

McKinsey Global Institute
McKinsey Operations Practice



November 2012

Manufacturing the future: The next era of global growth and innovation



The McKinsey Global Institute

The McKinsey Global Institute (MGI), the business and economics research arm of McKinsey & Company, was established in 1990 to develop a deeper understanding of the evolving global economy. Our goal is to provide leaders in the commercial, public, and social sectors with the facts and insights on which to base management and policy decisions.

MGI research combines the disciplines of economics and management, employing the analytical tools of economics with the insights of business leaders. Our “micro-to-macro” methodology examines microeconomic industry trends to better understand the broad macroeconomic forces affecting business strategy and public policy. MGI’s in-depth reports have covered more than 20 countries and 30 industries. Current research focuses on four themes: productivity and growth; the evolution of global financial markets; the economic impact of technology and innovation; and urbanization. Recent reports have assessed job creation, resource productivity, cities of the future, and the economic impact of the Internet.

MGI is led by three McKinsey & Company directors: Richard Dobbs, James Manyika, and Charles Roxburgh. Project teams are led by a group of senior fellows and include consultants from McKinsey’s offices around the world. These teams draw on McKinsey’s global network of partners and industry and management experts. In addition, leading economists, including Nobel laureates, act as research advisers.

The partners of McKinsey & Company fund MGI’s research; it is not commissioned by any business, government, or other institution. For further information about MGI and to download reports, please visit www.mckinsey.com/mgi.

McKinsey Operations Practice

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The practice combines practical, global operations expertise with the comprehensive business understanding that underpins all McKinsey disciplines. It works across a wide range of industrial, service, and institutional segments in functional areas that include procurement, product development, supply chain, manufacturing, service operations, and large-scale capital projects.

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Preface

Manufacturing has a special hold on the public imagination—and for good reason. The transition from agriculture to manufacturing is still the route to higher productivity and rising living standards for developing economies. In advanced economies, manufactured goods stand as the tangible expression of innovation and competitiveness. In this report, we see that manufacturing continues to exert a strong hold, even as its role in the economic lives of nations evolves. We also see that a new era of innovation and opportunities promises to inspire a new generation of manufacturing professionals.

The McKinsey Global Institute (MGI) undertook the research in *Manufacturing the future: The next era of global growth and innovation* to gain a better understanding of how manufacturing contributes to developing and advanced economies in the 21st century. Our goal was to establish a clear fact base on the current state of the global manufacturing sector and analyze how long-term trends will shape manufacturing in the coming decades. We find that manufacturing still matters a great deal, driving innovation and productivity in advanced economies and economic advancement in developing ones. Our segmentation model helped us understand what conditions are required for success in five broad industry groups and how factors such as proximity to markets or access to R&D talent determine footprints. These insights are useful for both manufacturing leaders and policy makers as they adapt to the forces shaping the global manufacturing sector.

Manufacturing the future is the result of a ten-month collaborative effort between MGI, McKinsey's economic and business research arm, and the firm's operations practice. Leaders and experts in McKinsey's automotive, aerospace, electronics, food, metals, and pharmaceuticals industry practices provided in-depth analyses and perspectives on their industries.

This research was led by James Manyika, an MGI director based in San Francisco and a nonresident senior fellow at the Brookings Institution, and Jeff Sinclair, a director in the operations practice based in Washington, DC. The research was co-led by Jan Mischke and Jaana Remes, MGI senior fellows, and by Louis Rassey, a partner in the operations practice, and David O'Halloran, a senior expert in the operations practice. Sree Ramaswamy led the project team, which included Michael Fleming, Shalabh Gupta, Philip Jones, Cyril Koniski, Sundeeep Kumar, Malcolm Lee, Tim McEvoy, Bryan Meyerhofer, Jean-Benoît Grégoire Rousseau, Vivien Singer, and Annaliina Soikkanen. We also thank MGI directors Charles Roxburgh and Richard Dobbs, and operations practice directors Katy George and Gernot Strube, for their generous support. In addition, we thank Susan Lund, MGI director of research, and MGI senior fellows Michael Chui, Anu Madgavkar, and Fraser Thompson for their insights. Geoffrey Lewis provided editorial support; Julie Philpot and Marisa Carder led production and design. We also thank Tim Beacom, Deadra Henderson, Rebeca Robboy, and Stacey Schulte for their support.

In addition to operations practice leaders, we wish to thank the many other McKinsey operations experts who contributed to this work, led by Isabel Hartung, Scott Nyquist, and Ashutosh Padhi, and including Harold Brink, Enno de Boer, Jorge Carral, Mike Doheny, Jack Donohew, Dave Fedewa, Eric Gaudet, Martin Lehnich, Carmen Magar, Yogesh Malik, Craig Melrose, Chris Musso, Venu Nagali, Maria Otero, Dickon Pinner, Brian Ruwadi, Helga Vanthournout, and Jim Williams. We also wish to acknowledge the contribution of our operations practice analysts Eli Ariav, Kyle Becker, Kimberly Farnen, and Milton Ghosh.

Additionally, we thank leaders and experts in our six “deep dive” industries. Directors David Chinn, John Dowdy, and Mark Mitchke contributed generously to our research into the aerospace industry. The aerospace team was led by Colin Shaw with expert insights provided by Kevin Dehoff, Davide Gronchi, John Niehaus, Katharina Peterwerth, and Wolff Sintern. Detlef Kayser, a director in Hamburg, provided leadership in the automotive industry. Jan Harre led the research team, with expert insights from Michael Beckham, Magnus Jarlegren, Doug Mehl, Ricardo Moya-Quiroga, and Jonathan Tilley, as well as Deryl Sturdevant, a senior advisor to McKinsey. Directors Luis Enriquez and Stefan Heck provided insights into the electronics industry. They were assisted by Mike Coxon, Auleen Ghosh, Michael Schmeink, Peter Spiller, Shekhar Varanasi, Florian Weig, Frank Wiesner, and Bill Wiseman. For their assistance on the metals industry, we thank Evgeniya Brodskaya, Niels Phaf, Diedrik Tas, Danny van Dooren, and Benedikt Zeumer.

We thank Peter Czerepak, who led the research in food processing industries, and expert contributors Philip Christiani, Bruce Constantine, Ignacio Felix, Søren Fritzen, Tony Gambell, Jan Henrich, Les Kalman, Ashish Kothari, Shruti Lal, Frédéric LeFort, Aasheesh Mittal, Frank Sängner, and Daniel Swan for their perspectives.

Directors David Keeling, Martin Losch, David Quigley, and Navjot Singh provided insights into the pharmaceuticals industry. We also thank Vikas Bhadoria, Peter de Boer, Thomas Ebel, Elizabeth Eliason, Ted Fuhr, Usoa Garcia-Sagues, Jake LaPorte, Erik Larsen, Patrick Oster, Janice Pai, Jaidev Rajpal, Paul Rutten, Ali Sankur, Katarzyna Smietana, Peter Stevens, and Vanya Telpis.

We are grateful to our academic advisers, Eberhard Abele, chair of the Institute for Production Management, Technology and Machine Tools, Technical University of Darmstadt; Martin Baily, Bernard L. Schwartz Chair in Economic Policy Development at the Brookings Institution; Richard Cooper, Maurits C. Boas Professor of International Economics, Harvard University; Wallace Hopp, associate dean for faculty and research and Herrick Professor of Manufacturing, Ross School of Business, University of Michigan; and Laura Tyson, S.K. and

Angela Chan chair in Global Management, Haas School of Business, University of California, Berkeley.

We also thank other academic and industry experts who provided additional insights: Robert Atkinson, president of the Information Technology and Innovation Foundation; Suzanne Berger, the Raphael Dorman-Helen Starbuck Professor of Political Science, Massachusetts Institute of Technology; Catherine Mann, professor of economics at Brandeis University; and Donald Rosenfield, director of the Leaders for Global Operations program at the Sloan School of Management, Massachusetts Institute of Technology.

Finally, we offer special thanks to the manufacturing and operations executives and other experts we interviewed during this project. Their insights about the future of manufacturing contributed enormously to our understanding. We interviewed them on condition that we would not identify them or their organizations. All references to specific companies in this report are from public sources.

This report is part of a large body of MGI research on manufacturing, productivity, and competitiveness. Recent reports in this series include *Trading myths: Addressing misconceptions about trade, jobs, and competitiveness*, May 2012; *An economy that works: Job creation and America's future*, June 2011; and *Big data: The next frontier for innovation, competition, and productivity*, May 2011.

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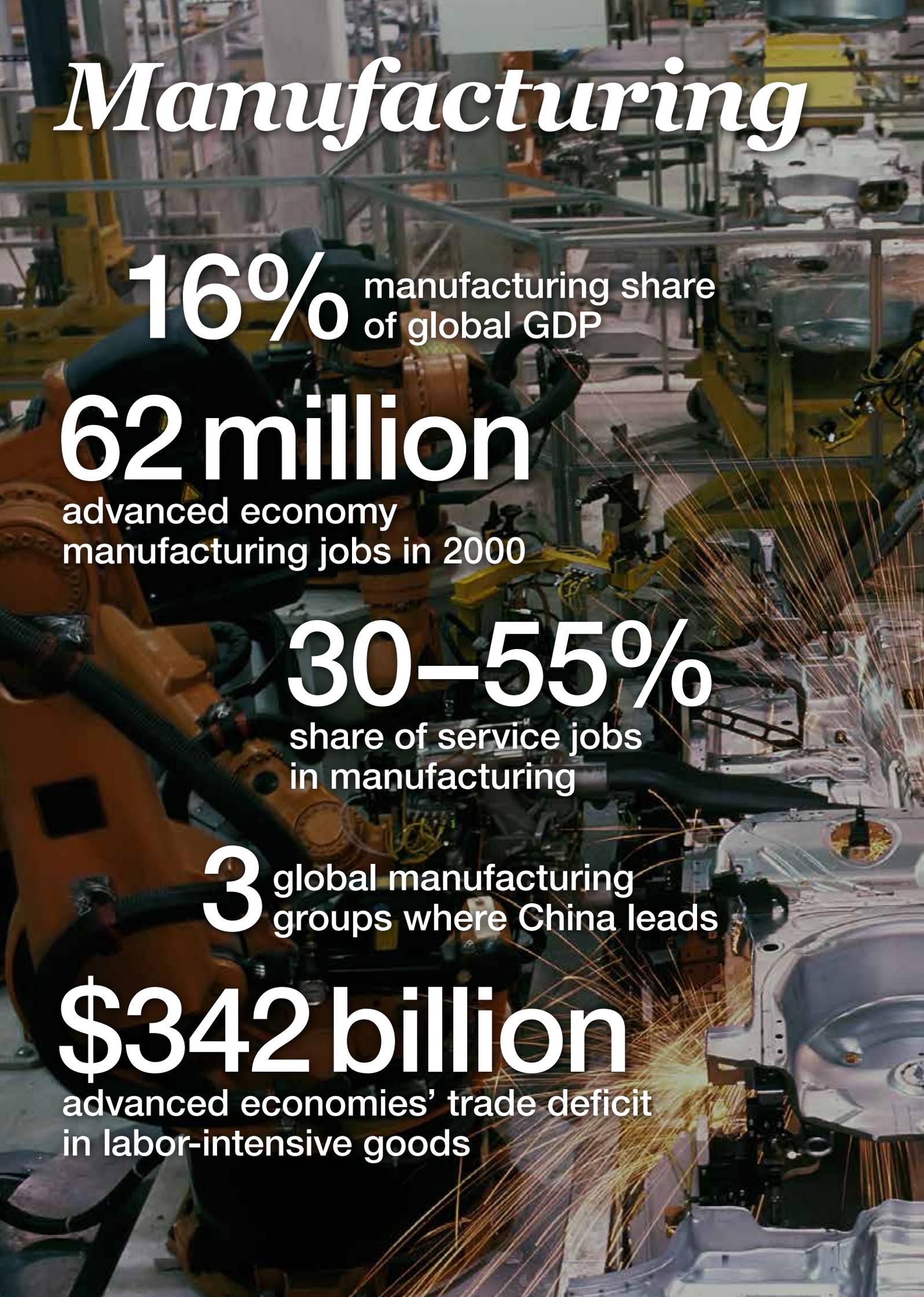
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Manufacturing



16% manufacturing share
of global GDP

62 million

advanced economy
manufacturing jobs in 2000

30–55%

share of service jobs
in manufacturing

3 global manufacturing
groups where China leads

\$342 billion

advanced economies' trade deficit
in labor-intensive goods

by the numbers

A large industrial robot arm is shown in a factory setting, grinding a metal part. The robot is orange and black, and the grinding process creates a large spray of bright orange sparks. The background shows other industrial equipment and a factory floor.

70% manufacturing share
of global trade

45 million

advanced economy
manufacturing jobs in 2010

19¢

of service input for every dollar
of manufacturing output

2 global manufacturing groups
where United States leads

\$726 billion

advanced economies' trade surplus
in innovative goods

Contents

Executive summary	1
1. Why manufacturing matters	17
2. The five segments of global manufacturing	44
3. Trends affecting the evolution of manufacturing	69
4. Implications for manufacturing companies	103
5. Implications for policy makers	129
Appendix: Technical notes	147
Bibliography	155

Executive summary

A decade into the 21st century, the role of manufacturing in the global economy continues to evolve. We see a promising future. Over the next 15 years, another 1.8 billion people will enter the global consuming class and worldwide consumption will nearly double to \$64 trillion. Developing economies will continue to drive global growth in demand for manufactured goods, becoming just as important as markets as they have been as contributors to the supply chain. And a strong pipeline of innovations in materials, information technology, production processes, and manufacturing operations will give manufacturers the opportunity to design and build new kinds of products, reinvent existing ones, and bring renewed dynamism to the sector.

The factors we describe point to an era of truly global manufacturing opportunities and a strong long-term future for manufacturing in both advanced and developing economies. The new era of manufacturing will be marked by highly agile, networked enterprises that use information and analytics as skillfully as they employ talent and machinery to deliver products and services to diverse global markets. In advanced economies, manufacturing will continue to drive innovation, exports, and productivity growth. In developing economies, manufacturing will continue to provide a pathway to higher living standards. As long as companies and countries understand the evolving nature of manufacturing and act on the powerful trends shaping the global competitive environment, they can thrive in this promising future.

The McKinsey Global Institute undertook the research and analysis that follows to establish a clearer understanding of the role of manufacturing in advanced and developing economies and the choices that companies in different manufacturing industries make about how they organize and operate. We started with an examination of how manufacturing has evolved to this point and then plotted its likely evolution based on the key forces at work in the global manufacturing sector. We also sought to understand the implications of these shifts for companies and policy makers. Our research combined extensive macroeconomic analyses with industry insights from our global operations experts. In addition, we conducted “deep dive” analyses of select industries, including automotive, aerospace, pharmaceuticals, food, steel, and electronics manufacturing.

We find that manufacturing continues to matter a great deal to both developing and advanced economies. We also see that it is a diverse sector, not subject to simple, one-size-fits-all approaches, and that it is evolving to include more service activities and to use more service inputs. And we see that the role of manufacturing in job creation changes as economies mature. Finally, we find that the future of manufacturing is unfolding in an environment of far greater risk and uncertainty than before the Great Recession. And in the near term, the lingering effects of that recession present additional challenges. To win in this environment, companies and governments need new analytical rigor and foresight, new capabilities, and the conviction to act.

MANUFACTURING MATTERS, BUT ITS NATURE IS CHANGING

Manufacturing industries have helped drive economic growth and rising living standards for nearly three centuries and continue to do so in developing economies. Building a manufacturing sector is still a necessary step in national development, raising incomes and providing the machinery, tools, and materials to build modern infrastructure and housing. Even India, which has leapfrogged into the global services trade with its information technology and business process outsourcing industries, continues to build up its manufacturing sector to raise living standards—aiming to raise the share of manufacturing in its economy from 16 percent today to 25 percent by 2022.¹

How manufacturing matters

Globally, manufacturing output (as measured by gross value added) continues to grow—by about 2.7 percent annually in advanced economies and 7.4 percent in large developing economies (between 2000 and 2007). Economies such as China, India, and Indonesia have risen into the top ranks of global manufacturing and in the world's 15 largest manufacturing economies, the sector contributes from 10 percent to 33 percent of value added (Exhibit E1).

Exhibit E1

Large developing economies are moving up in global manufacturing

Top 15 manufacturers by share of global nominal manufacturing gross value added

Rank	1980	1990	2000	2010
1	United States	United States	United States	United States
2	Germany	Japan	Japan	China
3	Japan	Germany	Germany	Japan
4	United Kingdom	Italy	China	Germany
5	France	United Kingdom	United Kingdom	Italy
6	Italy	France	Italy	Brazil
7	China	China	France	South Korea
8	Brazil	Brazil	South Korea	France
9	Spain	Spain	Canada	United Kingdom
10	Canada	Canada	Mexico	India
11	Mexico	South Korea ¹	Spain	Russia ²
12	Australia	Mexico	Brazil	Mexico
13	Netherlands	Turkey	Taiwan	Indonesia ²
14	Argentina	India	India	Spain
15	India	Taiwan	Turkey	Canada

1 South Korea ranked 25 in 1980.

2 In 2000, Indonesia ranked 20 and Russia ranked 21.

NOTE: Based on IHS Global Insight database sample of 75 economies, of which 28 are developed and 47 are developing. Manufacturing here is calculated top down from the IHS Global Insight aggregate; there might be discrepancy with bottom-up calculations elsewhere.

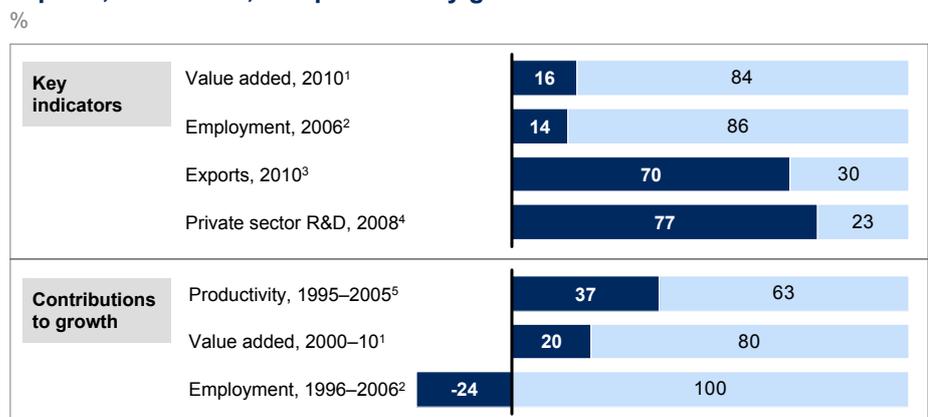
SOURCE: IHS Global Insight; McKinsey Global Institute analysis

1 India's national manufacturing policy, adopted in November 2011, calls for setting up national manufacturing zones, creating 100 million manufacturing jobs, and raising manufacturing's contribution to GDP from 16 percent today to 25 percent by 2022.

Manufacturing makes outsized contributions to trade, research and development (R&D), and productivity (Exhibit E2). The sector generates 70 percent of exports in major manufacturing economies—both advanced and emerging—and up to 90 percent of business R&D spending. Driven by global competition in many subsectors, manufacturing’s share of productivity growth is twice its share of employment in the EU-15 nations and three times its share of US employment. Such productivity growth provides additional benefits, including considerable consumer surplus: since the 1980s, rising efficiency and technological advances have limited increases in the cost of durable goods in the United States to a tenth the rate of consumer price inflation. To capture these economic benefits, countries must create and exploit comparative advantages to convince the most globally competitive and productive companies to participate in their economies.

Exhibit E2

Manufacturing contributes disproportionately to exports, innovation, and productivity growth



1 Manufacturing GDP as share of global GDP.
 2 2006 data for advanced economies sample of United States, Japan, and EU-15; employment growth contribution calculated for 1996–2006 period.
 3 Sample of 28 advanced and 8 developing economies.
 4 2008 average of manufacturing share of business R&D spend in Germany and Korea (89%), Japan and China (87%), Mexico (69%), and United States (67%).
 5 Manufacturing share of productivity growth in EU-15 for 1995–2005 period.
 SOURCE: EU KLEMS; IHS Global Insight; OECD STAN, and ANBERD; Eurostat; World Bank; McKinsey Global Institute analysis

The role of manufacturing in the economy changes over time. Empirical evidence shows that as economies become wealthier and reach middle-income status, manufacturing’s share of GDP peaks (at about 20 to 35 percent of GDP). Beyond that point, consumption shifts toward services, hiring in services outpaces job creation in manufacturing, and manufacturing’s share of GDP begins to fall along an inverted U curve. Employment follows a similar pattern: manufacturing’s share of US employment declined from 25 percent in 1950 to 9 percent in 2008. In Germany, manufacturing jobs fell from 35 percent of employment in 1970 to 18 percent in 2008, and South Korean manufacturing went from 28 percent of employment in 1989 to 17 percent in 2008.

As economies mature, manufacturing becomes more important for other attributes, such as its ability to drive productivity growth, innovation, and trade. Manufacturing also plays a critical role in tackling societal challenges, such as reducing energy and resource consumption and limiting greenhouse gas emissions.

As advanced economies recover from the Great Recession, hiring in manufacturing may accelerate. And the most competitive manufacturing nations may even raise their share of net exports. Whether such a rebound can be sustained, however, depends on how well countries perform on a range of fundamental factors that are important to manufacturing industries: access to low-cost or high-skill labor (or both); proximity to demand; efficient transportation and logistics infrastructure; availability of inputs such as natural resources or inexpensive energy; and proximity to centers of innovation.

Manufacturers in advanced economies will continue to hire workers, both in production and non-production roles, such as design and after-sales service. But in the long run, manufacturing's share of employment will continue to be under pressure in advanced economies. This is due to ongoing productivity improvements, the continued growth of services as a share of the economy, and the force of global competition, which pushes advanced economies to specialize in more high-skill activities. Manufacturing cannot be expected to create mass employment in advanced economies on the scale that it did decades ago.

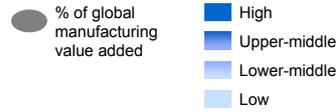
Manufacturing is not monolithic

In order to craft effective business and policy strategies in manufacturing, it is important to start with an understanding of the fundamental differences between manufacturing industries. We identify five broad segments that vary significantly in their sources of competitive advantage and how different factors of production influence where companies build factories, carry out R&D, and go to market. Depending on the industry, factors such as energy and labor costs or proximity to talent, markets, and partners such as suppliers and researchers have greater weight (Exhibit E3). Indeed, many manufacturing companies, including in industries such as automotive and aerospace, are already concerned about a skill shortage.

We find this segmentation a helpful way to see the global nature of different industries, anticipate where manufacturing activities are most likely to take place, and understand the role of innovation in various industries. For companies, the segmentation helps to explain the evolution of different parts of their operations, from individual business units to various stages of their supply chains. The segmentation can also clarify the differences between segments of the same industry—why suppliers of automotive electronic components respond to very different dynamics than suppliers of mechanical parts, for example. The framework also helps explain why the needs and factors of success vary even within the same industry; the carmaker that emphasizes its technological edge and precision engineering has very different requirements than the producer of low-cost models.

Exhibit E3

Manufacturing is diverse: We identify five broad groups with very different characteristics and requirements



Group	Industry	R&D intensity	Labor intensity	Capital intensity	Energy intensity	Trade intensity	Value density
Global innovation for local markets (34)	Chemicals	High	Low	High	High	High	High
	Motor vehicles, trailers, parts	High	Low	High	High	High	High
	Other transport equipment	High	Low	High	High	High	High
	Electrical machinery	High	Low	High	High	High	High
	Machinery, equipment, appliances	High	Low	High	High	High	High
Regional processing (28)	Rubber and plastics products	High	High	High	High	High	High
	Fabricated metal products	High	High	High	High	High	High
	Food, beverage, and tobacco	High	High	High	High	High	High
	Printing and publishing	High	High	High	High	High	High
Energy-/resource-intensive commodities (22)	Wood products	High	High	High	High	High	High
	Refined petroleum, coke, nuclear	High	High	High	High	High	High
	Paper and pulp	High	High	High	High	High	High
	Mineral-based products	High	High	High	High	High	High
	Basic metals	High	High	High	High	High	High
Global technologies/innovators (9)	Computers and office machinery	High	Low	High	High	High	High
	Semiconductors and electronics	High	Low	High	High	High	High
	Medical, precision, and optical	High	Low	High	High	High	High
Labor-intensive tradables (7)	Textiles, apparel, leather	High	High	High	High	High	High
	Furniture, jewelry, toys, other	High	High	High	High	High	High

SOURCE: IHS Global Insight; OECD; Annual Survey of Manufacturers (ASM) 2010; US 2007 Commodity Flow Survey; McKinsey Global Institute analysis

The largest group is global innovation for local markets, which is composed of industries such as chemicals (including pharmaceuticals); automobiles; other transportation equipment; and machinery, equipment, and appliances. These industries accounted for 34 percent of the \$10.5 trillion (nominal) in global manufacturing value added in 2010. Industries in this group are moderately to highly R&D-intensive and depend on a steady stream of innovations and new models to compete. Also, the nature of their products is such that production facilities are distributed close to customers to minimize transportation costs. The footprints of these industries may also be influenced by regulatory effects (e.g., safety standards) and trade agreements.

Regional processing industries are the second-largest manufacturing group globally, with 28 percent of value added, and the largest employer in advanced economies. The group includes food processing and other industries that locate close to demand and sources of raw materials; their products are not heavily traded and not highly dependent on R&D, but they are highly automated. Energy- and resource-intensive commodities such as basic metals make up the third-largest manufacturing group. For these companies, energy prices are important, but they are also tied to markets in which they sell, due to high capital and transportation costs.

Global technology industries such as computers and electronics depend on global R&D and production networks; the high value density of products such as electronic components and mobile phones, make them economically transportable from production sites to customers around the globe. Finally, labor-intensive tradables, such as apparel manufacturing, make up just 7 percent of

value added. The group's goods are highly tradable and companies require low-cost labor. Production is globally traded and migrates to wherever labor rates are low and transportation is reliable.

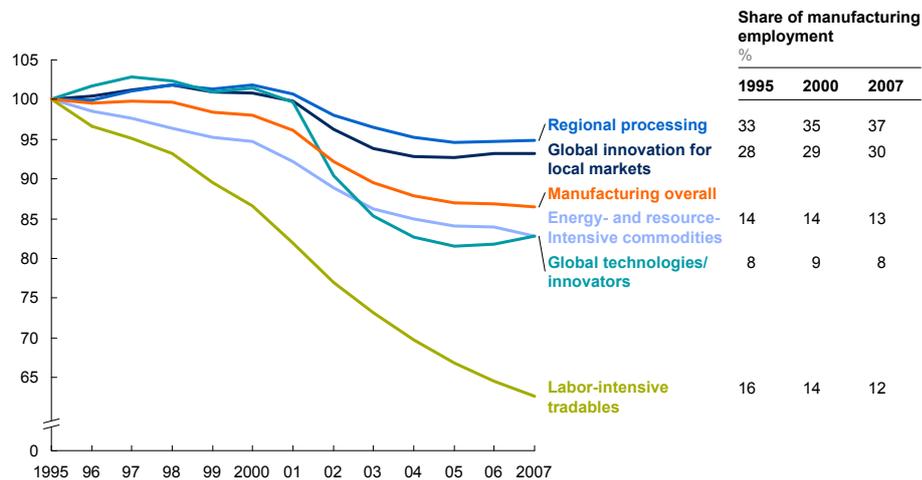
We see that the five segments make very different contributions to the global manufacturing sector and have evolved in dramatically different ways. Industries in just two of the five segments—regional processing and global innovation for local markets—together make up nearly two-thirds of manufacturing value added and more than half of manufacturing employment, both in advanced and emerging economies. Two other industry groups—global technologies and labor-intensive tradables—are both highly traded globally, but exist at opposite ends of the skill spectrum. Together, they make up only 16 percent of value added in both advanced and emerging economies.

The evolution of these manufacturing groups has resulted in some specialization across different types of economies. Advanced economies retain a lead in the global innovation for local markets group and are less competitive in labor-intensive manufacturing. In 2010, advanced economies ran a \$726 billion surplus in goods such as automobiles, chemicals, pharmaceuticals, and machinery, and had a \$342 billion trade deficit in labor-intensive tradables. While labor-intensive industries in advanced economies have shed 37 percent of their jobs since 1995, regional processing industries (e.g., food manufacturing) have lost only 5 percent of their employment (Exhibit E4).

Exhibit E4

Manufacturing employment in advanced economies has declined across all groups but has fallen most in the labor-intensive tradables group

Manufacturing employment by group in selected advanced economies, 1995–2007¹
Index: 1995 = 100



¹ Sample of 17 advanced economies: EU-15, Japan, and United States.

NOTE: Numbers may not sum due to rounding.

SOURCE: EU KLEMS; OECD; McKinsey Global Institute analysis

The distinction between manufacturing and services has blurred

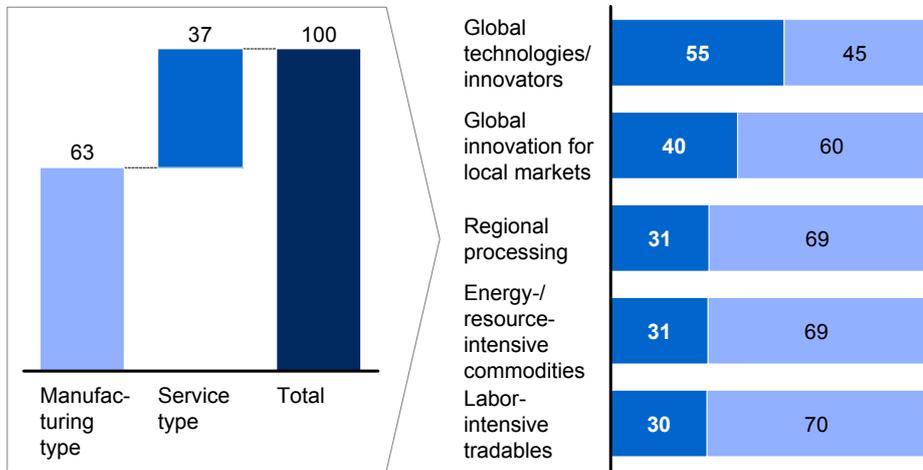
Manufacturing has always included a range of activities in addition to production. Over time, service-like activities—such as R&D, marketing and sales, and customer support—have become a larger share of what manufacturing companies do. More than 34 percent of US manufacturing employment is in such service-like occupations today, up from about 32 percent in 2002. Depending on the segment, 30 to 55 percent of manufacturing jobs in advanced economies are service-type functions (Exhibit E5), and service inputs make up 20 to 25 percent of manufacturing output.

Exhibit E5

Service type activities already make up 30 to 55 percent of manufacturing employment

Manufacturing occupations in the United States in 2010¹
%

■ Service type
■ Manufacturing type



¹ Manufacturing-type occupations refer to early-stage manufacturing and final assembly. Service occupations include R&D, procurement, distribution, sales and marketing, post-sales service, back-office support, and management.

SOURCE: US Bureau of Labor Statistics (BLS); McKinsey Global Institute analysis

Manufacturing companies rely on a multitude of service providers to produce their goods. These include telecom and travel services to connect workers in global production networks, logistics providers, banks, and IT service providers. We estimate that 4.7 million US service sector jobs depend on business from manufacturers. If we count those and one million primary resources jobs related to manufacturing (e.g., iron ore mining), total manufacturing-related employment in the United States would be 17.2 million, versus 11.5 million in official data in 2010. Including outsourced services, we find that services jobs in US manufacturing-related employment now exceed production jobs—8.9 million in services versus 7.3 million in production.

Just as manufacturing creates demand for services inputs, services also create demand for manufactured goods. For every dollar of output, US manufacturers use 19 cents of service inputs, creating \$900 billion a year in demand for services, while services create \$1.4 trillion in US manufacturing demand. In China manufacturing creates \$500 billion in services demand, and services demand \$600 billion a year in manufactured goods. And while manufacturing drives more than 80 percent of exports in Germany, services and manufacturing contribute nearly equal shares of value added to the country’s total exports.

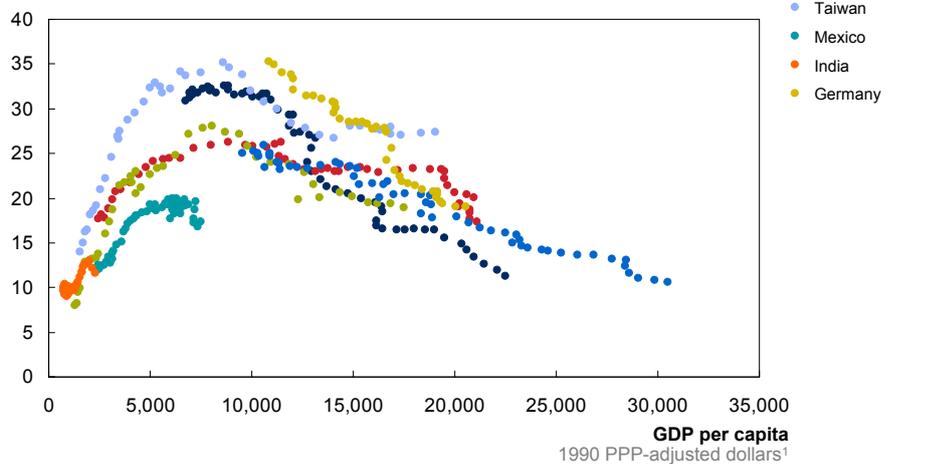
The role of manufacturing in job creation is changing

Manufacturing's role in job creation shifts over time as manufacturing's share of output falls and as companies invest in technologies and process improvements that raise productivity. Hiring patterns within manufacturing also change, with hiring skewed toward high-skill production jobs and both high- and low-skill service jobs, as hiring in production overall slows. At the same time, growth in service-sector hiring accelerates, raising that sector's share of employment. This pattern holds across advanced economies and will hold for today's developing economies as they become wealthier. As manufacturing's share of national output falls, so does its share of employment, following an inverted U curve (Exhibit E6).

Exhibit E6

Manufacturing's share of total employment falls as the economy grows wealthier, following an inverted U pattern

Manufacturing employment
% of total employment



¹ Adjusted using the Geary-Khamis method to obtain a 1990 international dollar, a hypothetical currency unit that allows international comparisons adjusted for exchange rates and purchasing power parity (PPP).

SOURCE: GGDC 10-Sector Database: "Structural change and growth accelerations in Asia and Latin America: A new sectoral data set," *Cliometrica*, volume 3, Issue 2, 2009; McKinsey Global Institute analysis

We find that manufacturing job losses in advanced economies have been concentrated in labor-intensive and highly tradable industries such as apparel and electronics assembly. However, overall in the United States, trade and outsourcing explain only about 20 percent of the 5.8 million manufacturing jobs lost during the 2000-10 period; more than two-thirds of job losses can be attributed to continued productivity growth, which has been outpacing demand growth for the past decade.

Even strong manufacturing exporting nations have shed jobs in the past decade. Germany's manufacturing employment fell by 8 percent and South Korea's by 11 percent. Our analysis indicates that while manufacturing output will continue to rise and manufacturers will hire more high-skill production workers and workers in non-production roles, overall manufacturing employment will remain under pressure in advanced economies; if current trends persist, manufacturing employment in advanced economies could fall from 45 million jobs today to fewer than 40 million by 2030.

