WORLD ECONOMIC FORUM

COMMITTED TO IMPROVING THE STATE OF THE WORLD

Manufacturing for Growth
Strategies for Driving Growth and Employment

Volume 2: Partnering for Competitiveness
A World Economic Forum Report
in collaboration with Deloitte Touche Tohmatsu Limited

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Introduction

The Future of Manufacturing report (April 2012) identified a number of factors that will shape the future of competition between countries and companies. Three areas rose to the top as the most critical: human capital and talent development; innovation and technology advancement; and strategic use of public policy emphasizing collaboration between policy-makers and business leaders. This series of Manufacturing for Growth reports addresses these key competitive factors and defines ways to drive economic growth and high-value job creation through manufacturing industry sectors.

The Manufacturing for Growth series comprises three volumes:

- **Volume 1: Globally Competitive Policy** seeks to define the features of effective, comprehensive national industrial policy. This volume focuses on six countries chosen to represent both historic manufacturing giants and new and emerging manufacturing powerhouses. This cross-section was selected as representative of developed and emerging economy nations to showcase the unique aspects of each and, more often than not, the similarities in what manufacturing executives recommend to policy-makers.

  Volume 1 was informed by discussions with over 70 chief executives of multinational manufacturing companies, which resulted in:

  - Policy recommendations common across all interviews conducted in support of this project
  - Specific country policy recommendations for:
    - Emerging economies – China, Brazil and India
    - Developed economies – Germany, Japan and the United States
  - An outline of various policy instruments that are available to policy-makers and significantly influence competitiveness
  - An analysis of some critical policy areas most frequently cited by chief executives around the world as having a direct impact on their companies' ability to compete

  In addition, an appendix comparing tax, energy and environmental policy instruments for the six focus countries discussed in Volume 1 is available for download at www.deloitte.com/us/policyframework.
- **Volume 2: Partnering for Competitiveness** examines case studies of public-private collaboration from around the world that enable innovation and technology advancement and promote talent development.
- **Volume 3: Manufacturing Value Chains Driving Growth** illustrates the value and jobs created by specific industry sectors – aerospace, automotive and chemicals – from a global macro-view as well as a micro-view of the impact that a single product value chain or single production facility can have on a location.

To access the entire series electronically, visit http://wef.ch/mfgla13.

Project Methodology

During the World Economic Forum Annual Meeting 2012, the Forum-Deloitte LLP project team presented key findings from *The Future of Manufacturing* report, the culmination of a one-year project that explores why manufacturing is a key driver of economic growth, how the global manufacturing ecosystem has changed and continues to change, and what the key factors for both companies and countries will be to compete in the future.

In a largely unified response, project stakeholders – senior manufacturing executives, policy-makers and civil society leaders – directed the Forum-Deloitte team to continue the project by defining specific, effective, near-term ways to react to these future competitive factors. The resulting project, Manufacturing for Growth, defines key strategies for driving growth and high-value job creation through manufacturing industry sectors, and provides best practice examples for reacting to universal challenges in the area of talent development and innovation.

The Manufacturing for Growth project brings together extensive primary and secondary research from industry, academic and policy leaders. The extended global project team conducted face-to-face interviews around the world with over 70 chief executives of multinational manufacturing companies. Insights from these interviews were supplemented with input collected during workshops hosting senior manufacturing leaders, including members of the Project Consultative Group, in the following locations:

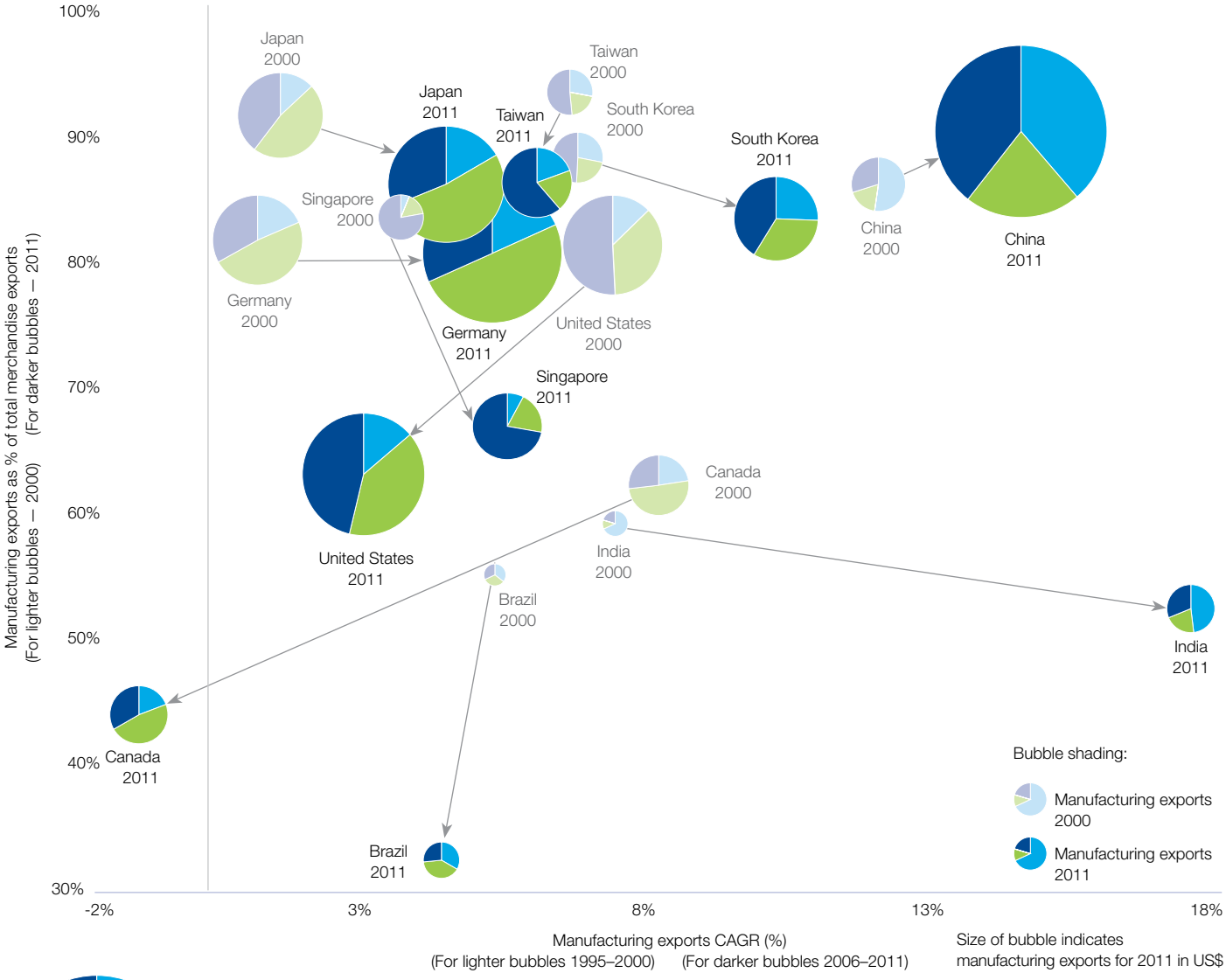
- World Economic Forum private session in Tokyo, Japan: 24 April 2012
- Manufacturing & Society in the 21st Century, in collaboration with the Aspen Institute, Aspen, USA: 17 August 2012
- World Economic Forum private session in Berlin, Germany: 17 October 2012
- World Economic Forum private session in New Delhi, India: 6 November 2012
- Talent-Driven Innovation Symposium, in collaboration with the Manufacturing Institute and Alcoa Foundation, Washington DC, USA: 28 November 2012
- World Economic Forum private session in Davos, Switzerland: 24 January 2013

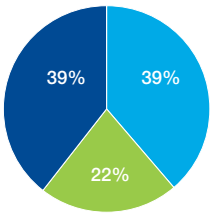
The project team also gleaned findings from the Forum's official sessions on manufacturing during the Annual Meeting of the New Champions in Tianjin, People's Republic of China, in September 2012 and the World Economic Forum on India in Gurgaon, India, in November 2012.

Additionally, this effort benefited from the invaluable time and content developed with a number of experts in the areas of policy, value chain analysis, human capital and specific manufacturing sectors: Deloitte Tax LLP; Deloitte Consulting's Energy Practice; the National Association of Manufacturers; Duke's Center on Globalization, Governance & Competitiveness; The Dow Chemical Company; and Nissan.

