is generated through contract research with industry and from publicly financed research projects. Likewise, Germany's Steinbeis Centers' budgets are mostly funded through client projects. Separately, as previously described, Germany will invest $1.83 billion from 2010-2011 in its ZIM programs designed to support SMEs' innovation efforts.

Spain's Federation of Innovation and Technology Organizations (FEDIT) are non-profit, privately owned, and based on membership. Half of their budgets come from private industry, and the other half from regional governments. In 2006, the total budget for Spain's FEDIT centers amounted to $838 million.[118]

Of Korea's total federal budget, 5.5 percent is allocated "toward promoting the competitiveness of Korean SMEs."[119] In total, the Korean government's investments in SME technology support, support for informatization projects, support for external linkage and inter-firm cooperation, and sales and marketing support totals $237.7 million annually. Additionally, Korea provides a total of $2.48 billion in loans to SMEs, including a $380.7 million guarantee for technology start-up evaluation and an SME venture companies start-up program; a $97.6 million development and patent technology commercialization fund; $341.7 million in loans for sales and marketing support; and $1.7 billion in loans as part of an "SME reorganization fund" that supports productivity improvement and reorganization.[120]

Australia provides $51.5 million annually for its Enterprise Connect Service.

UNDERSTANDING AND DISSEMINATION OF BEST PRACTICES

This section highlights various observed best practices from countries' SME manufacturing support programs. Several MAS Centers noted that they recognized the importance of applying lean practices to their own operations. For instance, MAS Southeast makes extensive use of teleworking and allows staff to work from home when not with clients.[121] Likewise, the United States' MEP not only helps SMEs implement Innovation Engineering Management Systems (IEMS) that help them continuously innovate, but MEP itself applies this systematic approach to its own operations, using the IEMS methodology to manage innovation internally.

MAS Centers also recognized that they could not simply wait for SME manufacturers to find and come to them, but proactively reached out to manufacturers in their communities. For example, 50 percent of the SMEs MAS Southeast works with came from direct telesales marketing activities.[122] MAS Southeast pushes the marketplace, they do not wait for the SME manufacturers to find them. For its part, Canada's IRAP proactively

seeks out what it regards as the SMEs with the highest growth potential and engages them; it does not receive applications, but rather chooses the firms it wishes to work with.[123]

Productivity Alberta offers both "Do it Yourself" and "Do it With Help" approaches to support SME manufacturers. For companies wishing to make improvements on their own, Productivity Alberta offers a highly popular online Productivity Assessment Diagnostic tool, which firms throughout not just Alberta but also the rest of Canada and even the United States use.[124] For companies that would like more personalized attention, Productivity Alberta provides free on-site diagnostic interviews as a springboard for a deeper intervention. Of course, that approach, with a complimentary up-front diagnostic review potentially followed by a customized intervention, is shared by the United States and the United Kingdom. The principle is that once the manufacturing extension service has demonstrated what it can deliver for an SME, the company will come back for a deeper engagement.

The development of best practice networks was common to all manufacturing extension programs reviewed.

The development of best practice networks was common to all manufacturing extension programs reviewed. The Canadian Manufacturers and Exporters association, in partnership with IRAP, operates an *Innovation Insights* program, which coordinates demonstration visits to showcase companies utilizing best practices in management of a technology, manufacturing operations, etc. Likewise, MAS has created a formal National Best Practice Program, which features a series of National Best Practice visits designed to look at larger companies that are seen as exemplars in manufacturing and to give smaller companies the opportunity to see how manufacturing best practices operate even in the largest environment.[125] Several MAS centers also supported their own Best Practice Networks, hosting events quarterly where representatives of SME manufacturers can meet, exchange best practices, and share stories about "what works and what does not." Manufacturing extension services often compile best practice resources and place them online. For example, MEP, MAS Northeast, Productivity Alberta, and several Japanese Kohsetsushi Centers have created comprehensive online resources covering everything from process technologies to innovation methodologies.

The U.S. Manufacturing Extension Partnership has a number of ways in which it shares best practices, including internal Web sites available to all MEP field offices and field staff across the nation where questions and answers are posed and discussion groups share best practices. Similarly, a Web portal has been developed for helping increase the innovation and growth capacity of SMEs. This innovation portal can be accessed to share tools and techniques for client engagement.

In FY 2010, the MEP program provided $9.1 million in competitive grant awards to twenty-two recipients. The projects are focused on either expanding growth services (primarily supplier development, sustainability, technology acceleration) or developing new tools in growth services. The awardees were brought together at an information sharing conference and likewise can communicate through electronic "communities of practice." MEP field offices and field staff are also brought together throughout the year for professional development, to share information, and to identify collaboration opportunities.