Manufacturing has been regarded as a source of “better” jobs than services, offering higher levels of compensation. However, we find that this distinction is far less clear today. It is true that in aggregate, average compensation is higher in manufacturing than in services (17 percent higher in 2006, measured as total labor compensation including social security payments). But when manufacturing and service jobs in industries that have similar factor intensity are compared, the wage differences are small. The gap in average pay between manufacturing and services also is seen in wage distribution. Manufacturing has a disproportionately high number of well-paying jobs in the United States (700,000 more) compared with services and a disproportionately small number of low-paying jobs (720,000 fewer). These wage differences may reflect trade and offshoring effects, unionization, and legacy wage arrangements.

NEW OPPORTUNITIES ARISE IN A MORE COMPLEX AND UNCERTAIN ENVIRONMENT

An exciting new era of global manufacturing is ahead—driven by shifts in demand and by innovations in materials, processes, information technology, and operations. The prospect is for a more “global” manufacturing industry, in which developing economies are the source of new customers as well as the source of low-cost production. It can also be a time of rapid innovation, based on new technologies and methods. However, these opportunities arise in a global environment that is strikingly different from that of the pre-recession period, with shifts in the cost and availability of factor inputs (e.g., labor and natural resources) and rising complexity, uncertainty, and risk.

Some forces are already being felt: the shift of global demand toward developing economies, the proliferation of products to meet fragmenting customer demand, the growing importance of value-added services, and rising wages in low-cost locations. Other trends are now becoming more pronounced, such as a growing scarcity of technical talent to develop and run manufacturing tools and systems, and the use of greater intelligence in product design and manufacturing to boost resource efficiency and track activity in supply chains.

Demand is shifting and fragmenting

The shift in global demand for manufactured goods is happening at an accelerating pace, driven by the momentum of emerging economies. In China, per capita income for more than one billion citizens has doubled in just 12 years, an achievement that took the United Kingdom 150 years with just nine million inhabitants as it industrialized. And China is not alone. With industrialization and rising productivity spreading to other parts of Asia and Africa, some 1.8 billion people are expected to join the global consuming class by 2025, expanding markets for everything from mobile phones to refrigerators and soft drinks.

These new consumers often require very different products to meet their needs, with different features and price points, forcing manufacturers to offer more varieties and SKUs (stock-keeping units). At the same time, customers in more established markets are demanding more variety and faster product cycles, driving additional fragmentation. Finally, customers increasingly look to manufacturers for services, particularly in business-to-business (B2B) markets, creating an additional demand shift.

Innovations create new possibilities

A rich pipeline of innovations promises to create additional demand and drive further productivity gains across manufacturing industries and geographies. New technologies are increasing the importance of information, resource efficiency, and scale variations in manufacturing. These innovations include new materials such as carbon fiber components and nanotechnology, advanced robotics and 3-D printing, and new information technologies that can generate new forms of intelligence, such as big data and the use of data-gathering sensors in production machinery and in logistics (the so-called Internet of Things).

Across manufacturing industries, the use of big data can make substantial improvements in how companies respond to customer needs and how they run their machinery and operations. These enormous databases, which can include anything from online chatter about a brand or product to real-time feeds from machine tools and robots, have great potential for manufacturers—if they can master the technology and find the talent with the analytical skills to turn data into insights or new operating improvements.

Important advances are also taking place in development, process, and production technologies. It is increasingly possible to model the performance of a prototype that exists only as a CAD drawing. Additive manufacturing techniques, such as 3-D printing, are making prototyping easier and opening up exciting new options to produce intricate products such as aerospace components and even replacement human organs. Robots are gaining new capabilities at lower costs and are increasingly able to handle intricate work. The cost of automation relative to labor has fallen by 40 to 50 percent in advanced economies since 1990. In addition, advances in resource efficiency promise to cut use of materials and energy (i.e., green manufacturing). An emerging “circular” economy will help stretch resources through end-of-life recycling and reuse.

An uncertain environment complicates strategy

Even as new markets and technologies open up fresh opportunities for manufacturing companies, a series of changes in the environment creates new challenges and uncertainty. The growth of global value chains has increased exposure of many companies to the impact of natural disasters, as Japan's 2011 earthquake and Thailand's flooding have demonstrated. And after years of focusing on optimizing their value chains for low cost, many manufacturing companies are being forced to reassess the balance between efficiency gains from globally optimized value chains and the resilience of less fragmented and dispersed operations.

Catastrophic events are not the only sources of uncertainty facing manufacturing companies. Manufacturers also face fluctuating demand and commodity prices, currency volatility, and various kinds of supply-chain disruptions that chip away at profits, increase costs, and prevent organizations from exploiting market opportunities. Price increases in many commodities in the past decade have all but erased the price declines of the past century. Volatility in raw materials prices has increased by more than 50 percent in recent years and is now at an all-time high.² Long-term shifts in global demand are accompanied by

² *Resource revolution: Meeting the world's energy, materials, food, and water needs*, McKinsey Global Institute, November 2011 (www.mckinsey.com/mgi).

significant upswings and downswings in demand, driven by changes in customer preferences, purchasing power, and events such as quality problems.

Government action is another source of uncertainty. Governments continue to be active in manufacturing policy, even as the path of economic growth and the outlook for fiscal and financial market stability remain uncertain. All too often government action (and lack of action) simply adds to uncertainty. This is the case with unclear energy and carbon emissions policies. And, while trade barriers continue to fall around the world with the proliferation of preferential trade agreements, there are many exceptions. Government interventions persist—sometimes with protectionist measures—in industries such as autos and steel, which many governments regard as national priorities for employment and competitiveness. Steel tariffs have fallen over the past 20 years, but governments continue to favor domestic steel production in other ways.

As the world works through the aftermath of the financial crisis with household, banking, and public sector deleveraging; as rebalancing of trade propels exchange rate swings; and as the momentum of emerging economies puts friction on natural resource prices, uncertainty will prevail.

Implications for footprints, investment, and competition

Taken together, the opportunities and challenges described here have the potential to shift the basis for how companies pursue new markets and how they will expand their production and R&D footprints. Not only will companies compete in different ways and build new production and supply networks as they respond to new kinds of demand and forces of change in the global environment, but nations also will learn to compete on a wider range of factors than labor cost or tax rates.

For example, rather than simply responding to changing labor rates, manufacturers will need to consider the full range of factor inputs as they weigh the trade-offs between where they produce their goods and where they sell them. Much has been made of rising Chinese labor costs and falling wages in the United States. However, for most manufacturers, the more pressing workforce issue likely will be the struggle to find well-trained talent. Manufacturing is increasingly high-tech, from the factory floor to the back offices where big data experts will be analyzing trillions of bytes of data from machinery, products in the field, and consumers. The global supply of high-skill workers is not keeping up with demand, and the McKinsey Global Institute projects a potential shortage of more than 40 million high-skill workers by 2020. Aging economies, including China, will face the greatest potential gaps.

Global competition will also be affected by demand shifts and changes in the cost and availability of various supply factors. The global footprint of regional processing industries such as food processing will naturally follow demand, but for other industries such as automobiles and machinery, transportation and logistics costs or concerns about supply-chain resilience may trump labor costs.

Assessing the future pattern of costs and availability of resources such as raw materials and energy has become more complex. Resource prices rose rapidly before the recession and remain high by 20th-century standards. Yet access to previously untapped sources, such as shale gas in the United States, can change the relative costs of energy inputs and promote domestic production as

a substitute for imports. Then again, many energy-intensive processing industries such as steel tend to be located near demand, and their footprints are “sticky” due to high capital investments and high exit costs. In many industries, market proximity, capital intensity, and transport and logistics matter as much as energy and labor costs.

Finally, to compete, companies also may need to consider access to centers of innovation. This applies to many industries, not just those that make high-tech products. In the United States, for example, a new auto industry technology cluster is emerging around South Carolina’s auto factories.

For companies, the new mindset for making footprint decisions is not just about where to locate production, but also who the competitors are, how demand is changing, how resilient supply chains have to be, and how shifts in factor costs affect a particular business. As new geographic markets open up, companies will be challenged to make location trade-offs in a highly sophisticated, agile way. They will need to weigh proximity to markets and sources of customer insights against the costs and risks in each region or country.

On their part, policy makers will need to recognize that every country is going to compete for global manufacturing industries. Governments will need to invest in building up their comparative advantages—or in acquiring new ones—to increase their appeal to globally competitive and productive companies. As governments compete, they can help tilt the decisions for these companies by taking a comprehensive view of what multinational manufacturing corporations need: access to talent, reliable infrastructure, labor flexibility, access to necessary materials and low-cost energy, and other considerations beyond investment incentives and attractive wage rates.

MANUFACTURERS WILL NEED DETAILED INSIGHTS INTO NEW OPPORTUNITIES, AGILITY, AND NEW CAPABILITIES

To take advantage of emerging opportunities and navigate in a more challenging environment, manufacturing companies need to develop new muscles. They will be challenged to organize and operate in fundamentally different ways to create a new kind of global manufacturing company—an organization that more seamlessly collaborates around the world to design, build, and sell products and services to increasingly diverse customer bases. These organizations will be intelligent and agile enterprises that harness big data and analytics, and collaborate in ecosystems of partners along the value chain, to drive decision making, enhance performance, and manage complexity. They will have the vision and commitment to place the big bets needed to exploit long-term trends such as rising demand in emerging markets, but also will use new tools to manage the attendant risks and near-term uncertainties.

Conventional strategies will be increasingly risky; granularity is key

Companies that stick to business-as-usual approaches will be increasingly at risk. Manufacturers will no longer succeed by “copying and pasting” old strategies into new situations. They must develop a granular understanding of the world around them—and plan the operations strategy to compete in it.

First, manufacturers must understand the dynamics of their segments (e.g., their labor, energy, or innovation intensity), and how new trends play against those requirements and have the potential to redefine sources of competitive advantage.

They will need to understand the trends thoroughly and how they apply to their industries, markets, and customers to identify new opportunities and develop strategies to capture them.

Second, companies must develop a detailed, granular view of markets and customer segments to identify and tailor products and supply-chain strategies to specific subsegments of markets. A McKinsey study, for example, found that segmenting the Chinese market on a national or even on a regional/city basis was not adequate. By analyzing consumer characteristics, demographics, government policies, and other factors, the study identified 22 distinct market clusters that can be targeted independently. In Africa, Nokia learned that consumers had a very different concept of what was valuable in a mobile handset: it had to be affordable, but it also had to have a built-in flashlight and radio, as well as a waterproof case.

Third, companies must match granular insights with granular operations strategy. This will be critically important for capturing new opportunities in developing economies. Recycling the proven methods from advanced economies or even from other emerging markets won't do. A consumer product manufacturer was frustrated in its attempts to enter an emerging market until it conducted detailed on-the-ground research. Only then did it learn that, unlike in every other nation where it sold this particular product, consumers in this emerging market required packaging that could be reused for other purposes after the contents were used up.

Beyond simple labor-cost arbitrage: total factor performance

The way footprint decisions have been made in the past, especially the herd-like reflex to chase low-cost labor, needs to be replaced with more nuanced, multi-factor analyses. Companies must look beyond the simple math of labor-cost arbitrage to consider total factor performance across the full range of factor inputs and other forces that determine what it costs to build and sell products—including labor, transportation, leadership talent, materials and components, energy, capital, regulation, and trade policy. In doing so, the answers to key questions will often shift: for example, where to locate plants, or whether to automate or not. While companies have talked about taking a total landed cost view for some time, few get it right.

In an increasingly uncertain and volatile world, companies also need to shift strategic and business planning from simple point forecasts to scenario assessments that accurately reflect the variability of key factors and drivers. We find that companies still make simple trade-offs because they are not equipped to deal with complexity and fail to take into account the full range of factors and possible outcomes.

Invest and operate with agility

Manufacturers need to be able to make major commitments and manage risk and uncertainty at the same time. The fundamental shifts in demand that are now under way will play out over decades, requiring long-term strategic bets and investments; it can take seven to ten years for even the most successful multinationals to break even in new emerging markets. Yet, even as companies make these commitments, they will face risk and complexity along the way. To achieve this balance between long-term commitment and risk management, companies are making diverse, agile investments. They are getting adept at

scenario planning and at dividing investments among smaller bets across a portfolio of initiatives. The goal is to make each strategic choice less critical, less permanent, and less costly to reverse or redirect. Manufacturers should also continue to heed the productivity imperative. The pursuit of “lean” manufacturing processes is not finished. There continues to be wide variation among the most and least productive players within industries, and the process of simplifying, consolidating, and removing inefficiencies from operations is extending to new areas, such as resource productivity.

To translate strategies into action and make the most of long-term investments, companies also will need to have agile operations. Agility in operations goes far beyond simply ensuring business continuity in the face of risk; it is also about exploiting opportunity, raising the clock rate, and building resilience to daily shocks. Companies with agile operations not only respond more successfully to the bumps along the way and the opportunities, but they also preempt possible disruptions. For example, agile food manufacturers have developed recipes that can accommodate different forms of sugar in case one variety is in short supply.

Build new capabilities for new times

To act on these new bets and execute with agility, companies also will need to develop new operational capabilities and methods. New data-gathering and analytical tools can help identify opportunities to serve new markets, better manage supply chains, and drive innovation and delivery in services. But to make use of big data and analytics, manufacturing companies will need to build new routines for cross-functional and cross-geography collaboration.

New information technologies and new methods will require new tools, talent, and mindsets. To respond quickly to changes in market requirements and meet the demand for faster product cycles, companies will need to build integrated ecosystems of suppliers, researchers, and partners. To design and manage global footprints, companies will need to develop skills in calculating total factor and lifecycle costs (including exit expenses). And the productivity imperative will not go away, but will continue and expand beyond traditional capital/labor trade-offs to include resource productivity.

Finally, manufacturing companies will need to invest in their organizations. Manufacturers have to fight hard to win the war for talent—everything from experts in big data, to executives with deep understanding of emerging markets, to skilled production workers. In many places, manufacturers will need to get more involved in building a talent pipeline. For example, Siemens is implementing a German-style apprenticeship program in Charlotte, North Carolina. Apprentices graduate from the work-study program with degrees in “mechatronics” (mechanical engineering, systems design, and electronics) and are qualified for employment with Siemens.

POLICY MAKERS WILL NEED NEW APPROACHES AND CAPABILITIES TO BOOST COMPETITIVENESS

As manufacturing evolves, policy makers must adjust their expectations and look at manufacturing not as a source of mass employment in traditional production work but as a critical driver of innovation, productivity, and competitiveness. Policies aimed at promoting the health of manufacturing industries also must incorporate the crucial contributions that service employees, services suppliers, and collaborators make. Take exports: between 2000 and 2011, services exports grew slightly faster than goods exports in most advanced economies. In addition, services such as training and maintenance are a growing complement to equipment and machinery exports.

Policy needs to be grounded in a thorough understanding of the diverse industry segments in a national or regional economy and the wider trends that are affecting manufacturing industries. For example, shapers of energy policy need to be cognizant of what industries will be affected by relative energy costs and how great the impact is likely to be—and what magnitude of difference is likely to trigger a location decision. Policy makers should also recognize that supporting new capabilities at home and forging connections needed to access rapidly growing emerging markets are likely to have greater long-term benefits than fighting against the tide. In the fierce competition for attracting and growing leading global companies, manufacturing policies also need to be evaluated against actions by other governments.

The role of policy in manufacturing is largely about enabling and creating an environment for competitive and innovative companies to flourish, helping create sustainable conditions for local manufacturing. There may also be an economic case for intervening to correct market failures or to support young industries, as with US defense spending on emerging technologies or the support that Taiwanese research institutions provided to that nation's semiconductor industry.³ As policy makers develop new approaches to support manufacturing, they need to consider the full policy tool kit. They need to remove regulatory barriers to growth (from red tape to trade barriers) and strengthen underlying enablers by supporting R&D and investing in infrastructure. In the increasingly competitive environment to attract global companies and encourage their expansion, governments that are able to coordinate their interventions with the private sector and excel in delivering a competitive ecosystem to sustain talent and innovation are more likely to succeed.

A key policy priority for manufacturing is education and skill development. The basis of competition in most manufacturing sectors is shifting and access to diverse talent pools is critically important. Companies need to build R&D capabilities as well as expertise in data analytics and product design. They will need qualified, computer-savvy factory workers and agile managers for complex global supply chains. In addition to continuing efforts to improve public education, particularly in teaching math and analytical skills, policy makers need to work with industry and educational institutions to ensure that skills learned in school fit the needs of employers.

3 *How to compete and grow: A sector guide to policy*, McKinsey Global Institute, March 2010 (www.mckinsey.com/mgi), includes a detailed discussion of the role different governments played in the early stages of semiconductor industry growth, among other examples.



As we publish this report, five years after the beginning of the Great Recession, we see a new era of global manufacturing beginning to take shape. Even as the global economy continues to deal with the aftermath of the recession and the lingering effects on demand and finance, companies are becoming energized by a new series of opportunities that shifting demand and innovation are creating. This new era of manufacturing unfolds in an environment in which old assumptions, strategies, and policies will no longer suffice. With a thorough understanding of the fundamental factors that matter to different manufacturing industries and a sharp focus on the trends shaping global manufacturing, both manufacturing leaders and policy makers can succeed in this new era. They will need to think and act in new ways, develop new sorts of capabilities, and move with conviction. Then, manufacturing can continue to make its great contributions to both advanced and developing economies.

1. Why manufacturing matters

Across nations and political systems, manufacturing is regarded as an essential and uniquely powerful economic force. In advanced economies, a strong manufacturing sector is celebrated for creating well-paid employment and maintaining technical prowess; a shrinking manufacturing sector is seen as evidence of decline. In developing economies, manufacturing is recognized as the engine of development, raising agrarian populations out of poverty and turning poor nations into players in the global economy.

Today, the global manufacturing sector faces a series of changes and challenges—ranging from the shift in demand to developing economies to new constraints on key inputs such as resources, energy, and transportation. And, like companies in other sectors, manufacturers face the prospect of talent shortages among high-skill workers. In this context, the McKinsey Global Institute undertook the research and analyses that appear in this report to make clear how manufacturing creates value for economies today and how it is likely to do so in the coming decades.

Our research finds that manufacturing continues to provide a path to middle-income and wealthy-nation status for developing economies. In advanced economies, manufacturing may no longer be a dependable source of large-scale job growth, but it is a critical contributor to productivity, innovation, and trade. Traditional views about manufacturing often overlook these developments, as well as the changing nature of manufacturing itself. Debates over the importance of manufacturing versus services in an economy, for example, ignore the fact that the divide between the two sectors has blurred. And the role that production itself plays in maintaining a country's innovative and industrial capabilities is more complex and nuanced than often is perceived.

Finally, our research emphasizes the wide diversity of manufacturing industries and how the requirements for success differ across broad industry groups and even within subsectors. Manufacturing is not monolithic, and monolithic manufacturing policies are unlikely to be effective. Among our most important findings about the nature of manufacturing today:

- Manufacturing still matters a great deal, but its primary importance is as a driver of productivity growth, innovation, and trade. Manufacturing continues to make outsized contributions to research and development, accounting for up to 90 percent of private R&D spending in major manufacturing nations. The sector contributes twice as much to productivity growth as its employment share, and it typically accounts for the largest share of an economy's foreign trade; across major advanced and developing economies, manufacturing generates 70 percent of exports.
- The contribution of manufacturing changes as an economy develops. Manufacturing value added and employment grow quickly as a nation industrializes, but manufacturing's share of output and employment falls as nations grow wealthier and consume more services.

- Locating production abroad does not necessarily lead to a loss of innovative capabilities. The link between production and innovation varies by industry, and many companies remain leading innovators when R&D is separated from production.
- The old manufacturing/services divide is no longer a useful distinction. Manufacturers employ a rising number of workers in non-production jobs, and service inputs represent a rising share of manufacturing output. Services are also changing, joining manufacturing as a source of exports.

MANUFACTURING MATTERS, BUT IN DIFFERENT WAYS AS ECONOMIES EVOLVE

Manufacturing remains a significant contributor to gross value added and GDP as well as employment across economies. But its role varies between economies and changes over time. As nations grow wealthier and develop other sources of income, manufacturing becomes a smaller portion of output and employment. Today, manufacturing, as a share of GDP and employment, is growing in low-income developing nations and falling in advanced ones. This, however, does not reflect intrinsic health or competitiveness, but rather the stage of development. Countries at similar stages of development—for example, Germany and the United States—also can have very different-sized manufacturing sectors, but this is a reflection of a broad range of factors, including trade specialization, outsourcing patterns, consumption preferences, and current account imbalances.

We find that even when manufacturing's relative size in the economy is diminished, it continues to make outsized contributions in exports, productivity growth, R&D, and broader innovation. Not all manufacturing industries or companies are innovative or contribute significantly to trade, but many do generate these positive externalities for their countries and beyond. Importantly, so do a growing number of service sectors. Policy makers must look broadly at their economies and identify which activities generate positive externalities that justify incentives such as R&D tax breaks, without an a priori bias in favor of manufacturing.

Because manufacturing makes such a strong contribution to innovation, which raises productivity across the economy and enhances competitiveness, there is a great deal of concern about losing innovative capacity when production processes move offshore. The link between production and innovation, however, is a complex one. In many instances, co-location of R&D and production is unnecessary—and may even be undesirable since the necessary talent for innovation may not exist in the places that offer low-cost production. Some innovation does require direct collaboration, or “co-creation,” with production, but even then the collaboration can be managed across organizations.

In the following pages we examine the shifting role of manufacturing in advanced and developing economies and the ways in which manufacturing industries continue to contribute across economies. Data on manufacturing in these analyses are based on an establishment view as used in national accounts: each establishment that reports “manufacturing” as its primary activity is included in the data. Non-assembly activities such as R&D, human resources, or direct sales are included if performed in a manufacturing establishment. Activities subcontracted to service suppliers, such as IT consulting or third-party logistics, in turn, are not included.

Manufacturing's role in GDP and employment declines as economies develop

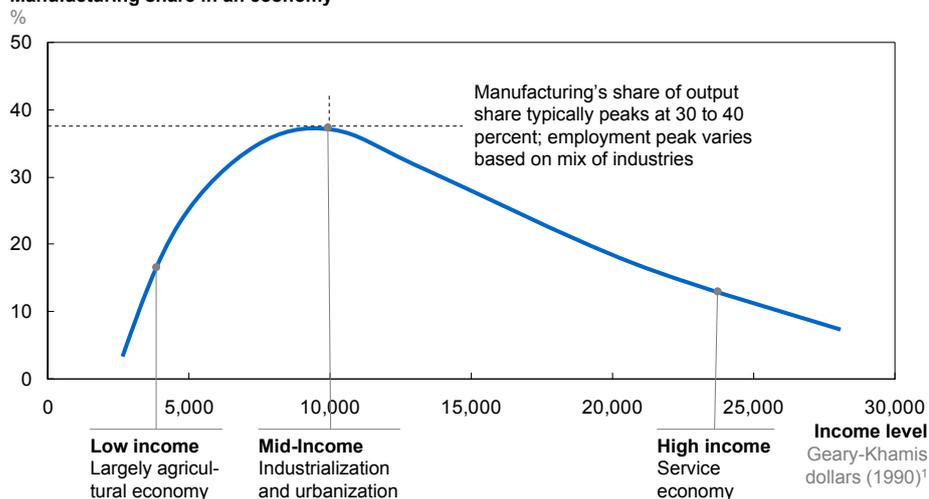
Over time, the share of value added and employment associated with manufacturing follows an inverted U shape, reflecting the traditional path of economic development (Exhibit 1). Economies progress from subsistence agriculture to manufacturing, then as incomes rise, large service sectors emerge. Manufacturing plays a crucial role in raising national wealth. It helps build the machines that allow agriculture and other sectors to become more productive; it provides the materials and tools to build and operate infrastructure; it enables people to move into urban areas and earn higher incomes; and it creates new products that open up new service growth opportunities, as computers and mobile phones have done recently for software applications.

Exhibit 1

Manufacturing's share of GDP rises as economies develop and falls as they become wealthy, following an inverted U curve

ILLUSTRATIVE

Manufacturing share in an economy



¹ The 1990 Geary-Khamis dollar, or 1990 international dollar, is a hypothetical currency unit that allows international comparisons adjusted for exchange rates and purchasing power parity.

SOURCE: McKinsey Global Institute analysis

Building an industrial base is still considered necessary for economic development; we are not aware of a nation that has skipped the industrial stage and moved up to wealthy-nation status.⁴ So, for example, even as India has jumped ahead into service exports with a successful business-services outsourcing industry, it continues to follow the traditional development path, too, building up physical infrastructure to support industry and removing barriers to enable manufacturing to expand and help more Indians move out of low-productivity agriculture.⁵

4 A number of economies grew rich via exports of primary resources, notably oil—allowing them to import the technology they required. Yet many resource-rich economies suffer from the “Dutch disease,” a phenomenon in which, because of a nation’s resource wealth, other sectors have less incentive to pursue productivity improvements.

5 *India: The growth imperative*, McKinsey Global Institute, October 2001; see also *New horizons: Impact on developing economies and policy implications*, McKinsey Global Institute, October 2003 (www.mckinsey.com/mgi).

The downward slope of the U curve begins when countries reach middle-income status and reflects a shift in consumption patterns as incomes rise. Early on in an economy's development, food represents most of the household consumption and agriculture dominates economic activity. Then, as countries go through the industrialization and urbanization process, cities need steel and cement to build houses and factories; companies need machinery and transportation equipment. As incomes rise, households spend more on products for personal use, for transportation, and to equip their homes. At the middle-income inflection point, demand for goods remains high and growing, but rising wealth leads to additional forms of consumption, and spending on services such as travel, education, or health care begins to take up a disproportionate share of incremental income. In South Korea, for instance, as per capita GDP increased by a factor of 11 from 1970 to 2010, spending on goods fell from 69 percent of final household consumption to 42 percent.

Several other factors reduce the relative size of manufacturing in an economy. Prices of manufactured goods, particularly durable goods, tend to rise more slowly than overall inflation, because innovation enables companies to produce goods more efficiently and to continuously raise value through improved performance. Also, activities that were once counted as manufacturing output but are now provided by outside suppliers (e.g., using third-party logistics suppliers instead of operating warehouses and trucking fleets) are no longer attributed to the manufacturing sector. Finally, rising productivity from product innovation, automation, and process optimization accelerates the decline in manufacturing's share of employment.

Manufacturing gross value added continues to grow globally

Manufacturing today represents 16 percent of global GDP, and manufacturing value added grew from \$5.7 trillion to \$7.5 trillion (in 2000 prices) between 2000 and 2010.⁶ Both advanced and developing economies have experienced growth in manufacturing value added. In 2007, before the Great Recession, manufacturing value added reached an all-time high, setting records even in "post-industrial" economies such as the United Kingdom and the United States. Overall, in high-income economies, manufacturing value added grew by 2.7 percent a year from 2000 to 2007 (Exhibit 2); US manufacturing value added grew by 2.6 percent between 2000 and 2007. In the same period, 26 percent of the total growth in value added in middle-income countries such as Brazil, China, and India was generated by manufacturing.

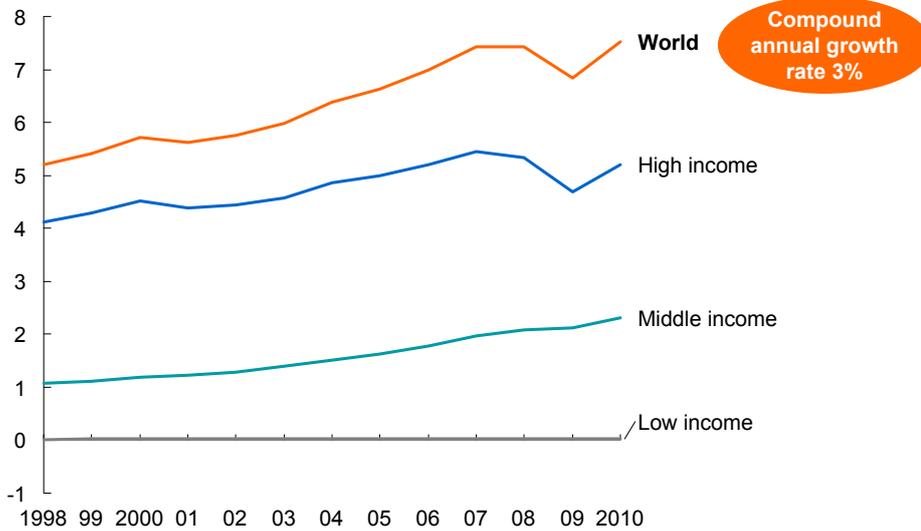
Large developing economies grew faster than established high-income economies (Exhibit 3). From 2000 to 2010, their share in global manufacturing value added almost doubled, from 21 to 39 percent.

⁶ Unless otherwise indicated, we use US dollars throughout this report.

Exhibit 2

Manufacturing value added was growing globally until the financial crisis

Real value added in manufacturing
Constant 2000 \$ trillion



SOURCE: World Bank; McKinsey Global Institute analysis

Exhibit 3

Large developing economies are moving up in global manufacturing

Top 15 manufacturers by share of global nominal manufacturing gross value added

Rank	1980	1990	2000	2010
1	United States	United States	United States	United States
2	Germany	Japan	Japan	China
3	Japan	Germany	Germany	Japan
4	United Kingdom	Italy	China	Germany
5	France	United Kingdom	United Kingdom	Italy
6	Italy	France	Italy	Brazil
7	China	China	France	South Korea
8	Brazil	Brazil	South Korea	France
9	Spain	Spain	Canada	United Kingdom
10	Canada	Canada	Mexico	India
11	Mexico	South Korea ¹	Spain	Russia ²
12	Australia	Mexico	Brazil	Mexico
13	Netherlands	Turkey	Taiwan	Indonesia ²
14	Argentina	India	India	Spain
15	India	Taiwan	Turkey	Canada

1 South Korea ranked 25 in 1980.

2 In 2000, Indonesia ranked 20 and Russia ranked 21.

NOTE: Based on IHS Global Insight database sample of 75 economies, of which 28 are developed and 47 are developing.

Manufacturing here is calculated top down from the IHS Global Insight aggregate; there might be discrepancy with bottom-up calculations elsewhere.

SOURCE: IHS Global Insight; McKinsey Global Institute analysis

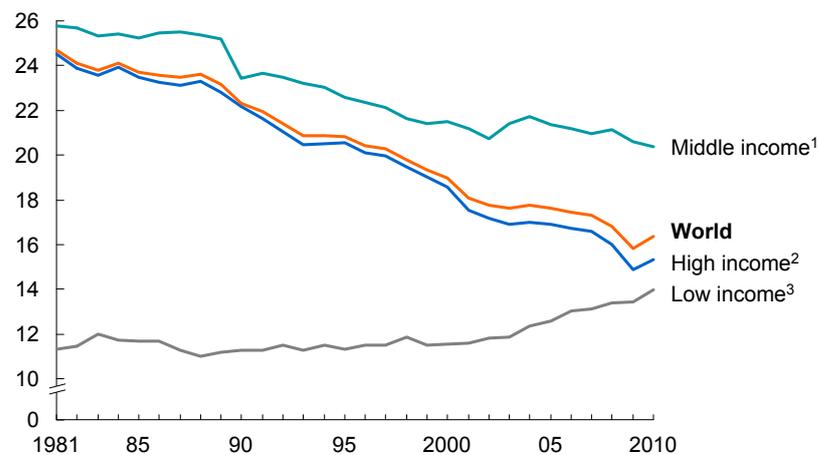
In both high-income and developing economies such as China and India, growth in services was faster during the decade and continues to outpace growth in manufacturing in current prices, in part because of price declines for durable goods. This growth helped reduce manufacturing's share of nominal global GDP from 22 percent in 1990 to 16 percent in 2010 (Exhibit 4). One country that seemed to defy this trend—for more than a decade—was Sweden (see Box 1, “The success of manufacturing in Sweden”).

Exhibit 4

Manufacturing's share of GDP has fallen in all but the poorest economies

Manufacturing value added as share of GDP

%



1 GNI per capita \$1,006–\$12,275. Example countries: India (lower middle), China (upper middle), Russia, Thailand.

2 GNI per capita \$12,276 or more. Example countries: EU countries, United States,.

3 GNI per capita \$1,005 or less. Example countries: Kenya, Nepal, Tanzania.

SOURCE: World Bank; McKinsey Global Institute analysis

The size of manufacturing sectors varies among economies, even those at the same stage of development

The relative size of the manufacturing industry reflects more than wealth and stage of development. It also reflects levels of domestic demand for manufactured goods, the relative strength of manufacturing versus services, and the level of outsourcing by manufacturers to domestic services providers, as well as imbalances in current accounts. The relative size of manufacturing sectors is also a reflection of policies and regulations that favor manufacturing firms. So, for example, the United Kingdom and the United States have large services sectors and derive a smaller share of GDP from manufacturing than countries such as South Korea, where policies have explicitly favored manufacturing. Finally, sector size differences can reflect natural resource endowments: Australia has a small manufacturing share because it exports natural resources that pay for manufactured imports.⁷ Japan is the opposite.

As a result of these factors, the share of GDP represented by manufacturing in the top 15 manufacturing nations of the world in 2010 ranged from just 10 percent

7 For further reading on the evolution of trade in these economies, see these McKinsey Global Institute reports: *Growth and renewal in the United States: Retooling America's economic engine*, February 2011; *From austerity to prosperity: Seven priorities for the long term* (UK), February 2010; and *Beyond the boom: Australia's productivity imperative*, August 2012 (www.mckinsey.com/mgi).

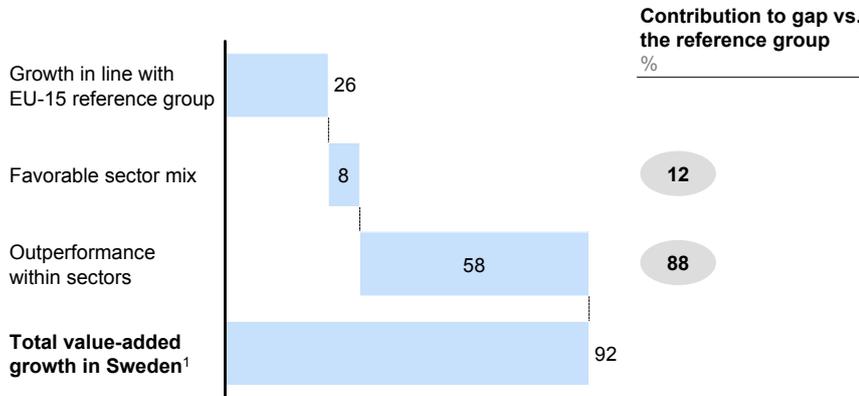
Box 1. The success of manufacturing in Sweden

While manufacturing’s role in high-income economies shrank by more than 25 percent in the past two decades, in Sweden manufacturing held nearly steady. During this time, manufacturing productivity growth in Sweden greatly outpaced that of other high-income economies. Sweden outperformed its EU-15 peers, focusing on high-growth sectors such as communication equipment, motor vehicles, and chemicals.¹ Favorable sector mix explains only 12 percent of outperformance; the other 88 percent is attributed to Sweden’s manufacturing sectors growing faster than such sectors in peer European countries (Exhibit 5).²

Exhibit 5

Sweden outperformed its EU peers in manufacturing value added, helping it maintain a larger manufacturing sector

Components of value-added growth in Swedish manufacturing, 1994–2005
%



¹ Discrepancy between this manufacturing growth number and the official, aggregate manufacturing growth number due to the use of chain-weighting in the aggregate manufacturing numbers.

NOTE: Nominal values are used for computers and office machinery, and communications equipment and TVs, because the hedonic price index yields very high growth rates which are problematic with the bottom-up approach.