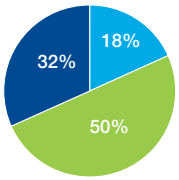
Comparative Economic and Related Data

2011 manufacturing export competitiveness by size, skill and technology

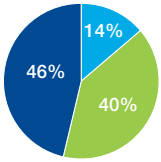




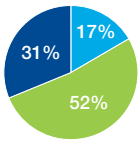
China
$1,768.5 billion (2011)
$219.3 billion (2000)



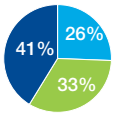
Germany
$1,226.3 billion (2011)
$459.2 billion (2000)



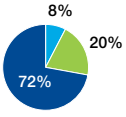
United States
$952 billion (2011)
$644.6 billion (2000)



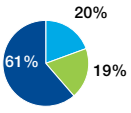
Japan
$724.8 billion (2011)
$449.4 billion (2000)



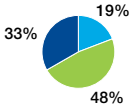
South Korea
$473.5 billion (2011)
$154.9 billion (2000)



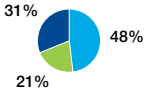
Singapore
$279 billion (2011)
$117.5 billion (2000)



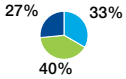
Taiwan
$270.7 billion (2011)
$141.0 billion (2000)



Canada
$202.3 billion (2011)
$175.4 billion (2000)



India
$151.7 billion (2011)
$26.0 billion (2000)



Brazil
$84.2 billion (2011)
$31.6 billion (2000)

Percentages in these bubbles are for 2011

Source: Deloitte Touche Tohmatsu Limited analysis [iv]

Key:

- Exports of manufactured goods with high skill and technology intensity
- Exports of manufactured goods with medium skill and technology intensity
- Exports of manufactured goods with low skill and technology intensity; and labour-intensive and resource-based manufactured goods

Note: The classification of goods into different degrees is based on Standard International Trade Classification (SITC) codes, UNCTAD [v]

Source: Deloitte Touche Tohmatsu Limited and US Council on Competitiveness, 2013 Global Manufacturing Competitiveness Index

Volume 1
Partnering for Competitiveness

Executives in developed and emerging economy nations alike are currently facing tremendous challenges when it comes to the manufacturing workforce. Almost universally, the executives interviewed expressed concern about identifying, attracting, training and retaining the most qualified talent. They described challenges with locating the next team of skilled engineers, top-tier supervisors, technologically savvy production workers and outstanding innovators. They also emphasized the need for greater collaboration between the public and private sectors and between universities, national labs and other non-profits to create environments that breed talent and innovation.

Link between Innovation, Talent and Competitiveness

This concern for finding and developing the next generation of high-performing talent is critical, as chief executives consistently viewed talent-driven innovation as the key catalyst for competitiveness and prosperity. Indeed, there is an intrinsic link between talent and innovation, and the success of any manufacturing economy depends ultimately on the quality of its innovation and innovators. Companies and nations have been found to flourish most when manufacturing innovation ecosystems are developed and fostered, a closed-loop product development life cycle exists, and research centres and manufacturing operations are co-located – creating an intimate connection where continuous product and process innovations thrive. These ecosystems foster an innovation pipeline in which breakthrough discoveries are developed and matured from basic to applied research, transitioned to pilot phases, and then fully ramped up to commercial applications. The key foundational element throughout the entire innovation ecosystems and pipelines is high-performing talent at all steps of the process.

The quality of this top talent starts with how their inherent human capital is nurtured throughout the lifespan of their education and careers: from fundamental primary and secondary development to post-secondary and professional skills enhancement. Certainly, basic training – with an emphasis on science, technology, engineering and mathematics (STEM) education, professional development in training and processes, etc. – is important for the future of manufacturing. However, as innovation is the by-product of imagination, all levels of training should also inspire imagination and new, integrated ways of critical thinking, problem-solving, entrepreneurial drive and leadership skills.

Policy-Maker Role in Talent-Driven Innovation

Countries traditionally have three major avenues to develop their skilled workforces: improve education at all levels, support retraining and skills advancement within the existing workforce, and attract and retain high-quality talent from across the world.

Improving education at all levels

To establish a foundation to build the necessary skills for the future, national education systems require a policy environment that focuses on STEM disciplines in particular. Countries have developed specific programmes to promote STEM education and have designated significant government funding to promote training in this area.

Moreover, some executives indicated that countries successful in making skills aspirational and glorifying careers in research, engineering and other areas of science, technology and mathematics will be better equipped to recruit top talent. Governments that employ focused, creative and impactful marketing targeted to youth, parents and schools of today and tomorrow will help to ensure their talent pool views manufacturing as an attractive industry and viable career path.[1]

However, while STEM education is important, it is not sufficient. Executives also consistently said that multidisciplinary thinkers with excellent problem-solving, communication, creativity and critical thinking skills are equally valuable for improving competitiveness. Furthermore, the increasingly globalized market requires an internationally minded workforce, and many executives said an understanding of and exposure to foreign markets is important to becoming a more effective manufacturing workforce of the future.

Supporting retraining

Executives also said that retraining the existing workforce is another pathway to developing talent-driven innovation. Some executives noted specifically that retraining and advancing skills often enable employees to face new challenges in the rapidly changing manufacturing environment, which also results in other benefits such as worker productivity and morale.

Furthermore, high unemployment is a consistent problem plaguing many countries despite companies looking to fill vacancies of highly skilled roles. To mitigate this situation, some governments are concentrating on supporting recruitment and providing sufficient training to fill these gaps. The Workforce Investment Fund, supported by the Department of Labor in the US, is a good example.[2] Another case in point is China, which has taken strong steps in recruitment development with the Employment Promotion Law that has been enforced since 2008.[3]

Emerging economy nations are particularly focused on skills advancement through the expansion of vocational and industrial training. For example, India has taken steps towards promoting skills development by increasing funds for its National Skill Development Fund (NSDF), launching the credit guarantee fund and exempting vocational training institutes from paying service tax in India.[4] China has embarked on the National Medium and Long Term Talent Development Plan for 2010-2020, which emphasizes vocational training and employment promotion.[5] In 2011, the Brazilian government launched the National Program for Access to Technical Education and Employment (Pronatec), which will create 8 million new vocational training opportunities by 2014.[6]

Attracting and retaining high-quality talent from around the world

The third area of improvement is to attract high-quality talent from around the globe. Countries are realizing that in order to stay competitive in manufacturing, they have to attract both domestic and foreign talent. China, through its "1,000 Top Talent Program", plans to recruit 1,000 top professionals from across the world to hold senior positions primarily in government, business, science and education.[7] Brazil is making changes to its immigration policy to attract qualified young professionals while restricting the inflow of unskilled workers.[8]

Among the developed countries, Japan is implementing a policy to accept overseas professionals through a point-based system, while Germany passed the Assessment and Recognition of Foreign Professional Qualifications Act as recently as April 2012, which will help to attract skilled immigrants. In contrast, some countries, like the US, appear to have relatively limited immigration policies that promote attracting top foreign talent. For the United States in particular, the absence of such policies may have an unintended consequence of curbing retention of top-performing students who are educated in the US and then subsequently sent back to their native countries.[9]

The Shared Responsibility of Talent-Driven Innovation

To improve their manufacturing competitiveness, governments of many nations are partnering with industry and academia in efforts to attract and retain top talent. Working with the Project Consultative Group and panellists at the symposium on Talent-Driven Innovation (November 2012), the Manufacturing for Growth project team identified dozens of organizations demonstrating best practices in the area of talent and human capital development or in science, technology and innovation. These public-private partnership organizations represent a broad range of geographies, sectors and missions, but all have impacted the competitiveness of manufacturing companies and countries.

Defining Best Practices in Public-Private Collaboration

The term public-private partnership (PPP) typically refers to a contractual relationship between the public and the private sector for the delivery of a specific product or service, such as the construction of a highway, bridge or hospital. For the purposes of this report, the PPP concept is broadened to include organizations that perform a service for the public good. These organizations are "partnerships" in that both public authorities and the private sector are stakeholders. While in most cases both public and private stakeholders provide some level of funding, the extent of financial contribution is not necessarily equal. In some cases, a stakeholder offers intellectual or physical capital in lieu of financial contribution. Some PPP organizations focus on applied or basic research while others emphasize training. Some focus on a single technology or service while others pursue a more diversified portfolio.

Some PPP institutions – such as Canada's National Research Council (NRC) and Singapore's A*STAR – have strong structural links with their respective governments. Others – such as the Irish Centre for Manufacturing Research – are more organizationally aligned with industry. The Fraunhofer Institute, Germany's leading PPP organization, focuses on applied and basic research, while India's National Skills Development Corporation (NSDC) provides manufacturing skills training. The collection of PPP organization case studies reflects a broad swath of geography, organizational mission, focus and structure. Each organization is marked by a unique combination of distinguishing characteristics across several key dimensions:

- Sector focus
- Funding source
- Tenure
- Focus of mission
- Geographic reach

Sector Focus

In the search for best practices, the project team found highly successful PPP organizations that were dedicated to a single sector and others that diffuse their efforts across sectors. For example, Sweden's Automotive Research and Innovation (FFI) and the EU's European Green Car Initiative both focus on vehicle-related research. In contrast, the NRC and the Fraunhofer Institute assume a broad-based, multi-sector approach.

To some degree, the extent to which a PPP institution focuses on one sector is a function of the organization's funding sources: FFI is formed by a partnership between the Swedish government and the automotive industry. On the other hand, the largely public funding of the NRC drives a wider array of stakeholder interests and a more diverse set of activities. It is important to note that a PPP organization's close alignment with a particular sector does not necessarily say anything about its focus on a particular technology. FFI is dedicated exclusively to the automotive sector, but its research programme is technologically broad, including automotive fuel, safety systems, vehicle electronics and software, among other areas.