An increasing number of manufacturing extension services are coaching SME manufacturers on sustainable and energy-efficient manufacturing operations. MAS has created an energy audit for SMEs. MAS has also developed a ten-point plan to help manufacturers obtain a strong position when it comes to resource efficiency. It helps show manufacturers how to reduce energy consumption, reduce material use, reduce creation of scrap materials, and reduce packaging needs (in part by improving product design).[126]

Authoring case studies of successful client engagements as proof points of value delivery to future clients was observed at all manufacturing extension services. At MAS East of England, each consultant must produce a case study for at least one out of every three client engagements. These case studies are posted online and in MAS annual reports. Productivity Alberta also makes extensive use of client case studies, but they do so through video storytelling—most of their case studies are offered as video testimonials and are available online.

In addition to case studies, MEP requires that each center report on a success story once per quarter. These stories are two to three pages in length and focus on the problem, the solution, and impact after the solution was provided. These success stories are available online and can be queried by center, state, industry, and congressional district to help inform key stakeholders.

One interesting facet of Alberta's technology-based economic development strategy is that it allocates a share of its university research funding directly to companies, and then encourages companies to engage universities and identify ones undertaking industrially oriented research relevant to their needs. Alberta has found that by allocating just a small share of funds ultimately destined for university research this way, they are able to bridge the gap between research and technology development coming out of universities and making it more commercially relevant. As Productivity Alberta's Senior Director, Lori Schmidt, explains, "It's a demand-pull approach to innovation rather than trying to push research into the system."[127]

From a lessons learned perspective, one of MAS's challenges has been that, because historically most of its centers were operated by different contractors, best practices were not extensively benchmarked between the MAS Centers, in part because the different contactors did not want to give their own best practices away (because they competed for Center management contracts). MAS will resolve that conflict in 2012 with a new national delivery model in which the operation of the various MAS locations will be brought under a single contract.

Another point of improvement identified in the Canadian and English (and to a lesser extent American) approach has been the need to create stronger linkages between universities and the private sector. Of course, Canada's ITA's are specifically tasked to help fill this gap. To address this challenge in England, the government has announced it will create several new Technology Innovation Centers (TICs), which will help bridge the gap between research and technology commercialization. The first new TIC will be the High Value Manufacturing TIC, which will integrate the activities of a number of existing centers that help companies develop and commercialize their technology.[128] Canada has

also created a Digital Technology Adoption Program (DTAP), specifically designed to help Canadian SMEs adopt manufacturing technologies such as robotics, automation, and advanced software to help them increase their productivity. In the United States, MEP is working with universities to translate their technologies into business opportunities and post them on the National Innovation Marketplace so MEP field staff across the United States can easily find university technologies and researchers to connect with their SME clients to accelerate commercialization.

In Japan, the Kohsetsuhsi Centers have done an effective job of connecting SMEs and public testing facilities to support process technology, quality, training, and incremental product improvement. However, there is a sense that one way the Kohsetsuhsi Centers can improve their already strong support for SMEs is by working even more closely with research universities to gain access to new research, faculty, and students in order to increase their exposure to emerging technologies and translate those to SMEs.[129]

ECONOMIC IMPACT OF SME MANUFACTURING SUPPORT PROGRAMS

The impact of countries' manufacturing extension programs on boosting SME manufacturers' sales and employment activity and contributing directly to economic growth is quite evident.

The impact of countries' manufacturing extension programs on boosting SME manufacturers' sales and employment activity and contributing directly to economic growth is quite evident. While it is more difficult to demonstrate the impact of manufacturing extension services at the macroeconomic level (simply because so many other variables cloud the picture), the evidence of their effectiveness at boosting economic growth from a microeconomic perspective is unequivocal.

For instance, a February 2011 study of the U.S. Manufacturing Extension Partnership found that every $1 of federal investment in MEP generates $32 of return in economic growth (see Figure 4), translating into $3.6 billion in total new sales annually for U.S. SME manufacturers.[130] Moreover, client surveys indicate that MEP centers create or retain one manufacturing job for every $1,570 of federal investment, one of the highest job growth returns out of all federal funds.[131] In fact, 2009 impact data show that the MEP program created and retained over 70,000 jobs.