SOURCE: EU KLEMS; McKinsey Global Institute analysis

Sweden’s manufacturing performance is attributable to reforms following its 1990s financial crisis.³ The krona was devalued 26 percent and an unwritten agreement allowed exporting sectors to set wage standards. Sweden joined the EU in 1995, ending capital controls and opening up foreign investment; Swedish multinationals expanded, and by 2007 ten multinationals were contributing 20 percent of gross value added and 35 percent of manufacturing growth. Swedish manufacturers continued to move up the value chain: from 2001 to 2007, the number of high-skill workers rose 1.7 percent annually and assembly worker rolls declined 2.6 percent. Swedish companies invested in vocational training at twice the EU-15 average.

1 The EU-15 are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom.
 2 For additional detail on methodology, see appendix.
 3 *Tillväxt och förnyelse i den svenska ekonomin*, McKinsey Global Institute, May 2012 (www.mckinsey.se). English version forthcoming.

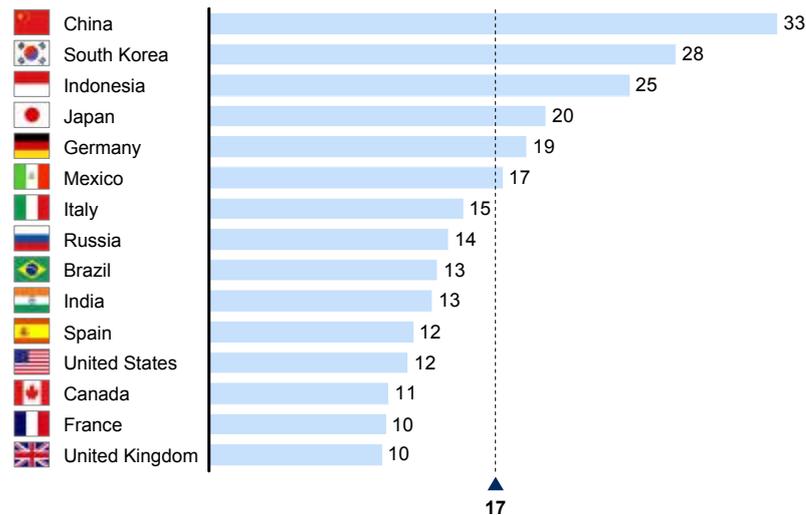
in the United Kingdom to 33 percent in China (Exhibit 6).⁸ The differences are large even among advanced economies that have similar levels of wealth: manufacturing accounted for 19 percent of GDP in Germany and 12 percent in the United States.

Exhibit 6

Manufacturing's share of GDP in the top 15 manufacturing nations ranges from 10 to 33 percent

Manufacturing share of GDP, 2010

%



SOURCE: United Nations Statistics Division; US Bureau of Economic Analysis (BEA); McKinsey Global Institute analysis

Macroeconomic forces, such as shifts in capital flows due to savings and aging or changes in currency exchange rates, can affect the size of a manufacturing sector. For example, a rapidly aging society tends to save more than it invests domestically, leading to current account surpluses. As retirees start spending their savings, the pattern is reversed.

Exchange rates remain an important factor for manufacturing. There has been much speculation about the role of China's control over its currency as a contributor to the nation's large trade surpluses—a notion that may have more credence since China's current account surplus fell following appreciation of the renminbi. Germany's high surpluses since the euro's introduction are often attributed in part to the euro's weakness relative to what the deutsche mark would command.⁹ Similarly, persistent US trade deficits are attributed to the dollar's status as reserve currency.

Differences in macroeconomic factors help explain how two wealthy advanced nations can have very different-sized manufacturing sectors. In 2010, the manufacturing sector accounted for 18.7 percent of GDP in Germany and 11.7 percent of GDP in the United States. To understand how Germany has retained a relatively large manufacturing sector, we analyze sector GDP as determined by domestic demand, net exports, and trade profiles, as well as its lower use of service suppliers. This is somewhat offset by higher domestic

⁸ The 2010 numbers in this exhibit may differ from numbers shown in other exhibits, which reflects use of different sources, the effects of the recession on estimates, as well as normal year-over-year variation in manufacturing output.

⁹ *Beyond austerity: A path to economic growth and renewal in Europe*, McKinsey Global Institute, October 2010 (www.mckinsey.com/mgi).

demand in the United States (see Box 2, “The difference between US and German manufacturing GDP”).

Box 2. The difference between US and German manufacturing GDP

What explains the 7-point difference in the manufacturing share of GDP in Germany and the United States? To decompose the gap, we start with differences in current accounts (Exhibit 7). Germany has built up a current account surplus since the introduction of the euro, while the United States has a long-running current account deficit. Demographic differences due to saving profiles (which vary as citizens age) make part of these current account imbalances structural.¹ Balancing current accounts would require a US manufacturing sector that is some 1.9 points larger than in 2010 and a German manufacturing sector that is about 3.8 points smaller. This difference of 5.7 points in trade contributes significantly to the difference in size of manufacturing sectors.

Differences in specialization contribute 2.5 points. Even if current accounts were balanced, Germany would run higher net exports of manufactures: in 2010, Germany had a deficit in resources while US domestic oil production yields a much smaller deficit in resources. Germany also ran a small deficit in services, while the United States had a surplus.

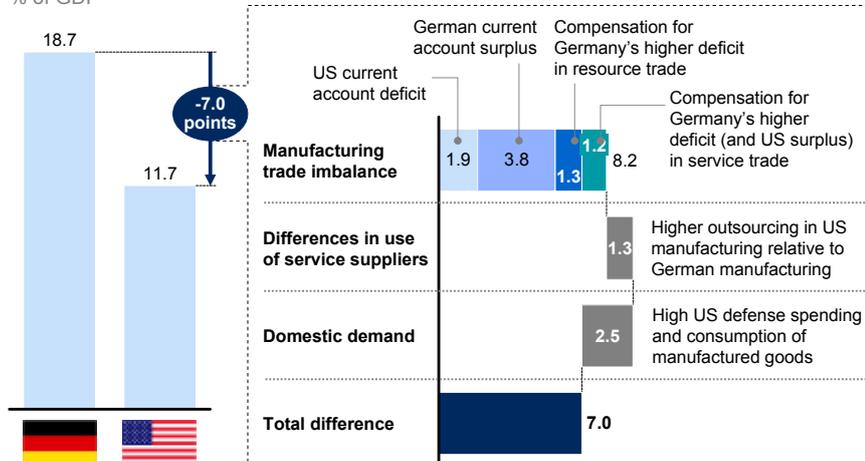
Higher use of service suppliers in the United States (for example, transportation, R&D, business services) contributes 1.3 points. US manufacturers acquire the equivalent of 24 percent of their output from such service providers, compared with 21 percent for German manufacturers.

Higher incomes of US consumers would normally widen the gap further. However, higher US household, business, and defense spending on manufactured goods offsets this effect and shrinks the gap between Germany and the United States by 2.5 points.

Exhibit 7

Differences in German and US manufacturing share of GDP reflect current account imbalances, trade specialization, outsourcing, and demand

Decomposition of the difference in the share of manufacturing in Germany versus United States, 2010 ESTIMATES
 % of GDP



SOURCE: OECD; Eurostat; BEA; McKinsey Global Institute analysis

1 D. Wilson and S. Ahmed, *Current accounts and demographics: The road ahead*, Goldman Sachs Global Economics paper number 202, August 2010.

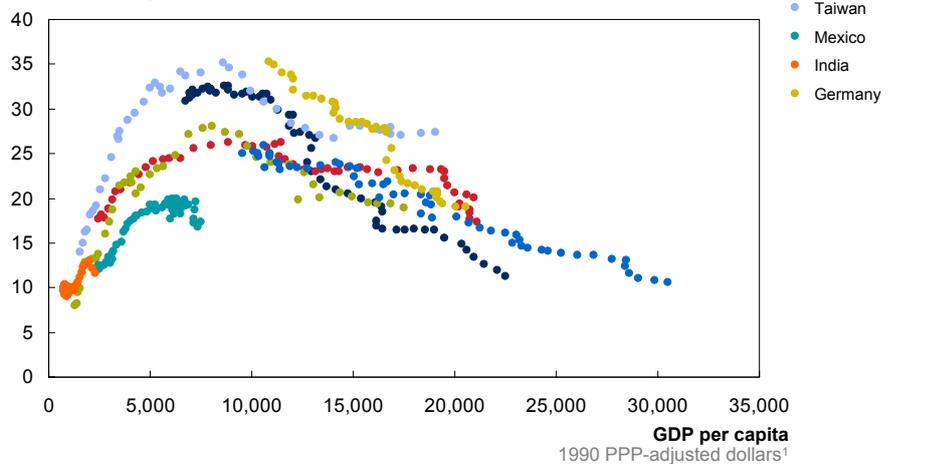
Manufacturing employment is rising globally but declining in all advanced economies including Germany and South Korea

Global manufacturing employment increased from roughly 270 million in 2000 to slightly more than 300 million by the end of the decade and accounted for around 14 percent of global employment. Virtually all the growth in manufacturing payrolls occurred in developing economies. In advanced economies, the level of manufacturing employment continues to fall, following the same inverted U pattern as manufacturing GDP (Exhibit 8).

Exhibit 8

Manufacturing's share of total employment falls as the economy grows wealthier, following an inverted U pattern

Manufacturing employment
% of total employment



¹ Adjusted using the Geary-Khamis method to obtain a 1990 international dollar, a hypothetical currency unit that allows international comparisons adjusted for exchange rates and purchasing power parity (PPP).
SOURCE: GGDC 10-Sector Database; "Structural change and growth accelerations in Asia and Latin America: A new sectoral data set," *Cliometrica*, volume 3, Issue 2, 2009; McKinsey Global Institute analysis

In China and India, manufacturing employment rose by nearly 30 percent between 2000 and 2008, as their workforces expanded and as these economies continued their transition from agrarian/rural to industrial/urban. Contrary to the expected pattern, Chinese manufacturing employment dropped in the 1990s, due to the restructuring of state-owned enterprises, and has grown rapidly since.

Manufacturing employment in advanced economies fell by 19 percent, from 63 million in 1998 to 50.5 million in 2008, due to automation, process optimization, and innovations in technology and organization, as well as accelerating growth in services; currently the total stands at about 45 million. The falloff was more dramatic in some economies, however. Japan shed 21 percent of manufacturing jobs from 1998 to 2008, the United States lost 26 percent, and the EU-15 nations lost 15 percent. South Korea shed 11 percent of manufacturing jobs from 2000 to 2009, and German manufacturing employment fell by 8 percent to about seven million.

Assuming that productivity grows at the same rate as in the decade prior to the crisis—about 2.7 percent per year—and demand levels and trade patterns do not shift dramatically, manufacturing employment in advanced economies is likely to fall from 12 percent of total employment (in 2010) to below 10 percent in those countries in 2030.¹⁰ Maintaining manufacturing employment at current levels would require an end to productivity growth or an increase of almost 50 percent

¹⁰ Based on a sample of advanced economies: EU-15, Japan, United States.

in manufacturing's share of final demand. Neither scenario seems probable or desirable.

While there has been a rebound in manufacturing hiring after the deep cuts during the Great Recession—US manufacturers added 480,000 jobs from February 2010 to September 2012—we do not anticipate any long-term change in the trend of manufacturing employment in mature economies. The US rebound so far has replaced only about 8 percent of the 5.8 million jobs lost from 2000 to 2010.

Shifting demand and productivity gains account for more changes in manufacturing employment than trade

Given the sharp decline in manufacturing employment in advanced economies in the past two decades, during which globalization opened up new, low-cost production capacity in developing economies, it appears that trade accelerated job losses. Indeed, from 1980 to 2000, US manufacturing employment fell by 1.5 million, or about 6 percent, but from 2000 to 2010, it fell by 33 percent—or by an estimated 5.8 million jobs.

By decomposing changes in employment levels, we can see more clearly the role that trade has played. In Exhibit 9, we look at three drivers of manufacturing employment: growth in domestic final demand, changes in net trade position, and differences in productivity growth. The results of our analysis show that productivity growth accounted for 3.7 million of the lost jobs.¹¹ This estimate is reduced by 600,000 to correct for cost savings related to offshoring, which we believe national accounts incorrectly record as productivity gains.¹² Those jobs are more properly grouped with the 700,000 trade-related job losses during the decade, bringing the total to 1.3 million. So we see that trade and offshoring explain around 20 percent of the decline in manufacturing jobs—still a significant force, but not the main driver of job loss.¹³

11 Our approach takes into account analytical difficulties that have been the subject of academic debate; in particular, it compensates for the vast measured productivity increases from performance improvements in computers and electronics and lower-cost offshored intermediate inputs. These measurement issues are the focus of an ongoing debate among economists about the measurement of value added, which uses hedonic deflation (i.e., adjusting for processing power and so on) in computers and electronics products and also includes profits from sourcing low-cost components. Metrics probably reflect the value delivered to consumers and businesses in mature economies reasonably well. But we take the position that this kind of hedonic deflation and accounting is not appropriate when looking at the number of jobs required to achieve a certain level of output. Correspondingly, we use non-deflated data for computers and electronics, which leads to a conservative downward revision to the impact of productivity in this sector. We also estimate the impact that lower-cost imports of components have on measured productivity and show the effects as offshoring gains explicitly rather than mixing them with other productivity effects. Of course, there are further uncertainties inherent to the national accounts source data. For instance, specialization along the value chain within sectors would affect productivity of the sector; our analysis suggests that the effect is moderate in aggregate, as there is both a shift toward high-value R&D activities and lower-value customer care. While we are not able to fully resolve issues inherent to source data, we believe our approach suggests that the key findings are robust even within the constraints of the data. See appendix for more detail on methodology. For a detailed discussion of measurement issues in manufacturing output, see R. Atkinson, L. Stewart, S. Andes, and S. Ezell, *Worse than the Great Depression: What experts are missing about American manufacturing decline*, The Information Technology and Innovation Foundation, March 2012.

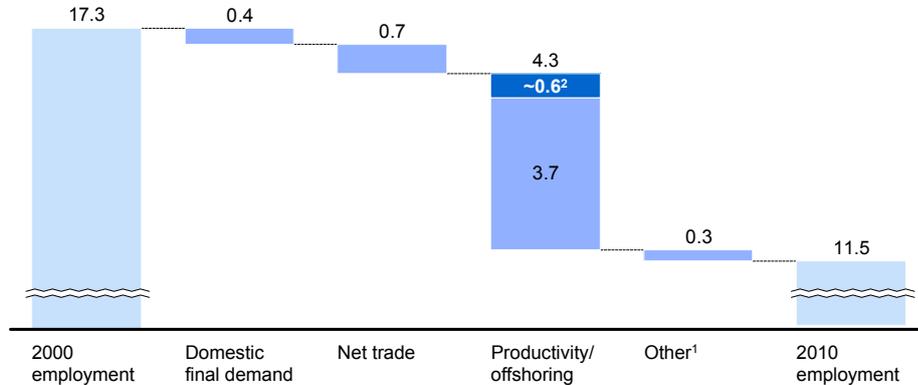
12 For a detailed analysis of offshoring biases, see Susan Houseman et al., "Offshoring bias in US manufacturing," *Journal of Economic Perspectives*, volume 25, number 2, Spring 2011.

13 Note that the figure of 20 percent is the net effect of trade over the decade and across sectors and trading partners. This does not preclude further negative transitional impact on individual companies, on specific industries, or with individual trading partners.

Exhibit 9

US manufacturing job losses in the past decade were driven mostly by productivity gains that were not matched by demand growth ESTIMATES

Contribution of various factors to US manufacturing job losses, 2000–10
 Million FTEs



1 Includes the multiplicative effect of productivity and demand combined; changes in value-chain compositions, e.g., increased outsourcing (-), more demand from outsourcers (+), or substitution of inputs; and residual differences.
 2 Cost savings from offshoring and low-cost imports; this leads to overstating of productivity metrics rather than being reflected in net trade.
 NOTE: Not to scale. Numbers may not sum due to rounding; FTE is full-time equivalent.
 SOURCE: BEA; Susan Houseman et al., "Offshoring bias in US manufacturing," *Journal of Economic Perspectives*, volume 25, number 2, Spring 2011; McKinsey Global Institute analysis

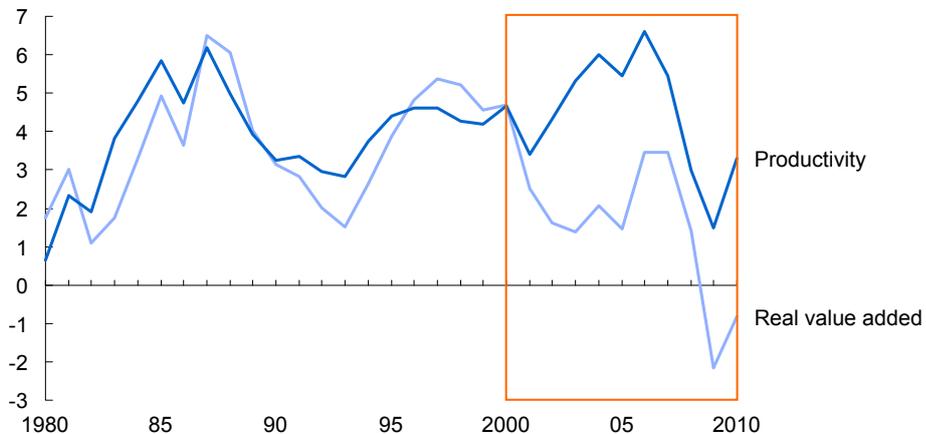
If we look at only productivity and demand, we also see that the collapse of demand during the past decade was the key departure from previous trends and caused manufacturing employment to "fall off a cliff" (Exhibit 10). While productivity growth continued to increase gradually, demand growth—which had kept up with productivity in the previous two decades—did not keep up in the 2000s.

Exhibit 10

After the global economic crisis, manufacturing productivity accelerated slightly while demand growth collapsed



US manufacturing value added and productivity growth
 5-year moving average of annual growth, 1980–2010¹



1 Adjusted by using a deflator of "1" for computer and electronics products to avoid effects of hedonic deflation; shorter averages used before 1982, as time series available only since 1977.
 SOURCE: Moody's Analytics; McKinsey Global Institute analysis

Trade-related manufacturing employment trends varied widely across industries, with some of the biggest losses in categories such as electronics, where there is a strong economic incentive to move labor-intensive production activities to low-wage nations. Products in these industries (such as computers and smartphones) have high value relative to weight, so transportation to the United States is cost-effective. According to our analysis, around half of the US electronics jobs lost from 2000 to 2010—or 400,000 jobs—were lost to trade, and we also assume that a large share of the job losses that national accounts show as productivity-related are concentrated in this segment.

Textiles and apparel are among the other manufacturing industries where job losses due to trade were exceptionally high. As China and other low-cost locations built up their textile and apparel industries, almost 300,000 US jobs (of 720,000 lost in total in those sectors) were lost to trade over the decade.

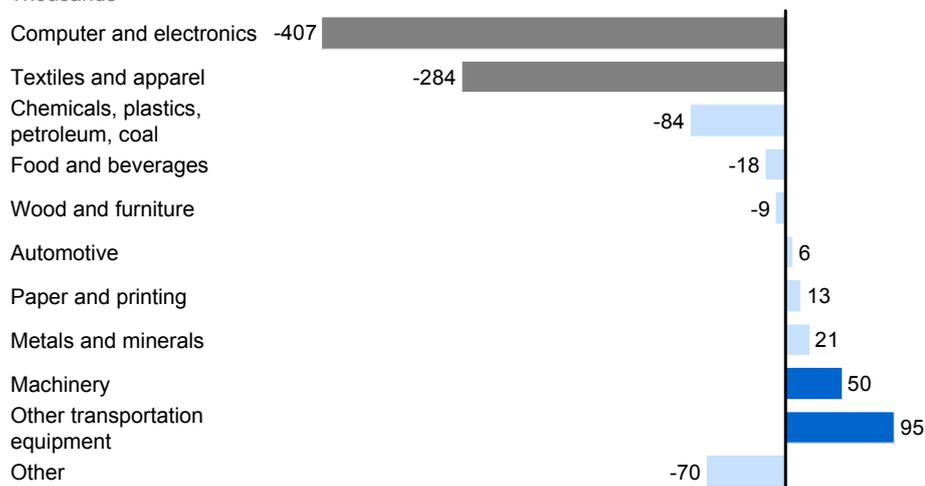
However, the bulk of US manufacturing employment—nearly 80 percent in 2008—remains concentrated in industries that are only partially traded and where offshoring is much less common than in the two globally traded segments. Some sectors, such as aerospace and machinery, even added employment as a result of trade (Exhibit 11).¹⁴

Exhibit 11

Most US job losses have been in apparel and electronics assembly; exports of machinery and “other transportation equipment” are up



Change in FTEs related to changes in the US trade balance, 2000–10
Thousands



SOURCE: Bureau of Economic Analysis; McKinsey Global Institute analysis

14 By using a multiplier approach, the net trade-related job losses or gains we show reflect changes in trade in a specific sector as well as changes in trade where the sector acts as a supplier. For instance, the 368,000 trade-related job losses in electronics not only reflect an increase in imports, but also include the electronics products that were exported in rising aircraft exports and the falling exports of cars with built-in electronics.

To put the trade-related job losses in perspective, if the United States were able to eliminate the entire 2010 current account deficit (3.2 percent of GDP) by increasing manufacturing exports, about 2.2 million jobs would be restored to the sector. While this is a sizable figure, it would bring US manufacturing employment back to 2007 levels but no higher.

This analysis is not intended to suggest that there is no need to strive to improve the competitiveness of US manufacturing. Competitiveness, particularly through innovation, should be a top priority for policy makers in high-wage economies that need to compete on factors other than cost. The thrust of manufacturing policy—if such policy is contemplated—should focus on value added, productivity, terms of trade, and efforts to build on the competitive advantages that manufacturing sectors have in the global economy.

It is no longer a given that manufacturing creates better-paying jobs

On an aggregate level, in advanced economies average compensation is higher in manufacturing than in services (17 percent higher in 2006, measured as total labor compensation including social security payments). However, if we cluster jobs by factor intensity, we find that compensation in manufacturing and services is similar. Jobs that are equally knowledge-, capital-, or labor-intensive offer similar compensation whether they are in manufacturing or services. There are also job categories in which services clearly offer higher compensation than manufacturing does. For example, if we look at jobs in all tradable industries, we find more jobs in well-paying tradable services such as business services than in manufacturing.¹⁵

The gap in average pay between manufacturing and services is also seen in wage distribution. In the United States, manufacturing has a disproportionately high number of well-paying jobs (700,000 more) and a disproportionately small number of low-paying jobs (720,000 fewer) compared with services (Exhibit 12). These differences may reflect trade effects (that is, low-paying, labor-intensive jobs moving offshore while jobs in knowledge-intensive activities expand domestically). Unionization, legacy wage arrangements, and better access to insurance and retirement benefits in manufacturing occupations also contribute to the 17 percent gap in total compensation.¹⁶

The spurt of hiring in manufacturing in the recovery from the Great Recession and reports of “re-shoring” assembly work to the United States have raised hopes that US manufacturing employment will rebound. Even if manufacturing job growth accelerates, these jobs are not likely to be “better” on average than those created in other sectors. US manufacturing compensation, in fact, has fallen recently: while overall employment cost (adjusted for inflation and occupation mix) increased slightly from December 2005 to June 2012, it dropped by 2.2 percent in manufacturing, according to the US Bureau of Labor Statistics.

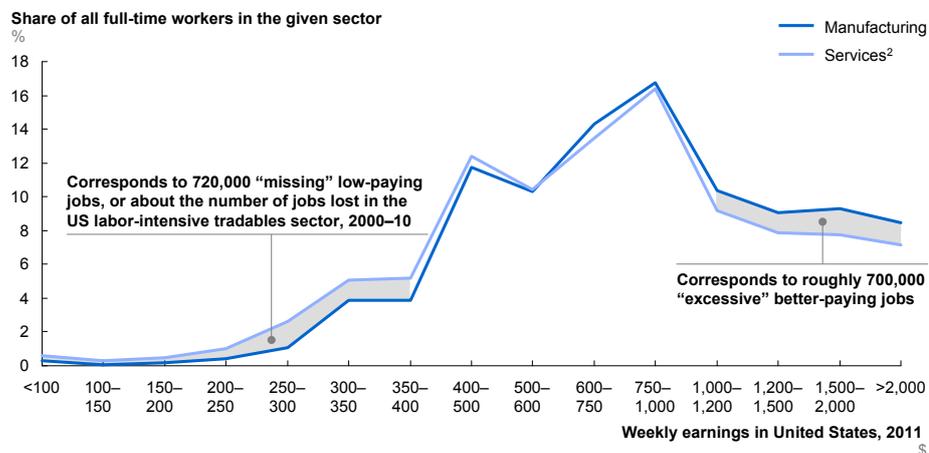
15 J. B. Jensen, *Global trade in services: Fear, facts, and offshoring*, Peterson Institute for International Economics, August 2011.

16 See David Langdon and Rebecca Lehrman, *The benefits of manufacturing jobs*, US Department of Commerce, May 2012. See also John Schmitt, *Unions and upward mobility for service-sector workers*, Center for Economic and Policy Research, April 2009.

Exhibit 12

In most pay bands, manufacturing and service pay is similar, but manufacturing has fewer low-end jobs and more high-paying ones 

US earnings¹ distribution of full-time, private-sector wage and salary workers, 2011



1 Actual return to the employee; rates are the amount stipulated for a given unit of work or time. It excludes benefits, irregular bonuses, retroactive items, payroll taxes, and earnings for those employees not covered under definitions of production employee, construction employee, or nonsupervisory employee.
 2 Includes utilities and construction.

SOURCE: Current Population Survey; McKinsey Global Institute analysis

Manufacturing continues to drive exports, but not as much as commonly used metrics suggest

The role of manufacturing in trade is important but is not always clearly understood. Manufacturing continues to dominate global trade, representing about 70 percent of the value of exports in both advanced and developing economies (Exhibit 13). However, services are gaining in importance and, we find, measures of manufactured exports overstate exported goods.

The trade figures distort the picture in two ways. By using the value of goods shipped to measure exports, the data fail to account for the impact of intermediate imports (for example, components sourced from abroad that went into the exported goods). Measuring this trade accurately is increasingly important because a rising volume of component and intermediate products is traded from one step in the value chain to another. In fact, the volume of manufactured goods trade can significantly exceed the sector's domestic value added. In the case of China, for example, overall exports as a percentage of GDP declines by almost half when the value of imported intermediate inputs is subtracted from gross export figures.¹⁷ In addition, inputs from service suppliers (everything from trucking to advertising) are measured as manufacturing exports. A far more insightful measurement of exports would account for the value added to an export in different sectors in each country that is part of the global value chain.¹⁸

17 See John Horn, Vivien Singer, and Jonathan Woetzel, "A truer picture of China's export machine," *The McKinsey Quarterly*, September 2010.

18 See Abdul Azeez Erumban et al., "Slicing up global value chains," June 2011, produced as part of the World Input-Output Database (WIOD) project funded by the European Commission and delivered at the World Bank workshop, "The Fragmentation of Global Production and Trade in Value Added." This paper introduced a global value chain (GVC) metric that shows in which countries value is being added along an industry value chain. The metric is based on the WIOD, which combines national input-output tables, bilateral international trade statistics, and production factor requirements. An important characteristic of GVC is the explicit recognition of national and international trade in intermediate products.

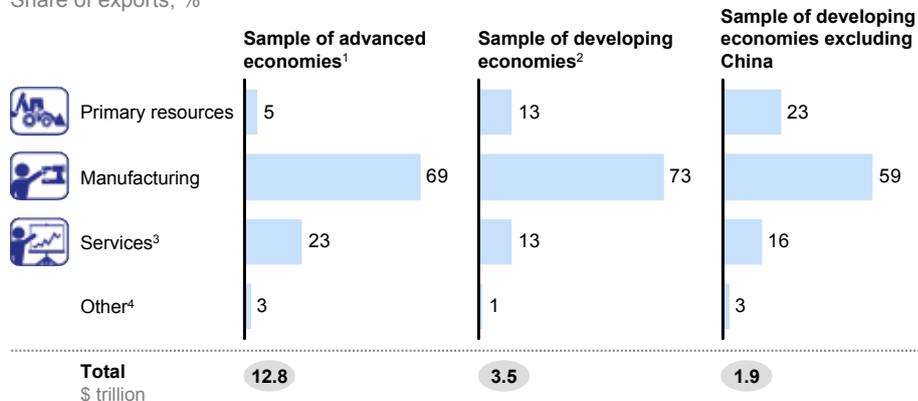
While manufacturing continues to drive trade patterns overall, the relative contribution of manufacturing and services to net exports varies. Some countries are net service exporters: Southern European nations ran a surplus equivalent to 1.6 percent of GDP in travel and transport services in 2009, for example, and the United Kingdom had a 3.8 percent surplus in financial and business services. Other countries, such as South Korea, are net manufactured goods exporters. Still others, such as Sweden, run surpluses in both services and manufactured goods, while countries such as Australia and Russia specialize in exporting natural resources. These different patterns stem from different endowments of natural resources and factors such as geography and savings and investment patterns, as well as strategic choices made by policy makers and companies.

Exhibit 13

Manufacturing drives roughly two-thirds of exports

Advanced and developing economies' exports

Share of exports, %



1 28 advanced economies: EU-15, plus Australia, Canada, Czech Republic, Hong Kong, Israel, Japan, Norway, Singapore, Slovakia, South Korea, Switzerland, Taiwan, and the United States.

2 Comprises eight developing economies: Brazil, China, India, Indonesia, Mexico, Russia, Thailand, and Turkey.

3 Since OECD has no service export data for Taiwan, Singapore, and Hong Kong, service export for them was estimated by applying IHS Global Insight's ratio of services-to-goods exports to OECD's goods exports figures.

4 Includes waste, recycling, and utilities (electricity, gas, and water).

NOTE: Numbers may not sum due to rounding.

SOURCE: OECD STAN; OECD EBOPS; UNCTAD (United Nations Conference on Trade and Development); IHS Global Insight; McKinsey Global Institute analysis

Manufacturing contributes disproportionately to national productivity growth and consumer surplus

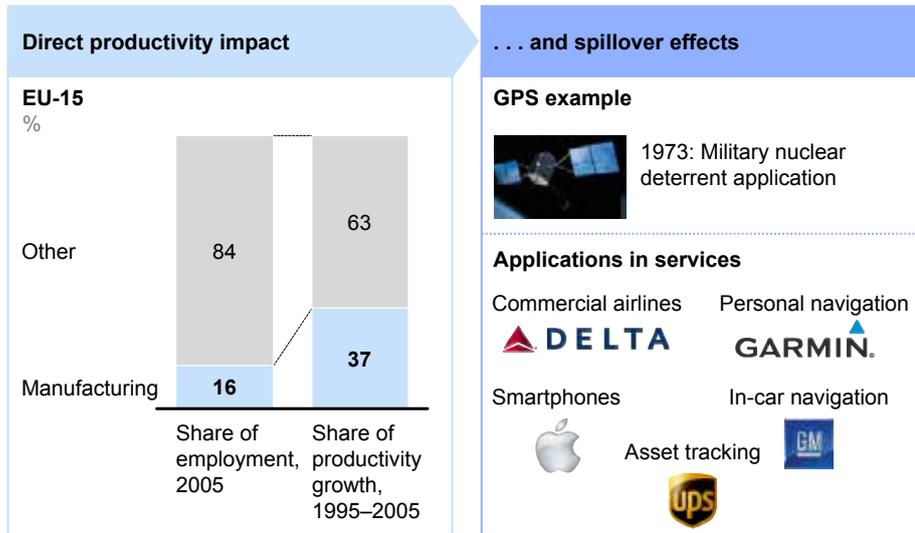
Manufacturing industries make strong contributions to productivity growth relative to their GDP shares across both advanced and developing economies, accounting for roughly one-third of overall productivity growth in the EU-15 nations and the United States between 1995 and 2005. This is more than twice manufacturing's share of employment (Exhibit 14).

One of the most obvious outcomes of rising manufacturing productivity has been a growing consumer surplus. Driven by the competitive pressure of increasingly global industries, companies have developed new and better products while reducing costs by improving processes or finding cheaper inputs. These gains have benefited companies through lower prices for the capital equipment they buy. In consumer categories, productivity gains have been passed on in the form of lower prices and improved quality and performance. The relative price of durable goods (those with a typical lifespan of more than three years, such as washing machines, refrigerators, and automobiles) has declined since the

mid-1980s (Exhibit 15). The quality-adjusted index of durable goods prices in the United States increased by only 7 percentage points between January 1985 and July 2011, compared with a rise of 118 points in the overall consumer price index, which was driven mostly by a 156-point increase in the cost of services.

Exhibit 14

Manufacturing contributes disproportionately to productivity growth, both directly and via technology spillovers

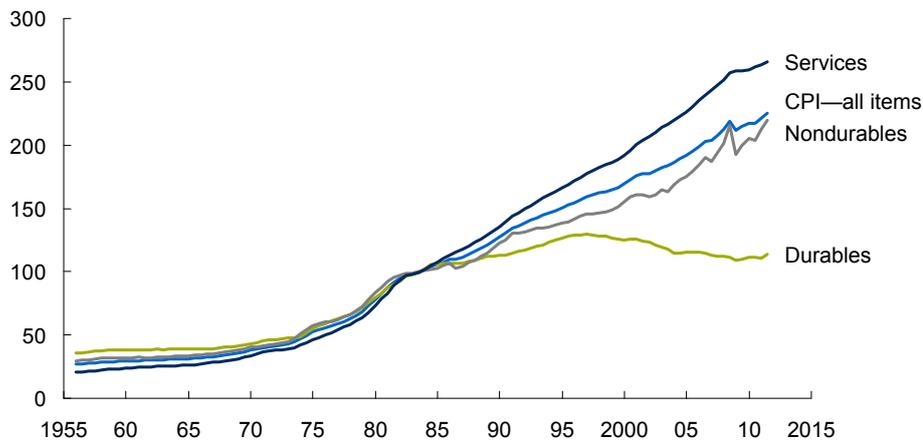


SOURCE: IHS Global Insight; BCC Research; IDC, May 2010; EU KLEMS; OECD STAN; McKinsey Global Institute analysis

Exhibit 15

Manufacturing productivity gains are passed on to consumers in the form of lower prices

Seasonally adjusted, monthly consumer price index (CPI) for US urban consumers (current series)
100 = 1982–84



NOTE: Uses seasonally adjusted monthly data for each January and July.