Source of Operating Budget

Another leading characteristic of the collection of PPP cases that was reviewed is source of operating budget. The funding for these organizations ranges from no overt governmental financial support to essentially full public funding. Some of the PPP organizations – such as the NRC, A*STAR and Enterprise Ireland – are themselves extensions of government and thus receive nearly all of their operational funding from public sources. Others – such as South Korea's Research Institute of Science and Technology – are private organizations with no apparent public operational funding. A third group relies on partial public operational funding. Fraunhofer relies on government sources for 30% of its operating budget. FFI and the NSDC reflect a nearly 50-50 public/private funding arrangement.

Certainly, the relative share of operational funding burden helps to inform the priorities of the partnership. PPP organizations that are entirely or even mostly self-financed by private sector member organizations have the greatest latitude in shaping their research and service agendas. Still, even organizations that rely overwhelmingly on public funding – often by legislative budgetary authority – involve and rely on industry to varying extents for licensing fees, consulting engagements, technology transfer, etc.

For example, the NRC – an agency of the Canadian government – is operationally funded by the budgetary authority that the Canadian Parliament provides. In 2011-2012, approximately C$ 700 million total authority was used. However, the institution also derived about C$ 60 million from research services on behalf of industry and academic clients in 2011-2012. As part of its organizational strategy, the NRC states that it is "looking to further increase external revenue in future years".

A more fundamental rationale explains the public-private integration for the research agendas of even mostly publicly funded institutions. The prime mission of those PPP institutions that are largely publicly funded – especially those that practice applied research – is to promote technologies and services that have widespread commercial viability. Government, alone, cannot know what the marketplace demands nearly as well as private sector players. For this reason, a close relationship is warranted even in the absence of substantial financial support from the private sector. In addition, the private sector is home to a deep reservoir of technical expertise that may not always be available elsewhere in the public sector.

Tenure

The project team looked at both nascent and well-established PPP organizations to collect best practices. Organizations such as Fraunhofer, NRC, and Embrapa are decades old. Others – such as FFI and the NSDC – are just a few years old. To some extent, an entity's longevity is a tribute to its success – particularly if the entity derives most of its operational budget from private sources. It is no surprise that more established PPP organizations tend to be more evolved than younger ones, with greater project differentiation. On the other hand, because newer PPP institutions – such as FFI and the NSDC – are often formed in response to current need, they may make up for in "industry relevance" what they lack in track record.

Focus of Mission

In general, most PPP organizations can be grouped into two categories: those that engage primarily in applied and/or basic research and those that engage mostly in talent and skills development. Leading examples of applied/basic research institutions include Fraunhofer, NRC and A*STAR. To a large extent these organizations are focused on applied/basic research to develop technologies and products that have commercial viability. Institutions such as the NSDC, the Manufacturing Skills Certification programme, Project Lead the Way, and WorldSkills International are examples of skills, training and education-based organizations.

Many institutions participate in both spaces, which is not surprising given the role of a talented workforce in driving innovation. For example, Fraunhofer operates the Fraunhofer Academy, a learning environment that offers its students – mostly from industry – a grounding in the latest findings from Fraunhofer's applied research organized by subject area.

Geographic Reach

Some PPP institutions are decidedly local in their reach. Others are truly global. To a meaningful extent, the geographic reach of a PPP institution is informed by the very nature of its mission. PPP institutions that engage in applied research, for example, aim to introduce products into the streams of commerce that transcend national borders. Fraunhofer is one such institution. On the other hand, PPP institutions that engage in skills training typically focus on a single nation. For example, in articulating its mission, the NSDC refers to the growing need in India for skilled manpower across sectors and the existing gap between the demand and supply of skills.

Common Best Practices across Public-Private Partnership Organizations

The leading public-private partnership organizations highlighted in this section, regardless of their location or focus, demonstrate a common set of best practices in developing talent that drives innovation.

- **Demand-driven and highly responsive to specific needs of industry and society:** The most effective public-private partnership organizations are demand-driven and have a mission focused on specific market needs, both from an industry or sector perspective and a societal point of view. These organizations address relevant and timely current issues while anticipating future demands and trends. While their work is practical and impactful to society in the present – whether that means supporting a particular type of training or advancing R&D critical to the competitiveness of a company, an industry sector or a country – they bring a forward-looking, visionary perspective to their work at the same time. Finally, they are able to continually evolve to meet changing demands while retaining their core mission.
- **Offers a differentiated value proposition that transcends traditional business barriers:** Each organization identified has a distinct and differentiated value proposition essential to its market success. Further, the organizations excel at creating bridges between groups that otherwise would operate in different spheres, extracting latent value from the combination of the collaborating networks. More than linking government and industry, these organizations establish connections between other disparate groups or fill a gap between where government and industry typically operate. For example, some leading public-private partnership organizations span multiple sectors or disciplines, allowing shared exchange of best practices and innovations. Others bring together large businesses and start-ups, or research groups in developed economy nations with those in emerging market nations to bridge the cultural and geographical divide.
- **Long-term horizon and flexible in measuring success:** Like well-managed businesses, leading public-private partnership organizations establish metrics for success and track themselves to those metrics. What differs are the type of metrics and the time horizon for success. A public-private partnership organization is not measured in quarterly earnings and may even use metrics other than monetary value. For example, skills development entities often define success by the number of people trained or certified and, in some cases, jobs secured. Additionally, leading research groups take a portfolio approach with the understanding of the risk involved in R&D investments. “Patient capital”, or long-term capital is a key foundation for success with a number of leading public-private partnerships – they do not expect overnight returns. In some cases, the return on the investment may not accrue directly to the public-private partnership organization; it might be a societal return or a spin-off based on a new technology that becomes a successful new business.
- **Seek revenue streams beyond government or public funding:** Leading organizations derive a much more significant portion of their revenue and funding from private sources than from public sources. In virtually all cases, they have multiple funding sources. There are a number of reasons why utilizing funding from multiple sources is a best practice. Government funding may vary based on annual budgets and may not necessarily reflect value-add or market demand. Sustained private sector funding requires public-private partnership organizations to be successful in a highly competitive ecosystem, and continually drive innovation, efficiency and return on investment.
- **Core structural integrity:** Leading public-private partnership organizations display unapproachable integrity when it comes to intellectual property protection and creating trust and credibility. Leading organizations establish a track record of trust and respect with a country, with industry and with customers. Researchers, scientists and engineers trust that their projects and work products will be respected and treated properly. Similarly, with skills-based institutions, the graduates or recipients of certifications trust that there is credibility in the industry for their certification. Leading organizations develop reputations and brands synonymous with: trustworthy, on time, on budget, innovative, productive, reliable, resourceful and quality.
-

Leading Examples of Public-Private Partnerships around the World

Scientists at work at A*STAR's SBIC, Singapore Bioimaging Consortium. This research institute consolidates bioimaging capabilities across local research institutes, hospitals and universities, accelerating the development of biomedical research discoveries.

Source: Agency for Science, Technology and Research

Agency for Science, Technology and Research
Singapore

INSEAD's Global Innovation Index 2012 ranks Singapore as the third most innovative country in the world. The Agency for Science, Technology and Research (A*STAR) is part of what makes Singapore a global leader in scientific research and talent development and an attractive location for investment. A government agency under the Ministry of Trade and Industry, A*STAR oversees 20 biomedical sciences, physical sciences, and engineering research institutes, consortia and centres. Additionally, A*STAR supports extramural research with a number of local and international partners and works with a diverse set of industries, from biomedical sciences to aerospace, cleantech, media and telecommunications. A*STAR has an impressive list of partnership companies, including Bombardier, Hitachi Asia Ltd, Alcatel-Lucent, and Siemens Medical Solutions.[10]

Representative Best Practices

- **Managed through operations groups that drive accountability and allow for diversification of activities:** These groups oversee distinct research or talent segments, allowing for specialization and expertise. A*STAR is broken into five operations groups:
  1. Biomedical Research Council (BMRC) – Manages public sector biomedical R&D activities and oversees over a dozen specialized research entities[11]
  2. Science and Engineering Research Council (SERC) – Coordinates public sector R&D in the physical sciences and engineering including chemicals, computational sciences, microelectronics, process manufacturing and metrology, among others[12]
  3. A*STAR Joint Council (A*JC) – Promotes research between the BMRC and SERC to capitalize on the advantages of interdisciplinary, collaborative innovation
  4. A*STAR Graduate Academy (A*GA) – Targets human capital development
  5. Exploit Technologies Pte Ltd (ETPL) – Focuses on commercialization to provide a smooth transition from research to commercialization through the formation of key relationships between industry and academia, creation of public-private partnerships, and promotion
- **Strong research facilities and accessibility to high-performance computational resources:** A*STAR's centres are located in Fusionopolis and Biopolis, leading biomedical and engineering R&D hubs. These locations house state-of-the-art research facilities, including high-tech, capital-intensive equipment and capabilities, such as a visualization chamber allowing high-end 3-D visualization for product evaluation. Additionally, Fusionopolis houses the Computational Resource Center (A*CRC), which provides the entire A*STAR research community access to high-performance computational resources, such as advanced computers and sophisticated data storage.
- **Incentives for innovation:** The A*STAR Graduate Academy (A*GA) offers scholarships to students and scientific talent to prepare them for careers in R&D. A*STAR reports having supported and nurtured a pipeline of 1,000 local PhD talent since 2001.