Similarly, an extensive 2010 review of the United Kingdom's Manufacturing Advisory Service found it to be one of the British government's most successful programs, generating $6.2 of additional gross value-added for every $1 of public investment between 2002 and 2009.[132] Several of the regional MAS agencies reported much higher paybacks: MAS East of England found rates of return of $11 for every $1 invested in 2009-2010.[133] A January 2011 independent assessment of the MAS Northeast program found that for every $1 of public money invested, $30 is generated in gross value-added.[134] Overall, since its inception in 2002 through 2009, public spending on the MAS program has totaled $178.8 million and delivered at least $1.23 billion in gross value-added. The MAS program has fielded 161,000 technical enquiries, performed 31,069 manufacturing reviews, and completed 12,682 Level 4 projects since its inception.[135]

As with the U.S. MEP program, MAS is one of Britain's best performing programs in terms of job creation per government-dollar invested. The MAS Northeast program assessment found that the cost per net additional job created or safeguarded was $9,100,

which was significantly below the average benchmark cost per net job for 'Sector/Cluster Support' of $19,450.[136] Program-wide, the MAS 2010 review found that jobs were created or safeguarded in 60 percent of the MAS Level 4 engagements and in 38 percent of the MAS level 2 engagements. Further, the assessment found that MAS Level 4 interventions have created or safeguarded 10.1 jobs per firm.[137]

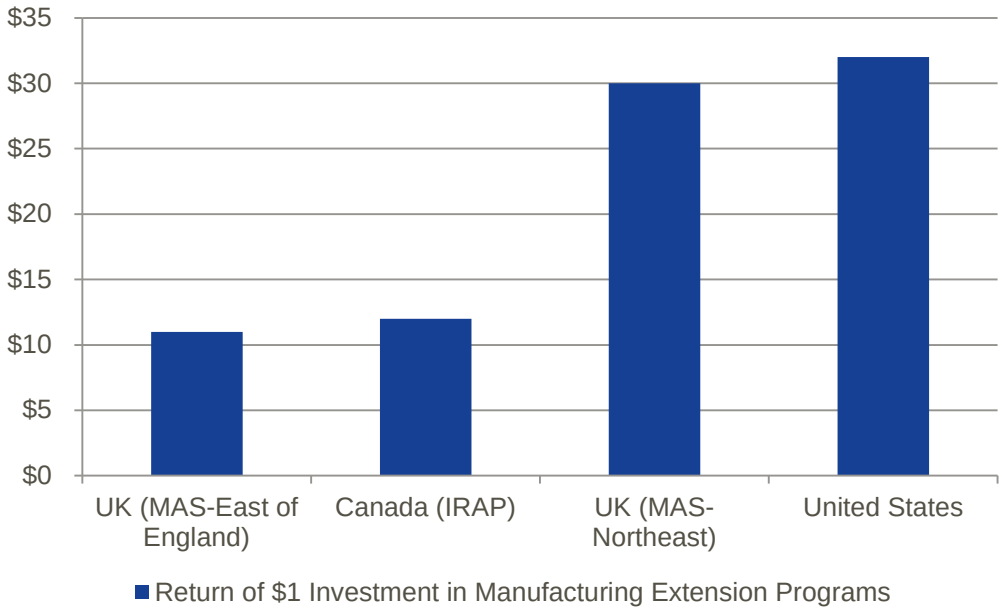

Figure 4: Return on $1 Invested in Manufacturing Extension Programs

One of the true strengths of the MEP and MAS programs is that they are supporting productivity enhancement projects that otherwise simply would not occur. The 2010 MAS program review found that, "If MAS did not exist, no other service/product in the market could deal with the very technical nature of many requests received from manufacturers [that are] currently dealt with by MAS." Moreover, the assessment found the additionality of the in-depth intervention workouts to be 90 percent, meaning that, without government assistance, nine out of ten MAS Level 4 interventions would not have occurred.[138] For their part, 67 percent of English businesses working with MAS reported that they would not have achieved all or part of the improvements they had experienced or could not have done so as quickly without MAS support.[139]

Canada's IRAP provides customized solutions to some 10,000 SMEs annually.[140] Further, IRAP assists in the development, risk-taking, and cost sharing of over 30,000 technology projects annually.[141] As with the MEP and MAS programs, an evaluation of the NRC-IRAP program found that the R&D capacity and capabilities of NRC-IRAP clients grew over the evaluation period and that NRC-IRAP clients have on average greater capabilities and capacity than non-client SMEs. The evaluation found that NRC-IRAP stimulates wealth creation within Canada, with the total wealth creation benefits of the program between 2002 and 2007 in the range of $2.4 to $6.7 billion.[142] The evaluation concluded that, "By contributing to the development of research and development capacity, the

overall growth of SMEs, the commercialization of new products, services and process, as well as the creation of new knowledge and intellectual property, NRC-IRAP has positively stimulated overall innovation in Canadian SMEs and in Canada as a whole."[143] An updated 2010 review of the IRAP program found that each $1 of public investment in IRAP resulted in a $12 impact on the Canadian economy.[144] Moreover, a one percent increase in IRAP assistance has led to an 11 percent increase in firm sales, 14 percent increase in firm employment, and 12 percent increase in firm productivity. Likewise, a one percent increase in IRAP funding has led to a 13 percent increase in R&D spending and 3 percent increase in R&D staff.[145]