SOURCE: US Bureau of Labor Statistics (BLS); McKinsey Global Institute analysis

Manufacturing is core to R&D and broader innovation

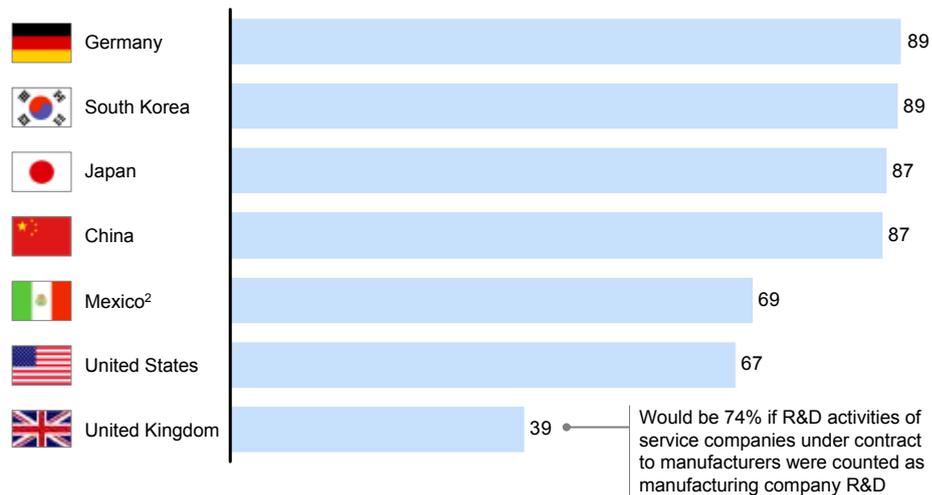
In addition to its contribution to productivity and consumer surplus, manufacturing is a disproportionately important driver of R&D. Many innovations and technologies that are developed in manufacturing also can be used to increase productivity in other sectors, multiplying the benefits beyond the manufacturing sector. In the 20th century, heavy machinery raised the productivity of agriculture and construction. More recently, manufacturing innovations have led to developments such as automated checkout systems in retail or RFID tags and global positioning systems (GPS) for transportation and logistics services.¹⁹

Among a small set of countries that we analyzed, manufacturing shouldered between 67 and 89 percent of business R&D expenses in 2008 (Exhibit 16), and in Germany, Japan, and the United States, manufacturing companies registered between 53 percent and 73 percent of all patents between 2007 and 2009. These data do not include the additional investment made through R&D service companies that do work for the manufacturing sector. Counting such investments in the United Kingdom, for example, would raise manufacturing's recorded 39 percent share of commercial R&D there to 74 percent. We acknowledge that R&D spending provides only a crude metric for actual innovation; it does not account for the effectiveness of research, nor does it capture the innovations in business models, processes, and organizations that arise outside of formal R&D functions.

Exhibit 16

Manufacturing accounts for most business R&D spending

Manufacturing share of business R&D in 2008¹
% of total business R&D



¹ These sectoral R&D figures are based on the main activity of the enterprise carrying out the R&D.

² Data from 2007 due to unavailability of newer data.

SOURCE: OECD ANBERD; Eurostat (for UK); UK Office for National Statistics; McKinsey Global Institute analysis

¹⁹ *How IT enables productivity growth*, McKinsey Global Institute, October 2002, and *Reaching higher productivity growth in France and Germany*, McKinsey Global Institute, October 2002. (www.mckinsey.com/mgi).

HOW PRODUCTION AND INNOVATION DEPEND ON ONE ANOTHER—AND HOW THEY DON'T

The extent to which manufacturers have moved production activities from advanced economies to offshore locations has raised concerns that R&D and manufacturing know-how will follow and also be “lost.”²⁰ While the concern is not misplaced—advanced economies have seen entire industries disappear—this is not an inevitable outcome.

Even in industries where innovation and production are tightly linked, companies don't automatically relocate R&D to their offshore production sites. In semiconductors, for example, a great deal of process-related innovation occurs at the nexus of design and production, but “fabless” chipmakers that rely entirely on outsourced fabrication capacity continue to innovate, often far from production facilities. Food processing companies must tailor their products to local tastes in places where they make and sell their products. Yet Nestlé develops many of its products for local markets such as India in Europe. To turn around new designs quickly, makers of mobile phones and other consumer electronics products need to engage with dozens of parts suppliers that cluster around Asian production sites. Even so, Apple continues to come up with its innovative iPhone designs in California. And German automotive companies are among the most global players, yet Volkswagen maintains most of its platform development in Wolfsburg.

Innovation follows different location criteria than production, and proximity requirements vary by type of R&D

Overall, the companies in advanced economies that lead in innovation have been far slower to globalize their R&D operations than production and marketing activities.²¹ The primary reason is that site selection for an R&D facility is guided by very different criteria. The R&D footprint is dictated primarily by access to research talent, customers, and suppliers who can provide important design input. In many manufacturing segments, it is also important to connect to knowledge clusters where the industry's best thinkers and most innovative companies come together. In contrast, the production footprint is dictated primarily by total landed costs.

The location of R&D is also influenced by the phase of research or development and the focus: basic research, product platform development, manufacturing process development, customer application development, and production support (Exhibit 17). For process development, for instance, proximity to production is typically of high importance.²² Collaboration with machine tool suppliers, essential for getting new designs into production, benefits greatly from close interaction at the plant, too. Yet the benefits of proximity to production—

20 Andy Grove, “How America can create jobs,” *Bloomberg Businessweek*, July 1, 2010.

21 See *Private Sector R&D: A global view* report by the Locomotive project, a European Commission program, August 2007; also see *Globalization of R&D and developing countries*, UNCTAD report, January 2005.

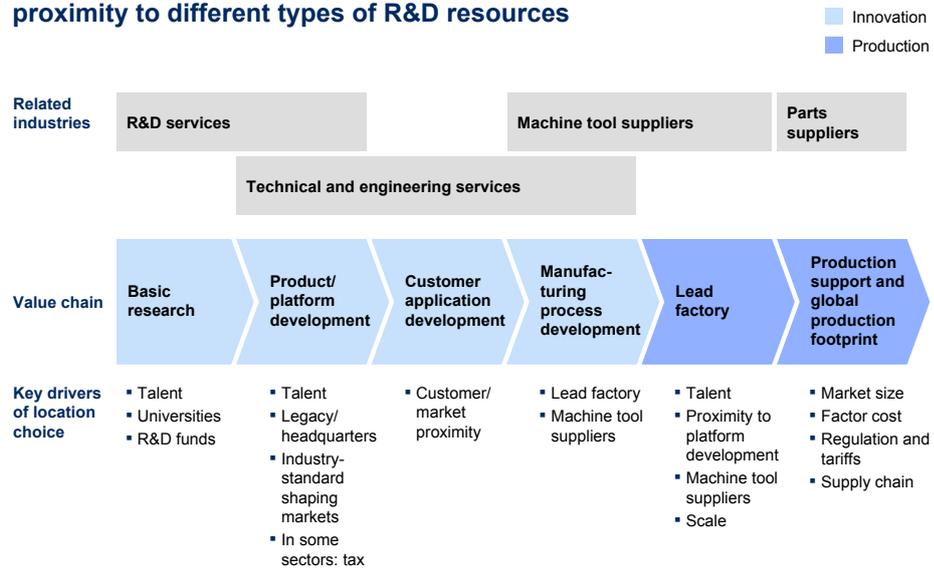
22 For more explanation of the importance of proximity of innovation and production to process development, see Gary P. Pisano and Willy C. Shih, “Does America really need manufacturing?”, *Harvard Business Review*, March 2012. The authors apply the twin concepts of modularity (or the degree to which product design can be separated from production) and maturity of the production process. These two concepts give rise to four relationship models between innovation and production: pure product innovation, pure process innovation, process-embedded innovation, and process-driven innovation. The authors point out that proximity of innovation and production is particularly important to the latter two models.

as well as to the industrial capabilities offered by machine tool suppliers, and technical, engineering, and R&D services—vary strongly by R&D stage. In the basic research stage, for example, company R&D facilities or partners may be located away from production and close to specialized research talent.²³

Exhibit 17

Different phases of innovation and production require proximity to different types of R&D resources

ILLUSTRATIVE



SOURCE: E. Abele et al., eds., *Global production: A handbook for strategy and implementation*; McKinsey Global Institute analysis

Many global manufacturers have chosen a “lead factory” model that concentrates process development at the lead plant (often the headquarters plant). The platforms, processes, and applications that are developed and standardized in the lead factory, are then codified and disseminated to branch factories. So even as Toyota production has spread to markets around the world, its central R&D labs are still located in Japan’s Aichi prefecture, site of the Toyota City complex. And German automotive companies, which are among the most globalized in the world and employ more than 500,000 workers outside Germany, also maintain lead factories at home, amid clusters of R&D facilities, machine tool suppliers, and component makers.²⁴ Volkswagen’s platform development, for example, is still located at its group research site in Wolfsburg, Germany. For similar reasons, Detroit remains a center of global automotive innovation even though the percentage of global output originating in Detroit has fallen and Detroit-based automakers and suppliers run production facilities all over the world.

Other criteria can also tilt the R&D location decision toward the lead factory or home country. Most pharmaceutical R&D, for example, is still concentrated in advanced economies due to intellectual property protection, availability of talent, and access to the consumers who demand early-lifecycle drugs. Pharmaceutical R&D location choices are also influenced by favorable tax policies and other incentives that nations such as Ireland offer.

²³ See Eberhard Abele et al., eds., *Global production: A handbook for strategy and implementation*, McKinsey & Company and Darmstadt University of Technology (Berlin: Springer Verlag, 2008).

²⁴ Eurostat foreign affiliate trade statistics.

Industry innovation cycles and the complexity of manufacturing also influence choice of R&D location

The complexity of the production process and the degree of innovation required in the industry dictate strong links between R&D and production. In industries with simple processes and low R&D intensity, production and development can be separated more easily. Exhibit 18 shows how an industry’s need for innovation and the complexity of production processes push companies toward co-locating R&D and production.²⁵

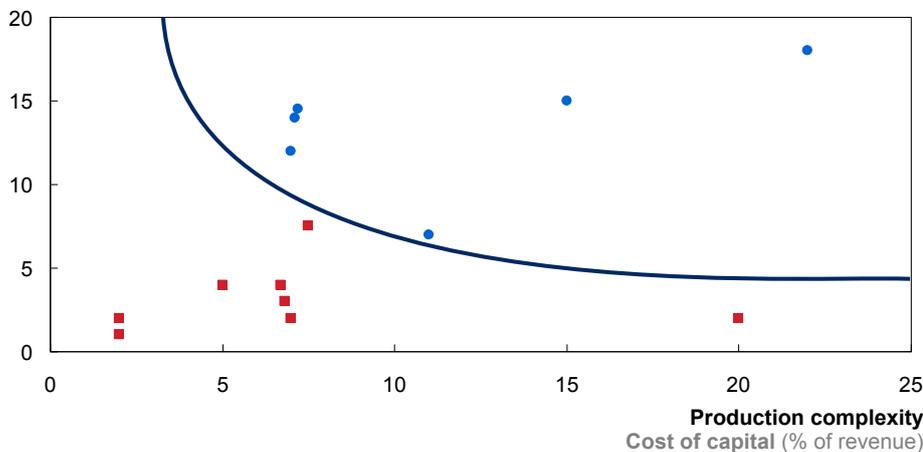
Exhibit 18

Complexity of production and level of innovation determine need for co-locating R&D and production

Drivers of R&D co-location

Innovation level of industry
 R&D intensity (% of revenue)

- Minimal co-location of R&D and production
- More extensive co-location of R&D and production



SOURCE: McKinsey & Company and Darmstadt University of Technology’s ProNet (production network) survey of more than 100 managers at 54 manufacturing companies; McKinsey Global Institute analysis

Even in industries with complex production processes and rapid product cycles, innovation and production can continue in different locations. The flat-panel displays that are now ubiquitous in everything from GPS systems to high-definition TVs are a classic example of a manufacturing sector that became concentrated in Asia. The basic technologies were created in labs in the United States and Europe, but mass production quickly moved to Japan, then to South Korea and Taiwan, following massive investments in production capacity in those nations.²⁶ Yet two decades later, several US companies remain leading innovators. Applied Materials and Corning have managed to stay close enough to their customers in Asia to maintain leads in liquid crystal materials, glass surfaces, chemical deposition techniques, and testing equipment.²⁷ Similarly, in

25 The chart data are from a survey by McKinsey & Company and ProNet (production network run by Darmstadt University of Technology) of more than 100 managers at 54 companies. Circles represent companies that extensively co-located R&D and production; squares represent companies that did not. The chart plots responses against innovativeness (R&D intensity) and process complexity (measured as cost of capital). The curved line indicates the “frontier” that separates extensive co-location from less co-location. See Eberhard Abele, et al., eds., *Global Production: A handbook for strategy and implementation*, McKinsey & Company and Darmstadt University of Technology (Berlin: Springer Verlag, 2008).

26 Jeffrey T. Macher and David C. Mowery, eds., *Innovation in global industries: U.S. firms competing in a new world (collected studies)*, Committee on the Competitiveness and Workforce Needs of U.S. Industry, National Research Council, 2008.

27 Ibid.

semiconductors, many fabless integrated circuit (IC) manufacturers based in the United States don't own any production capacity. Nevertheless, they manage to remain competitive in innovation and sales. Qualcomm, Broadcom, AMD, Nvidia, and other US companies captured eight of the ten top places in a 2011 sales ranking of global fabless IC suppliers by market researcher IC Insights.²⁸

Innovation is not a zero-sum game: A loss in one sector does not necessarily mean a loss of national competitiveness

Finally, innovation is not a zero-sum game. Flat-panel innovation in Asia, for example, benefits US and European businesses and consumers just as much as it does Asian customers. Moreover, losing the footprint of an industry to another location should be a concern only if the industries that spring up or expand to use the capacity and talent of the old industry are clearly less competitive. If the new industries can command better terms of trade, or enable higher productivity in the economy than the activities that they replace, the nation benefits. Germany, for instance, has largely ceded its position in consumer electronics, yet it is hailed as a global manufacturing powerhouse that is known for innovative design and engineering and runs a large trade surplus in manufactured goods.

THE DEFINITION OF MANUFACTURING IS CHANGING: THE MANUFACTURING/SERVICES DIVIDE HAS BLURRED

To understand the future of manufacturing, we need a definition that better reflects how the field is evolving. The growth of service jobs and service inputs in manufacturing makes the manufacturing/services divide anachronistic. Similarly, in a world of global supply chains, an accurate accounting of value added must include intermediate inputs of services involved in manufacturing. Finally, the traditional manufacturing/services perspective does not account for the synergies between the two economic realms—how each creates demand and employment in the other. The old manufacturing/services divide obscures a complete and accurate view of the role of manufacturing in the economy.

Manufacturing includes more service-like activities, performed by manufacturers and service suppliers

Manufacturing has always included a range of activities in addition to production. Over time, service-like activities—such as R&D, marketing and sales, and customer support—have become a larger share of what manufacturing companies do. More than 34 percent of US manufacturing employment is in such service-like occupations today, up from about 32 percent in 2002 (Exhibit 19).

At the same time, manufacturing companies rely on a multitude of service providers to produce their goods. These include telecom and travel services to connect workers in global production networks, logistics providers, banks, and IT service providers. In the United States, nearly one-quarter of manufacturing output is derived from service inputs (Exhibit 20).

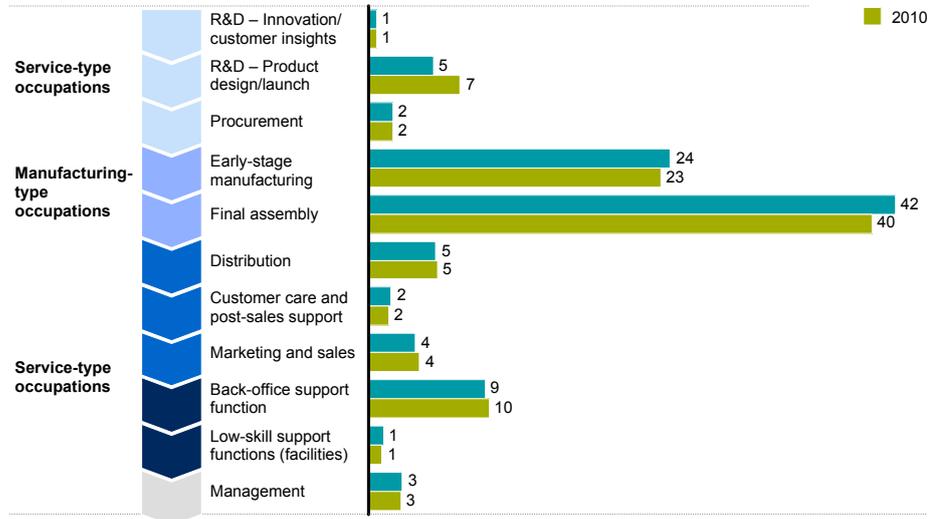
²⁸ IC Insights, April 2012.

Exhibit 19

The share of service-type jobs in manufacturing increased by 2.4 percentage points in the United States between 2002 and 2010



% of total manufacturing employment



NOTE: Numbers do not sum to 100% because a residual "other category" is not included.

SOURCE: BLS; McKinsey Global Institute analysis

Exhibit 20

Share of service inputs in manufacturing output varies from 24 percent in the United States to 15 percent in China

Intermediate services input purchases as share of manufacturing total, mid-2000s
Gross output (nominal), %



SOURCE: OECD STAN; McKinsey Global Institute analysis

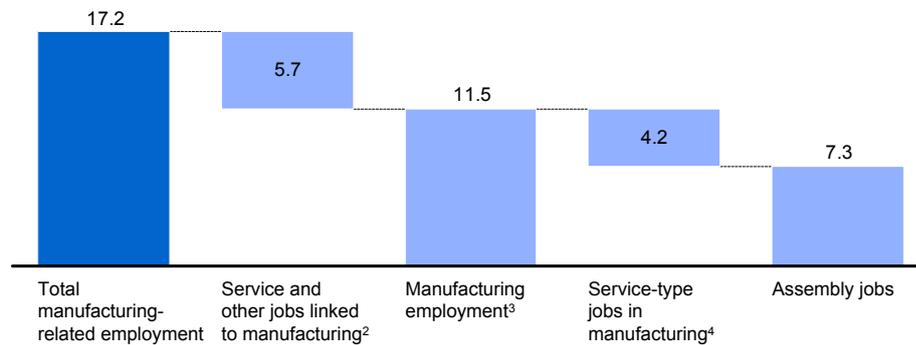
This leads to different views of manufacturing-related employment. In the United States, there were around 7.3 million production jobs in 2010. Adding in service-type activities in manufacturing brings the number of jobs registered in national accounts in the manufacturing sector to 11.5 million. Adding jobs created through purchases by manufacturing companies from service providers (4.7 million) and primary resource companies (one million) brings total US manufacturing-related employment to 17.2 million (Exhibit 21).

Exhibit 21

In the United States, production jobs make up less than half of total manufacturing-related employment

US manufacturing employment, 2010¹

Million



¹ Employment is total FTEs plus self-employed.

² 4.7 million jobs in services and 1 million jobs in primary resource industries that are directly and indirectly linked to manufacturing. Employment multipliers were applied to import-adjusted final demand for manufacturing. Employment multipliers were calculated applying employment to output ratios to the output multiplier table. Output multipliers were advanced using an import-adjusted input-output table.

³ Manufacturing employment as reported by the US Bureau of Economic Analysis.

⁴ Non-production jobs in manufacturing sectors, such as product R&D, marketing and sales, customer care and service, back-office functions, and facilities management.

SOURCE: BEA; BLS; McKinsey Global Institute analysis

Manufacturing exports embody uncounted service exports

Similar to the way in which many types of published trade volume data do not capture the value of intermediate goods in manufacturing exports, they do not reflect the true role of service inputs and service value added to manufacturing in a nation's exports. These sources of value added include services such as the engineering and design, transportation, and business services used to produce a manufactured good. Nor do the data account correctly for the telecommunications equipment or vehicles purchased in order to support an outsourced call center or transportation service.

Taking into account this more complete measure of manufacturing value added alters the picture of trade substantially. We conducted an analysis based on input-output table data for Germany, a manufacturing export powerhouse that officially generates 81 percent of gross exports from manufactured goods (Exhibit 22). We find that imported components and services make up more than half of the value added of these exports. In contrast, while service-sector exports equal only 7 percent of GDP, nearly all of the value added is domestic. Overall, service value added contributes the equivalent of 13 percent of GDP to exports—almost equal to the 15 percent of GDP contributed by manufacturing value added.²⁹ In both the United Kingdom and the United States, domestic service value added in exports

²⁹ The total is reached by adding up service value-added in services exports plus the service value added embedded in manufacturing exports.

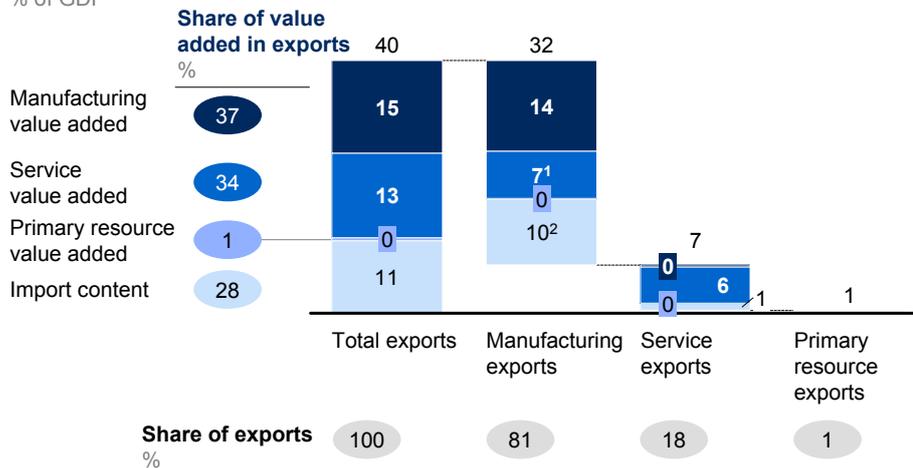
exceeds domestic manufacturing value added in exports (49 percent versus 32 percent in the United States).

Exhibit 22

The service component of German manufacturing is about the same as total German service exports



Share of value added of exports, 2009
 % of GDP



1 Includes third-party logistics, IT, legal, management consulting, and other business services.
 2 Imported components such as electronic parts from Asia or auto engines from Eastern Europe.
 NOTE: Numbers may not sum due to rounding.
 SOURCE: OECD; McKinsey Global Institute analysis

At the same time, service industries, notably business and financial services, are becoming more and more globally traded. Knowledge-intensive services have achieved a particularly strong trade performance since 2000. Despite fears that such jobs are threatened by offshoring, knowledge-intensive services contributed a trade surplus equivalent to 0.7 percent of GDP for advanced economies in 2008.³⁰ Experts expect service exports to continue to grow. Of 53 million export-related jobs in 2009 in the EU-15 (excluding EU internal trade), Japan, and the United States, around eight million are related to knowledge-intensive service exports. Another eight million export-related jobs were in labor-intensive service industries, such as travel.

Manufacturing and services are synergistic, and both sectors have strong multiplier effects

Manufacturing is often hailed for its spillover effects on local services, the creation of demand and income, and high employment multipliers. In reality, though, a boost in final demand in services typically creates more jobs than a boost in manufacturing output. In other words, most service industries exhibit higher values in final demand to employment multipliers (Exhibit 23).

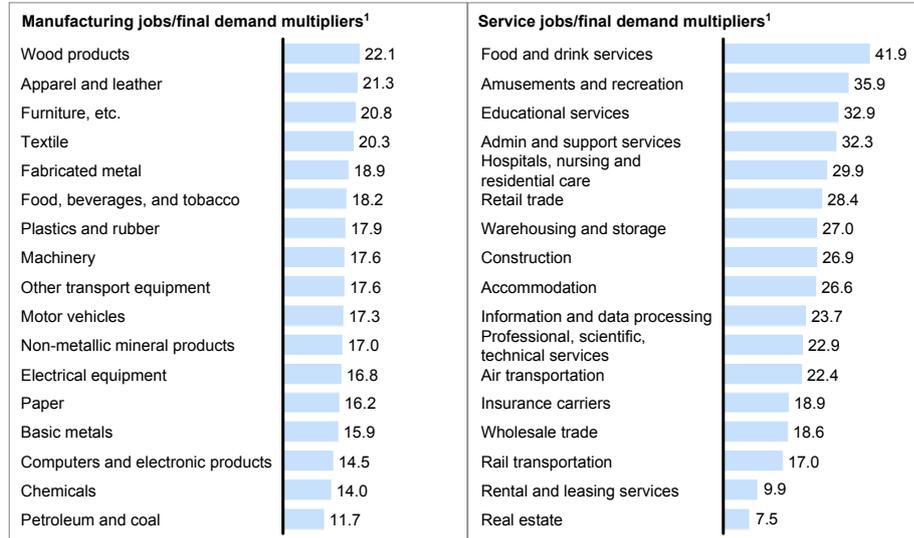
In addition, just as manufacturing creates demand for service inputs, services create demand for manufactured goods. In the United States in 2010, every dollar of manufacturing output used 19 cents of service inputs, while every dollar of service output used 7 cents of manufacturing input. Overall, manufacturing created more than \$900 billion a year in demand for service inputs, while service companies generated \$1.4 trillion of demand for manufactured goods. A similar pattern is observable in developing economies: China's manufacturers created

30 Based on a sample that includes the EU-15, Japan, and the United States.

demand for \$500 billion in services, while its service companies created demand for \$600 billion in manufactured goods inputs (Exhibit 24).

Exhibit 23

The multiplier effects of additional jobs in services are typically higher than in manufacturing



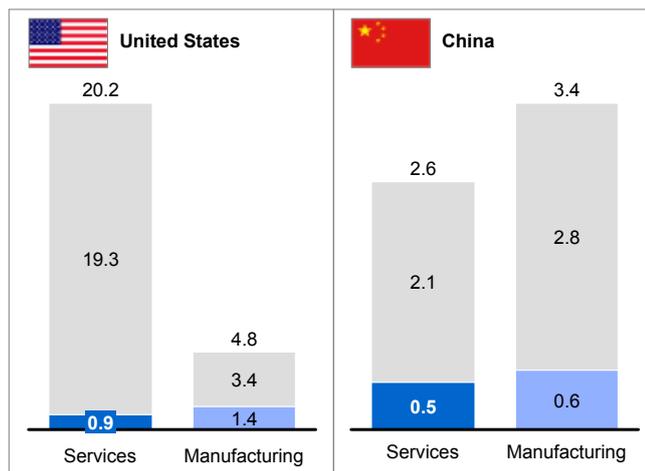
¹ Domestic jobs; includes direct effects from producers, indirect effects in supply chain, effects from increased income.
 SOURCE: Regional Input-Output Modeling System (RIMS II), Regional Economic Analysis Division, BEA; McKinsey Global Institute analysis

Exhibit 24

Services drive demand for manufactured goods and vice versa

Gross output¹
 \$ trillion

Other demand
 Intermediate demand from manufacturing
 Intermediate demand from services



¹ Mid-2000s domestic only for China; 2010 including imports/exports for the United States.
 NOTE: Not to scale. Numbers may not sum due to rounding.
 SOURCE: BEA; OECD; McKinsey Global Institute analysis

Policy makers have long sought to build up manufacturing industries to create employment, raise incomes, and create demand for service businesses in their regions. It is true that manufacturing creates income and demand for local economies: because manufacturers typically produce goods for sale outside the local economy, the net exports generated add to local aggregate demand and income, and they act as a stimulus that cascades through the local economy—an effect particularly desirable in economically depressed areas. This effect, however, is not exclusive to manufacturing. It is inherent in the nature of tradable activities and holds true just as much for tradable service activities such as corporate headquarter functions, wholesale financial services, business services, tourism, or transport. London’s financial services district, Bangalore’s IT services cluster, or Hawaii’s tourism economy are just a few examples. In the United States, the number of tradable service jobs today vastly exceeds the number of tradable manufacturing jobs.³¹



Manufacturing will continue to matter a great deal to both developing and advanced economies. However, the way manufacturing contributes to national economies and competitiveness changes over time as economies grow wealthier. And manufacturing itself is evolving. Distinctions between manufacturing and services are blurring. Manufacturing industries are increasingly large users of service inputs and employ many workers in service roles. They are also service providers. Service industries are joining manufacturing as sources of export growth and innovation. Understanding how manufacturing and its role in national economies are evolving is critical to devising policy and manufacturing sector strategy.

31 J. B. Jensen, *Global trade in services: Fear, facts, and offshoring*, Peterson Institute for International Economics, August 2011.

2. The five segments of global manufacturing

A great challenge for policy makers and business leaders seeking to improve competitiveness in manufacturing is understanding the broad range of industries, which vary substantially in the nature of their products, operations, and competitive dynamics. Steel and aluminum plants are resource- and energy-intensive and their products are heavy and bulky, so the most important factors for success in those industries include easy access to raw materials, low-cost energy, and inexpensive transportation. By contrast, the basis of success for makers of medical products or semiconductors is their ability to innovate and bring new products and technologies to market. Their biggest requirements are skilled workers and access to capital to finance R&D and production equipment.

To understand the characteristics that are most relevant to success across various manufacturing industries, we classify manufacturing industries into five global groups, based on shared characteristics. Industries in each group have similar sources of competitiveness and share important factor inputs and geographic requirements, such as the need for proximity to certain types of transportation infrastructure. These groups are quite broad and include subsectors that may not conform precisely to the general pattern of the group.

We believe this segmentation provides a useful framework for assessing the needs of different kinds of manufacturing industries. For companies, it is a way to understand the evolution of different parts of their businesses—business units, individual products, and even stages of supply chains. In the automotive industry, for example, suppliers of electronic components respond to very different dynamics than suppliers of mechanical parts, and suppliers of rubber and plastic components respond to still another set of dynamics. Even within industry segments, requirements vary: a carmaker that emphasizes its technological edge and precision engineering has very different requirements than a producer of low-cost, high-value products. Segmentation provides a way to understand the positioning of companies and industries and the factors that influence their evolution.

For policy makers, we believe this analytical framework can help governments isolate the factors that are most important to the success of manufacturing in their nations or regions. To craft actual strategy, however, they will need to develop a more detailed view of their specific industries.

In this chapter we describe how we created our groups and the ways in which they differ, and then we provide an in-depth look at each. To create our groups, we first look at three overarching factors that drive location choices and competitiveness: the cost composition of factor inputs, or the portion of total costs consumed by labor, capital, and raw materials, including energy; the degree of innovation, or the speed of technological change and degree to which commercializing new technologies and innovations determines success; and tradability, or the degree to which goods are traded globally in the sector and the

degree of freedom (or limitations) companies have in choosing where they want to locate facilities and export output.

We used six measures to evaluate manufacturing sectors on their cost composition, innovation, and tradability (see Box 3, “Framework for segmenting manufacturing industries”), which enabled us to identify five distinct global groups. The groups are named to reflect their most important characteristics and range from “global innovation for local markets” to “labor-intensive tradables” (Exhibit 25). For example, in the global innovation for local markets group, which includes such industries as automobiles, equipment, and machinery, R&D is a large cost and competition revolves around innovation and new products. But the nature of the products limits their tradability and ties them to local markets.

In the labor-intensive tradables group, which includes industries such as textiles and apparel, low-cost production is critical to success and end products are shipped from low-cost production sites to customers around the globe. In only two segments does significant global trade occur for finished goods, and they are at opposite ends of the skill spectrum: labor-intensive tradables such as apparel, and global technologies segments such as semiconductors and electronics. The remaining three segments are marked by varying degrees of local or regional focus, driven by access to markets, resources, or knowledge clusters, and by costs of shipping relative to product value. In these segments trade is limited to specific products, short distances, or intermediate goods.

Exhibit 25

Manufacturing is diverse: We identify five broad groups with very different characteristics and requirements

 % of global manufacturing value added

Sector	Traits	Industry examples
Global innovation for local markets  34	<ul style="list-style-type: none"> Competition based on innovation and quality; high R&D intensity¹ (5–25%) Some components traded globally (40–50% trade intensity²) with more regional assembly and production 	<ul style="list-style-type: none"> Chemicals and pharmaceuticals Transport equipment including automotive Machinery, electrical machinery, appliances
Regional processing  28	<ul style="list-style-type: none"> Low tradability (5–20% trade intensity²) Highly complex and costly logistics Freshness requirements, and local tastes drive proximity need Relatively automated; little R&D 	<ul style="list-style-type: none"> Rubber and plastics Fabricated metals Food and beverages Printing and publishing
Energy-/resource-intensive commodities  22	<ul style="list-style-type: none"> Provide commodity-type inputs to other sectors; low tradability Energy- and resource-intensive (energy intensity³ 7–15%) Price competition; little differentiation 	<ul style="list-style-type: none"> Wood products Paper and pulp Basic metals Minerals-based products Refined petroleum, coke, and nuclear products
Global technologies/innovators  9	<ul style="list-style-type: none"> Competition based on R&D and cutting-edge technology, with high R&D intensity¹ (25–35%) Highly tradable (55–90% trade intensity²) in both components and final products 	<ul style="list-style-type: none"> Computers and office machinery Semiconductors and electronics Medical, precision, and optical equipment
Labor-intensive tradables  7	<ul style="list-style-type: none"> High labor intensity⁴ (30–35 hours per \$1,000 value added) High exposure to price competition Globally traded (50–70% trade intensity²); low proximity needs 	<ul style="list-style-type: none"> Textiles, apparel, leather Furniture, jewelry, toys, and other manufactured goods not classified elsewhere

1 R&D intensity = R&D expenditure divided by value added (nominal), US, 2007.
 2 Trade intensity = Exports divided by gross output (nominal), world, 2006-10 average.
 3 Energy intensity = Cost of purchased fuels and electricity divided by value added (nominal), US, 2010.
 4 Labor intensity = Hours worked per \$1,000 value added (nominal), EU-15, 2007.
 SOURCE: OECD; 2010 Annual Survey of Manufactures; US 2007 Commodity Flow Survey; IHS Global Insight; McKinsey Global Institute analysis

Box 3. Framework for segmenting manufacturing industries

To understand the differences among manufacturing sectors, we look at criteria about cost, innovation, and tradability. Within the cost criteria we use three parameters—capital intensity, labor intensity, and energy intensity (Exhibit 26). For innovation, we consider R&D intensity, measured as R&D expenditure as share of value added. Finally, to assess tradability, we use two parameters—trade intensity, measured as exports' share of industry gross output (global sample, 2006–10) and value density or bulk-to-value ratio (US data).¹

Exhibit 26

Industries are grouped on the basis of cost, innovation, and tradability

Legend: High (Dark Blue), Upper-middle (Medium Blue), Lower-middle (Light Blue), Low (Very Light Blue)

Group	Industry	R&D intensity ¹ %	Labor intensity ²	Capital intensity ³ %	Energy intensity ⁴ %	Trade intensity ⁵ %	Value density ⁶
Global innovation for local markets	Chemicals	25	10	50	5	42	1
	Motor vehicles, trailers, parts	16	14	32	2	39	8
	Other transport equipment	25	19	29	1	42	8
	Electrical machinery	6	17	30	2	46	7
	Machinery, equipment, appliances	8	18	32	2	48	8
Regional processing	Rubber and plastics products	3	21	33	5	21	3
	Fabricated metal products	1	23	28	3	14	3
	Food, beverage, and tobacco	2	23	40	4	15	1
	Printing and publishing	2	19	33	3	4	3
Energy-/resource-intensive commodities	Wood products	1	31	35	7	13	0.5
	Refined petroleum, coke, nuclear	1	6	56	10	21	0.4
	Paper and pulp	2	18	37	10	24	1
	Mineral-based products	3	20	39	11	14	0.1
	Basic metals	1	14	41	14	26	1
Global technologies/innovators	Computers and office machinery	25	15	41	1	91	72 ⁷
	Semiconductors and electronics	33	15	38	1	60	
	Medical, precision, and optical	35	17	40	1	57	
Labor-intensive tradables	Textiles, apparel, leather	2	35	31	5	50	5
	Furniture, jewelry, toys, other	2	30	33	1	69	4

1 R&D expenditure divided by value added (nominal), US, 2007.

2 Hours worked per \$1,000 value added (nominal), EU-15, 2007.

3 Gross surplus divided by value added (nominal), world, 2006-10 average.

4 Cost of purchased fuels and electricity divided by value added (nominal), US, 2010.

5 Exports divided by gross output (nominal), world, 2006-10 average.

6 Value of shipments divided by weight of shipments (\$ thousands per ton), US, 2007.

7 Value density for these industries based on aggregate data provided for computer and electronic products.

SOURCE: IHS Global Insight; OECD; ASM 2010; US 2007 Commodity Flow Survey; McKinsey Global Institute analysis

Due to data limitations, these groups are based on two-digit industry codes, which masks diversity within industries. Chemicals includes bulky, commodity-type products with relatively low trade intensity, sharing many of the characteristics of the industries within the energy- and resource-intensive commodities group, as well as R&D-intensive pharmaceuticals that have high value density and tradability. Food manufacturing has very low trade overall, but some products such as powdered milk and frozen seafood are heavily exported. Understanding the drivers of competitiveness in each industry can help manufacturing leaders set strategy and better inform policy debates.