Making an Impact

Since January 2002, A*STAR's technology transfer arm, Exploit Technologies Pte Ltd, has:

- 3,500 active patents[13]
- Licensed over 400 A*STAR technologies which have generated over US$ 500 million in revenue[14]
- Spun off over 40 start-ups in industries like ICT, biotech, manufacturing, shipping, etc.[15]

Recent Innovations

- Researchers at the A*STAR institute of High Performance and Computing led by Teck Leong Tan developed a computing method to aid in discovering techniques to alter the atomic structure of a nanoparticle to bolster the performance of catalysts. Due to this discovery, researchers do not have to waste time trying to discover new combinations of bimetallic materials because they can simply adjust the structure of the existing nanoparticles for enhanced results. This more efficient, cost-effective process could mean increased popularity of fuel cells in energy systems, as fuel cell costs are largely driven by the high cost of catalysts.[16]
- A*STAR scientists have linked the enzyme telomerase to chronic inflammation, which can lead to human cancers.[17] The discovery has a huge impact on the healthcare industry because developing drugs to target telomerase can potentially save the healthcare industry both time and money.
- A*STAR's Institute of Materials Research and Engineering (IMRE) and Cima NanoTech have signed an agreement to work on developing advancements for transparent conductive materials. If these enhancements are successful, it could lead to innovations for solar cells, touchscreen displays, flat panel TVS, etc.[18]

Brazilian Agricultural Research Corporation (Embrapa)
Brazil

Brazil has transformed from a food importer to one of the world's largest agricultural producers over the past several decades, catching up with developed countries that have historically dominated grain exports.[19] The Brazilian Agricultural Research Corporation (Embrapa) was a key reason for this extraordinary growth, literally changing the landscape of Brazil to increase the cultivation of the cerrado, Brazil's savannah.

Although it is connected to the Brazilian Ministry of Agriculture, Livestock and Supply, Embrapa was established in 1973 as a public company. Its mission is "to provide feasible solutions for the sustainable development of the agricultural sector through knowledge and technology".[20] The company comprises a broad network of research and service centres across the country, and is engaged in a huge variety of activity in agro-energy, agribusiness, food technology, biotechnology, nanotechnology, animal production and forestry. It is present in all states of Brazil, and employs over 9,000 people including over 2,000 researchers, three-fourths of whom have doctoral degrees.

The organization has created and recommended more than 9,000 technologies for Brazilian agriculture since its inception.[21] Innovations include new seeds, edible wrapping paper for foodstuffs, and biodegradable fabrics and bandages, among other highly sophisticated product and process improvements in the agricultural sector.[22]

According to Embrapa, which receives most of its funding from the federal government, every R$ 1 invested in Embrapa generates an average return of R$ 13.20 for the Brazilian society.[23]

Representative Best Practices

- **Managing both the knowledge produced and knowledge development process:** The Embrapa Management System (SEG) aligns the company's research, development and innovation activities with the organization's overall communication efforts and knowledge management. The SEG model incorporates learning that takes place during the research process itself into its overall strategic planning, communications and competitive intelligence work. Embrapa emphasizes knowledge management in its strategy and seeks to develop innovative approaches to internal and external technology transfer.[24]
- **Engaging in innovative international knowledge transfer:** Embrapa currently has 78 bilateral agreements with 56 countries and 89 institutions, consisting of research partnerships as well as technology transfers.[25] The organization conducts technology transfers with markets in Africa (including Ghana, Senegal, Mozambique and Mali) and the Americas (such as Venezuela, Ecuador, Colombia and Panama). For example, in 2012 Embrapa established a partnership with the Forum for Agricultural Research in Africa (FARA) to share technologies that support cotton production.[26]

Additionally, Embrapa has developed cooperative arrangements in the US, Europe and Asia with a programme known as Labex, "virtual laboratories abroad without walls".[27] Through Labex, senior scientists are posted to an international team and spend two-thirds of their time on a project of joint interest, fostering collaborative innovation.

Example Innovations

- The Embrapa Swine and Poultry team has been working on mapping the chicken genome to identify which molecular markers and genomic regions allow for optimal poultry traits and also discover new genes in chickens that are important for meat production and quality.[28]
- Since 1991, Embrapa has been monitoring burning sites in Brazil through orbital systems and remote sensing. Burning impacts ecological and agricultural systems in Brazil, which in turn affects local and regional economies[29]
- Other ongoing initiatives include:[30]
  - Alternative agro energy
  - Forests for energy production
  - Functional foods – adding value to health-promoting foods
  - Science and technology for organic agriculture

Commonwealth Scientific and Industrial Research Organization Future Manufacturing Flagship
Australia

Manufacturing represents a vitally important component in Australia's larger economic picture. It accounts for nearly 10% of Australia's GDP and almost one-third of the country's exports. The Commonwealth Scientific and Industrial Research Organization Future Manufacturing Flagship (CSIRO-FMF) addresses the issues that help to keep Australia at the forefront of leading manufacturing economies.

One of the country's 11 state-funded national research flagships, CSIRO-FMF's research agenda is broad and focuses on the following areas:

- Manufacturing technologies for transport and mining
- Sustainable high-performance materials
- Agile manufacturing technologies
- Flexible electronics
- Titanium technologies

CSIRO-FMF pursues this research agenda in partnerships with organizations of varying size – in any given year, the organization partners with some 150 private sector entities.

What Makes CSIRO-FMF a Best Practice?

CSIRO-FMF's success stems from a number of differentiating factors:

- **Flexibility in partners:** Unlike some organizations, CSIRO-FMF does not use a "one size fits all" approach in the kinds of business with which it partners. Rather, CSIRO-FMF adopts a flexible approach in that it partners with companies of all sizes – from modestly sized enterprises to large multinational companies – cutting across a wide swath of industries from aerospace to healthcare.
- **Flexibility in partnership models:** CSIRO-FMF also exhibits flexibility in that it will pursue whatever partnership model is most appropriate under the circumstances – from direct company engagement to supporting governmental initiatives.
- **Flexibility in research objectives:** CSIRO-FMF pursues small and large-scale research projects. It will perform research that expects to improve a technology or manufacturing process only marginally. It also pursues research that aims to create new markets. In this sense, CSIRO-FMF shows flexibility in what it considers worthwhile research programmes.

Forward Looking Research at CSIRO-FMF [31]

- A new kind of bonding and coating material that is used on over 800 Boeing Aircraft – this development improves the durability of the aircraft's coating.
- A lithium metal battery used by soldiers in the battlefield – it is considerably lighter than other lithium metal batteries, making the technology especially useful in extended soldier expeditions. It also has potential applications for rescue and recovery and emergency medical personnel.
- A process that makes biodegradable shipping pallets – This will have positive environmental impact as it will reduce landfill waste.

Fraunhofer-Gesellschaft
Germany

Europe's largest application-oriented research university, the Fraunhofer Institute partners with the government and the private sector across a range of industries including health, energy, transportation, information technology and security. The Fraunhofer describes its work as a "dynamic balance between applied basic research and innovative development projects".[32] It has over 6,000 active rights and patent applications, representing work generated by over 80 research centres, including 60 located in Germany.

Representative Best Practices

- **Breadth and depth of the Fraunhofer expertise and relationships:** Each of the 80 Fraunhofer centres operates with a high level of independence, establishing its own research strategy and priorities. At the same time, the centres are highly connected to each other and to businesses and universities with related expertise. This model allows a high degree of specialization as well as access to a broad array of talent.[33]
- **Mixed funding model includes patient funding:** The Fraunhofer has a total annual budget of approximately € 1.8 billion and is funded by both the public and the private sector: 30% is contributed by the German federal and Länder governments to fund basic research and about 70% comes from contracts with industry and the public sector. The approximately € 1.5 billion generated through contract research ensures that the Fraunhofer operates like a business, while the € 300 million basic funding provides an ongoing source of income for longer-term innovative development projects.[34]
- **Source of innovative expertise for small, medium-sized and large companies:** The institutes directly employ over 20,000 individuals, most of whom are scientists and engineers. Expertise-for-hire is particularly important for small and medium-sized companies with limited in-house R&D capabilities.
- **Alignment with national industrial policy in Germany:** A key part of Germany's high-tech strategy is to promote cluster initiatives. Fraunhofer has implemented innovation clusters, leveraging skills and resources from both research and business in a given region. For example, over the past 15 years, the Saar region has developed into one of the largest sites in the automotive supplier sector. The Fraunhofer Automotive Quality Saar AQS, located in the area, comprises R&D, industry and professional associations. There is a shared facility where non-destructive testing technologies are made available, developed and enhanced.

The MP3 is perhaps the best known public innovation developed by one of the Fraunhofer institutes – the Fraunhofer Institute for Digital Media Technology.[35] In 2012, the global market for home and portable audio equipment is expected to reach US$ 28 billion in revenue, driven largely by the popularity of MP3 players.[36]

Recent Innovations

- The Fraunhofer Institute for Solar Energy Systems ISE in Freiburg and Soitec solar GmbH developed a way to convert almost twice the incident sunlight into electricity as compared to conventional silicon-based systems. Additionally, Fraunhofer ISE and Soitec advanced the commercialization so that the concentrator photovoltaic module is in serial production and today is a global market leader. The Soitec Company's solar power plants – which have a total capacity in excess of 10 megawatts – are already operating in 14 countries.[37]

Heribert Schmidt, winner of the Fraunhofer Prize 2011, invented a new circuitry for the inverter. With the HERIC® technology, it was possible to achieve a world record for inverter efficiency of >99% at Fraunhofer ISE.