While information on program-wide returns from Japan's Kohsetsushi Center investments are more difficult to find, the Tokyo Metropolitan Industrial Research Institute (Tokyo's largest Kohsetsushi Center) reports that the total economic effect (benefit) for customers who used the TIRI service in FY 2009 was $260 million.[146] (In FY 2009, the Tokyo Metropolitan Industrial Research Institute received $107 million in funding). Dr. Korenaga, Deputy Director of METI's Startup and Technology Division, notes that "only a few Kohsetsushi Centers quantify and report the economic impact of their services, by conducting external assessments," although he notes a special survey of the total economic impact of the Kohsetsushi Centers is scheduled to be conducted.[147]

In Austria, SMEs participating in AWS's PROTRANS program reported it to be instrumental in helping them introduce new products and services and diversifying into new fields. Sixty-two percent of participating SMEs reported that it led them to introduce products new to the market. Eighty percent responded that their R&D project wouldn't have happened without the program's support, and 95 percent replied that it will enable them to develop new applications for existing technological know-how within the company.[148]

Another piece of evidence suggesting the impact of manufacturing extension services is the change in manufacturing output per hour from 2000 to 2008. It is apparent that countries with effective SME manufacturing support programs or systems have seen substantial improvements in manufacturing productivity levels over the past decade, especially in the United States, Germany, the United Kingdom, and Canada, as shown in Figure 5. As explained previously, manufacturing extension services play a strong role in helping SME manufacturers boost their productivity, and have likely made important contributions to the growth in manufacturing productivity seen in many economies from 2000 to 2008.

Thus, the microeconomic evidence supports the conclusion that countries' manufacturing extension services and efforts to support the R&D and innovation activities of their SME manufacturers generate impressive returns on investment, thereby producing substantial economic and societal returns.

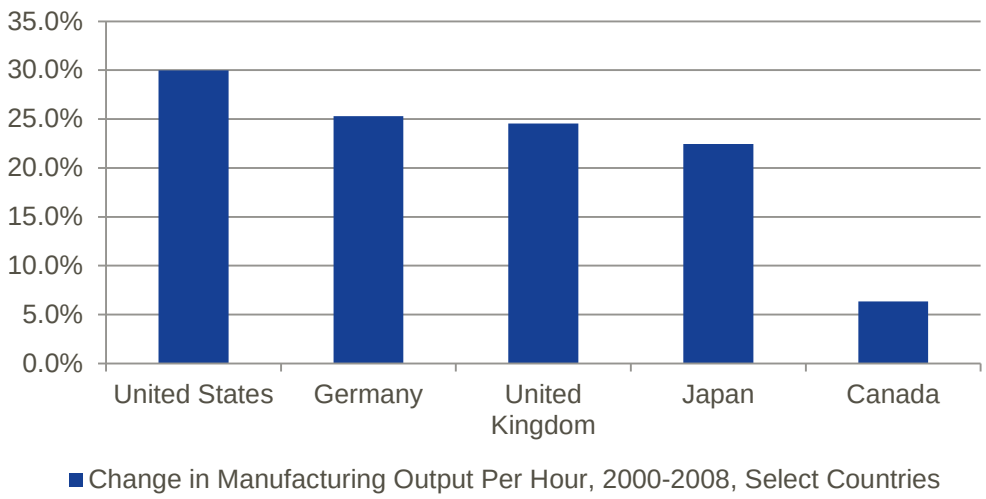

Figure 5: Change in Manufacturing Output Per Hour, 2000-2008, Select Countries[149]

Manufacturing extension programs need to explicitly respond to the specific current challenges, needs, skills, and capabilities of a country's SME manufacturing base, while at the same time charting a path to help SME manufacturers acquire the next generation of engineering, innovation, and product development and commercialization skills.

LESSONS AND INSIGHTS FROM FOREIGN SME MANUFACTURING SUPPORT PROGRAMS

Perhaps the most important lesson to be drawn from other countries' SME manufacturing support programs/services is that manufacturing extension programs need to explicitly respond to the specific current challenges, needs, skills, and capabilities of a country's SME manufacturing base, while at the same time charting a path to help SME manufacturers acquire the next generation of engineering, innovation, and product development and commercialization skills. A critical implication of this is that country's manufacturing extension services must likewise continuously develop and extend their own capabilities to serve SME manufacturers, for the challenges SME manufacturers themselves face are constantly evolving in a dynamic market landscape. Therefore, manufacturing extension services must also demonstrate flexibility and adaptive capability to ensure their service offerings evolve and remain responsive to the unique needs of their country's SME manufacturing base. Moreover, the need for manufacturing extension services to be responsive to the strengths and weaknesses of the existing skills and capabilities set of their SME manufacturers explains to some degree the slightly different approaches or emphases certain countries take in their SME manufacturing support strategies.