1 Global sample refers to IHS Global Insight sample of 75 countries; cost of purchased fuels and electricity obtained from US Annual Manufacturers Survey data, 2010; bulk-to-value ratio calculated from US Commodity Flow Survey data, 2007.

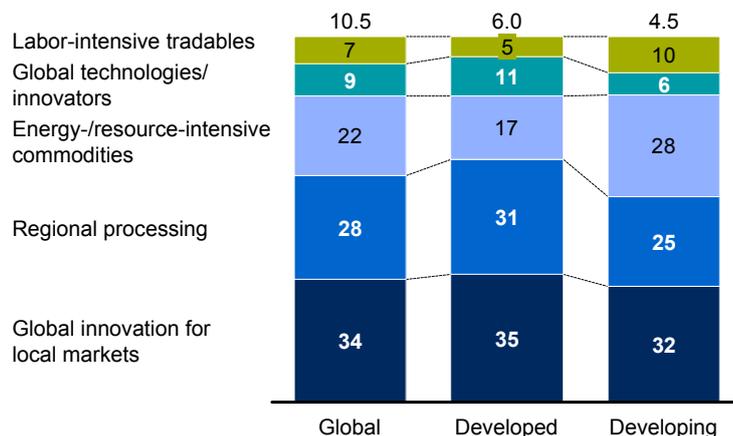
The largest of the five groups, based on value added, is “global innovation for local markets.” The smallest is “labor-intensive tradables” (Exhibit 27).

Exhibit 27

The largest of the five groups is global innovation for local markets, accounting for 34 percent of global manufacturing value added in 2010

Manufacturing gross value added by group and region, 2010

%; \$ trillion



NOTE: Calculations compiled bottom up from all two-digit ISIC manufacturing industries from IHS Global Insight, excluding (D37) Recycling, as well as 75 of the largest economies, of which 28 are advanced and 47 are developing. There might be a discrepancy between the manufacturing total here and manufacturing aggregate value added as this total is calculated bottom up. Numbers may not sum due to rounding.

SOURCE: IHS Global Insight; McKinsey Global Institute analysis

The regional processing group is the largest employer in advanced economies, followed by the global innovation for local markets group. In developing economies, the global innovation for local markets group is the biggest employer and the regional processing group is the second biggest (Exhibit 28).³²

The global technologies/innovators, regional processing, and global innovation for local markets groups are somewhat more common in advanced economies, where these industries generate around 60 percent of total global group value added (Exhibit 29).³³ Companies in the energy- and resource-intensive commodities group tend to be concentrated in developing economies that have large reserves of natural resources, such as Brazil, Indonesia, and Russia.³⁴ Because of their low wage rates, developing economies also have many companies in the labor-intensive tradables group. This geographic distribution is mirrored in trade profiles: advanced economies have surpluses of industries in the global innovation for local markets group, while industries in the labor-intensive tradables group drive exports from developing economies. China and some other developing economies also have surpluses in goods produced by the global technologies/innovators group, such as electronics products.

32 Granular industry-level employment data are not available on a global basis. We use 2007 employment data for advanced economies (EU-15, Japan, United States) and a small sample of developing economies: Brazil, China (2008 data used because earlier census data are not available), Indonesia, Mexico, Russia, and Turkey. Employment numbers for developing economies are based on the paid manufacturing employment data from ILO Laborsta. These data include only paid employment, and in some cases only companies above designated sizes are counted in the data. The bottom-up total manufacturing employment number may fall below the aggregate, top-down manufacturing employment number. However, these data give a good picture of the distribution of employment by sectors.

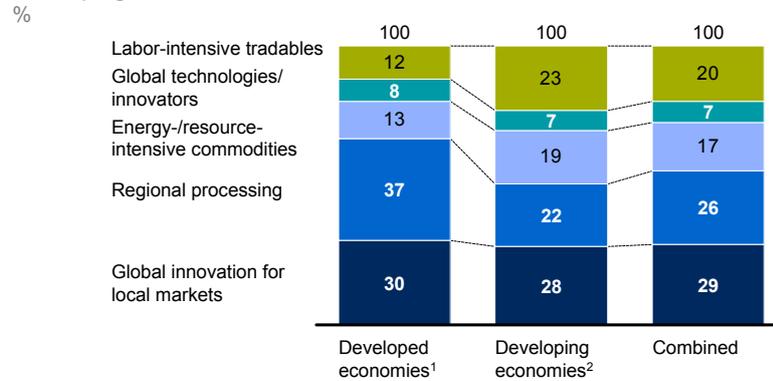
33 Sample of 28 advanced economies from the IHS Global Insight database.

34 Sample of 47 developing economies from the IHS Global Insight database.

Exhibit 28

Regional processing is the largest employer in advanced economies; global innovation for local markets is largest in developing

Manufacturing employment by group in selected advanced and developing economies, 2007



1 Sample of 17 advanced economies: EU-15, Japan, and United States.

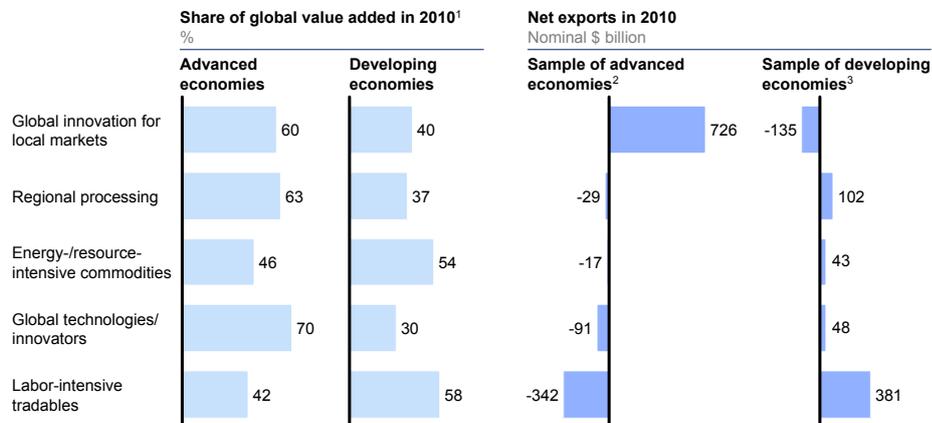
2 Sample of six developing economies: Brazil, China, Indonesia, Mexico, Russia, and Turkey.

NOTE: Emerging economies data based on the "Paid manufacturing employment," from ILO Laborsta. Data include only paid employment (and in some cases only companies above a designated size) and may not match bottom-up employment numbers. However, these data give a good picture of the distribution of employment by sector. 2008 China numbers used because 2007 census is unavailable from CNBS. All mature economies numbers exclude recycling except for Japan and the United States, in which cases recycling is included in labor-intensive tradables. Numbers may not sum due to rounding.

SOURCE: EU KLEMS; OECD STAN; ILO Laborsta; IHS Global Insight; CNBS; McKinsey Global Institute analysis

Exhibit 29

Advanced economies have a strong position in the global innovation for local markets group in both value added and net exports



1 Based on IHS Global Insight sample of 75 economies (28 are advanced and 47 are developing).

2 EU-15 plus Australia, Canada, Czech Republic, Hong Kong, Israel, Japan, Norway, Singapore, Slovakia, South Korea, Switzerland, Taiwan, and the United States.

3 Based on a sample of eight developing economies: Brazil, China, India, Indonesia, Mexico, Russia, Thailand, and Turkey.

NOTE: Calculations compiled bottom up from all two-digit ISIC manufacturing industries from IHS Global Insight, excluding recycling. Thus there might be a discrepancy between this manufacturing total and the manufacturing aggregate value added.

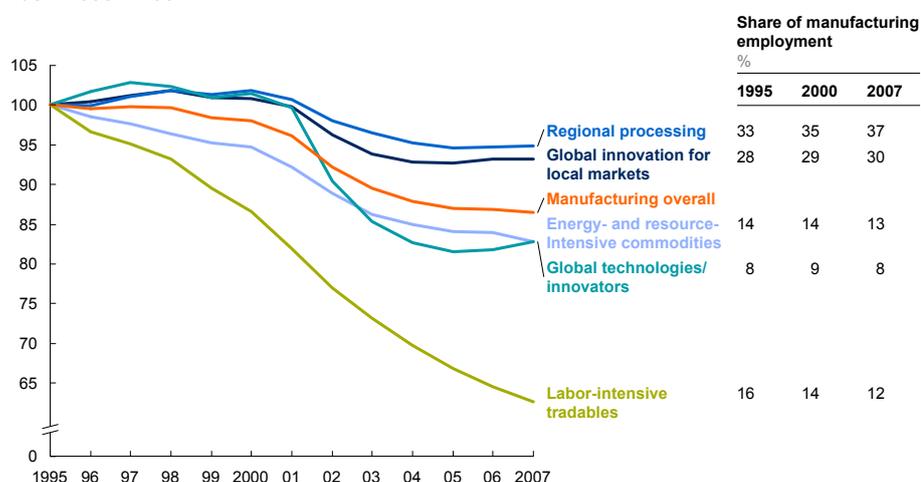
SOURCE: IHS Global Insight; OECD; McKinsey Global Institute analysis

In advanced economies, total manufacturing employment has been falling for many years and dropped by 14 percent from 1995 to 2007. However, the rate of job losses varies across the five groups (Exhibit 30).³⁵ The labor-intensive tradables group had the largest losses, shedding 37 percent of employees between 1995 and 2007. The global technologies/innovators group experienced a 17 percent decline in employment, driven by the 24 percent drop in US employment in those industries. The industry group that suffered the smallest employment decline—5 percent—was regional processing. This reflects both low tradability and modest productivity increases of industries in the group (e.g., food and beverage processing).³⁶

Exhibit 30

Manufacturing employment in advanced economies has declined across all groups but has fallen most in the labor-intensive tradables group

Manufacturing employment by group in selected advanced economies, 1995–2007¹
 Index: 1995 = 100



¹ Sample of 17 advanced economies: EU-15, Japan, and United States.
 NOTE: Numbers may not sum due to rounding.
 SOURCE: EU KLEMS; OECD; McKinsey Global Institute analysis

Our five groups also vary in how value added is generated along the value chain. For example, US companies in the global technologies/innovators group exhibited the highest share of employees engaged in R&D tasks of all groups—around 20 percentage points higher in 2010 than in the regional processing group, which had the lowest share of R&D workers in the US sample (Exhibit 31).³⁷ Fewer than half of employees in the global technologies/innovators group are involved in early-stage manufacturing and final assembly, but in segments such as labor-

³⁵ This rate is based on a sample of 17 advanced economies: EU-15, Japan, and the United States.

³⁶ Between 1995 and 2005, productivity (compound annual growth in value added per hour worked in EU-15 countries) grew modestly among industries in the regional processing (1.6 percent), labor-intensive tradables (1.6 percent), and energy- and resource-intensive commodities (1.8 percent) segments. Growth was moderate in the global innovation for local markets segment (2.7 percent) and high in the global technologies/innovators segment (7.5 percent). Calculations are based on EU KLEMS data, which use hedonic price indexes; 2005 was used as reference year.

³⁷ We do not have globally comprehensive information on this attribute; this US example is illustrative.

intensive tradables, energy- and resource-intensive commodities, and regional processing, employment is concentrated in those stages of production.³⁸

Exhibit 31

US global technologies/innovators industries have the highest share of workers engaged in R&D activities



Share of total group employment in 2010

		Global innovation for local markets	Regional processing	Energy- and resource-intensive commodities	Global technologies/innovators	Labor-intensive tradables
Service-type occupations	R&D	12.0	2.5	3.4	22.0	3.5
	Procurement	2.4	1.7	1.2	2.8	1.6
Manufacturing-type occupations	Early-stage manufacturing	21.0	27.6	35.3	14.2	19.5
	Final assembly	41.4	42.2	36.4	31.7	51.2
Service-type occupations	Distribution	3.7	8.4	8.7	2.9	5.0
	Customer care, post-sale support	2.5	1.3	1.1	2.2	1.9
	Marketing and sales	3.3	4.4	2.9	5.7	4.3
	Low-skill support (facilities)	0.7	1.5	1.1	0.5	0.8
	Back-office support	10.3	8.1	7.7	14.2	9.5
	Management	2.7	2.3	2.2	3.8	2.6

SOURCE: BLS; McKinsey Global Institute analysis

INDUSTRY GROUPS HAVE DISTINCT CHARACTERISTICS AND RESPOND DIFFERENTLY TO CHANGES IN ENVIRONMENT

Each of the industry groups has a unique profile that is the result of a combination of characteristics. These characteristics—how much industries in the group depend on R&D proficiency or access to inexpensive transportation—determine to a large degree the global footprints of industries within a group and determine the drivers of competitiveness for such industries (Exhibit 32). In the following pages, we profile each of the five groups, highlighting some of the key drivers of success for companies in each segment.

1. Global innovation for local markets

This group accounts for 34 percent of global manufacturing value added and is made up of four major global industries: chemicals (including pharmaceuticals); machinery, equipment, and appliances; motor vehicles, trailers, and parts; electrical machinery; and other transport equipment sectors including aerospace and defense. The largest industry within the group, by value added, is chemicals, and the smallest is other transport equipment—aircraft, ships, railway locomotives, and other vehicles (Exhibit 33). The biggest industry by employment is machinery, equipment, and appliances.³⁹ Chemicals has modest employment in relation to its value added, reflecting the industry's high capital intensity and high prices in recent years.

³⁸ The representativeness of this distribution is somewhat affected by the global technologies/innovators group including industries in which US assembly and production employment has declined dramatically over the past ten years, largely due to offshoring production to Asia.

³⁹ Based on employment in a sample of 17 advanced economies (EU-15, Japan, United States) and a sample of developing economies including Brazil, China, Indonesia, Mexico, Russia, and Turkey, as global data are not available.

Exhibit 32

The five segments have different attributes, which shape location requirements

ILLUSTRATIVE

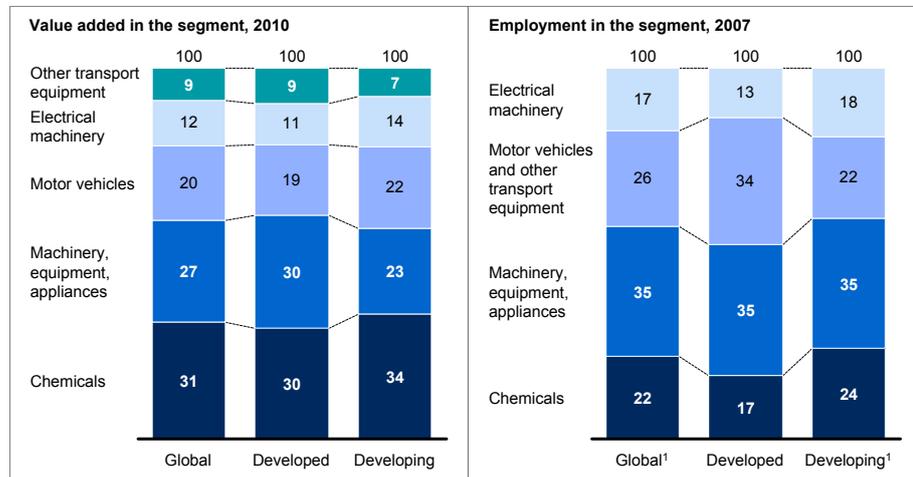
Segment	Key attributes required
Global innovation for local markets	<ul style="list-style-type: none"> Proximity to demand Government regulation and intervention Ability to innovate Access to supply chains
Regional processing	<ul style="list-style-type: none"> Access to raw materials and suppliers Transport costs and infrastructure Proximity to demand
Energy-/resource-intensive commodities	<ul style="list-style-type: none"> Access to raw materials Proximity to demand Transport costs and infrastructure Cost and availability of energy
Global technologies/innovators	<ul style="list-style-type: none"> Ability to innovate Low labor costs Access to supply chains
Labor-intensive tradables	<ul style="list-style-type: none"> Low labor costs Short lead times to market

SOURCE: McKinsey Global Institute analysis

Exhibit 33

Chemicals generates the largest value added in the global innovation for local markets group; machinery and equipment is the largest employer

%



1 Includes those developing economies for which data were available: Brazil, China, Indonesia, Mexico, Russia, and Turkey.
 NOTE: Calculations compiled bottom up from all two-digit ISIC manufacturing industries from IHS Global Insight, excluding recycling; IHS sample of 28 advanced and 47 developing economies. Numbers may not sum due to rounding.
 SOURCE: IHS Global Insight; McKinsey Global Institute analysis

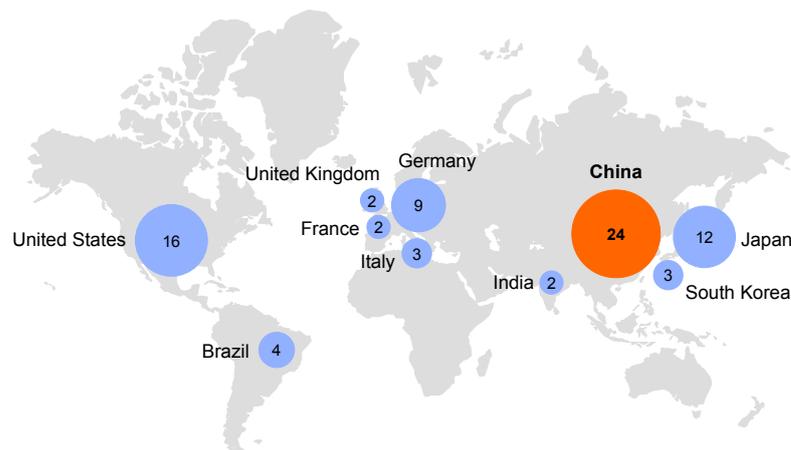
The global innovation for local markets group is characterized by high R&D intensity (R&D expenditures range from 5 to 25 percent of value added), and competition is based largely on R&D quality and the ability to bring new products to market. To a larger degree than in most groups, government plays a significant role—through direct support and incentives, trade policies, regulatory policy, and intellectual property protection. For high-margin products such as some branded pharmaceuticals, tax policy can also influence the footprint. Because of their R&D intensity, for most industries in this group access to high-skill and specialized talent is of critical importance. Only a few products from these industries—such as automotive lamps, compressors, alternators, and generic pharmaceutical ingredients—are traded globally to take advantage of low labor and material costs; most products are produced and consumed regionally.⁴⁰

Measured by value added, China is the largest producer nation in the global innovation for local markets segment, followed by the United States and Japan (Exhibit 34). Advanced economies held 60 percent of the market in 2010, versus 40 percent for developing economies.⁴¹ Developing economies have strengthened their positions significantly, but only three—Brazil, India, and China—were among the global top ten in 2010. Together, advanced economies have a sizable trade surplus (\$726 billion in 2010) in goods produced by industries in the global innovation for local markets group, with strong contributions by Japanese and German machinery, equipment, and appliance industries.⁴² Overall, developing economies ran a trade deficit of \$135 billion in 2010 in these sectors.⁴³

Exhibit 34

In the global innovation for local markets group, China leads in value added, followed by the United States and Japan

Global market share of top ten countries (based on gross value added), 2010
%



NOTE: Calculations compiled bottom up from all two-digit ISIC manufacturing industries from IHS Global Insight, excluding (D37) Recycling, as well as 75 of the largest economies, of which 28 are advanced and 47 are developing.

SOURCE: IHS Global Insight; McKinsey Global Institute analysis

40 Timothy Sturgeon, Johannes Van Biesebroeck, and Gary Gereffi, *Value chains, networks, and clusters: Reframing the global automotive industry*, MIT IPC working paper number 08-002, February 2008.

41 Calculation based on an IHS Global Insight sample of 75 countries, of which 28 are developed and 47 are developing.

42 Based on a sample of 28 advanced economies: Australia, Canada, Czech Republic, EU-15, Hong Kong, Israel, Japan, Norway, Singapore, Slovakia, South Korea, Switzerland, Taiwan, and the United States.

43 Based on a sample of eight developing economies: Brazil, China, India, Indonesia, Mexico, Russia, Thailand, and Turkey.

Success for companies in the global innovation for local markets group depends heavily on four factors: proximity to demand; established supply chains; favorable regulation and government intervention policies; and access to talent for R&D and production. In industries within this group that are more labor-intensive, such as machinery, equipment, and appliances, favorable wage rates are also important for competitiveness.

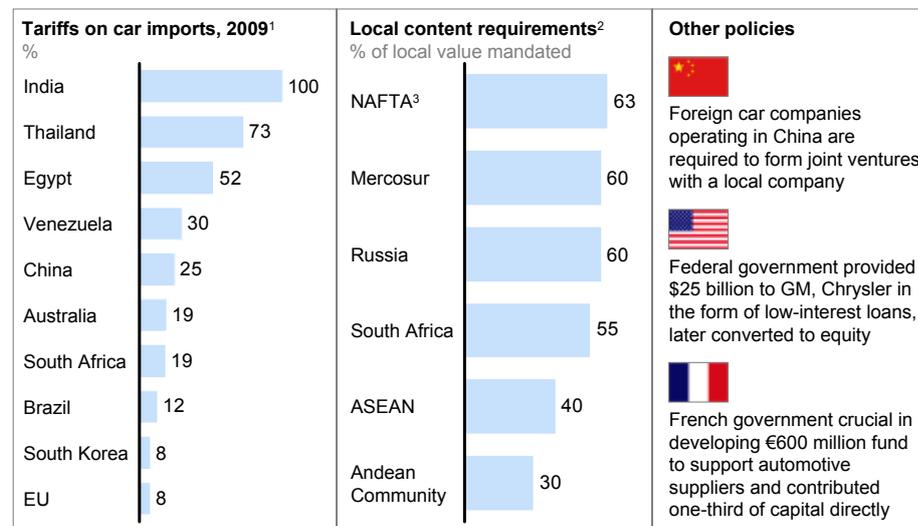
- **Proximity to demand.** Products made by the industries in the global innovation for local markets group often are assembled in the same region where they are sold. High transportation costs for many sector products— industrial machinery, commodity chemicals, and other heavy, bulky, or fragile items—and just-in-time delivery requirements, as in the automotive sector, dictate short distances between producers and customers. Given the geographic constraints of the group and relatively strong GDP growth rates in developing economies, industries in the global innovation for local markets group are likely to continue growing rapidly in countries such as China and India. Opportunities will be available both to local players and to multinational companies from advanced economies whose home markets are growing at a slower rate.
- **Established supply chains.** Companies in this group often have very complex supply-chain requirements. In autos, for example, just-in-time and just-in-sequence production systems require tight coordination with suppliers and machine tool developers. In addition, several suppliers can be present at any stage of the supply chain. In aerospace, the engines and avionics sub-segments are highly consolidated; the top five manufacturers in each make up 85 to 95 percent of the market. However, aerostructure suppliers and aircraft systems suppliers remain fragmented, despite a push by large aircraft manufacturers such as Airbus and Boeing for consolidation.
- **Regulation and government intervention.** Industries in the global innovation for local markets group often build and sell in the same markets because of government policies. Governments in both advanced and developing economies intervene in these manufacturing sectors, with measures such as tax incentives for investment, support for local production, restrictions on trade, and requirements for product quality and safety.

The prevalence of governmental support and interventions limits globalization and has resulted in overcapacity in industries such as autos and some chemicals subsectors. For decades, local governments have offered a range of land, infrastructure, and financial incentives to attract automotive assembly plants to their jurisdictions—the collective value of these incentives commonly exceeds \$100,000 per assembly job created (Exhibit 35).⁴⁴

44 *New horizons: Multinational company investment in developing economies*, McKinsey Global Institute, October 2003 (www.mckinsey.com/mgi).

Exhibit 35

Traditionally, governments have supported automotive sectors



¹ Weighted average of all trading partners.

² Requirements that needed to be met in order to mitigate tariffs. Other restrictions may also apply.

³ Based on "net cost" method.

SOURCE: TRAINS database operated by World Integrated Trade Solution; US Department of Commerce; McKinsey Global Institute analysis

Our analysis indicates that the pharmaceutical industry's footprint is partially a reflection of government regulations such as rules that seek to protect product quality, integrity, and safety. The European Union (EU) mandates drug retesting for pharmaceuticals that are produced outside of the EU; the US Food and Drug Administration imposes strict compliance rules on plants anywhere in the world that manufacture drugs for sale in the United States. Because production processes need to be approved by regulators, and pharmaceutical companies have limited flexibility to switch production among facilities, the industry has ended up holding excess capacity to anticipate demand growth and hedge against quality risk. In this way, government regulation may contribute in part to the industry's 75 percent overcapacity, although other factors contribute as well.

Trade regulations also affect the pharmaceuticals industry in some countries. For example, Brazil imposes an import tax and a value-added tax on drug imports. In each of these cases, as governments create incentives for local production they may also unintentionally slow the rate of productivity growth.

Another form of government intervention to support industries in the global innovation for local markets group is intellectual property protection. This assures companies that their R&D investments, which they count on for competitive advantage, can be used to maximum effect. Conversely, locations where there is a high risk of technologies and designs being stolen or copied are not attractive locations. The strategic decisions that countries make to support local production have affected not only their own competitive positions, but also the global footprints of industries in the group. As we will see in the following chapter, governments continue to seek ways to strengthen domestic manufacturing, which also affects footprint decisions.

- **Availability of skilled workers.** Companies in the global innovation for local markets segment must have access to engineers and other talent with specific skills, particularly in areas such as drug development. Industries in this group also need skilled production workers and craftsmen to sustain competitiveness. Such workers are expected to be in short supply, particularly in Japan and the aging economies of Europe, where industries in this sector face large-scale retirements.

Meanwhile, talent pools in developing economies are growing. These labor market shifts may create an additional impetus for companies to look to Asia for skilled employees. Attracted by an enormous talent pool and strong engineering and IT competence, global auto equipment makers are already using India as an R&D hub. Similarly, thanks to strong process chemistry capabilities in India, the number of drug master file submissions to the US Food and Drug Administration (FDA) from India has been growing at roughly three times the rate of total filings and now accounts for 31 percent of all filings.⁴⁵

Access to low-cost skilled labor is very important in several sectors in the group: generic drugs, standard equipment machinery, labor-intensive specialty chemicals (such as pesticides and food and plastics additives), and lightweight, generic auto parts.

2. Regional processing

This group accounts for 28 percent of global manufacturing value added and is made up of four major industries: food, beverage, and tobacco; fabricated metals; printing and publishing; and rubber and plastics. Food, beverage, and tobacco is the largest sector within this group, both in value added and employment; rubber and plastics is the smallest in value added and second-smallest in employment (Exhibit 36).⁴⁶

This group depends on proximity to materials and markets. Across industries in this group, technology innovation requirements are low (average annual R&D spending is less than 3 percent of industry value added), and capital intensity is relatively high (30 to 40 percent of industry value added). Tradability is generally low (exports represent 5 to 20 percent of gross global output). Reasons for low tradability vary; food and beverages, for example, must be fresh and comply with local preferences, while fabricated metal is often more costly to transport and requires highly complex logistics.

As would be expected from such localized industries, regional processing segments are not geographically concentrated. The top three countries make up only 50 percent of the global value added in this group, the lowest level among the groups and significantly below the 62 percent in the global technologies/innovators group. The United States and China are the leading producers, with almost equal value added (Exhibit 37). Advanced economies had a small trade

45 McKinsey estimate; a drug master file is “used to provide confidential detailed information about facilities, processes, or articles used in the manufacturing, processing, packaging, and storing of one or more human drugs,” according to the Food and Drug Administration.

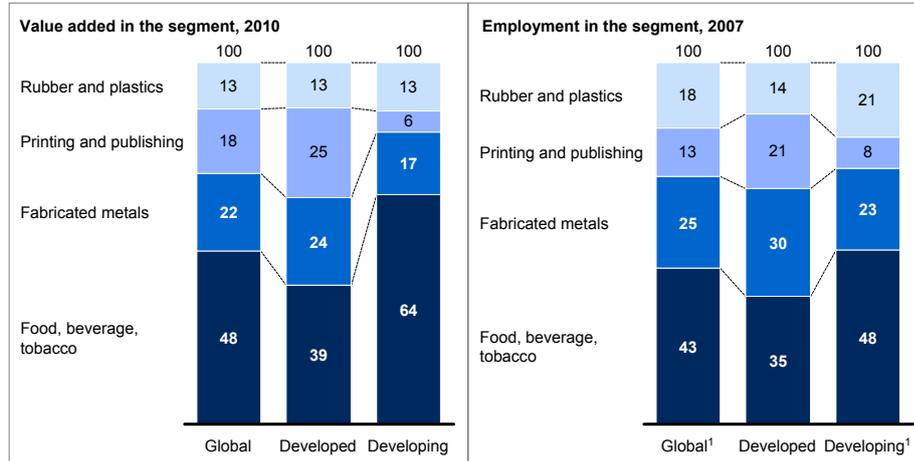
46 Based on employment in a sample of 17 advanced economies (EU-15, Japan, United States) and a sample of developing economies including Brazil, China, Indonesia, Mexico, Russia, and Turkey, as global data are not available.

deficit in this group during the past decade.⁴⁷ Major developing economies increased exports from \$14 billion in 2000 to \$102 billion in 2010.⁴⁸

Exhibit 36

In the regional processing group, food, beverage, and tobacco is the largest industry in both employment and value added

%



1 Includes those developing economies for which data were available: Brazil, China, Indonesia, Mexico, Russia, Turkey.
 NOTE: Calculations compiled bottom up from all two-digit ISIC manufacturing industries from IHS Global Insight, excluding (D37) Recycling, as well as 75 of the largest economies, of which 28 are advanced and 47 are developing. Numbers may not sum due to rounding.

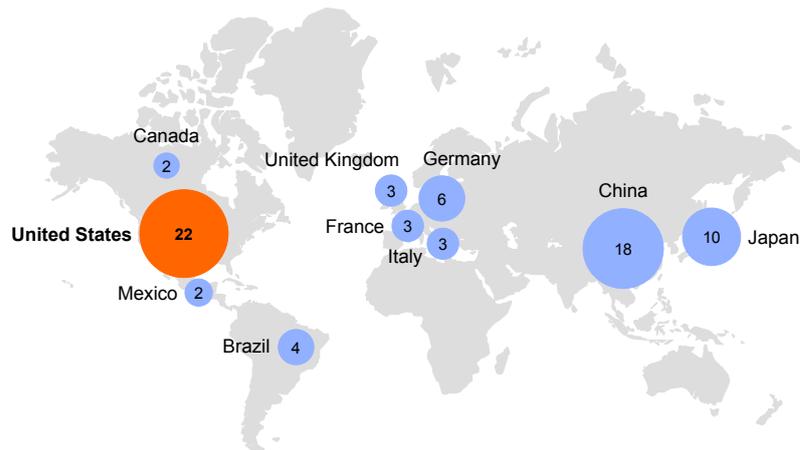
SOURCE: IHS Global Insight; McKinsey Global Institute analysis

Exhibit 37

The United States and China lead in value added in the regional processing group, with about 20 percent each

Global market share of top ten countries (based on gross value added), 2010

%



NOTE: Calculations compiled bottom up from all two-digit ISIC manufacturing industries from IHS Global Insight, excluding (D37) Recycling, as well as 75 of the largest economies, of which 28 are advanced and 47 are developing.

SOURCE: IHS Global Insight; McKinsey Global Institute analysis

47 Based on a sample of 28 advanced economies: Australia, Canada, Czech Republic, EU-15, Hong Kong, Israel, Japan, Norway, Singapore, Slovakia, South Korea, Switzerland, Taiwan, and the United States.

48 Based on a sample of eight developing economies: Brazil, China, India, Indonesia, Mexico, Russia, Thailand, and Turkey.

Competitiveness in this group depends on two main factors: proximity to demand and proximity to raw materials and suppliers (weighed against transportation costs and infrastructure quality). In addition, legacy factors—such as the history of tariff escalation in processed food products—continue to play a role. Trade barriers have been coming down gradually as large trading nations join the World Trade Organization (WTO) or enter into bilateral or regional trade arrangements. But the impact of protectionist or “national importance” policies in some of these industries (food manufacturing being a prime example) can still be seen in the footprint of this segment.

- **Proximity to demand.** Most industries within the regional processing group are characterized by low trade intensity. Companies locate close to customers for a variety of reasons. Producers of fabricated metals and rubber and plastic products, for example, mostly sell intermediate products to assemblers and final manufacturers and locate next to downstream customers such as automakers to minimize transportation costs, meet just-in-time deadlines, and participate in the design process (an increasingly important requirement).⁴⁹ Proximity to markets helps the food and beverage manufacturing industry ensure freshness and reduces transportation of perishable, bulky, and fragile products. Food and beverage companies also must cater to local consumer preferences. In developing economies, access to food at low prices is a critical factor; in advanced economies, proximity is driven more by consumer demands for convenience, traceability, safety, choice, and environmental or ethical considerations. For printing and publishing, proximity is driven by timeliness: publications such as newspapers and magazines require rapid delivery.
- **Proximity to raw materials.** Many industries in the regional processing segment—fabricated metals, plastics, food processing—function in supply chains that require easy access to raw materials and suppliers, such as agricultural producers, toolmakers, and manufacturers of packaging materials. To ensure a reliable, flexible, and cost-efficient supply of raw materials, these industries cluster around their upstream partners and raw material suppliers or where there is excellent transportation infrastructure and many possible connections.⁵⁰

Although most industries in the regional processing group have low tradability, there are exceptions. For example, some US book publishers that have large runs, noncritical turnaround times, and labor-intensive finishing requirements have offshored printing and binding to China. In food and beverage manufacturing, products such as frozen fish and powdered milk are traded extensively.

49 Ed McCallum and Jeannette Goldsmith, “Site selection for the plastics industry,” *Trade and Industry Development*, Summer 2003; *Competitiveness of the EU metalworking and metal articles industries—FWC sector competitiveness studies*, Ecorys Consulting, November 2009.

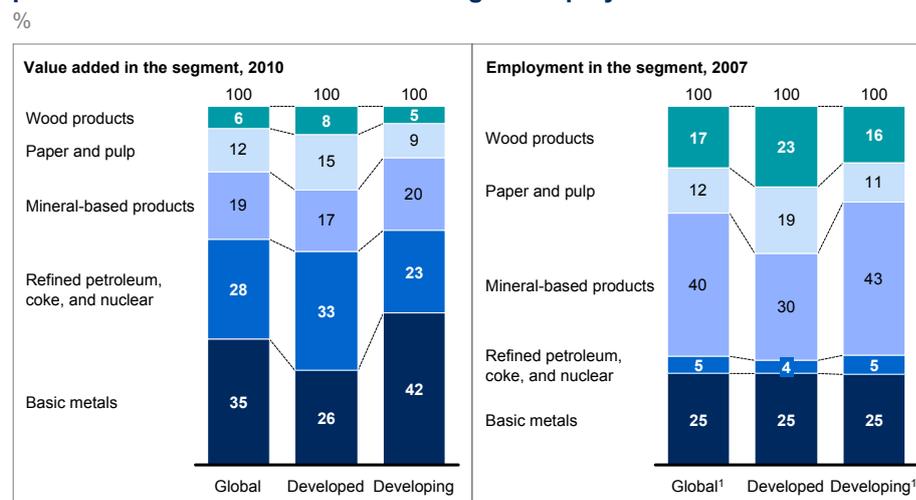
50 Ed McCallum and Jeannette Goldsmith, “Site selection for the plastics industry,” *Trade and Industry Development*, Summer 2003; *Competitiveness of the EU metalworking and metal articles industries—FWC sector competitiveness studies*, Ecorys Consulting, November 2009; Dayton M. Lambert and Kevin T. McNamara, “Location determinants of food manufacturers in the United States, 2000–2004: Are non-metropolitan counties competitive?” *Agricultural Economics*, volume 40, number 6, 2009.