Source: Fraunhofer Institute for Solar Energy Systems ISE. © Dirk Mahler.

TPedge module passes a mechanical load test.

Source: Fraunhofer Institute for Solar Energy Systems ISE©

- The Institute for Interfacial Engineering and Biotechnology IGB in Stuttgart has developed a chemical-free, eco-friendly process that enables the recovered salts from sewage sludge, wastewater and liquid manure to be converted directly into organic food for crop plants (August 2012).
- Researchers at the Fraunhofer Center for Organics, Materials and Electronic Devices Dresden have created data glasses fitted with displays that can be controlled by movements of the human eye. The displays include an "augmented reality", layering the real world with additional visual information. Key applications include mechanics conducting complex repairs.[38]
- The Bystronic glass Group and the Fraunhofer ISE jointly developed a new process for photovoltaic module production – in other words, a more innovative, cost-effective way of making solar panels. The TPedge technology reduces the costs of module production by 30-40% and as a result can reduce the overall costs of a photovoltaic module – depending on the cost proportion of the solar cells – by an estimated 14%.[39] The time and cost savings are a consequence of a simplified modular structure and a completely innovative production technology.[40]

FFI – Strategic Vehicle Research and Innovation (Programme of VINNOVA)
Sweden

FFI is a partnership between the Swedish government and automotive industry to perform research on climate, environment and safety issues. Two-thirds of the project portfolio focuses on climate and environment while the remainder of the portfolio addresses safety issues. FFI's overarching mission is to reduce the environmental impact of transportation, minimize the number of traffic accidents, and preserve and strengthen Sweden's leadership position in the automotive sector.

Representative Best Practices

- **Investments in FFI flow through five collaborative programmes:**
  1. The primary objective of the Energy & Environment programme is to reduce greenhouse gas emissions from road vehicles and working machinery.
  2. The Vehicle and Traffic Safety programme assists in the creation of vehicles with specific requirements to reduce the number of accidents, through increased focus on research and innovation so Sweden can maintain its global leadership position in traffic safety.
  3. The Vehicle Development programme focuses on enhancing and furthering embedded vehicle software progress as well as building Sweden's proficiencies in vehicle design.
  4. The purpose of the Sustainable Production Technology programme is to develop eco-friendly manufacturing systems and establish the conditions for their implementation.
  5. The Transport Efficiency programme will create a functioning and well-established, overarching transport arena to improve and generate new forms of collaboration.[41]
- **Anyone can apply for funds:** Funding is an open environment for any company from any nation, provided the company has some kind of formal business involvement with an industrial contract party within FFI. Industrial contract parties include Volvo Group, FKG (Scandinavian Automotive Suppliers), Saab Automobile, Scania CV and Volvo Car Corporation. The projects that are eligible for funding must have some sort of affiliation with the Swedish automotive industry and allow Sweden to improve its global automotive presence.
- **FFI Board and independent experts examine and oversee projects:** The FFI board manages the project portfolio, ensuring a proper balance between short- and long-term engagements. The FFI board also oversees and encourages collaboration between the different parties in the Swedish road traffic system. In addition, independent experts are called upon to examine project applications on the basis of such criteria as "how the project might contribute to the programme's goals; quality of the project proposal; applicants' ability to implement it; and strategy for utilizing and disseminating results".[42]

Making an Impact

- 351 projects to date with 233 PhD researchers
- R&D activities worth approximately € 100 million per year, with half coming from governmental funding[43]
- Energy use per vehicle (based on a life cycle perspective) to be reduced by 20% by 2020[44]

Representative Project Overviews

- One project is the design of an electric car that is both safe and practical for the average daily commuter. FFI has already built a prototype based on the C30 model.[45]
- The DFEA2020 project takes a detailed view into the electrical systems of future cars. This initiative allows for manufacturers to make a seamless transition to the eco-friendly car of tomorrow by creating the environment necessary for rapid technological development. [46]
- Another project involves the development of a new dynamic model of the human body with human-like neck and shoulder kinematics based on active muscles, to be used in the design of:[47]
  - Pedestrian restraint systems
  - Pedestrian, sport and fall accident reconstructions

Innovation Network Corporation of Japan
Japan

In 2009, Japan's Ministry of Economy, Trade and Industry launched the Innovation Network Corporation of Japan (INCJ), a sovereign wealth fund specifically targeted to promote innovation in Japan. The INCJ offers financial backing and managerial and technological support to businesses with high-growth potential, innovation capacity, new technologies, and social benefits. To date, the government has given 142 billion yen, with 27 corporations contributing a total of 14 billion yen, to the partnership. Over its life (a period of 15 years), the INCJ is expected to have investment capability of approximately 2,000 billion yen.[48]

The INCJ is highlighted as a best practice in public-private collaboration based on conversations with manufacturing leaders during the World Economic Forum private session in Tokyo in April 2012. They believed that the INCJ holds tremendous promise as a way to develop Japanese ventures and facilitate R&D in the areas of environment, energy, electronics, bio-technology and infrastructure.

Representative Best Practices

- **A focus on open innovation:** The INCJ model emphasizes open innovation, "facilitating the flow of technology and expertise across the traditional boundaries of existing organizational structures".[49] In its attempt to promote innovation collaboration among Japanese enterprises, the INCJ serves as an active broker – "an honest catalyst" – for networking among technologists, functional and operational experts, and business builders.[50] As part of this core principle, the INCJ sponsors three key bodies:
  1. Innovation Design Laboratory – Leaders of medium-sized enterprises create deals and partnerships related to high-potential technological spin-offs.[51]
  2. KK Forum – Experts in intellectual property, finance and management meet to review the commercialization potential of underutilized intellectual property held by universities and businesses.[52]
  3. Roma no Ichiba nite – A monthly gathering of entrepreneurs and experienced mentors to discuss new business ideas with the goal of accelerating the growth of the most promising ones.[53]
- **An emphasis on fostering partnerships between competing enterprises:** The INCJ helps to identify promising opportunities for and facilitates the integration of smaller businesses (or business units) to become next-generation Japanese businesses. With INCJ financing and expertise, the resulting enterprises can pool expertise, capabilities and human capital to become global players. Notably, in August 2011, the INCJ effected the integration of the small- and medium-display businesses of Sony, Hitachi and Toshiba, forming Japan Display Inc. This new company is poised to take advantage of growing demand for high-resolution small and medium-sized displays used in smartphones and tablet computers.[54] More recently, the INCJ played a key role in fostering the integration of Nissan Motor's and Hitachi Construction Machinery's forklift businesses.[55] The INCJ's is in a unique position to help break down barriers between competing Japanese companies and improve overall national competitiveness, creating value for all entities involved.
- **A relationship that leverages financial, technological and managerial resources:** In addition to providing medium- and long-term patient risk capital, the INCJ also offers its investment targets' managerial expertise. INCJ employees have a broad range of backgrounds in areas such as manufacturing, banking, private equity, venture capital, research and government.

Furthermore, the INCJ's cooperation with other non-profit and government organizations, including the Kauffman Fellows Program, the National Institute of Advanced Industrial Science and Technology, and the Japan Science and Technology Agency, further augment the INCG's ability to promote next-generation businesses.

Industry Technology Research Institute[56]
Taiwan

Founded in 1973, the Industry Technology Research Institute (ITRI) is Taiwan's largest research and development organization. Focused on applied research and technical services, ITRI has played a crucial role in transforming Taiwan's economy from one based on labour-intensive industries to one centred on high-technology.

A non-profit, ITRI has a subsidiary company in Silicon Valley and branch offices in Tokyo, Berlin and Moscow. It receives approximately 50% of its funding from the government. The remainder is provided by the 30,000 private sector enterprises that issue ITRI consulting, training, research and service contracts and lease its technology. Led by a research-oriented workforce of roughly 5,800 – most of whom hold advanced degrees – ITRI's applied research has contributed to the development of WIMAX wireless broadband, solar cells, radio-frequency identification, light electric vehicles, flexible displays, 3-D integrated circuits, and telecare technologies. Through its Open Lab/Incubator programme, ITRI has incubated more than 174 start-ups and spin-offs, including Taiwan Semiconductor Manufacturing Company and United Microelectronics Corporation. In total, ITRI has invested close to US$ 2 billion in its Open Lab/Incubator programme.

ITRI holds more than 17,000 patents – nearly 1,600 granted in 2011 alone – a result of its advanced technology research and development in the following fields:

- Information and communication technologies
- Electronics and optoelectronics technologies
- Material, chemical and nanotechnology
- Medical device and biomedical technologies
- Mechanical and systems technologies

Representative Best Practices

The success of ITRI in applied research can be attributed to three principal factors:

1. **Innovation and human capital generator:** In addition to generating more than 17,000 patents, ITRI has developed more than 70 local chief executive officers and an alumni base of 160,000. ITRI alumni go on to become industrial pioneers and leaders of Taiwanese industry.
2. **Successfully mitigating patent issues:** ITRI's research and innovation helps to stimulate the local economy. ITRI closely collaborates with and assigns patents to local enterprises, extending their manufacturing capabilities and minimizing their risk of patent infringement and exposure to lawsuits from foreign plaintiffs.
3. **Strong partnerships around the globe:** ITRI's footprint is not limited to Taiwan. Rather, ITRI maintains a global presence with offices in Moscow, Berlin, Tokyo and Silicon Valley. Moreover, ITRI partners with 143 leading research universities, governmental organizations and corporations headquartered in 25 countries around the world. Teva Pharmaceuticals, Volkswagen AG, Rensselaer Polytechnic Institute, Carnegie Mellon University, SUMITOMO, General Electric, the European Bank of Reconstruction and Development and Microsoft, among many others, demonstrate the diversity of the many partners with which ITRI collaborates on cutting-edge research initiatives.