One way to examine this is by assessing the composition of a nation's manufacturing base, in terms of the "technological intensity" of its manufacturing sectors as either "low-technology", "medium-low technology", "medium-high technology", or "high-technology", as figure 6 illustrates. (The OECD classifies a sector as "high-technology" if global R&D expenditure is greater than 5 percent of sales; "medium-high technology" if global R&D expenditure is 3-5 percent of sales; "medium-low technology" if global R&D is 1-3 percent of sales; and "low technology" if global R&D expenditure is less than 1 percent of sales.)

Approximately 37 and 33 percent of the UK and U.S. manufacturing sectors, respectively, can be characterized as having low technological intensity. Another 23 percent of the

manufacturing sector can be characterized as having medium-high technological intensity, and about twenty percent with high-technological intensity. In noticeable contrast, over 45 percent of Germany's manufacturing industries, and about 35 percent of Japan's, are in medium-high technology sectors. In other words, whereas just short of 60 percent of Germany's manufacturing sectors are in medium-high technology or high-technology industries and 40 percent are in low- or medium-low technology industries (with Japan's about evenly split), those percentages are reversed in the United Kingdom and the United States, with each having about 60 percent of their manufacturing sectors in low- or medium-low technology sectors and 40 percent in higher-tech ones.

Clearly then, these countries' SME manufacturing support services will need to be responsive not only to the types of industries their SME manufacturers are in, but also to the technological intensity of their SME manufacturing base. Of course, the best programs are both responsive to the existing skill sets of their SME manufacturing base, while at the same time devising strategies to bolster SME's technological capabilities and help "take them to the next level" by "moving them up the value curve," in large part by assisting in their efforts to commercialize new technologies and develop the next generation of technology-intensive advanced manufactured products.

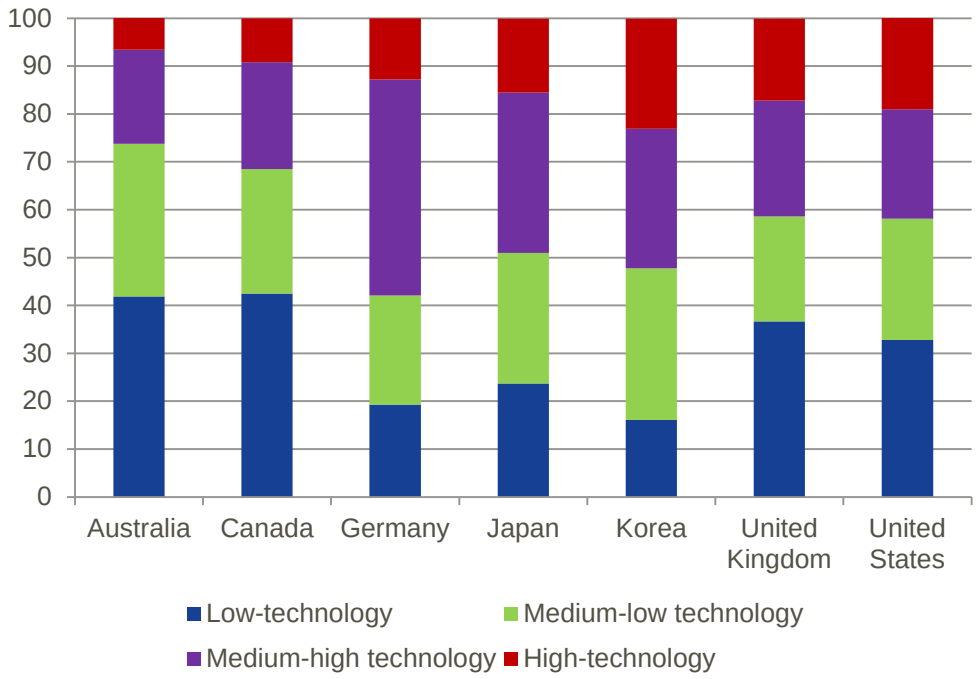

Figure 6: Composition of Manufacturing Sector by Technological Intensity, 2007[150]