3. Energy- and resource-intensive commodities

This group accounts for 22 percent of global manufacturing value added and is made up of five industries: basic metals; refined petroleum, coke, and nuclear materials; mineral-based products; paper and pulp; and wood products. The largest industry within the group, measured by value added, is basic metals; wood products is the smallest (Exhibit 38). In terms of employment, mineral-based products, such as glass, cement, and ceramic products, is the largest sector, while the highly capital-intensive refined petroleum, coke, and nuclear products industries are the smallest employers in this group.⁵¹

Exhibit 38

In the energy- and resource-intensive commodities group, mineral-based products and basic metals are the largest employers



1 Includes those developing economies for which data were available: Brazil, China, Indonesia, Mexico, Russia, and Turkey.
NOTE: Calculations compiled bottom up from all two-digit ISIC manufacturing industries from IHS Global Insight, excluding (D37) Recycling, as well as 75 of the largest economies, of which 28 are advanced and 47 are developing. Numbers may not sum due to rounding.

SOURCE: IHS Global Insight; McKinsey Global Institute analysis

The group's industries are only moderately traded; exports account for roughly 15 to 25 percent of gross global output, higher than only the regional processing industries. The group is highly resource- and energy-intensive: purchased fuel and electricity are between 7 and 15 percent of value added, compared with a global manufacturing sector average of 4 percent. Trade is more regional than global, due to the low value density of products (\$100 to \$1,250 per ton), although trade is higher where inexpensive water transportation is accessible. Competition is mainly based on price.

China leads the energy- and resource-intensive commodities group with a 29 percent global share of value added. Resource-rich countries such as Brazil and Russia also have a strong position in this group—stronger than in the other four manufacturing groups (Exhibit 39). In the energy- and resource-intensive commodities group, developing economies account for 54 percent of value added.⁵² Developing economies have recorded positive trade balances in these commodities since 2004.

51 Based on employment in a sample of 17 advanced economies (EU-15, Japan, United States) and a sample of developing economies including Brazil, China, Indonesia, Mexico, Russia, and Turkey, as global data are not available.

52 Calculation based on an IHS Global Insight sample of 75 countries, of which 28 are developed and 47 are developing.

Exhibit 39

In the energy- and resource-intensive commodities group, emerging economies such as China, Brazil, and Russia have strong positions

Global market share of top ten countries (based on gross value added), 2010
 %



NOTE: Calculations compiled bottom up from all two-digit ISIC manufacturing industries from IHS Global Insight, excluding (D37) Recycling, as well as 75 of the largest economies, of which 28 are advanced and 47 are developing.
 SOURCE: IHS Global Insight; McKinsey Global Institute analysis

Competitive strength in this segment is derived from four primary factors: transportation costs and infrastructure, proximity to demand, access to raw materials, and cost of energy. In some industries, government policy and capital costs also play a role. In developing economies, government policies work in two ways: via infrastructure investments (directly or through public/private partnerships) and through market interventions such as China’s current efforts to consolidate its steel industry.

In mature economies, government policies aim to increase competitiveness through focused policies such as funding for R&D projects, tax breaks, import restrictions, and subsidies. Access to capital, cost of capital, and capital efficiency can also drive footprint decisions in some cases. The Chinese steel industry, for example, has benefited from economies of scale in design and construction of new plants as a result of the great expansion of the industry over the past decade. By some estimates, China has reduced capital costs of new plants by up to 40 percent compared with advanced economies.⁵³ Additionally, the high cost of closing old production facilities and the high investment needed to develop capacity in more favorable geographies increase the difficulty of exiting capacity.

- **Transportation costs.** Because many products that fall under the energy- and resource-intensive commodities group are bulky and have low value density, transportation costs and infrastructure are key determinants of location economics. As a result, transportation and logistics costs help explain the localized nature of industries such as steel, where global imports of semi-finished steel and ingots make up only 4 percent of total crude steel production. In long and flat steel, global imports make up only 18 percent of hot rolled (finished) production. In these industries, trade economics are favorable only in the case of short-distance shipping or when trading very high

53 *How to compete and grow: A sector guide to policy*, McKinsey Global Institute, March 2010 (www.mckinsey.com/mgi).

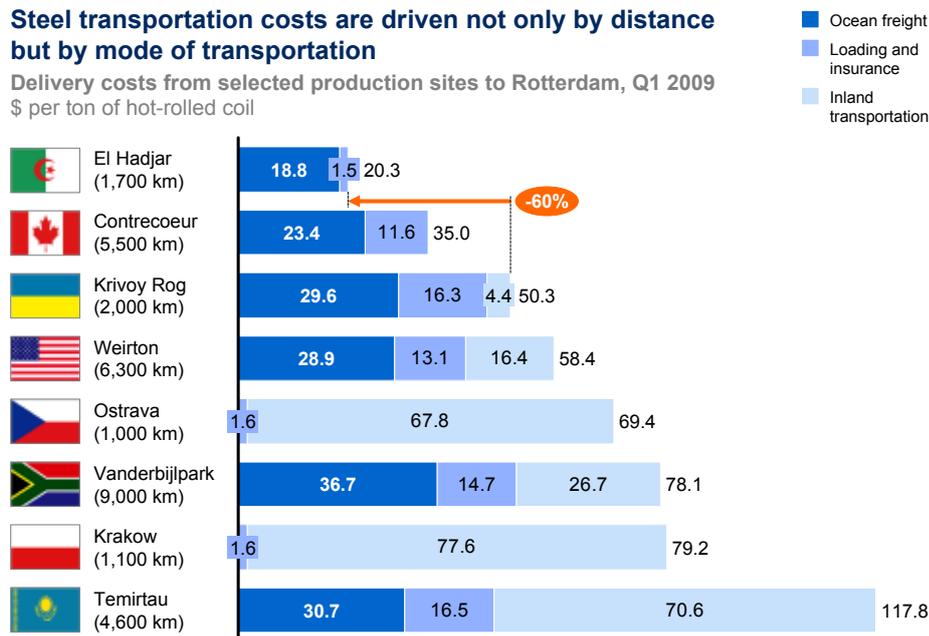
value-added products. Transportation cost is driven not only by distance, but also by mode of transportation. Exhibit 40 illustrates the benefit of access to water transportation: while El Hadjar and Krivoy Rog are similar distances from Rotterdam, an important entry point into the European market, the all-water route from El Hadjar gives its steel exporters a nearly 60 percent advantage in shipping cost.

Many production facilities are located near large seaports or inland waterways, such as the steel mills along the Great Lakes and major rivers of North America in cities such as Cleveland and Pittsburgh.

Exhibit 40

Steel transportation costs are driven not only by distance but by mode of transportation

Delivery costs from selected production sites to Rotterdam, Q1 2009
\$ per ton of hot-rolled coil



SOURCE: James F. King; Geobytes Distance Tool; McKinsey Global Institute analysis

- Proximity to demand.** The output of industries in the energy- and resource-intensive commodities group is generally consumed locally, and demand for these mostly commodity products tracks GDP growth. We find in our analysis of the steel industry that 85 percent of low-value-added long steel (rebar rods, for example) and 70 percent of higher value-added flat steel are produced and consumed locally. We expect the balance of global production to continue to shift toward developing economies, tracking the buildup of infrastructure, housing, and productive capacity. Another factor enforcing the local nature of these businesses is that most large commodity subsegments are viewed by policy makers as highly strategic, because they enable national infrastructure development and supply materials to a wide variety of downstream higher-value-added industries. Therefore, governments in developing economies actively intervene to strengthen domestic steel markets to ensure supply.
- Access to raw materials.** Industries in the energy- and resource-intensive commodities group require access to materials such as iron ore, crude oil, limestone, and wood. Raw materials represent the majority of production costs—70 to 80 percent of the cost for steel, for example. As a result, having a cost advantage in key raw materials—such as Brazil and Russia enjoy in iron ore and coking coal—is a significant driver of competitiveness. Producers

must have both secure sources of supply and favorable raw material prices after factoring in transportation costs and the effect of exchange rates. As a result, in some sectors production has been shifting closer to sources of inexpensive raw materials. For example, new pulp capacity is being added nearer to the cheap plant and wood fiber sources in the Southern Hemisphere.

- **Cost and availability of energy.** As the name implies, industries in the energy- and resource-intensive commodities group rely on plentiful supplies of low-cost energy, although the importance of energy costs varies by industry. Aluminum production and smelting have the highest needs, and recent investments have tended to be in locations that have access to long-term, low-cost hydro, nuclear, or coal power. Rio Tinto Alcan recently invested in new capacity in Iceland, and Russian aluminum giant UC Rusal has invested in facilities in Siberia—in both cases to take advantage of access to hydro power. Similarly, Chinese aluminum producers are building plants in Northwest China, where supplies of hydro power and coal are plentiful.⁵⁴ In steel, energy is a less important factor, about 10 percent of value added versus 25 percent for aluminum. While steel production is energy-intensive, by-products from the coking coal that is used to react with iron ore are recycled to provide energy to the process. Alternate technologies such as DRI (direct reduced iron) replace coking coal with natural gas as a reactive agent and could increase the competitiveness of countries that have access to low-cost gas.

4. Global technologies/innovators

This group accounts for 9 percent of global manufacturing value added and is made up of three industries: semiconductors and electronics; medical, precision, and optical equipment; and computers and office machinery. The largest industry measured by value added is semiconductors and electronics, which accounts for more than half of the global group value added. The smallest is computers and office machinery (Exhibit 41).

The group is highly globalized and relies heavily on innovation—R&D expenditure is 25 to 35 percent of value added in these industries. Depending on the industry, exports represent 55 to 90 percent of gross output, including both intermediate and final products. These industries are highly traded because of the high value density of products (\$72,000 per ton for computers and electronics), the high degree of modularity in components, and fragmented value chains. In most subsectors, work can be split easily across great distances, often resulting in complex supply chains spanning several countries.⁵⁵ The combination of high tradability and rapid pace of innovation explains the many specialized clusters in this segment. These clusters of concentrated talent, experience, and broad supply-chain ecosystems help speed up design and development that can then be transferred to assembly locations around the world relatively easily. In turn, specialized component and assembly locations also benefit from co-locating suppliers across the complex value chain.

54 *Competitiveness of the EU non-ferrous metals industries—FWC sector competitiveness studies*, Ecorys Consulting, April 2011.

55 Timothy J. Sturgeon and Momoko Kawakami, *Global value chains in the electronics industry: Was the crisis a window of opportunity for developing countries?*, World Bank policy research working paper number 5417, September 2010; Gary P. Pisano and Willy C. Shih, "Restoring American competitiveness," *Harvard Business Review*, July-August 2009; also Gary P. Pisano and Willy C. Shih, "Does America really need manufacturing?" *Harvard Business Review*, March 2012.

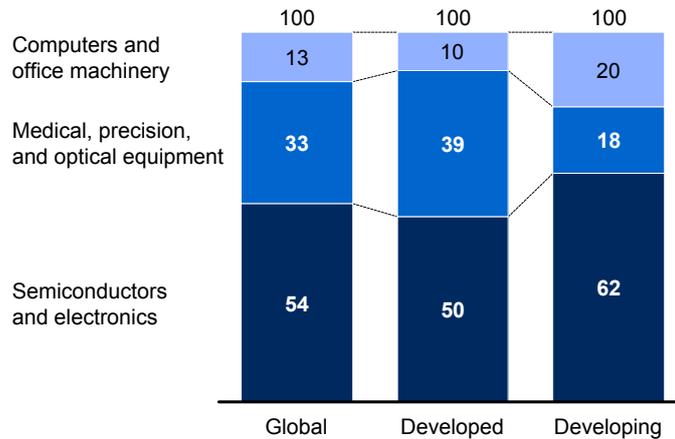
Traditionally, the global technologies/innovators group has been led by companies from advanced economies, such as Apple and Hewlett-Packard in the United States; Fujitsu, Hitachi, and Toshiba in Japan; and Ericsson, Nokia, Philips, and Siemens in Europe. Advanced economies contribute 70 percent of the global value added, and the United States retains the lead with 27 percent of the group's global value added in 2010 (Exhibit 42).⁵⁶

Exhibit 41

Semiconductors and electronics is the largest industry in global technologies/innovators, with 54 percent of global value added

Global value added by industry, 2010

%



NOTE: Calculations compiled bottom up from all two-digit ISIC manufacturing industries from IHS Global Insight, excluding (D37) Recycling, as well as 75 of the largest economies, of which 28 are advanced and 47 are developing. No employment breakdown is provided as the data available for the developing economies are not granular enough.

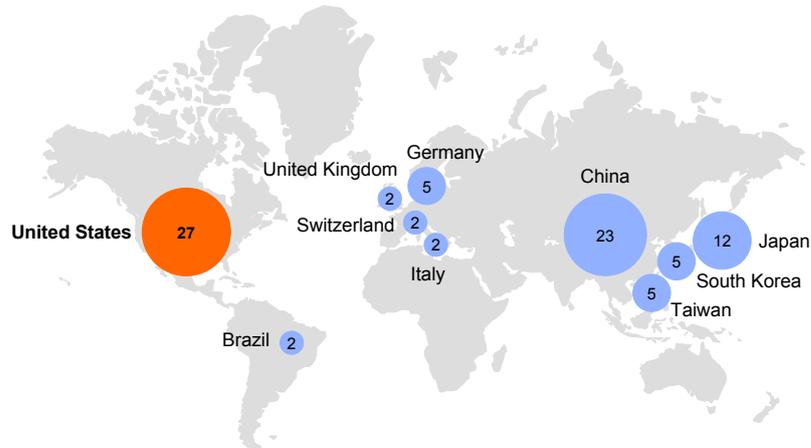
SOURCE: IHS Global Insight; McKinsey Global Institute analysis

Exhibit 42

In the global technologies/innovators group, the United States leads in value added, with a 27 percent share

Global market share of top ten countries (based on gross value added), 2010

%



NOTE: Calculations compiled bottom up from all two-digit ISIC manufacturing industries from IHS Global Insight, excluding (D37) Recycling, as well as 75 of the largest economies, of which 28 are advanced and 47 are developing.

SOURCE: IHS Global Insight; McKinsey Global Institute analysis

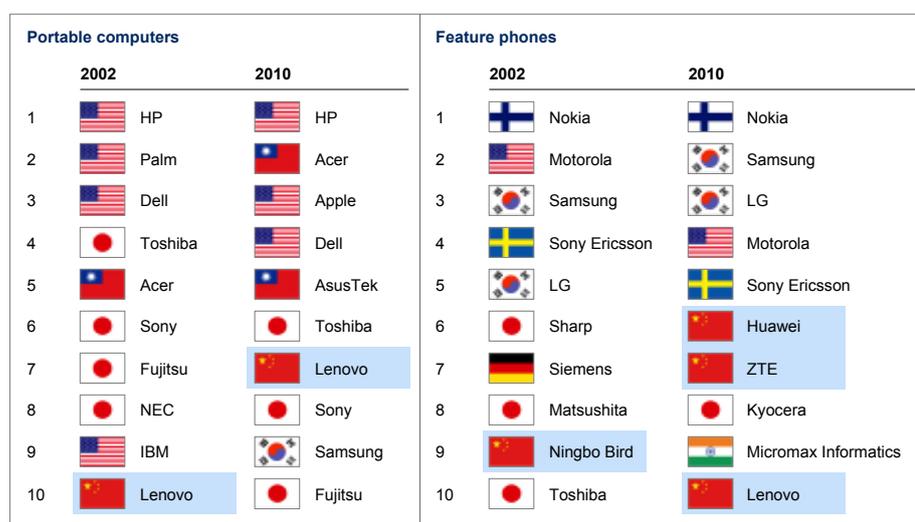
⁵⁶ Calculation based on an IHS Global Insight sample of 75 countries, of which 28 are developed.

South Korea, with companies such as LG and Samsung, and Taiwan, with Acer and AsusTek, also have strong positions. Other Asian economies, particularly China, are building capabilities in the global technologies/innovators group (Exhibit 43). Overall, developing economies have nearly tripled their share of group value added, rising from 11 percent in 2000 to 30 percent in 2010.⁵⁷ During that time, China's share grew from 4 percent to 23 percent.⁵⁸ Net exports from developing economies turned positive in 2005, also led by China. Advanced economies have had a growing trade deficit in goods produced by industries in the global technologies/innovators group, which reached \$91 billion in 2010.⁵⁹ The Asian countries have focused mainly on consumer electronics, semiconductors, and computer machinery. Advanced economies continue to dominate medical, precision, and optical equipment and were net exporters of those products in 2010.

Exhibit 43

Chinese companies have gained in key consumer electronics categories in the past decade

Top ten companies (global brand owners) by share of retail volume



SOURCE: Euromonitor; McKinsey Global Institute analysis

Competitive strength in this segment is driven primarily by two factors: capacity to innovate and low labor costs for assembly. Other factors that make a difference include cost of capital, the ability to scale capacity up and down quickly, and proximity to supply chains.

- **Ability to innovate.** The ability to innovate and develop new products and technologies is a key driver for competitiveness, which makes this group highly R&D-intensive. Due to rapid product cycles, the ability to innovate in the early value chain stages (i.e., product development and design, and production design) can be critically important. In many semiconductor segments, for

57 Calculation based on an IHS Global Insight sample of 75 countries, of which 47 are developing.

58 Based on a sample of eight developing economies: Brazil, China, India, Indonesia, Mexico, Thailand, Turkey, and Russia.

59 Based on a sample of 28 advanced economies: Australia, Canada, Czech Republic, EU-15, Hong Kong, Israel, Japan, Norway, Singapore, Slovakia, South Korea, Switzerland, Taiwan, and the United States.

example, only the player that gets to market first makes a profit, because it can dominate sales in the early stages of the product life cycle, when prices are highest. So far, advanced economies have maintained a lead in the high-value-added stages of research and development, but developing economies such as China are rapidly building technological capabilities. China is following the path up the value chain from contract manufacturing that Singapore, South Korea, and Taiwan have followed.⁶⁰

The ability to innovate—the key competitive enabler—depends on building and maintaining strong technological capabilities as well as having access to R&D financing. Governments play an important role in fostering technological capabilities by acting as the initial purchasers of new innovations, providing R&D funding or incentives, offering capital subsidies, investing in applied research and education, and fostering close collaboration between universities and industry.

- **Labor cost.** While R&D strength and the ability to innovate are essential for nations that wish to compete in these industries, labor costs are also important. Our analysis of the electronics industry confirms that final assembly and after-sales support and maintenance for high-tech products are both labor-intensive activities. Addressing these stages of the value chain has provided a way for developing economies such as China, Mexico, and Hungary to enter the global technologies/innovators group, using their comparative advantage in labor costs. The share of mobile phone handsets manufactured in the Asia-Pacific region doubled to more than 80 percent from 2001 to 2011, with more than 60 percent of production now in China. In the same period, Eastern European countries expanded their assembly businesses, raising their share of handset production over the decade from 2 percent of the global total to 6 percent.

As labor costs in China increase, less developed countries are likely to emerge as low-cost production and assembly sites. According to some research, China is already losing some new factory investments to lower-cost locations such as Vietnam.⁶¹

5. Labor-intensive tradables

This group accounts for just 7 percent of global manufacturing value added and is made up of industries such as textiles, apparel, and leather; and furniture, jewelry, toys, and “other manufacturing goods not classified elsewhere.” Of these, textiles, apparel, and leather is largest, measured both by value added and by employment (Exhibit 44).⁶²

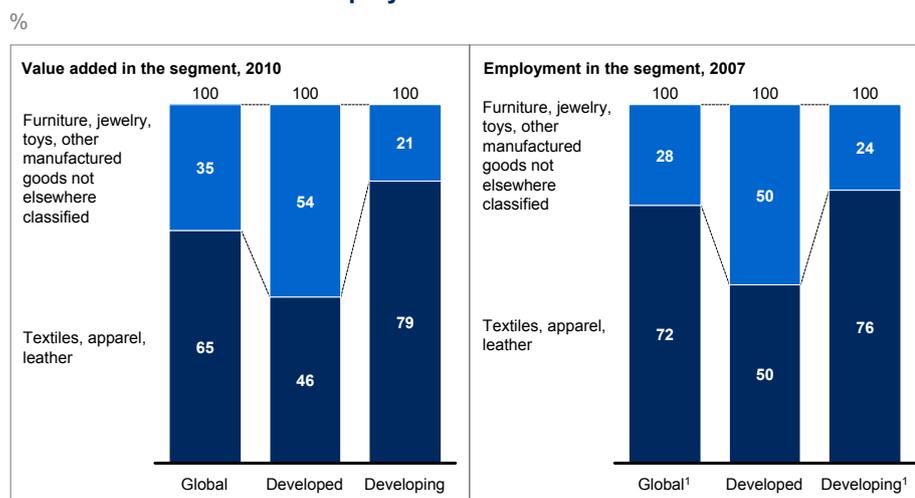
60 Timothy J. Sturgeon and Momoko Kawakami, *Global value chains in the electronics industry: Was the crisis a window of opportunity for developing countries?* World Bank policy research working paper number 5417, September 2010.

61 Greg Linden, Jason Dedrick, and Kenneth L. Kraemer, *Innovation and job creation in a global economy: The case of Apple's iPod*, Personal Computing Industry Center, University of California, Irvine, working paper, January 2009.

62 Based on employment in a sample of 17 advanced economies (EU-15, Japan, United States) and a sample of developing economies including Brazil, China, Indonesia, Mexico, Russia, and Turkey, as global data are not available.

Exhibit 44

In the labor-intensive tradables group, textiles, apparel, and leather leads in both value added and employment



1 Includes those developing economies for which data were available: Brazil, China, Indonesia, Mexico, Russia, and Turkey.
 NOTE: Calculations compiled bottom up from all two-digit ISIC manufacturing industries from IHS Global Insight, excluding (D37) Recycling, as well as 75 of the largest economies, of which 28 are advanced and 47 are developing. Numbers may not sum due to rounding.

SOURCE: IHS Global Insight; McKinsey Global Institute analysis

Overall, this group is characterized by high labor intensity (every \$1,000 of value added typically requires 30 to 35 hours of labor).⁶³ These industries are also highly tradable, with 50 to 70 percent of global output consumed by customers outside the country of origin.

Many economies have used textile and apparel manufacturing as an early step in economic development, facilitating the transition from rural subsistence agriculture to urban manufacturing and starting with low-skill employment. As national incomes and wage levels rise, the comparative labor-cost advantage erodes and developing economies shift focus toward more complex and less labor-intensive activities. This trend is illustrated in Exhibit 45: high-income countries such as Norway, Singapore, and Switzerland have very small shares of labor-intensive tradables in their manufacturing bases. In contrast, countries such as Bangladesh, Honduras, and Sri Lanka have exceptionally large shares of their manufacturing bases in labor-intensive tradables. Interestingly, the chart also shows the outlying positions of Italy and Portugal; both are considered wealthy nations, but their economies continue to rely heavily on labor-intensive manufacturing.⁶⁴

Today, the group is heavily concentrated in low-cost locations in Latin America and Asia, most notably in China (Exhibit 46). In 2010, China accounted for 36 percent of the group’s global value added, up from just 7 percent in 2000. The share of global sector value added generated by all developing economies rose from 25 percent to 58 percent during the same period.⁶⁵ As a result, advanced

63 Based on EU-15 sample.

64 Gary Gereffi and Stacey Frederick, *Global apparel value chain, trade and the crisis: Challenges and opportunities for developing countries*, World Bank policy research working paper number 5281, April 2010.

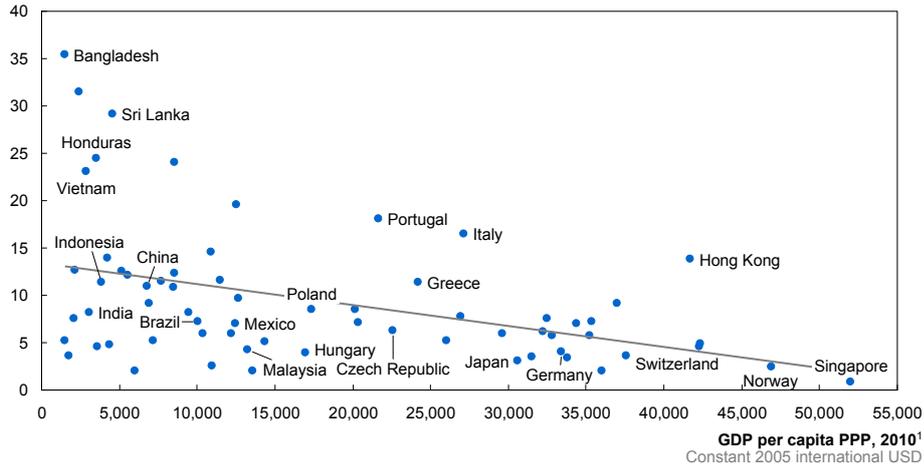
65 Based on an IHS Global Insight sample of 75 countries, of which 47 are developing economies

economies are recording rising trade deficits in these industries, more than doubling from \$140 billion in 2000 to \$342 billion in 2010. Meanwhile, developing economies tripled their surplus in these goods, from \$120 billion to \$381 billion.⁶⁶

Exhibit 45

The share of a nation’s manufacturing output from labor-intensive tradables declines as wealth rises; Italy and Portugal are exceptions

Value-added share of labor-intensive tradables group
% of total manufacturing value added

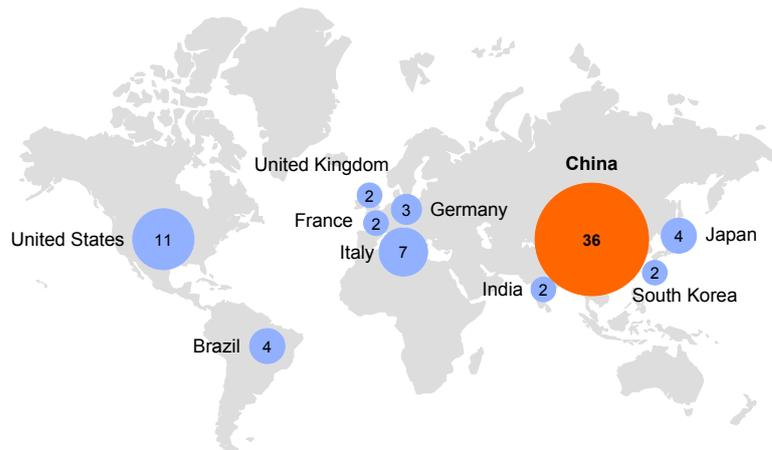


¹ PPP = purchasing power parity.
NOTE: Calculations compiled bottom up from all two-digit ISIC manufacturing industries from IHS Global Insight, excluding (D37) Recycling, as well as 75 of the largest economies, of which 28 are advanced and 47 are developing.
SOURCE: OECD STAN; IHS Global Insight; World Bank; McKinsey Global Institute analysis

Exhibit 46

In the labor-intensive tradables group, China leads in value added, accounting for 36 percent

Global market share of top ten countries (based on gross value added), 2010
%



NOTE: Calculations compiled bottom up from all two-digit ISIC manufacturing industries from IHS Global Insight, excluding (D37) Recycling, as well as 75 of the largest economies, of which 28 are advanced and 47 are developing.
SOURCE: IHS Global Insight; McKinsey Global Institute analysis

⁶⁶ Eight developing economies are Brazil, China, India, Indonesia, Mexico, Russia, Thailand, and Turkey; 28 advanced economies are Australia, Canada, Czech Republic, EU-15, Hong Kong, Israel, Japan, Norway, Singapore, Slovakia, South Korea, Switzerland, Taiwan, and the United States.

Competition among industries in the labor-intensive tradables segment has given rise to frequent international interventions as well as regulations such as the 1995 WTO Agreement on Textiles and Clothing and the 1974–2004 Multi Fiber Arrangement (MFA), which imposed quotas and preferential tariffs on textiles and apparel imported by Canada, the European Union, and the United States from countries outside that group. The dissolution of the MFA and the WTO's Agreement on Textiles and Clothing at the end of 2004 altered the industry landscape, accelerating the shift of production to low-cost locations, with China attracting the bulk of the activity; China's share of global apparel exports rose from 18 percent in 2000 to 33 percent in 2009. Other nations also benefited, including Bangladesh, whose share of global apparel exports rose from 2.6 percent in 2000 to 3 percent in 2009, and Vietnam, whose share went from 1.7 percent in 2005 to 2.5 percent in 2009.⁶⁷ Cambodia, Egypt, and Pakistan have also expanded their textile and apparel sectors. After the phasing out of quotas (and because of the global recession), these sectors have declined sharply in Mexico, Morocco, Thailand, and Tunisia, as well as in Canada and several European countries.⁶⁸

- **Labor costs.** In the wake of trade liberalization, low labor costs have become an even more critical factor in most industries in this group, which is why advanced economies have been losing share in these industries for 40 years. In addition, products tend to have rather high value density and there is little need for production to be located near design or final markets. Therefore, companies are able to take full advantage of labor cost arbitrage opportunities and can shop the globe for the best deals.

Assuming a continuation of liberalized trade policies, we expect that production of apparel, textiles, leather, and footwear, as well as goods such as furniture and toys, will continue to follow the path of lower labor costs. Despite rising wages in some regions, China is likely to continue to be a major producer, thanks to its relatively low average labor costs, good transportation, large labor pool, and increasingly affluent domestic market. The sheer size of China's labor force gives it advantages: in 2008, roughly 24 million Chinese were employed in labor-intensive tradables industries, including 18 million in textiles, apparel, and leather industries. Nevertheless, escalating costs in coastal China and a desire by manufacturers to diversify locations to mitigate political and supply-chain risk are pushing companies to look for new locations.⁶⁹ Low-end clothing manufacturing is already moving to Cambodia and Vietnam and other low-cost locations. Meanwhile, Japan has explicitly declared its interest in reducing its reliance on China in textiles and apparel.⁷⁰ Guess, an American fashion brand, announced in 2011 that within 18 months

67 Based on a sample of 60 countries from the OECD Bilateral Trade Database as a proxy for "world exports" in calculating the export shares.

68 Gary Gereffi and Stacey Frederick, *Global apparel value chain, trade and the crisis: Challenges and opportunities for developing countries*, World Bank policy research working paper number 5281, April 2010.

69 Suzanne Berger and the MIT Industrial Performance Center, *How we compete: What companies around the world are doing to make it in today's global economy* (New York: Crown Business, 2005).

70 Gary Gereffi and Stacey Frederick, *Global apparel value chain, trade and the crisis: Challenges and opportunities for developing countries*, World Bank policy research working paper number 5281, April 2010.

it planned to reduce the share of Asian goods it sources in China from one-half to one-third.⁷¹

- **Lead times and technological skills.** For some sectors within the group, considerations other than cost can factor into location choices. For example, in fashion-sensitive products, the ability to meet short lead times is a key criterion. For high-end, tailored clothing, technical skills factor heavily in the location decision.⁷² The same holds true for furniture: in high-end furniture, design and innovation with materials play a role in the location decision. While the value density of products in the labor-intensive tradables group usually makes transportation costs a secondary factor, when global freight routes are close to full capacity and charges rise, companies look for alternative locations to maintain timely deliveries. These include Eastern Europe (Hungary and Poland, and more recently Bulgaria, Romania, and Ukraine), as well as Italy and Portugal.⁷³

□ □ □

Even using very broad groups, we see the great diversity within the manufacturing sector and the ways in which various types of industries succeed. Companies can protect or extend their advantages by understanding how proximity requirements or sensitivities to changes in factor inputs affect their competitive positions. Clearly identifying the forces that determine where companies choose to locate (or withdraw) will enable policy makers to adapt their manufacturing policies to have greater impact. As we will discuss in Chapters 4 and 5, actual strategy and policy making will require more granular views, as well as an appreciation for the forces of change at play in global manufacturing that we describe in the next chapter.

71 McKinsey Global Institute, *Sustaining Vietnam's growth: The productivity challenge*, February 2012 (www.mckinsey.com/mgi). Also see "Good darnin, Vietnam: Rising costs in China are sending more buyers to Southeast Asia," *The Economist*, June 4, 2011.

72 Suzanne Berger and the MIT Industrial Performance Center, *How we compete: What companies around the world are doing to make it in today's global economy* (New York: Crown Business, 2005).

73 Ibid.

3. Trends affecting the evolution of manufacturing

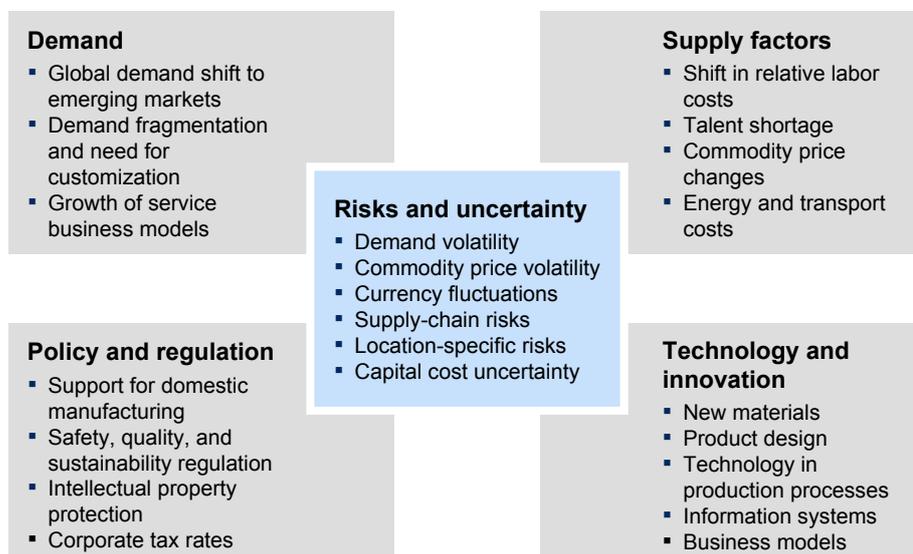
In the wake of the Great Recession, the global economy has entered a period of high volatility and uncertainty that has been particularly challenging for manufacturing companies. Even as the global economy recovers, manufacturing faces long-range shifts in the environment—including changes in patterns of demand, rising factor input costs, talent shortages, the spread of new technologies and innovations, and the effects of government policies to foster and support domestic manufacturing.

Some forces are already being felt: the shift of global demand toward developing economies, the proliferation of products to meet customer requirements, the growing importance of value-added services, and rising wages in low-cost locations. Others are just emerging, such as a growing scarcity of technical talent to develop and run manufacturing tools and systems, and the use of greater intelligence in product design and manufacturing to boost resource efficiency and gain greater visibility into supply chains.