Representative Project Overviews

A central mission of ITRI is the development of new products, technologies and processes with an industrial impact. Recent examples include:

- Assembly process technology for steel mill power generation modules[57]
- Flameproof fiber technology used in textile manufacturing[58]
- Technology design to lower cost of LED manufacturing[59]

Phison Electronics: ITRI Plants the Seeds of Success

In 2000, Phison Electronics was little more than an idea. Today, it is a major player in the NAND flash memory chip sector, with more than US$ 1 billion in annual revenue and 530 employees. ITRI's relationship with Phison in 2000-2001 planted the seeds of success that Phison enjoys today. Specifically:

- ITRI worked with Phison to secure government loans in its early, financially struggling period.
- Phison used ITRI's Open Lab/Incubator to promote its early products, directly leading to a major order from Toshiba. ITRI also helped to persuade Toshiba to make a capital investment in Phison.
- ITRI worked with Phison in securing bank loans when the company's early efforts were unfruitful.

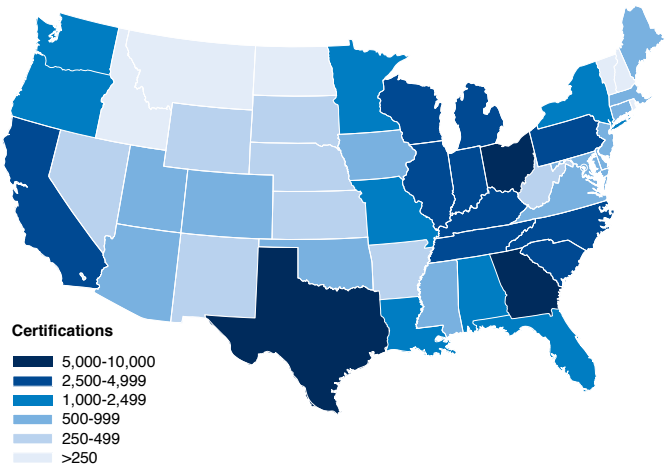
Shortly after these efforts, Phison ramped up production and sought larger facilities.

The Manufacturing Institute
United States

Skills Certification System

A recent study states that some 600,000 US manufacturing jobs – 5% of total – will go unfilled simply because employers cannot find people with the right set of skills.[60] Three-quarters of manufacturers indicate that this skills gap has hindered their ability to expand operations or improve productivity.[61] That is where the Manufacturing Institute's Skills Certification System (SCS) comes in. Through the SCS, the Manufacturing Institute, an affiliate of the National Association of Manufacturers (NAM), aims to close the manufacturing skills gap through the standardization of manufacturing education and training and the creation of a skilled manufacturing workforce qualified to meet the future needs of employers. The Manufacturing Institute issued 84,738 certifications in 2011 and aims to award 500,000 cumulatively by 2016.[62]

To realize its goal, the Manufacturing Institute has partnered with 16 industry and professional associations that sponsor and collaborate in the design of dozens of tailored certifications that address employers' needs. These NAM-endorsed certifications reflect the full range of manufacturing sectors – from aerospace to food processing to chemicals, among many others.



2011 Distribution of Manufacturing Industry Certifications by State

Source: National Association of Manufacturers

The certifications may be offered at high schools, community colleges or four-year institutions and cover four general skill groupings:

1. Personal effectiveness skills
2. Basic academic requirements
3. General workplace competencies
4. Industry-wide technical competencies

At present, the Manufacturing Institute is active in promoting the SCS programme in 32 states – from early grassroots efforts to well-established relationships with state-level manufacturing organizations.[63]

Representative Best Practices

There are four key features that make the programme effective:

1. **Credibility:** In advancing the SCS programme, the Manufacturing Institute has partnered with leading certification programmes – such as the National Institute for Metalworking Skills (NIMS) and American Welding Society (AWS) – that are well recognized by manufacturing employers and academic/training institutions. This credibility will help the programme to achieve its long-term goal of 500,000 cumulative certifications by 2016.
2. **Wide-ranging levels of certifications:** The NAM-endorsed certifications are progressive or "stackable" in that they serve the full range of the educational institution – from high school and vocational training to four-year institutions and level of career achievement – from machine operator to engineering manager.
3. **Engagement with industry incumbents that builds demand:** The SCS identifies manufacturing champions in a state or region and generates awareness among key stakeholders.
4. **Efficient talent connections:** The credibility of a given SCS certification is a measure of a particular skill level. Prospective manufacturing employers rely on that measure in identifying the right talent for the right position. In that sense, the SCS certification makes the hiring process more efficient, for both employer and employee.

Making an Impact

The following are supplying US manufacturers with certified workers.

- **Forsyth Tech/Caterpillar:** Forsyth Technical Community College integrated the SCS into its four focus programme areas: mechanical engineering technologies, machining technologies, industrial system technologies and welding. Forsyth's curriculum was reviewed for industry certification alignment and gaps were filled. In addition to their degree, Forsyth alumni graduate with the National Career Readiness Certificate, which establishes Reading for Information, Applied Math, and Locating Information standards. Graduates may also obtain a wide array of SCS-endorsed, profession-specific certifications. These certifications prepare alumni for promising technical careers with salaries of up to US$ 79,000 a year. By providing an attractive, certified labour force, Forsyth Tech played a critical role in luring a US$ 426 million Caterpillar plant to the region; the facility provides career opportunities to more than 500 employees.[64]
- **Energizer Battery:** Working with the North Carolina Employment Security Commission, Energizer uses the SCS-endorsed National Career Readiness Certificate (NCRC) to screen job applicants. Energizer initially applied this approach to nine production positions and is in now in the process of applying it to additional positions, including continuous improvement leaders and quality lab assistants. Both the NCRC and the larger SCS programme make the hiring process more efficient and accelerate diffusion of specialized skills across the workforce.[65]

National Association of Manufacturers' Competencies Chart

Source: National Association of Manufacturers

National Research Council Canada[66]
Canada

The National Research Council (NRC), Canada's premier organization for research and development, is a government organization that provides innovation support, strategic research, and scientific and technical services to address industry needs in Canada. Established in 1916, the NRC's scientists, engineers and business experts collaborate closely with thousands of Canadian firms, helping them to bring new technologies to market. NRC personnel enjoy a long history of innovation and have served as chief contributors to the development of a wide array of products including an artificial pacemaker, canola, the Crash Position Indicator, the Cesium Beam atomic clock, biofuels[67] and computer animation.[68]

Representative Best Practices

- **Robust technical and advisory services capabilities:** The NRC helps Canadian enterprises to overcome workforce constraints and limited resources, accelerating design cycles and helping to identify product performance limits. Its 4,000 employees address pressing technical problems associated with the transfer, adoption and diffusion of technology. Technical service offerings include testing, certifications, calibration, prototyping, demonstrations, scale-up and consulting.
- **Access to leading research facilities:** The NRC offers Canadian businesses access to its research infrastructure and experts to optimize its use. The NRC's 27 facilities augment the research capabilities in disciplines as varied as aerospace engineering and manufacturing, astronomy, high-throughput DNA sequencing, neutron beam facilities, photonics, biotechnology and nanotechnology. The facilities allow Canadian businesses to carry out "blue sky" R&D domestically while minimizing the costs, infrastructure requirements and risks that often accompany R&D and product development programmes.
- **Licensing opportunities for commercialization-ready R&D solutions:** With an expansive portfolio of innovations ready for commercialization, the NRC transfers patented technologies to its Canadian industry partners – helping businesses to develop "cohesive, integrated and market-ready solutions that attract investment and drive revenue".[69] Innovations in multi-dimensional MRI data software, air diffusion cathodes for fuel cells and radio frequency inhomogeneity are available for exploitation, helping Canadian enterprises to become more globally competitive.
- **Research and business partnerships that accelerate R&D and commercialization:** The NRC offers multiple forms of research project partnership models with industry partners. These partnership models offer bidirectional benefits: industry research partners benefit from a potential acceleration of the commercial development time, and NRC benefits from a deeper understanding of the commercial direction that a particular technology may be taking in the marketplace, thereby making its research priorities more commercially relevant.

NRC's IRAP: An Effective Driver of Growth in Canadian SMEs

The NRC's Industrial Research Assistance Program (IRAP) offers Canadian small and medium-sized enterprises at all stages of development an array of advisory services that "build their innovation capacity, understand technology issues and opportunities, and provides linkages to various experts". The IRAP also provides SMEs with financial assistance and advice. IRAP has helped SMEs in a full range of sectors including food production, pharmaceuticals, energy, medical devices, and manufacturing materials, among many others.