Of course, what Figure 6 really reflects is the great strengths of Germany's so-called *Middelstand* and Japan's *chuken kigyo* (strong, medium-sized) firms. Germany's *Mittelstand* dominate the global market in an astonishing range of sectors: from printing presses (Koenig & Bauer), to industrial chains (RUD), to high-pressure cleaners (Kärcher), to vacuum cleaners (Miele).[151] Ninety percent of Germany's *Mittelstand* operate in business-to-business markets and 70 percent are found in Germany's countryside, but such is their

dominance that 80 percent of the world's medium-sized market leaders are based in Germany or Scandinavia.[152] Germany's *Middelstand* employ over one million workers and export more than 80 percent of their production.[153] Japan likewise boasts a host of *chuken kigyo* that dominate specialized global markets. In fact, according to METI, Japanese companies serve more than 70 percent of the worldwide market in at least thirty industrial technology sectors worth more than $1 billion apiece.[154] Clearly then, Germany and Japan dominate scores of medium-high technology manufacturing sectors. Moreover, Germany's strength in these medium-high technology sectors explains why the country has been able to maintain a robust manufacturing industry that supports high wages for German manufacturing workers.

It is also interesting to note in Figure 6 that Korea, the United States, and the United Kingdom have the highest share of manufacturing sectors with high-technology intensity (with Korea at 23 percent, the United States at 19 percent, and the United Kingdom at 17 percent) the latter of which is slightly ahead of Japan and Germany (at 15.4 and 12.8 percent, respectively). In part, this reflects those countries' strengths at introducing new high-technology manufacturing firms and sectors to their economies (think information and communications technology, medical devices, pharmaceuticals, etc.) However, in part, it reflects the fact that spin-offs and start-ups out of established companies tend to be less common in Germany and Japan than in the United States, with would-be entrepreneurs in those countries often preferring to exploit new technologies in the comfortable confines of an existing company rather than incurring the risk of starting a new venture.[155]

But perhaps the most intriguing feature of Figure 6 is that it may explain the slightly different orientations (at least historically) of the Anglo-American as opposed to the German and Japanese SME manufacturing support programs. It is possible that German and Japanese SME manufacturers may be enjoying the benefits of the more advanced technical and engineering apprenticeship training programs these countries are renowned for (particularly Germany's famed Technische Hochschules), meaning that their SME manufacturing support efforts have historically been able to focus more on the "front-end" of innovation, R&D, and new product development and introduction, instead of having to invest as much effort in assisting manufacturers with adopting lean manufacturing principles, improving process techniques, and adopting new technologies. In contrast, the U.S. and UK programs, which were historically focused more on technology adoption, lean, Six Sigma, and operational and process improvement efforts—though, as noted, this is now changing to focus much more on the "front-end" of innovation—may suggest that these programs have had to start by building-up skills in U.S. and UK SME manufacturers that were simply already resident in German and Japanese SMEs as a product of their advanced technical education systems and the historical strengths of their *Middelstand* or *chuken kigyo* companies. (As *The Economist* notes, "Japan's brilliant steel forgings are a vestige of ancient swordmaking.") Regardless of whether that historical narrative is unassailable or not, Germany and Japan's unquestioned strength in capturing high levels of market share for their SMEs in medium- and highly-technological intensive industries suggests lessons for how the United States can better support its SME manufacturers.

Indeed, it does seem that the German R&D and innovation-focused approach may be successfully helping German SME manufacturers maintain (and extend) their strength in these medium and high-technology manufacturing industries. As Dr. Jäkel of Germany's Federal Ministry of Economics and Technology explains:

> A key component of Germany's industrial success is infusing cutting-edge technology into legacy industries. In many old industry sectors, such as textiles or steel, we do high-tech research in our Industrielle Gemeinschaftsforschung program; for example, integrating nanotechnology and even biotechnology into textiles or advanced technologies into steel-making. We are good at integrating high-tech into otherwise low- and medium-tech sectors, allowing SMEs to renew themselves and to find profitable high-tech niches in these otherwise legacy industries. We have a lot of this type of innovation taking place in established SMEs, with many continuously reinventing themselves. We also provide direct R&D funding to support the research, innovation, and product development and commercialization efforts of our SME manufacturers.[156]

As a share of GDP, Germany's export of research-intensive products is almost seven times greater than the United States.

This focus on R&D and innovation fits the German model well. The county boasts a high-proportion of research-intensive industries, with 30,000 firms performing R&D continuously. Germany is the leading exporter of research-intensive products, with $670 billion in exports of research-intensive products in 2010, compared to $561 billion in the United States, and $388 billion in Japan.[157] Put differently, research-intensive exports account for 20 percent of Germany's GDP, compared to 3 percent of U.S. GDP. This means that, as a share of GDP, Germany's export of research-intensive products is almost seven times greater than the United States', a substantial difference, even accounting for the greater degree of cross-border trade in Europe. (U.S. weakness in exports is also reflected in the fact that the global average export intensity—the ratio of a nation's exports to its total manufacturing sales—is twice as high as that of the United States', which ranked thirteenth out of the fifteen largest manufacturing countries in 2009 in export intensity.)[158]