Manufacturing companies and policy makers will need to understand these forces and their dynamics in order to adjust their strategies and processes. Rising factor costs will push companies to raise productivity. Advances in materials will require new production processes, and more capable and low-cost robotics will change the labor/capital calculus in many sectors. These trends will present a new set of risks and uncertainties (Exhibit 47). In Chapters 4 and 5, we present detailed analyses of the strategic implications of these trends for companies and nations. In this chapter, we lay out the major trends and describe their impact on industries across the five segments of manufacturing.

Exhibit 47

The future of manufacturing is influenced by changes in demand, factor costs, innovation, and policy and regulation—raising risk and uncertainty



SOURCE: McKinsey Global Institute analysis

DEMAND IS SHIFTING TO EMERGING MARKETS AT AN ACCELERATING RATE AND IS BECOMING MORE FRAGMENTED

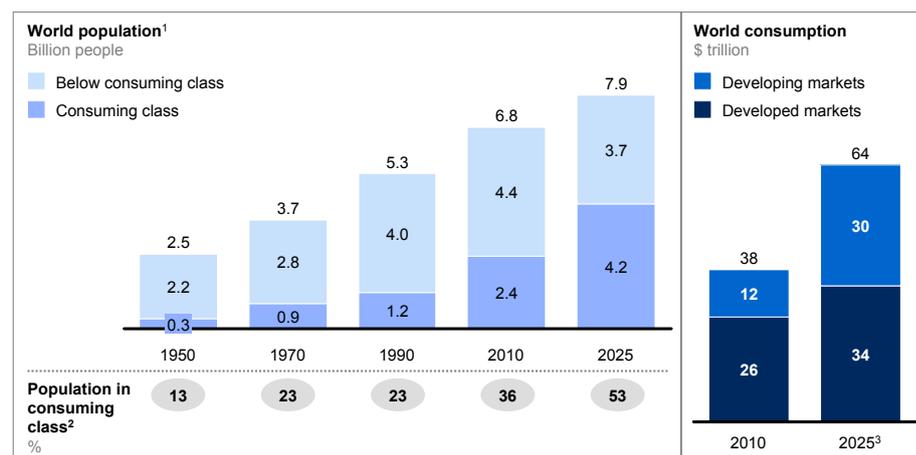
In the previous chapter, we showed that proximity to demand is a significant driver of competitiveness in manufacturing groups such as those for global innovation for local markets, regional processing, and energy- and resource-intensive commodities. The footprints of these segments tend to follow demand volume, and today the flow of volume dictates expansion into a growing list of developing economies. This proliferation of markets, as well as rising requirements for customized products, is fragmenting demand; companies need to produce more local-market variations and ship a wider variety of SKUs to compete. Another change in demand for manufacturers in certain sectors—particularly those that sell to other businesses (i.e., business-to-business, or B2B, segments)—is the growing demand for value-added services and software to go along with manufactured goods.

Demand is shifting to emerging markets at an accelerating rate

It is widely known that economic growth has shifted toward developing economies, but the momentum of that shift is not fully appreciated. According to recent McKinsey research, consumption by developing economies could rise from \$12 trillion annually in 2010 to \$30 trillion in 2025 (Exhibit 48). As developing economies grow wealthier, some 1.8 billion individuals are likely to enter the global consuming class, and 60 percent of households in the world with incomes of at least \$20,000 a year will likely be in developing economies.⁷⁴ By 2025, it is estimated that developing economies could account for nearly 70 percent of global demand for manufactured goods.

Exhibit 48

Demand shift: By 2025, half of global consumption will be in emerging markets



1 Historical values for 1820 through 1990 estimated by Homi Kharas; 2010 and 2025 estimates by McKinsey Global Institute.

2 Defined as people with daily disposable income above \$10 at PPP.

3 Estimate based on 2010 private consumption share of GDP per country and GDP estimates for 2010 and 2025; assumes private consumption share of GDP remains constant.

NOTE: Numbers may not sum due to rounding.

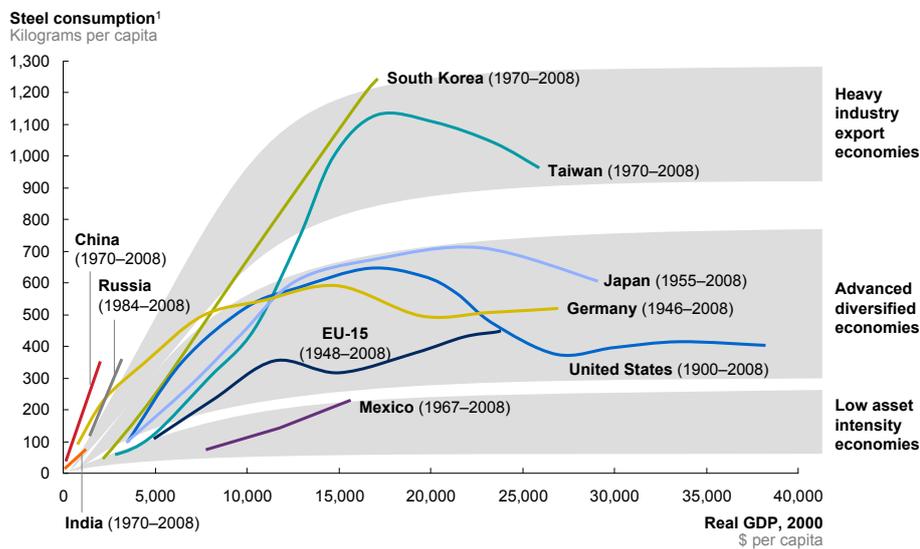
SOURCE: Homi Kharas (Wolfensohn Center for Development, Brookings Institution); Angus Maddison (founder of Groningen Growth and Development Centre); McKinsey Global Institute Cityscope 2.0

74 *Urban world: Cities and the rise of the consuming class*, McKinsey Global Institute, June 2012 (www.mckinsey.com/mgi). Also see Yuval Atsmon, Peter Child, Richard Dobbs, and Laxman Narasimhan, "Winning the \$30 trillion decathlon: Going for gold in emerging markets," *The McKinsey Quarterly*, August 2012.

Demand shifts to emerging markets are being driven not just by large economies such as China and India but also by economic growth in Indonesia, Kenya, Vietnam, and other smaller emerging markets. Few multinationals today, however, are fully positioned to meet this demand. A recent McKinsey survey of 100 of the world’s largest companies that are headquartered in advanced economies found that, on average, they generate only 17 percent of their sales in developing economies.⁷⁵

The effect of this demand shift—as well as the challenges and opportunities it presents—varies across the five manufacturing segments. In regional processing industries such as food processing, for example, capacity grows where demand grows. So, not surprisingly, food processing output in Brazil, China, and India has increased by 8 to 18 percent annually in nominal terms since 1995, reflecting growth in local consumption. At the same time, annual growth in food processing in advanced economies has averaged 2 to 3 percent. In energy- and resource-intensive industries such as steel, production facilities also mostly serve local demand, which has driven a shift in global steel production to developing economies to fill the need for construction material, machinery, and automobiles (Exhibit 49). China’s share of global demand for finished flat steel more than doubled to 42 percent in the past decade, while the share of consumption by EU and North American nations fell by 23 percentage points. China is expected to continue driving global consumption, with markets in India and smaller developing Asian nations growing rapidly as well.

Exhibit 49
Global steel consumption growth is driven by large emerging economies



¹ Crude steel equivalent.
 SOURCE: World Steel Association; IHS Global Insight; IMF; US Geological Survey; McKinsey Global Institute analysis

75 Ibid.

In industries in the global innovation for local markets group, the shift of demand to developing economies is changing the nature and the pricing of products that companies must sell to compete. For example, in pharmaceuticals, global demand for generics is projected to grow by 80 percent through 2015.⁷⁶ That growth is fueled by changes in preferences in advanced economies (where health care “payers” are attempting to reduce costs) as well as by the demands of emerging-market customers. Countries such as India that already have significant installed production capacity are well positioned to meet this demand.

Demand for automobiles in developing economies has already exceeded demand in advanced economies, and sales are growing nearly four times as quickly: demand in developing economies is projected to grow by 6.1 percent annually from 2012 to 2018, compared with 1.6 percent annually in advanced economies.⁷⁷

In aerospace and defense, the difference between demand in advanced and developing economies is striking. In advanced economies, governments and businesses are constrained by debt overhang and the slow recovery. As a result, while airline fleets are expected to double in size in the next 20 years, more than half of new deliveries are destined for emerging markets. Nevertheless, the shift in demand is not yet redrawing the global footprint of the industry: more than 90 percent of production capacity remains in Canada, Europe, and the United States. According to our analysis, even by 2020, less than 10 percent of global civil aerospace production is expected to be located in China, despite local production of China’s own C919 design and local assembly of the Airbus A320 in Tianjin.

Increasing demand fragmentation and customization

The shift in demand growth to developing economies greatly increases the complexity of manufacturing. Africa, Brazil, China, and India are not monolithic markets—they are made up of extraordinarily diverse regional, ethnic, income, and cultural segments, most of which can be large enough to compare to entire developed-nation markets. For example, at \$527 billion, Shanghai’s GDP is the same size as Switzerland’s and larger than that of Belgium, Denmark, and Norway. As the number of markets (and submarkets) in the developing world multiplies, manufacturers must manage product proliferation to keep up with customer tastes (Exhibit 50). This raises the pressure to adapt manufacturing and design footprints to the new patterns of demand. And with greater variation in products, the productivity challenge is likely to intensify.

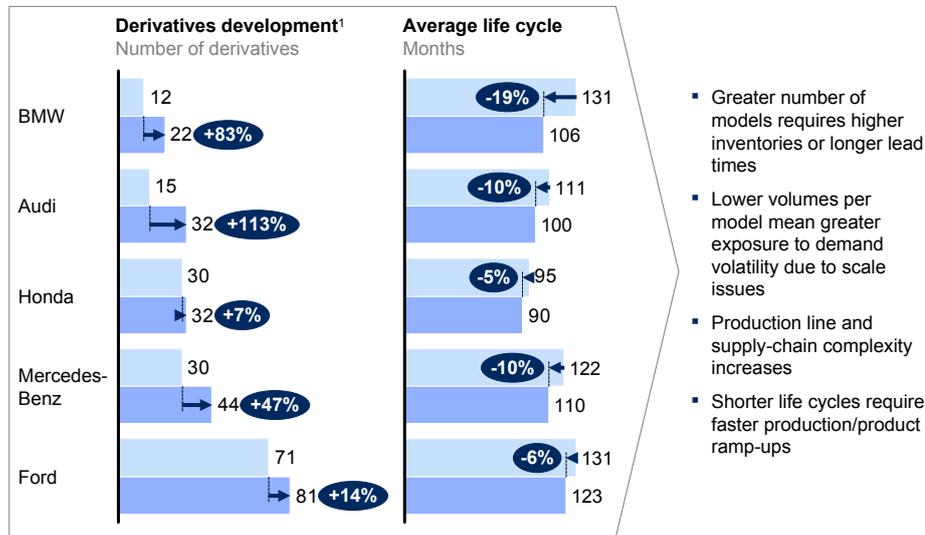
Another demand shift is the growing need for customization, which is seen across manufacturing sectors. In the global innovation for local markets segment, aircraft manufacturers face pressure from airlines that demand more flexibility in customizing aircraft configurations to meet the needs of specific routes. Many airlines are also looking toward a dual strategy, using a mixture of “hub-and-spoke” and “point-to-point” operating models. This also has implications for customization.

⁷⁶ IMS market prognosis, 2011.

⁷⁷ IHS Global Insight forecast, June 2012.

Exhibit 50

Fragmentation of demand: More consumer options and shorter product cycles (automotive example)



¹ Number of models including body variations, as well as hybrid models, not including different engine types, tuning models, or OEM-owned brands (e.g., Mini).
 SOURCE: R.L. Polk & Co.; IHS Automotive Industry Solutions; Bloomberg; McKinsey Global Institute analysis

- Greater number of models requires higher inventories or longer lead times
- Lower volumes per model mean greater exposure to demand volatility due to scale issues
- Production line and supply-chain complexity increases
- Shorter life cycles require faster production/product ramp-ups

Automakers and other manufacturers are preparing for further proliferation of models, greater customization, and shorter life cycles. Personalization today is a competitive tool in the high-end luxury goods segment but may well expand to the mid-market to keep up with consumer demand. So, even as they face the challenge of competing in generics, pharmaceutical companies will need to meet demand for specialty and niche products and even personalized medicines.

In regional processing industries such as food and beverage manufacturing, the proliferation of retail SKUs that has challenged suppliers in advanced economies is spreading to emerging markets as consumer preferences evolve. In developed markets, SKU proliferation is driven by product introductions for niche growth markets (such as functional foods and organic foods) and the globalization of supply (bringing global food specialties into developed markets, for example). As companies consider ways to reduce SKUs to manage production complexity, even as they try to accommodate new market requirements, we may see an emphasis on SKU rationalization or platform design to improve efficiency of plants. The underlying drivers of demand fragmentation, however, are not likely to change basic footprint dynamics.

Rising demand for services related to manufactured goods

Increasingly, manufacturers in many sectors—particularly in B2B markets—provide services along with their products, both to expand margins and to meet customer needs and competitive requirements. This has raised the share of manufacturing sector revenue and employment associated with services to as high as 55 percent in some sectors (Exhibit 51). Demand for services is highest in capital goods industries. For example, in electrical and industrial machinery, services account for 30 to 40 percent of total cost of ownership. In transportation equipment, such as fleet vehicles and forklift trucks, services can be as high as 40 to 45 percent of total cost of ownership. In comparison, services make up less than 10 percent of total cost of ownership for commodity manufactured goods such as appliances, furniture, and commodity chemicals.

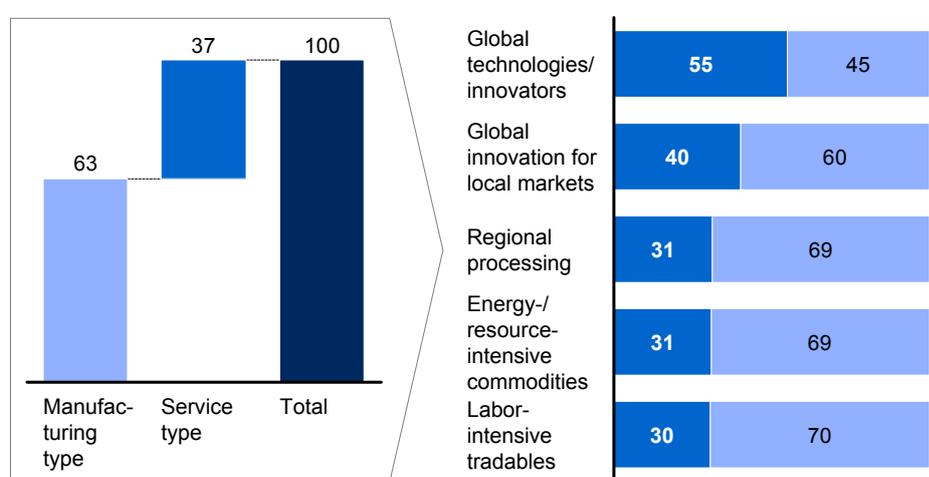
Makers of capital goods in globally innovative segments, such as automobiles, aerospace, machinery and equipment, electronics, and medical devices, must provide local customer service as well as local parts and maintenance. Service and maintenance can make up 50 percent of revenue in aerospace avionics and engines; more than a third of revenue in automobile manufacturing; and around 20 percent in industrial machinery, life sciences and medical devices, and high-tech and telecom equipment.

Aerospace firms provide a growing number of pre- and post-sale services to their customers: maintenance, financing, risk sharing, and training and support. Private defense companies, for example, increasingly provide leased aviation services, including pilots, air-to-air refueling, and “power by the hour.” The opportunity to expand service revenue varies across sectors. In aerospace, the service share of revenue appears to be nearing a limit, and there is considerable competition between aircraft manufacturers and traditional service providers (such as airlines and third-party aviation service providers) as to who captures the value. In automotive manufacturing, services are a critical competitive feature in the luxury sector for cars with extensive warranties. For some medical device and high-tech companies, services are an important competitive factor and selling point.

Exhibit 51

Service type activities already make up 30 to 55 percent of manufacturing employment

Manufacturing occupations in the United States in 2010¹



¹ Manufacturing-type occupations refer to early-stage manufacturing and final assembly. Service occupations include R&D, procurement, distribution, sales and marketing, post-sales service, back-office support, and management.

SOURCE: US Bureau of Labor Statistics (BLS); McKinsey Global Institute analysis

FACTORS OF PRODUCTION CHALLENGES: UNCERTAINTY IN ACCESS TO TALENT AND RESOURCES

Today, the global manufacturing sector faces change on many fronts. These shifts relate to the availability and costs of various factors of production, from rising wages in China and other developing economies, to shortages of workers with specific technical skills, to volatile (but generally higher) costs for raw materials, energy, and transportation. These discontinuities represent additional operating constraints and will require careful management and innovative responses. Availability of technical talent, for example, will play a strong role in footprint decisions for certain industries, such as medical devices, and will require new strategies by policy makers. In some cases, a strong supply of skilled talent will become the basis of comparative advantage for national economies. Higher and more volatile resource prices affect manufacturers everywhere and are creating new uncertainty about production and transportation costs as well as affecting cost differentials between locations.

Rising wages in “low-cost” locations

A by-product of rising wealth and productivity in developing economies is rising wages. From 2000 to 2008, real wages in the group of advanced economies grew at about 0.5 to 0.9 percent per year. In those years, real wages in Asia grew by 7.1 to 7.8 percent annually, and in emerging Central and Eastern European countries, real wages rose by 4.6 to 6.6 percent annually. In Latin America, real wages grew at 2 to 4 percent annually from 2006 to 2008.⁷⁸ Rising wages remain a mark of success for developing nations, the result of economic development and rising prosperity. However, for companies, higher wages can raise relative costs and may require changes in location choices. Exchange rate appreciation is another outcome associated with rapid economic growth, which can also accelerate changes in relative labor costs.

Rising wage costs are most likely to affect industries in the labor-intensive tradables group and the assembly steps in global technologies/innovators businesses—places where labor is a relatively large fraction of compressible costs. Companies typically respond to rising wages by moving on to lower-cost locations. Today, this presents opportunities for “next frontier” developing economies to capture any labor-intensive work that leaves countries with rapidly rising wages such as China. Countries such as Bangladesh, Cambodia, Indonesia, Vietnam, and other developing economies are already experiencing growth in labor-intensive industries because of their cost advantages (Exhibit 52).⁷⁹ At the same time, the severe economic downturn has led to declines in manufacturing wages in some regions of advanced economies. As noted, in the United States, for example, real wages in manufacturing have declined by 2.2 percentage points since 2005.

However, rising labor costs in low-cost locations affect industries only when the trend materially changes the total landed costs of production and when it is relatively easy for the industry to move location; in many industries, this is not the case. For example, on the basis of production costs alone, European pharmaceutical plants (even the most productive ones) are not competitive today

⁷⁸ *Global wage report 2010/11: Wage policies in times of crisis*, International Labour Organization, December 2010.

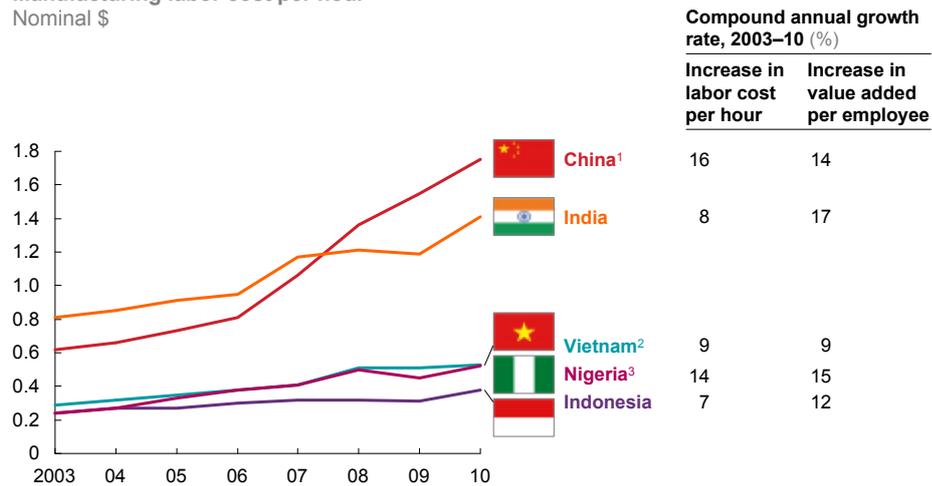
⁷⁹ *Sustaining Vietnam's growth: The productivity challenge*, McKinsey Global Institute, February 2012 (www.mckinsey.com/mgi).

with Indian producers to supply the Indian market. Even if Indian wages were to increase by 10 percent annually over the next five years and European wages rise by just 2 percent annually, Indian plants would still have a cost advantage in their home market.

Exhibit 52

With wages rising in China and India, other developing economies have an opportunity to gain share in labor-intensive industries

Manufacturing labor cost per hour
Nominal \$



1 2003–09.

2 2005–10.

3 2003–07.

SOURCE: Economist Intelligence Unit; IHS Global Insight; country labor ministries; McKinsey Global Institute analysis

Growing talent shortages

In a 2011 survey, 26 percent of employers from European, Middle-Eastern and African (EMEA) nations reported having difficulty filling jobs for lack of qualified talent, particularly technicians and engineers, and 80 percent of Japanese companies reported the same problem.⁸⁰ In the same year, when the US unemployment rate exceeded 9 percent, a survey of 2,000 US companies found that 30 percent of all companies, and 43 percent of manufacturing companies, had positions open for more than six months that they could not fill.⁸¹ Based on current trends in supply and demand, MGI projects potential shortages of high-skill workers around the world and potential oversupplies of less-skilled workers (Exhibit 53). For example, in Brazil, China, and India, the rapid growth in knowledge-intensive manufacturing is expected to create shortages of both high-skill workers (such as engineers and scientists) and medium-skill workers (such as technicians and factory workers) by 2030.⁸²

80 *2011 Talent shortage survey results*, Manpower Group, 2011, surveyed 39,641 employers in 39 countries.

81 *An economy that works: Job creation and America's future*, McKinsey Global Institute, June 2011 (www.mckinsey.com/mgi).

82 *The world at work: Jobs, pay and skills for 3.5 billion people*, McKinsey Global Institute, June 2012 (www.mckinsey.com/mgi).

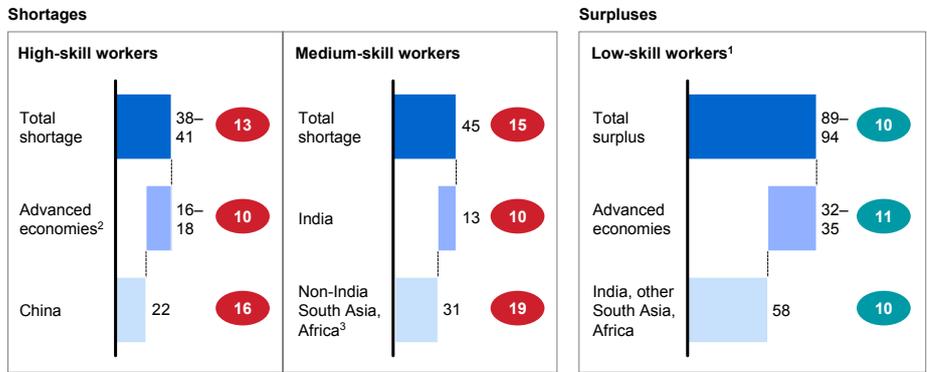
Exhibit 53

The world is likely to have too few high-skill workers and not enough jobs for low-skill workers

Demand and supply of workers by educational attainment, 2020E

Million workers

● % of supply of skill cohort
● % of demand for skill cohort



1 Low-skill defined as no post-secondary education in advanced economies; primary education or less in developing.
 2 25 countries that have GDP per capita greater than \$20,000 at 2005 purchasing power parity (PPP) levels in 2010.
 3 11 countries from South Asia and sub-Saharan Africa, with GDP per capita less than \$3,000 at 2005 PPP levels in 2010.
 NOTE: Numbers may not sum due to rounding.
 SOURCE: McKinsey Global Institute analysis

Three of the top five hardest-to-fill jobs in 2011—technicians, skilled trades workers, and engineers—are directly relevant to manufacturing.⁸³ In some industries, access to talent will become a key driver of competitiveness. This creates opportunities for large emerging economies that can become major research hubs as well as regions in advanced economies that retain deep pools of talent.

New expertise will be required in many industries. The automotive industry, for example, will need workers skilled in “me-chem-tronics”—an understanding of mechanical, chemical, and electronic systems—to support development of hybrid and all-electric power trains.

The manufacturing talent shortage is exacerbated by demographic trends, particularly the aging of the labor forces in advanced economies and China. In the next two decades, the growth of the global labor force will slow; in many advanced economies, the growth will be negligible. The average growth rate of labor forces in advanced economies will be about 0.7 percent annually, but in some places, such as Japan, labor forces are expected to shrink, due to aging and low birthrates.⁸⁴ In the United States, older workers (55 years of age or older) make up 40 percent of the workforce in agricultural chemical manufacturing, more than a third of the workforce in ceramics and in some metal manufacturing, and more than a quarter of aerospace, engine, turbine, and precision equipment manufacturing. Including workers in the 45 to 55 age group, the number of middle-aged and older workers swells to 60 to 70 percent of workers in these industries. Manufacturing companies risk losing much of this valuable expertise and experience to retirements in the coming decade.

83 “Manufacturing” talent for the human age, Manpower Group, 2011.
 84 *The world at work: Jobs, pay and skills for 3.5 billion people*, McKinsey Global Institute, June 2012 (www.mckinsey.com/mgi).

Adjusting to high and more volatile commodity prices

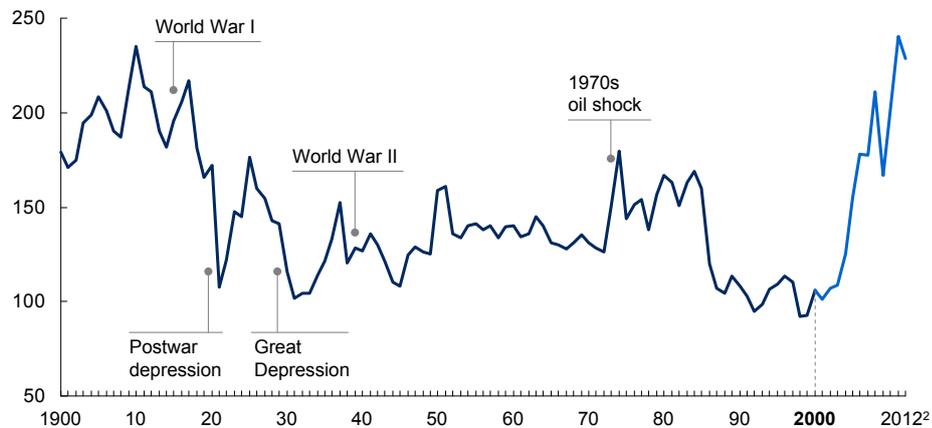
In the past decade, commodity prices have risen to levels not seen since the early 1900s in real terms, undoing the price declines of the entire 20th century (Exhibit 54). When global growth returns, commodity prices are likely to remain high and volatile as global resource markets oscillate in response to surging global demand and inelastic supplies.⁸⁵

Exhibit 54

Commodity prices have increased sharply since 2000, erasing all the declines of the 20th century

McKinsey Global Institute Commodity Price Index

Index: 100 = years 1999–2001¹



¹ For details on the McKinsey Global Institute Commodity Price Index, see *Resource revolution: Meeting the world's energy, materials, food, and water needs*, McKinsey Global Institute, November 2011.

² 2012 prices are based on the average of the first six months.

SOURCE: Grilli and Yang; Stephan Pfaffenzer; World Bank; IMF; OECD; UN Food and Agriculture Organization; UN Comtrade; McKinsey Global Institute analysis

Over the next 20 years, resource markets are likely to behave very differently than they have in the past (once the recovery from the Great Recession takes hold and growth resumes).⁸⁶ Across all major commodities, demand is expected to increase by 30 to 80 percent, driven by the unprecedented addition of 1.8 billion new members to the global consuming class over the next 15 years, mainly in Asia. By 2030, the global car fleet is expected to double to 1.7 billion. Calorie intake is projected to rise in India by 20 percent. Demand for urban infrastructure will soar: China is adding floor space totaling 2.5 times the entire residential and commercial square footage of the city of Chicago each year to meet the needs of its urban citizens.

As a result, it is unlikely that the pattern of declining resource prices that marked the second half of the 20th century will return. Furthermore, based on the pattern of the past decade, resource prices will almost certainly be more volatile. This represents an increasingly large challenge for industries in which raw materials are a major factor cost. Our analysis of the food and beverage manufacturing industry showed that raw materials can make up 65 percent of total cost. The costs of cereal, sugar, and meat have risen by 5 to 15 percent annually since 2000. Large and global consumer packaged goods manufacturers such as Unilever, Nestlé, Sara Lee, and Kimberly-Clark have all warned of rising commodity prices

⁸⁵ Richard Dobbs, Jeremy Oppenheim, and Fraser Thompson, "A new era for commodities," *The McKinsey Quarterly*, November 2011.

⁸⁶ *Resource revolution: Meeting the world's energy, materials, food, and water needs*, McKinsey Global Institute, November 2011 (www.mckinsey.com/mgi).

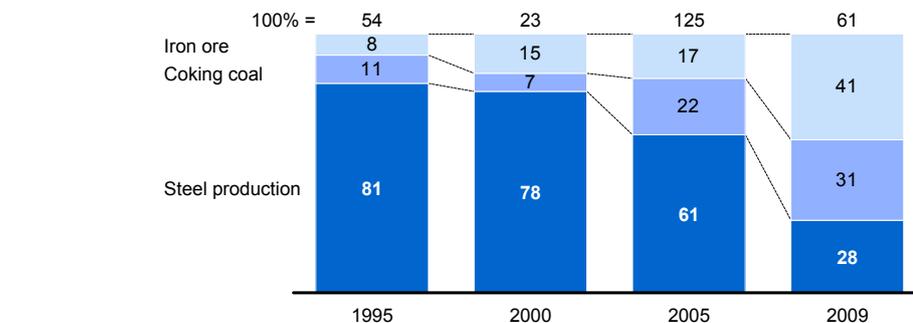
and the need to pass on some of these increases to consumers, even though consolidation in grocery retail and food service markets limits the manufacturers' ability to pass on price increases.

In the steel industry, where raw materials contribute 70 to 80 percent of costs, our research showed how rising commodity prices have shifted the value dynamics. From 2000 to 2010, the share of steel industry profits that went to producers fell from 80 percent to less than 30 percent, as value shifted upstream to suppliers of iron ore and other resources (Exhibit 55). Returns to capital for steel manufacturers fell from 20 to 25 percent in 1995 to about 5 percent in 2010. Combined with overcapacity, this reduces the incentive to expand steel footprints in order to exploit cost differences or meet demand growth.

Exhibit 55

High raw material prices can shift value upstream and reduce incentive to make large investments in manufacturing capacity

Steel profit pool split (hot rolled coil)¹
 Earnings before interest and taxes (%; \$ billion)



Return on capital employed (ROCE) %	Mining ²	1995	2000	2005	2009
	Steel production ³	20–25	5–10	20+	~5

1 Profit pool = EBITDA × demand/production for 12 major regions; EBITDA based on historical highs and lows.
 2 Based on reported ROCE for top 40 mining companies.
 3 ROCE estimated using average worldwide depreciation, capital employed, and working capital assumptions.
 NOTE: Based on a sample of ~15 large steel players; example for 100 percent captive ore and non-captive ore; rounded.
 SOURCE: McKinsey Global Institute analysis

Technological changes can lead to shortages in specific commodities. The aerospace industry's move to carbon structures requires titanium to replace aluminum for adjacent structures to avoid corrosion. That substantially increases the demand for titanium. The automotive industry's move to lightweight materials and new power train and chassis technologies can put significant strain on the supply of aluminum, carbon, and rare earth materials. It is estimated that a shift to electric drive trains in autos could raise demand by carmakers for rare earth materials such as neodymium from 15 percent of current global production to 550 percent by 2020. Demand for carbon fiber could reach 600 kilotons—about 20 times the current demand—causing bottlenecks in the automotive supply chain and competition for resources with industries such as aerospace.

Rising transportation costs and frequent bottlenecks

While the slow recovery from the global recession has depressed demand for goods in many places, the long-term trend points to tight shipping capacity, as growth in shipping volumes outpaces expansion of transportation capacity. In developing countries, rapid urbanization and the expanding base of middleweight cities are straining the capacity of transportation infrastructure and exacerbating transportation problems.⁸⁷ Advanced economies also struggle to keep pace with rising volume; road traffic in the United States has increased by 3 percent a year over the past two decades, while capacity has increased by only 1 percent a year. Infrastructure players are also raising fees and tolls; some US ports now charge an additional \$100 per 20-foot equivalent transportation unit, contributing to rising transport costs.

High transportation costs are most damaging for manufacturers of products that have relatively low value density, such as consumer goods, appliances, and furniture. They also hit manufacturers with long supply chains and distribution networks. In the previous chapter, we discussed the importance of transportation costs in keeping steel production and consumption local. Now, P&G, IKEA, Emerson, and other manufacturers are responding to higher transportation costs by “regionalizing” production footprints near large markets (Exhibit 56). In industries that are already regional, such as food processing, rising transportation costs are likely to keep footprints local. For products such as semiconductors, electronics, and office machinery, with value densities exceeding \$70,000 per ton—as much as ten times as high as for automobiles and machinery—landed costs are not affected as much by rising transportation costs. So footprints for these manufacturing industries are less likely to change as a result.

Exhibit 56

As a result of rising transport costs, manufacturing companies are rethinking supply-chain configurations

Company	Nearshoring solution
	<ul style="list-style-type: none"> Launched a strategic review of supply operations to respond to changes in the global operating environment Conclusion: Price increases have changed the math. In the past, the cost of building a factory or distribution center far outweighed transportation costs. Now transportation costs are critical to the distribution of products
	<ul style="list-style-type: none"> With rising transportation costs, shipping bookshelves, coffee tables, and entertainment centers exceeds cost of making them Moving to a more regional manufacturing footprint by opening first US production facility to cut distribution costs
	<ul style="list-style-type: none"> Electrical equipment maker regionalized manufacturing for items such as appliance motors to offset rising transportation costs Relocated plants from Asia to Mexico and the United States to be closer to customer base

SOURCE: AMR Research; *The Wall Street Journal*; other press; McKinsey Global Institute analysis

⁸⁷ Middleweight cities are defined as those with populations between 150,000 and ten million, which are the fastest-growing urban centers around the world. See *Urban world: Cities and the rise of the consuming class*, McKinsey Global Institute, June 2012 (www.mckinsey.com/mgi).

GOVERNMENT POLICIES CONTINUE TO SHAPE MANUFACTURING

After decades of liberalization, privatization, and deregulation, the pressure to generate growth and employment in the wake of the Great Recession has elevated manufacturing on the policy agenda. As we will see in Chapter 5, efforts by governments to make their manufacturing sectors more successful and their nations more attractive expansion sites for multinational manufacturing corporations take on many forms. These include incentives to support local industry, which are spreading to a broader set of countries and also include measures such as reducing corporate tax rates. In some industries, such as pharmaceuticals, regulations about health, safety, and quality may be starting to converge across countries, potentially easing the overall impact of regulation on manufacturing location decisions. Intellectual property protections seem to be rising globally, but with some high-profile exceptions. Here we discuss two commonly used policies: industry incentives and tax policies.