The NRC recently conducted an audit of IRAP's effectiveness. Among the audit's findings:[70]

- Over the evaluation period (2007-2012), IRAP programme costs were about C$ 130 million per year, but the audit credited IRAP with the direct generation of increased wages and salaries among programme participants of slightly more than C$ 1.1 billion per year and incremental taxable income of about C$ 360 million per year – a return on investment of slightly more than 11 to one.
- Incremental participant employment attributable to IRAP assistance over the five-year period was measured at 8,564, of which some 78% were positions related to R&D.
- Attributable incremental annual revenue was estimated at approximately C$ 2.3 billion.

National Skills Development Corporation[71]
India

India faces a daunting challenge: by 2022, the country will see a manufacturing skills gap of nearly 90 million workers – almost twice the current figure – and some 500 million workers across all skilled sectors. India's National Skills Development Corporation (NSDC), a non-profit company, aims to help solve this problem. Over the next 10 years, the NSDC aspires to create 150 million skilled labourers across 21 sectors that meet or exceed international standards. A main thrust of the NSDC's mission resides in the promotion of skill development through the funding – either through loans or equity – of large, quality, for-profit vocational training institutions, programmes that are proposed by way of private (both for profit and not for profit) sector initiative. It is truly a demand-led model, designed to develop and supply the talent needed by the private sector to grow.

Formed in the 2008-2009 budget year, the NSDC is driven by the private sector, which maintains control of 51% of the partnership and holds eight of the 13 seats on the board. The National Skill Development Fund, which enables the NSDC's financing operations, is a government-owned trust and is run by professional fund managers. Initial funding for the NSDC was 10 billion rupees (US$ 185 million). Current funding stands at 25 billion rupees (US$ 462 million).

When it comes to funding selected projects, the NSDC provides between 75% and 85% of total required upfront investment, depending on whether the investment is considered for profit or not for profit. Investments are intended to fill skill gaps identified in 21 sectors including a number of priority sectors, such as automobiles and components, electronics hardware, textiles/ garments, leather goods, chemical, pharmaceuticals and food processing. The NSDC has a particular focus on the large unorganized sector in India, as well as the underprivileged sections of society. To maximize its impact, the NSDC segments investment opportunities by the marketability of the skill targeted and the income level of the student population served. In effect, the NSDC plays the role of a "market maker" – providing financing to projects that traditional market mechanisms ignore – with the aspiration of making investments in for-profit training more attractive to the private sector.

To date, the NSDC is working with 37 active partners and has contributed billions of rupees in the formation of hundreds of permanent and mobile training centres across India. About 266,000 workers have received training in these centres thus far, of whom about three quarters have secured placement in the sectors covered by the NSDC.

Beyond funding, the NSDC plays an advocacy role in skills development throughout India. The organization also helps shape the training curricula.

Representative Best Practices

To address the skills gap and prepare Indian workers to fulfil the future needs of employers, the NSDC plays three key roles.

- **Developing the market:** The NSDC identifies critical skill groups, designs models for skill development and proactively encourages large-scale participation by private players in skill development.
- **Making the market:** The NSDC benefits its selected private sector initiatives through several vehicles – primarily loans, equity, grants and tax breaks. NSDC's longer-term objective is to support training programmes that are based on self-sufficient business models – diminishing the roles of outright grants.
- **Supporting the market:** The NSDC and partner industry organizations work jointly in establishing standards in accreditation systems. The NSDC actively seeks to shape the curricula of training programmes and other development activities. It also sets forth quality criteria in faculty, technology platforms and student placement mechanisms.

Hands-on training for students on repairing security systems

Source: National Skills Development Corporation

Making an Impact

Centum WorkSkills: A goal of 12 million trained

With 160 million rupees (US$ 3 million) provided by the NSDC, Bharti, India's largest telecom service provider, established Centum WorkSkills India. Founded in late 2010, the mandate of Centum WorkSkills is to train some 12 million workers at 383 centres across 11 states by 2022, with a near-term goal of 100,000 workers by the end of 2013. These centres will remediate skills gaps in the automobile, organized retail, telecommunications, healthcare and construction industries. Centum WorkSkills operates on a hub and spoke model, with one franchisee per state. Enrolment revenue, grants, student fees, placement fees and franchising fees ensure the sustainability of the business model.[72]

SkillsUSA
United States

SkillsUSA is a nationwide partnership of students, instructors and industry, which works to ensure America has a skilled workforce. More than 300,000 students and advisors join SkillsUSA annually. SkillsUSA's Program of Work is delivered through almost 17,000 SkillsUSA member sections (classrooms) in more than 3,700 public schools (chapters) in all 50 states, Washington DC and three US territories. The schools are comprehensive high schools with career and technical curricula, regional career and technical education centres, and two-year colleges. SkillsUSA also has begun to develop chapters in workforce development agencies outside of traditional schools.

One hundred thirty trade, technical and skilled service occupational titles are represented in the curricula of SkillsUSA member students. Titles cover construction, manufacturing, transportation, health sciences, information technology, communications, personal services, hospitality, public safety, and engineering technology industries.

Representative Best Practices

SkillsUSA's success stems from a number of differentiating factors:

- **Breadth of partnerships:** SkillsUSA has the support of more than 1,100 corporations, trade associations, businesses, and labour unions at the national level.
- **Multidiscipline curricula:** SkillsUSA programmes help to establish industry standards for job skill training in the lab and classroom, and promote community service. SkillsUSA is recognized by the US Department of Education and is cited as a "successful model of employer-driven youth development training programme" by the US Department of Labor.

Sample Programmes[73]

- SkillsUSA programmes include local, state and national competitions in which students demonstrate occupational and leadership skills. At the annual national-level SkillsUSA Championships, over 5,600 students compete in 94 occupational and leadership skill areas.
- The SkillsUSA Work Force Ready System is a comprehensive tool to help students to document entry-level skills as defined by industry and accepted by state education policy. Developed under a W. K. Kellogg Foundation grant, this programme features 47 industry-driven assessments.
- The Career Skills Education Program (CSEP) contains 49 online lessons teaching basic employment and life skills to college/post-secondary students.
- Student2Student Mentoring gives high school students a chance to mentor younger students in the area of career development.

Making an Impact

SkillsUSA is helping manufacturers to close the skills gap:

- Caterpillar has recruited several top SkillsUSA students for its fast-track management programme and for CAT's ThinkBIG technician training programmes in selected community colleges. Caterpillar has been a leader in providing top-level executives to serve in SkillsUSA governance.
- Air Products has disseminated information to its operating facilities on how to engage with SkillsUSA local chapters and encouraged new chapter development near their facilities. Lynn Scheitrum, Manager, Talent Management and Central Staffing for Air Products, said, "One of the things we have looked to SkillsUSA for, and why it has become such an important talent pipeline for us, is that we are seeing students coming through with the capacity to understand complex skills and innovate creatively to function in manufacturing."

A two-person team competes in mobile robotics during the 2012 SkillsUSA Championships.

Source: SkillsUSA

Company-sponsored Partnerships

Executives interviewed often gave examples of ways in which their companies engage in communities around the world where they have major operations. Often, these companies partner with a university or institute to develop a pool of local skilled talent. This method benefits the businesses, which are shaping their future workforce, as well as society. Below are a few examples.

Company	Partnership	Description
Bombardier	Partnerships with government and universities in Mexico	Since 2006, Bombardier Aerospace has been manufacturing aircraft components in Querétaro, Mexico. State and federal government in Mexico have supported the growth of the aerospace industry, ensuring that Querétaro has industrial and educational infrastructures, a skilled population, dynamic economic development policies and a modern airport. Bombardier has invested in the Querétaro community, developing close ties with local universities that offer advanced aerospace engineering curricula and hiring a number of engineering graduates. Additionally, Bombardier works closely with the local base of suppliers to assist in developing capabilities.[74]
Nissan	Skills Academy for Sustainable Manufacturing and Innovation (SASMI)	Operated by long-term Nissan training provider Gateshead College, the £ 9.8 million SASMI focuses on electric vehicle battery assembly, manufacturing, testing, charging and safety. Opened in September 2011 next to Nissan's Sunderland Plant, the SASMI is also home to one of two Nissan Global Training Centers, focused on Nissan staff in the Africa, Middle East, India and Europe region. More than 8,200 courses have been delivered to more than 2,800 people at SASMI, covering areas from health and safety to kaizen, from wiring skills to employer law, from factory automation to plastic moulding and robot programming. Since it opened, the Pre-Employment Training Programme has equipped more than 1,000 local unemployed people with the basic skills required to work at Nissan; more than 600 went on to secure a job at Nissan or in the automotive supply chain.[75]
Schaeffler	Partnerships for innovation	Schaeffler, together with CemeCon, H-O-T Tribotechnik and Stiftung Institute für Werkstofftechnik Bremen, and financing from the German Federal Ministry of Education and Research, developed engine and roller bearing parts with super low friction. Project results not only contributed to protect the environment by saving lubricants, but also increased the load carrying capacity of the relevant parts.
System Capital Management (SCM)	Education reform in Ukraine	As the largest employer in Ukraine, SCM is an important stakeholder in the improvement in quality of higher education. Since 2008, SCM has implemented a programme of education reform to help ensure that Ukrainian graduates meet the needs of the economy. One component of the reform programme is the Compass National University Ranking, which SCM develops in partnership with government education and businesses. The ranking evaluates the education level in the areas of finance, law, engineering/ technical professions, information technologies and architecture. The ranking is determined by employers' evaluation of recent graduates and helps both students and employers to make better decisions about school and hiring, respectively. Another component of SCM's education programme is FormulaS. SCM senior managers deliver master classes for Ukrainian students at top universities on topics such as public speaking, eloquence, time management, leadership, negotiations and project management.
Volkswagen	Volkswagen Academy (partnership with Chattanooga State University)	Volkswagen AG and Chattanooga State University have partnered to create the Volkswagen Academy, which provides vocational training programmes for people interested in working in the automotive industry. Each year, 24 students are selected for the three-year programme through a competitive admissions process. Volkswagen Academy offers students a dual model, using both classroom instruction and paid, on-the-job-training.[76]

Leading Examples of Cross-border Public-Private Partnerships

Just as manufacturing is taking on an increasingly global character, so are the most successful public-private partnerships. This is especially true in skills development programmes. Indeed, one of the most compelling drivers of successful training partnerships is the extent to which they give their trainees exposure to international markets and cultures.