Moreover, Germany's and Japan's experience belies the received wisdom that manufacturing as a share of GDP is falling in most advanced economies over time. In fact, as Figure 7 shows, manufacturing's share of German and Japanese GDP has actually held stable between 1970 and 2008, even as the United States' share experienced a steep decline.[159] Clearly, Germany and Japan's SME manufacturing support programs have played an important role in sustaining the strength and vitality of their nations' manufacturing sectors over the past forty years. So too have the level of investments each country has placed in manufacturing support programs, as evidenced in Figure 3 where Japan and Germany had substantially greater investments per GDP than the U.K., U.S., or Canada.

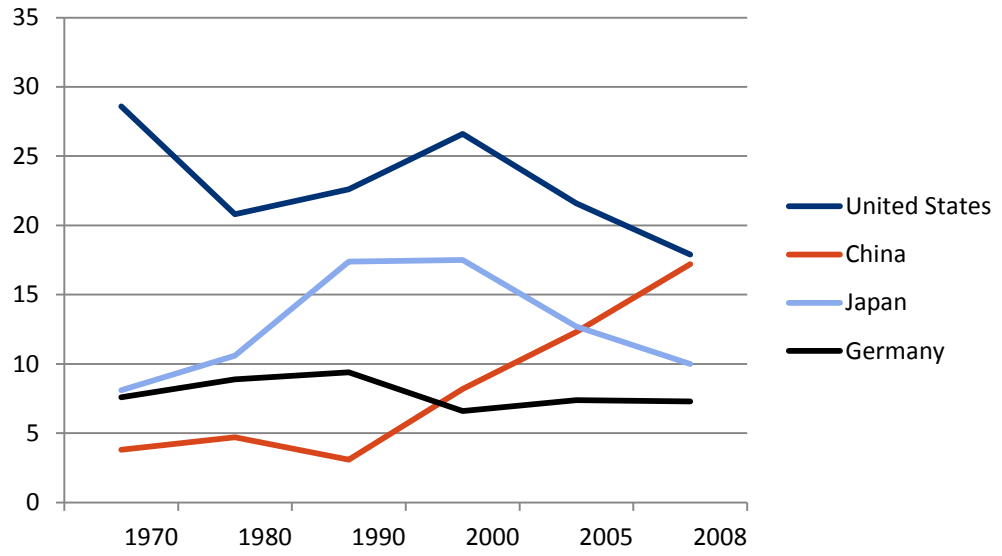

Figure 7: Select Country Share of World Manufacturing Output, 1970-2008[160]

What lessons, then, can the United States take from global best practices in SME manufacturing support programs—particularly those in Germany and Japan—but also those of other countries such as Australia, Canada, and the United Kingdom?

From Germany, the United States can learn from the country's sophisticated model of technology creation and diffusion. Germany specializes particularly in bringing new technologies to what might otherwise be written-off as low-technology manufacturing industries, such as textiles, steel, or electrical appliances, by infusing emerging technologies (e.g. advanced materials/composites, advanced machining, nanotechnology, microelectricalmechanical systems, etc.) into these once-legacy industries. This transforms these would-be "low- or medium-low technology" industries into the "medium-high technology" industries that many of Germany's Mittelstand companies do so well in. Critically, Germany's system focuses on technology development and diffusion horizontally, with regard to specific technologies, and vertically, within specific industries. Germany's Fraunhofer Institutes bring businesses and universities together to conduct industrially-relevant translational research in a specific advanced technology area (whether ICT, robotics, nanotech, sensors, surface materials, etc.), with the technological advancements made available to all German industries. This cross-sector approach is complemented by the Industrielle Gemeinschaftsforschung program, which brings consortia of companies from the same industry together to perform pre-competitive research relevant to specific industry problems. Thus, the great strength of Germany's approach is collaborative research between consortia of universities and firms (or firms and firms) designed to perform applied (e.g. translational) R&D of relevance to industry needs. Another strength is that Germany is now playing a direct role in co-funding the R&D, innovation, and new product development activities of its SMEs through instruments like grants and innovation vouchers.

Japan's Kohsetsushi Centers, operating over the past century, have become deeply embedded in the local ecosystems of Japan's SME manufacturers. The Kohsetsushi Centers are true public-private partnerships, partnering with Japan's SMEs in every sense, even to the point of conducting research and development alongside the SMEs, inviting SMEs to send staff members to work on research projects, and providing facilities and test beds for prototyping or trial industrial production. Like Germany's Fraunhofer Institutes, the Kohsetsushi Centers are focused on industrially relevant research (and problems), yet also because they are so localized, they can be highly responsive to the specific needs of local SME manufacturers, while also providing a robust range of support services, from technology guidance and technical assistance to testing, analysis, and instrumentation. Like Germany, Japan's Kohsetsushi Centers are also well-positioned to facilitate SMEs' adoption of a range of emerging technologies, from sensors and embedded intelligence to robotics and automation, and apply those technologies both in their manufacturing processes and in the products they manufacture. And to support this wide and deep set of services, Japan funds its SME manufacturing support programs more robustly than any other country in the world.

Global best practice has moved from helping SMEs with process and productivity improvements to supporting their R&D, innovation, and growth efforts.

In summary, the leading countries feature an integrated, multifaceted approach toward supporting their SME manufacturers and fund them robustly. Their focus is not only "on the shop floor" supporting SMEs' manufacturing, quality, and process capabilities, but is specifically targeted also toward supporting SME manufacturers' efforts to innovate and commercialize new technologies. They help SMEs move from "exploiting known certainties" to "exploring unknown possibilities." In other words, they are concerned not only with fostering "technology uptake and use" by SME manufacturers—although to be sure this remains vitally important—but they are *also* concerned with facilitating innovation and growth through new products and processes including but not limited to technology transfer from universities or national laboratories into SMEs so they can transform them into commercially viable products. The focus is on helping the SMEs themselves develop their own indigenous and repeatable capabilities at developing innovative new products. Further, global best practice not only teaches SMEs innovation skills, but also provides funding for SMEs' R&D efforts, which are so often the predicate to the development of new technologies and their commercialization through innovative products. Put simply, global best practice has moved from helping SMEs with process and productivity improvements to supporting their R&D, innovation, and growth efforts.

At the same time, leading programs are responsive to the range of challenges SME manufacturers confront. Thus, the best manufacturing extension programs are developing new offerings to help SMEs understand: energy efficient manufacturing principles, the role of design principles in designing both attractive products and efficient processes, and how their products need to be designed in conformity with evolving global technical standards. They are also helping SME manufacturers export to new markets, in part by helping them to identify opportunities for export, or opportunities to identify unmet customer needs in foreign markets and to respond to them with innovative product offerings. Where manufacturing extension services are not themselves equipped to address certain SME manufacturer needs, they are positioning themselves as a conduit or broker to the wider range of assistance services SMEs may receive from governments. In other words, the best

manufacturing extension services are becoming the central hub, or delivery system, for SME support services in a country.

In order to support this broader range of services—and to be able to directly help finance SMEs' R&D and innovation activities—the leading countries are providing significantly more funding, relative to the size of their economies, to their SME manufacturing support programs than the United States. Such robust funding is enabling SME manufacturing support programs—particularly in Canada, Germany, and Japan—to have a substantial impact on the innovative capabilities of their SME manufacturers.

Yet, perhaps the most important lesson the United States can learn from this benchmarking study is that countries' manufacturing support services play a vital and indispensible role in ensuring the vitality of a nations' manufacturing base and the health of its industrial ecosystems. If the United States wants to renew its manufacturing base, it must continue to provide support in an integrated fashion that focuses on technology adoption, new product development, and the innovation activities of U.S. SMEs. The Manufacturing Extension Partnership can continue to play a vital role in this area.

CONCLUSION

An increasing number of countries recognize that supporting the competitiveness, productivity, and innovation capabilities of their SME manufacturers is crucial not just so those firms can compete effectively on international markets but also so that healthy manufacturing ecosystems can thrive in their economies. In recognition of this, many countries operate manufacturing extension services that play effective and vital roles in enhancing the productivity, efficiency, and competitiveness of their SME manufacturers. These manufacturing extension services produce significant and positive economic impact for their countries, in terms of employment, export, and economic growth. Amongst these manufacturing extension services, there is an emerging tier of "next-practices" focused on more explicit support for the R&D and innovation efforts of manufacturing SMEs, especially financial support and strategies to engage them in collaborative research consortia and partnerships with other firms, universities, and national laboratories. The evolution of the United States' Manufacturing Extension Partnership's SME support offerings towards technology acceleration, innovation, and growth-supporting activities is in line with international trends. Yet the United States has an opportunity to continue to learn from its peers. If U.S. SME manufacturers are to continue to enjoy the full and substantial benefit of manufacturing support services, the United States must recognize the indispensible role played by public-private partnerships and that there are many entities and programs that must be leveraged and aligned to support this mission. The Manufacturing Extension Partnership can play a critical role in this moving forward, building on existing efforts to partner with federal agencies, national organizations, state and local governments, manufacturers and trade associations, and leading universities and research institutions such as federal laboratories.

ENDNOTES

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