A particularly innovative kind of skills training partnership – the "bilateral" partnership – takes the idea of international exposure a step further. Instead of providing international exposure merely in a classroom setting, the bilateral partnership brings together nationals from different countries in some kind of training endeavour. Often, a bilateral partnership involves government agencies, although this is not always the case. Regardless of the exact makeup, all bilateral partnerships share a common purpose in the cross-pollination of cultures and ideas in advancing the objectives of a training curriculum.

What Makes Bilateral Partnerships a Best Practice?

An international component in any kind of training programme redounds to the benefit of the trainees. Bilateral partnerships are best practices because their very premise is rooted in an international sensibility:

- Global perspective on what works: The bilateral partnership is a forum in which the best ideas on labour practices, manufacturing process and training methodology – among a whole host of other ideas – are shared in a type of global laboratory. The direct interaction of world-class ideas contributes more to an efficient knowledge-sharing process than a more traditional classroom setting.
- Promotes foreign direct investment: One kind of bilateral partnership occurs when a company that makes a direct investment in another country offers training of nationals from the host country. Beyond the other benefits that come from bilateral partnerships generally, this kind of bilateral partnership also serves to promote foreign direct investment.
- Promotes cultural understanding: The bilateral partnership is by definition the bringing together of people from different cultural backgrounds in a training setting. It serves to engender the kind of cultural understanding that will facilitate cross-border trade.

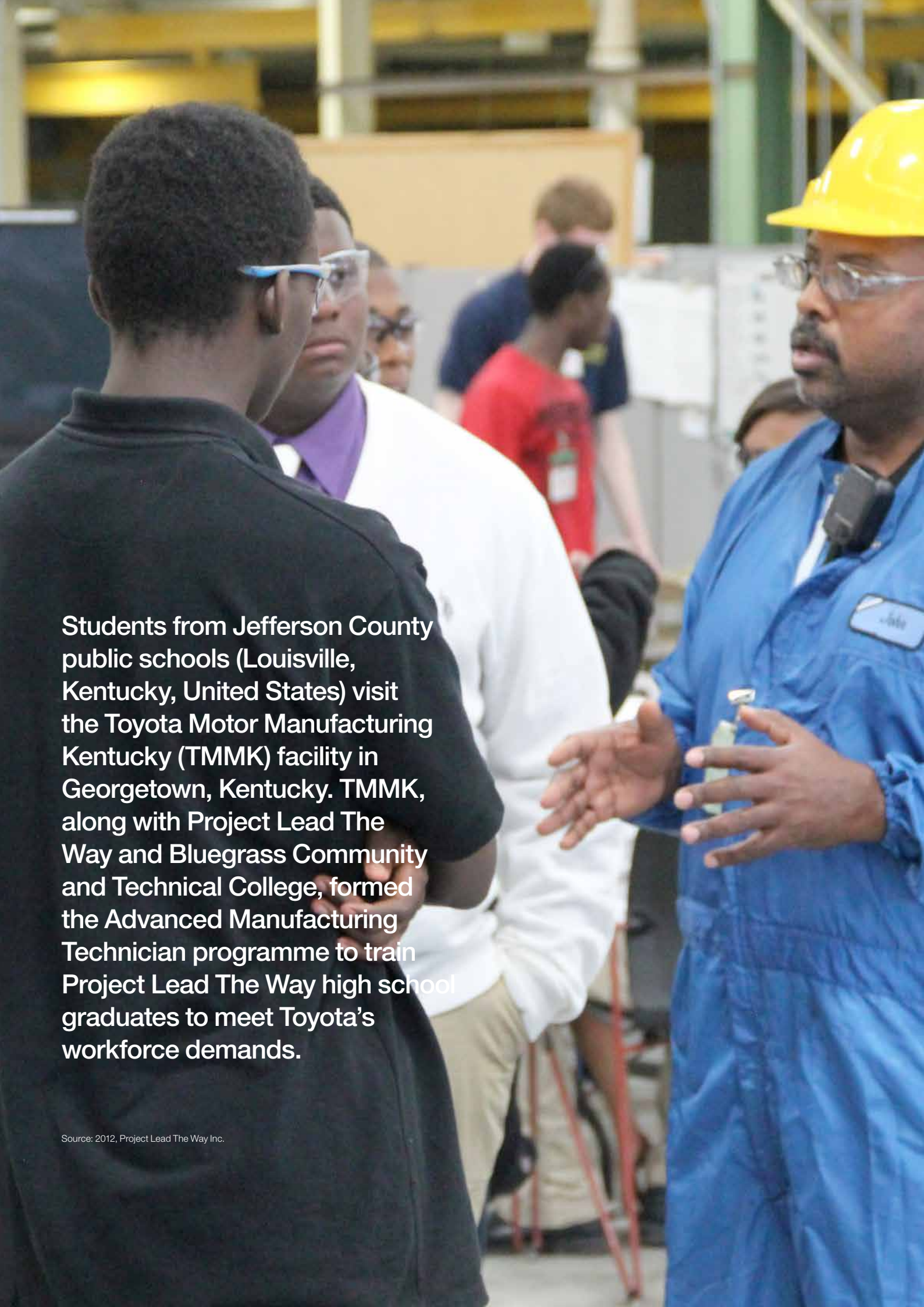
Bilateral Partnerships in Action

- German Embassy Skills Initiative: The purpose of this joint effort between the German Embassy in the United States and regional/state educational authorities is for German companies located in the US to provide workforce training to US nationals who live in the communities where the German companies operate in the US.[77]
- Fraunhofer USA: A primary reason that Fraunhofer is so successful is its fundamental understanding that science and its industrial applications transcend national borders. At the same time, Fraunhofer recognizes that the best relationships are forged locally. In that spirit, the organization formed Fraunhofer USA in 1994 to serve the US market in a more effective manner. Since its founding, Fraunhofer USA has grown to some 200 employees and US$ 45 million in revenue. It now has six research centres across the United States – ranging in scope from manufacturing innovation to laser technology. It also has established relationships with leading research universities – including MIT and the University of Michigan – as well as an array of federal and state agencies.[78]
- US-Brazil Connect: Effectively a two-way cultural exchange programme in which US teenagers – identified for their leadership potential – spend four to six weeks in Brazil immersed in training in the country's science and technology industries as well as in broader cultural exchange activities.[79]
- BMW/China Business Journal: In 2011, BMW's Chinese operations and the China Business Journal joined forces to create a think tank that focuses on an array of topics related to manufacturing, including competition, sustainability and government/enterprise relationships, among other areas.

Other Leading Examples of Public-Private Partnerships

The previous pages showcase a number of leading public-private partnerships highlighted by executives participating in the face-to-face interviews and workshops around the world. The table below lists other effective institutions that are also worthy of mention and that are to be congratulated on their success.

Name of Organization	Country
Singapore Economic Development Board	Singapore
Tata Institute of Fundamental Research	India
Enterprise Connect	Australia
Simply Science	Switzerland
CFMA/School to Work	China
Sustainable Manufacturing and Innovation	United Kingdom
SPRING	Singapore
Edison Welding Institute	United States
Project Lead the Way	United States
Max Planck Society	Germany
Indian Institute of Technology Bombay	India
EU European Green Cars PPP	European Union
Enterprise Ireland	Ireland
Irish Centre for Manufacturing	Ireland
Masdar Institute	United Arab Emirates
Korean Institute of Industrial Technology	South Korea
Research Institute of Science and Technology	South Korea
European Robotics PPP	European Union
WorldSkills International	Netherlands
SEMATECH	United States
National Center for Manufacturing Services	United States
Electric Power Research Institute	United States
Partners for a Competitive Workforce	United States
Advanced Manufacturing Talent Development Institute	United States
Industrial Research Limited	New Zealand



Students from Jefferson County public schools (Louisville, Kentucky, United States) visit the Toyota Motor Manufacturing Kentucky (TMMK) facility in Georgetown, Kentucky. TMMK, along with Project Lead The Way and Bluegrass Community and Technical College, formed the Advanced Manufacturing Technician programme to train Project Lead The Way high school graduates to meet Toyota's workforce demands.

Source: 2012, Project Lead The Way Inc.

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