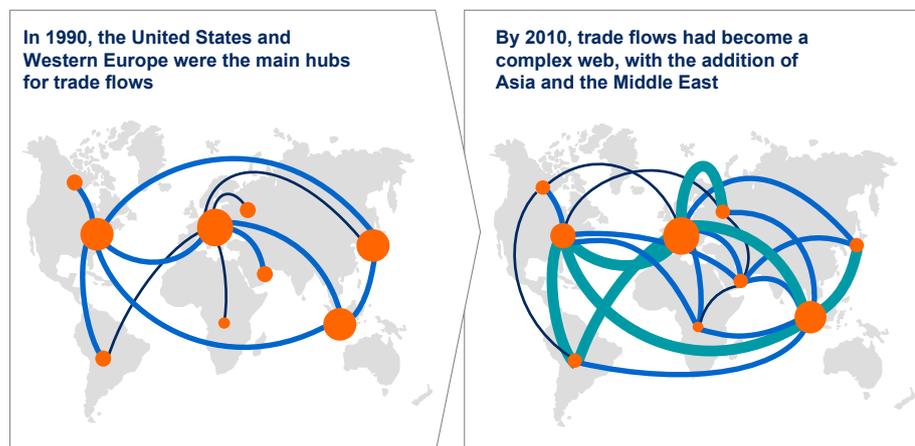
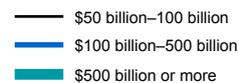
How restrictive trade policies persist in a free-trading world

Around the world, trade barriers are generally on the decline, and global trade has grown roughly twice as fast as global GDP for the past 20 years, creating a complex web of east-west, north-south, and intra-regional trade flows (Exhibit 57).

Exhibit 57

Trade routes have expanded, and trade patterns have become increasingly complex

Lines show total trade flows¹ between regions
 \$ billion



¹ Corresponds to exports of goods.

SOURCE: IHS Global Insight; IMF's Direction of Trade; McKinsey Global Institute analysis

The rise in global trade has been enabled by declining trade barriers and the rise of trading agreements and sanctioning bodies such as the WTO. The number of smaller multilateral trade agreements, such as the North American Free Trade Agreement, and the Trans-Pacific Partnership, has increased from fewer than 50 in the 1980s to around 250 today. More than three-quarters of these are cross-regional trade agreements. As a result of these agreements, average applied tariff rates fell from 30 percent in the mid-1980s to roughly 10 percent by 2010. There are notable exceptions in certain categories such as motor vehicles and food and beverage, where tariffs remain in place, and countries, such as India and Thailand impose prohibitive tariffs.

Despite pressures to remove non-tariff measures, nations continue to use them to protect their manufacturing sectors. These include local content and offset requirements for market access and subsidies for domestic producers. India's defense offset policy stipulates that foreign defense contractors that win contracts worth \$60 million or more must spend the equivalent of 30 to 50 percent of the sale price on goods and services from Indian defense industries or make direct investments in Indian defense industries or R&D organizations. Advanced economies, particularly in Europe, provide subsidies in food manufacturing, and globally the aerospace industry receives a range of supports from governments—from funding and demand incentives (e.g., low-cost loans, and military and commercial aircraft orders) to broad support for industry investments (R&D funding, training grants, and tax, trade, and labor agreements).

Around the world, companies in the global innovation for local markets segment, which includes autos and pharmaceuticals, are exposed to government interventions that stimulate domestic investment by supporting local production, restricting trade, and imposing non-tariff barriers such as product quality and compliance requirements. As Exhibit 58 shows, these supports range from national R&D subsidies to tax incentives and wage agreements to attract plants to certain locations.

Exhibit 58

Global innovation for local markets industries are subject to government regulation and benefit from government support

NOT EXHAUSTIVE

Examples of government interventions

Sector	Country	Government action
Automotive	 Brazil	<ul style="list-style-type: none"> Two-tiered import tariff for non-local automotive players to incentivize importers to build domestic plants in Brazil
	 China	<ul style="list-style-type: none"> National R&D fund to encourage new local technology growth, targeted to manufacturers of new-energy vehicles
Aerospace	 India	<ul style="list-style-type: none"> Offset policy for defense procurement contracts mandating that a specific portion of total deal value be sourced or invested within India, for deals larger than a threshold Offset clauses also apply to procurement by India's state-owned airlines
Pharmaceuticals (included within chemicals sector)	 Brazil	<ul style="list-style-type: none"> Import tax and higher value-added tax on imported pharmaceutical products to incentivize local production
	 EU	<ul style="list-style-type: none"> Retesting requirement for medicinal products entering the EU market from manufacturers in other countries
Electrical machinery	 United States	<ul style="list-style-type: none"> Government incentives for equipment, appliance and other manufacturers to relocate production within the United States
Chemicals	Middle East	<ul style="list-style-type: none"> Job creation incentives that boost buildup of new domestic chemicals capacity to create jobs at the expense of return on investment

SOURCE: McKinsey Global Institute, *How to compete and grow: A sector guide to policy*, March 2010; McKinsey & Company industry practices

Government interventions are also common in energy- and resource-intensive industries. Steel is regarded in many nations as critical to economic and national security. Historically high import tariffs in the sector have fallen over the past 20 years, but rules remain in place that favor domestic steel production. For example, Japan's regulatory regime requires very high-quality steel in construction projects to provide earthquake resistance; these products are made only by Japanese firms.

As a result, demand for steel in developing economies is largely met by domestic production. Meanwhile, steel producers in advanced economies struggle with substantial overcapacity and high exit costs. Widespread regulatory and policy

support—such as tax breaks and operating subsidies, and establishment of state-owned steel producers—explains the limited degree of globalization. In some cases, such regulation has contributed to significant overcapacity in industries such as autos, steel, and certain chemical sectors. The automotive manufacturing industry suffers from overcapacity globally, with more than 35 percent overcapacity in Europe and the Asia-Pacific region, while, as noted in Chapter 2, the pharmaceutical industry suffers from 75 percent overcapacity globally.

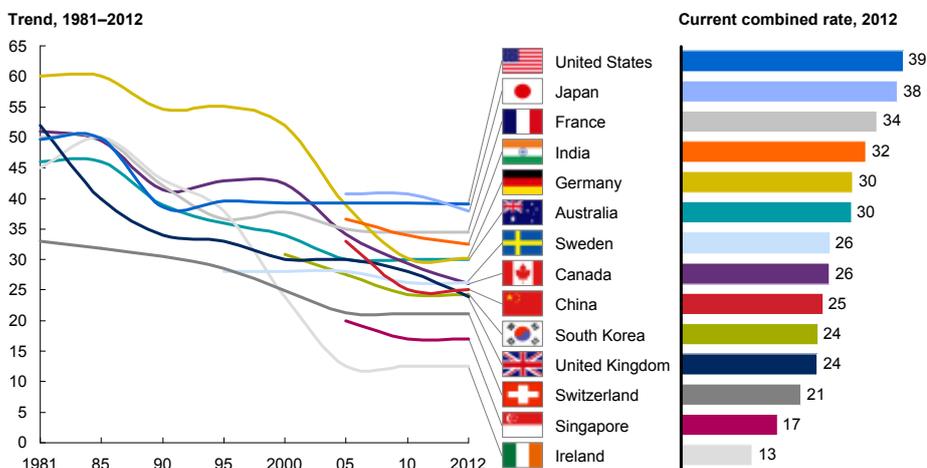
Corporate tax rates: Continuing decline

Statutory corporate tax rates (at the national, state/province, and local levels) have been declining in both advanced and emerging economies, falling from more than 50 percent in 1980 in countries such as France, Germany, and the United Kingdom. The average has fallen to about 23 percent today across the Organisation for Economic Co-operation and Development (OECD) countries (Exhibit 59). After adjustments, special exemptions, and other breaks, effective corporate taxes can vary significantly from these statutory rates. Academic studies and our own research have confirmed that statutory rates do in fact influence location decisions because of their impact on cost of capital, rate of return, and relative competitive positions—even if the effective tax rate paid by companies is lower than the statutory rate.⁸⁸

Exhibit 59

Total (national and state/local) statutory corporate tax rates have declined over the past 30 years in most large manufacturing countries

Statutory corporate tax rates in select OECD countries and emerging economies¹
 %



¹ Data show the basic combined central and sub-central (statutory) corporate income tax rates (i.e., combined national, state/regional and local tax rates).
 SOURCE: OECD Tax Database; KPMG; McKinsey Global Institute analysis

In some cases, nations have lowered tax rates, in combination with other incentives, to attract specific industries. For example, to attract pharmaceutical companies, Ireland has offered lower corporate tax rates either directly or through R&D tax breaks. These tax benefits can be applied to R&D, manufacturing, or both. As a result, efficient tax planning can reduce taxes paid by up to

⁸⁸ *Growth and competitiveness in the United States: The role of its multinational companies*, McKinsey Global Institute, June 2010 (www.mckinsey.com/mgi); also see M. P. Devereux and G. Maffini, *The impact of taxation on the location of capital, firms and profit: A survey of empirical evidence*, Oxford University Centre for Business Taxation working paper, number 07/02 April 2006.

60 percent. Even when manufacturing is performed elsewhere, profits attributable to the intellectual property of a specific drug can be registered in the tax-advantaged country, provided that the drug is registered there early in its life cycle and that sufficient R&D is based there. In some cases, companies moving R&D and drug registration to low-tax countries may also locate production there, but that is usually only to claim additional tax benefits and maximize negotiating leverage with the tax authorities, not due to interdependence of R&D and production functions.

While low taxes are an incentive, they rarely determine location decisions by themselves. Taxes tend to be less important in sectors where profit margins are lower and intra-firm cross-border trade is large, enabling transfer pricing to shift profits into favorable locations. In fact, academic research has found that tax treatment affects cost of capital, rate of return, and relative competitive position more directly than it does business locations or jobs.⁸⁹ More often, low tax rates, in combination with other factors, such as rising domestic demand, availability of intellectual property protection, or a skilled workforce, persuade manufacturers to invest or expand in particular places. Earlier MGI research on multinational company investments found that most companies indicated that they would rather have developing economies invest in infrastructure and talent than offer tax incentives.⁹⁰

INNOVATION IN MATERIALS, PROCESSES, AND PRODUCTS

In the past decade, increasingly capable tools have enabled substantial productivity gains in manufacturing. We see a robust pipeline of technological innovations that suggest that this trend will continue to fuel productivity and growth in the coming decades. Manufacturing will benefit from important innovations in materials, product design, production processes, and manufacturing business models. Companies now have more scale options, not just in the volume of production but also in the markets they can target and materials they can manipulate. Advances in lightweight materials, additive manufacturing, frugal innovation, and the so-called circular economy (i.e., recovering and recycling materials used in finished products) will change how manufacturers use metals and other materials and raise resource productivity and efficiency.

Finally, innovation is enabling information-driven intelligence in both products and processes. Big data, advanced analytics, social technologies, and use of intelligent devices to monitor production machinery, supply chains, and products in use (also known as the “Internet of Things”) are all bringing intelligence to how products are designed, built, and used.”⁹¹

In this section we look at how these trends affect the materials used as inputs, the production processes employed, and the business models and information flows used to create new designs, manage supply chains, and bring products to market.

89 Ibid.

90 *New horizons: Multinational company investment in developing economies*, McKinsey Global Institute, October 2003 (www.mckinsey.com/mgi).

91 The “Internet of Things” refers to networks of sensors and actuators embedded in physical objects from roadways to pacemakers and churning out large volumes of real-time data. See Michael Chui, Markus Loffler, and Roger Roberts, “The Internet of Things,” *The McKinsey Quarterly*, March 2010.

Innovation in materials

The need for new capabilities and higher performance in materials, the need for greater customization, and a greater focus on long-term cost and resource sustainability are all driving innovations in materials. These advances—in nanotechnology, biologics, and lightweight composites—affect manufacturing industries as diverse as aerospace and food.⁹² There are challenges to achieving scale, reducing cost, and developing new applications, but recent successes have rekindled interest in the application and processing of these new materials in manufacturing.

- **Nanomaterials.** Since the late 1990s, there has been a concerted effort to investigate nanotechnology applications. In the United States, government funding for nanotechnology research increased by 15 percent annually from 2001 to 2010, reaching more than \$1.6 billion. Large manufacturing companies such as GE and Intel are devoting significant resources to nanotechnology. Today applications are most advanced in semiconductors, electronics, and structural materials. Nanotubes and graphene—both carbon lattice structures created from nano-confined graphite forms—have been used to create high-performance transistors and ultra-strong composite materials. Fluorescent nanoparticles, or “quantum dots,” synthesized from semiconductors and some metals, are used in biological labels and solar cells. In electronics and semiconductor manufacturing, nanotechnology (graphene-based electronics, spintronics, and photonics) may replace silicon. Nano-structuring advances may lead to higher-density batteries, cheaper and more efficient solar cells, and ultra-strong composites. Advances in nanotechnology will require long time horizons and continued investments in materials, platforms, and applications across manufacturing industries. Further research is also needed to gauge the long-term environmental and health effects of products manufactured with nanotechnology.
- **Biotechnology and biological agents.** The traditional role of biologics—vaccines, serums, and antitoxins—is expanding, and there is growing convergence between biologics and nanotechnology. For example, nanofibers—molecules formed from proteins induced to self-assemble in desired patterns—present peptide sequences that trigger specific biological responses (as in nerve regeneration). This has applications in pharmaceuticals and has been used to reverse spinal-cord damage in laboratory mice. Pharmaceuticals will also benefit from nano-enabled biotechnologies that allow for more rapid and sensitive diagnostics and more effective therapeutics. The food manufacturing industry is interested in nanolaminates—made from edible lipids or polysaccharide compounds—that can be sprayed on food products to provide protection from air and moisture. Biological sensors that have already been used in glucose monitors are also being adapted to other applications. Nanosensors, whether carbon-based or bio-analytical, can detect traces of contaminants such as toxins or bacteria and are being used in consumer packaged goods, electronics, and security applications.

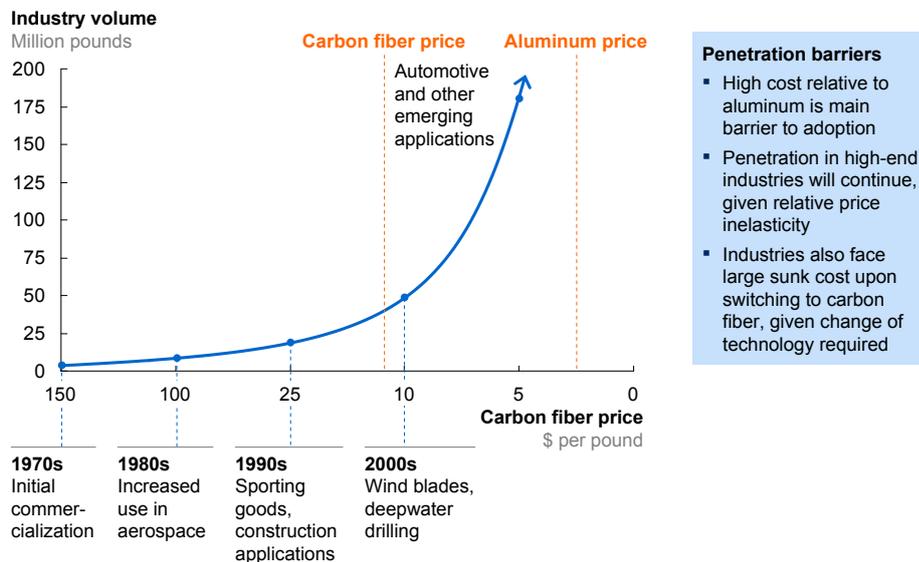
⁹² “Nanoscience” and “nanotechnology” refer to the study and development of materials with critical dimensions ranging from 1 to 100 nanometers (1–100 billionths of a meter, or 20–200 gold atoms). At this scale of operation, new and significant properties emerge in conventional materials used in manufacturing.

- Lightweight materials.** High-strength steel, aluminum, and carbon composites have been an important part of industrial design and manufacturing since the 1970s. The drive for resource efficiency and carbon emissions reductions are driving more widespread use. Carbon fiber composites accounted for 5 percent of aircraft design in the 1980s. In Boeing's new 787 Dreamliner, composites account for 50 percent of the plane's weight. Lightweight materials are used increasingly in automobile and wind-turbine manufacturing. In 2013, BMW is set to start shipping the iSeries cars, a series of urban and sports cars with body support structures consisting primarily of plastic reinforced with carbon fiber. Many German and Japanese carmakers are partnering with carbon fiber suppliers to use the material more widely. Should the technology take off in this sector, demand for carbon fiber composites could reach 20 times the current demand (Exhibit 60).

Exhibit 60

Large-scale adoption of carbon fiber is hindered by high cost

Carbon fiber market evolution



SOURCE: Deutsche Bank; expert interviews; Zoltek; McKinsey Global Institute analysis

The use of advanced materials in manufacturing is still relatively new and limited, and a number of challenges stand in the way of increased use. One is cost: for the weight saving to be cost-effective, we estimate that the prices of lightweight materials will need to fall by at least 60 percent. Another challenge is automation: cycle times for plastics reinforced with carbon fiber that are used in the automotive sector need to drop to 1 to 2 minutes from 10 to 12 minutes to make the process suitable for mass production. There are also issues with predictability: at present, designers have low confidence in computer models for carbon fiber design. Recyclability is also a challenge because of the use of thermoset resins.

Finally, there are industry-specific technical challenges. For example, in automobiles, manufacturers are being asked to switch from stamped steel and spot-welding—a production method that has dominated for decades—to use of high-strength steel and aluminum and carbon fiber, all of which require different production and joining techniques.

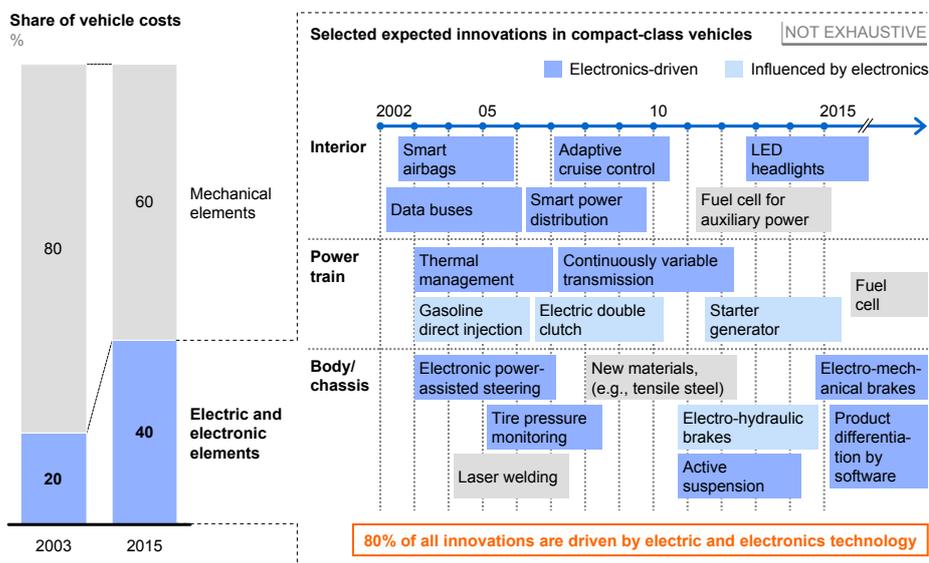
Innovation in product design

Perhaps the most important change in how products are designed and used is the addition of computer intelligence (e.g., sensors and onboard computers). Some of the most interesting possibilities arise in the automobile industry. In the coming years, electric and electronic elements will likely account for more than 80 percent of all innovations in the automotive industry (Exhibit 61). Many new cars come with electronic stability control technology that improves safety by detecting and reducing the loss of traction. Parking assist systems steer cars into parking spaces, computer chips monitor tire pressure, and rain-sensing windshield wipers activate themselves. The all-electric Chevrolet Volt boasts ten million lines of software code for more than 100 electronic controllers, more than two million more than in the 787 Dreamliner.

Exhibit 61

Innovations in electric and electronic technologies are the main drivers of auto industry value creation

ILLUSTRATIVE



SOURCE: McKinsey automotive & assembly practice; McKinsey Global Institute analysis

Toyota and Ford are working with Microsoft to co-develop software technologies. A result of increased software in devices has been the increased availability of data. This has led to the application of advanced analytics and machine learning techniques. Google’s self-driving cars, BMW’s ConnectedDrive, or Volvo’s driverless “road trains” are prime examples of where auto technology may be headed. Bill Ford, executive chairman of the Ford Motor Company, predicts a “melding of the auto industry with the tech industry,” in which sensory intelligence in automobiles not only improves performance and safety, but also provides data to build new services. One example: using data collected from windshield wiper activity to create more accurate weather forecasts.

To improve their technological capabilities, car companies have been setting up shop in Silicon Valley. A GM lab has been working on projects such as the Cadillac CUE infotainment interface; Volkswagen is exploring systems to start and stop cars automatically in traffic jams and monitor driver stress levels; BMW’s Group Technology Office specializes in mechatronics, information

and entertainment systems, and telematics.⁹³ Winning this battle will require that manufacturers build new capabilities and collaborate with new partners across industries.

Innovation in production processes

Four trends will affect production process and platform design in manufacturing in the coming years: digital modeling, simulation, and visualization; advances in industrial robotics; additive manufacturing; and green manufacturing. Adoption rates for these technologies vary widely, but the trend is clear. Even in China and other emerging economies, the economics of automation are increasingly attractive as wages rise and automation costs fall.

- **Digital modeling, simulation, and visualization.** With inputs from product development and historical production data (such as order data and machine performance), manufacturers can apply advanced computational methods to create a digital model of the entire manufacturing process. A “digital factory,” including all machinery, labor, and fixtures, can simulate the production systems. In addition, ubiquitous sensor technologies (such as cameras and transponder chips) help to “synchronize” simulation and reality at every point in the production timeline. Leading automobile manufacturers have used this technique to optimize the production layout of new plants. P&G partnered with scientists at Los Alamos National Laboratory to develop simulations to improve the reliability of P&G’s complex production lines, leading to a 44 percent increase in plant productivity and savings of \$1 billion in manufacturing costs globally.⁹⁴

Manufacturers can also use big data techniques and analytics to manage complex manufacturing processes and supply chains in industries such as aerospace where products are assembled with components from hundreds of suppliers around the world. Big data can also facilitate greater experimentation at the product design stage. Toyota, Fiat, and Nissan have all cut new-model development time by 30 to 50 percent by allowing designers and manufacturing engineers to share data quickly and create simulations to test different designs and choice of parts and suppliers.

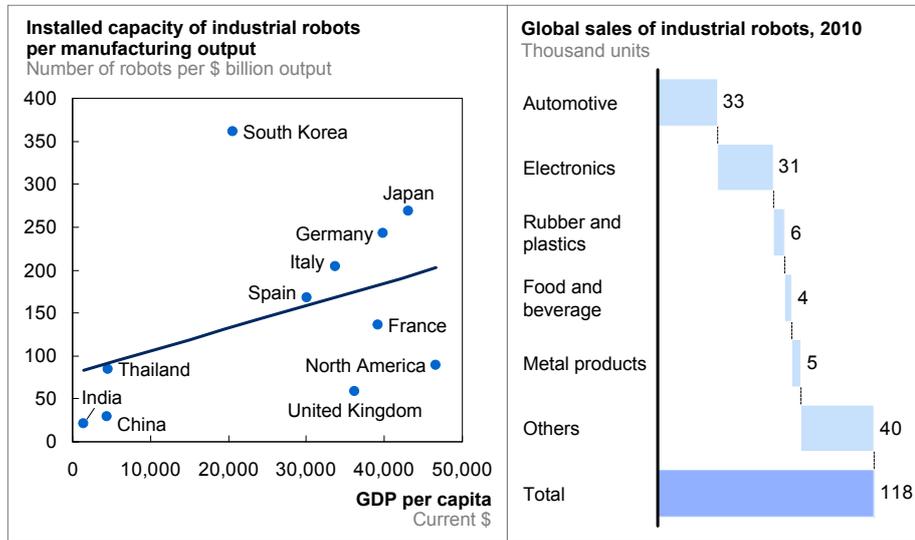
- **Advances in industrial robotics.** At the end of 2010, an estimated one million industrial robots were in use and 118,000 were being sold annually. Robot use is highly skewed by region and by industry: in 2010, automotive and electronics manufacturing each accounted for more than 30,000 robot units sold globally, while industries such as food and beverage, rubber and plastics, and metal products each bought only 4,000 to 6,000 new robots. Robots are more widely used in less labor-intensive industries and are more concentrated in advanced economies where wages are higher and the workforce is more highly educated (Exhibit 62). In Germany and Japan, there are 200 to 250 robots per \$1 billion of output; China and India have fewer than 50. South Korea is an outlier with more than 350 robots installed per \$1 billion of output, driven by the large share of highly automated industries such as automotive and electronics in its manufacturing base.

93 “Mechatronics” is a multidisciplinary approach being adopted by engineering and polytechnic schools, combining mechanical and electronics engineering with control, software, electrical, and systems engineering fundamentals.

94 *Improved manufacturing processes save company one billion dollars*, US Department of Energy, October 2011, www.energy.gov.

Exhibit 62

Advanced economies and innovative industries have installed the most industrial robots



NOTE: Numbers may not sum due to rounding.
 SOURCE: International Federation of Robots; World Bank; McKinsey Global Institute analysis

Across manufacturing industries, robots are used increasingly to reduce variability, increase speed in repetitive processes, get around ergonomic restrictions, and improve plant utilization and productivity. By one estimate, installations will grow 26 percent from 2010 to 2014, bringing robots to new regions and industries.⁹⁵ This adoption is driven largely by falling costs; average robot prices have declined by 40 to 50 percent relative to labor compensation since 1990 in many advanced economies. Another factor is the growing variety and complexity of tasks that robots can perform with the integration of machine learning and natural language processing. In addition, manufacturers are installing robots to meet demands for higher quality from customers and regulators and to match competitors. Robotics can also help manufacturers adapt to changes in the global labor market, such as the aging of working-age populations and rising labor costs in developing economies. In industries that adopt more modularization and standardization of processes, robots could become prevalent even in low-cost regions.

- **Additive manufacturing.** Additive manufacturing (AM) refers to a wide set of technologies, including 3-D printing, that build up solid objects from small particles. AM technologies—selective laser sintering, fused deposition modeling, and stereolithography—are key technologies for industrial AM today. These technologies are used over a range of products, materials, and sizes, with no single technology capable of covering the entire range. Some 6,500 industrial AM production units were shipped to manufacturing customers in 2011, nearly twice as many as in 2005. At this point, fewer than 30 percent of AM-produced components are used as parts or in fit and assembly; the majority are used as functional models, prototypes, and casting patterns, or

⁹⁵ The International Federation of Robotics, a non-profit organization established by robotics institutes from 15 countries, estimated in 2011 that the stock of roughly one million robots at the end of 2010 would grow to 1.3 million by the end of 2014.

for presentation models.⁹⁶ The aerospace, automotive, and industrial plastics industries are the primary applications, although AM is used increasingly in customized consumer goods such as jewelry, prosthetics, and dental implants. AM can be a truly transformative force for manufacturing flexibility by cutting prototyping and development time, reducing material waste, eliminating tooling costs, enabling complex shapes and structures, and simplifying production runs.

Some experts believe AM is nearing an inflection point, as new advances enable more applications, reduce costs, and increase adoption by downstream industries. However, AM still faces technological hurdles that are likely to delay mainstream adoption. Compared with traditional casting, AM is still far less accurate and an order of magnitude slower. In addition, AM is expensive to operate: capital costs for high-volume applications can be high, and powders used in AM can be 200 times as costly as sheet metal. New technologies must improve material deposition rates and enable larger production scale. AM technologies that achieve mainstream success will need to have potential for mass customization, enable larger printer sizes and a broad technology base, and exploit new materials. All of this will take time and investment. Until then, AM will continue to help in rapid prototyping and early production runs for small, complex, and low-volume parts.

- **Green manufacturing.** The main drivers of adoption of this technology are to improve energy productivity and reduce greenhouse gas emissions. Energy costs can make up 20 percent of total landed costs for energy-intensive commodities such as cement and aluminum and are also a factor in chemicals, industrial gases, and rubber and plastics. Regulatory pressure to reduce carbon emissions levels may also be a factor, affecting sectors such as steel, chemicals, and refined energy products, which contribute nearly 60 percent of the manufacturing sector's global carbon dioxide emissions (Exhibit 63). Finally, there are additional advantages in going "green," since consumers and investors have a favorable perception of environmentally sustainable products and practices.

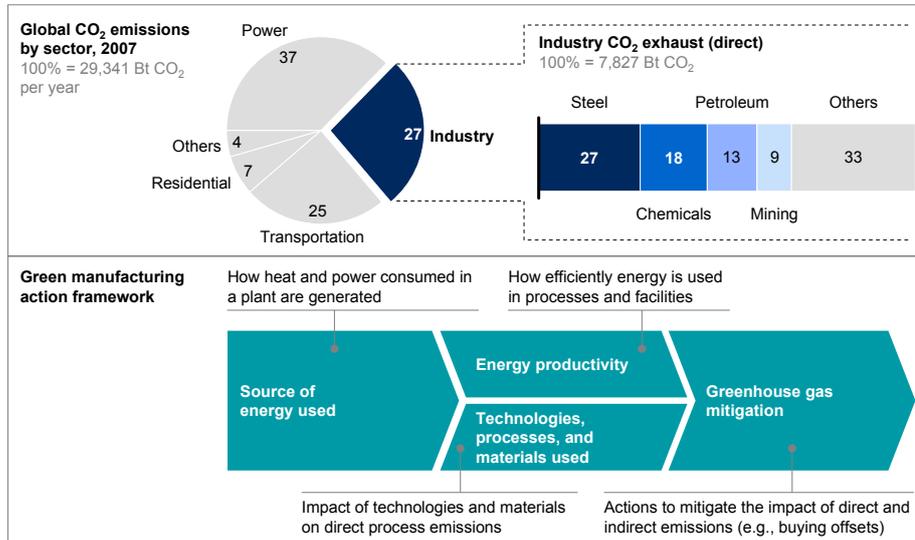
One way for manufacturers to reduce emissions is to change the mix of energy inputs from coal to cleaner fossil fuels or renewables, including by switching to hybrid or electric engines in manufacturing facilities. The most significant opportunities are in improving energy efficiency in heating and cooling in factories and warehouses and in process heating and machine drives. Together these savings could reduce energy use by manufacturers by as much as 50 percent.⁹⁷ Upgrading to newer technologies and better processes and changing the materials mix can also help reduce emissions: for example, adding 5 percent limestone in cement can reduce greenhouse gas emissions by 3 percent. Right-sizing combustion, steam generation, and HVAC systems—and installing energy-efficient motors and variable-speed drives—can reduce energy consumption by 50 to 85 percent.

⁹⁶ *Wohlers Report 2012: Additive manufacturing and 3D printing state of the industry*, Wohlers Associates, 2012.

⁹⁷ *Resource revolution: Meeting the world's energy, materials, food, and water needs*. McKinsey Global Institute, November 2011 (www.mckinsey.com/mgi). Also see Diana Farrell and Jaana Remes, "Promoting energy efficiency in a developing world," *The McKinsey Quarterly*, February 2012.

Exhibit 63

Green manufacturing is driven by the need to improve energy productivity and reduce greenhouse gas emissions



SOURCE: International Energy Agency; McKinsey Global Institute global energy demand model; McKinsey Global Institute analysis

Innovation in manufacturing information systems

Major information technology trends such as big data, advanced analytics, social technologies, and the Internet of Things all can be harnessed in supply-chain management and other aspects of manufacturing (Exhibit 64).

Exhibit 64

Big data has impact across the manufacturing value chain

	R&D and design	Supply-chain management	Production	Marketing and sales	After-sales service
Build interoperable, cross-functional R&D and product design databases to enable concurrent engineering, rapid experimentation, simulation, and co-creation	✓		✓		
Aggregate and share customer data to improve service, increase sales, and enable design-to-value	✓	✓		✓	
Source and share data through virtual collaboration sites (idea marketplaces to enable crowdsourcing)	✓		✓	✓	
Implement advanced demand forecasting and supply planning across suppliers and use external variables		✓	✓	✓	✓
Implement lean manufacturing; model and optimize production; develop dashboards			✓		
Implement sensor data-driven analytics to improve throughput and enable mass customization			✓		
Collect real-time after-sales data from sensors and customer feedback to trigger services and detect flaws		✓	✓	✓	✓
Improve supply-chain visibility through control towers and organization-wide collaboration		✓	✓	✓	✓

SOURCE: McKinsey Global Institute analysis

In supply-chain management, big data helped John Deere realize \$900 million in savings in inventory control over two years. Coca-Cola Enterprises has used daily vehicle-routing systems based on big data to save \$45 million annually. P&G's competitive supplier bidding system, based on advanced optimization models, led to an additional \$300 million in savings.⁹⁸ Sensors to track RFID tags on products have helped to improve inventory management while reducing working capital and logistics costs. Airline, shipping, and trucking lines already are getting up-to-the-second data on weather conditions, traffic patterns, and vehicle locations.

In customer-facing activities, social technologies can generate deeper customer insights to fine-tune product development and provide a way for customers and other outside contributors to participate in co-creation of new products and features. Texas Instruments uses online panels of engineers to evaluate new semiconductor products in development, helping the company avoid over-engineering its products. In response to a request from the Defense Advanced Research Projects Agency (DARPA) in 2010, a crowdsourcing competition provided the design for a fully functional, combat-ready vehicle.

Analyzing the after-sales data reported by sensors embedded in complex products enables manufacturers of goods from aircraft to data center servers to refine preventive maintenance strategies. MGI's analysis of the impact of social technologies across four manufacturing sectors—consumer packaged goods, semiconductors, automotive, and aerospace—indicates that there are potential margin improvements of 2 to 6.5 percentage points, providing companies can transform traditional manufacturing IT into an all-encompassing information strategy to fine-tune product requirements, improve manufacturing processes, and boost quality and productivity.

Innovation in manufacturing business models

The environment compels manufacturers to adopt new business models that are more responsive to swings in demand or input costs and faster product cycles. Manufacturers are pressed to respond to the fragmentation of demand and need for customized products for new market segments, even as private and public sector buyers demand greater value. As a result, emerging business models emphasize efficiency and resource productivity. This section discusses three trends that demonstrate the emerging business models: mass customization, circular economy, and frugal innovation.

- **Mass customization.** Mass customization is a manufacturing industry innovation that has been evolving for many years.⁹⁹ Some consumer products manufacturers have made progress, including Nike, whose NIKEiD customization program for sports apparel generated revenue of more than \$100 million in 2009. Other efforts are under way. In pharmaceuticals, the concept of personalized medicine is gaining traction. Eli Lilly, for example, is increasingly focusing efforts on tailored therapeutics, using advanced diagnostics to identify specific subgroups of patients with the highest efficacy

98 Sourced from several editions (2005–10) of *Interfaces*, the INFORMS Journal on the Practice of Operations Research; articles on supply-chain innovations by John Deere, Coca-Cola Enterprises, and P&G.

99 Mani Agrawal, T. V. Kumaresh, and Glenn A. Mercer, "The false promise of mass customization," *The McKinsey Quarterly*, August 2001.

Renault and Caterpillar have run remanufacturing facilities for several years. Resource-intensive industries such as basic metals also are moving to this model. In steel manufacturing, the use of scrap metal instead of virgin iron ore is beginning to influence the industry footprint. As access to both virgin and high-quality recycled material streams becomes more costly, ownership and control of those streams will be increasingly important. Such a model will have implications across the value chain. It will encourage different manufacturing techniques. A shift from subtractive processes such as cutting and machining to additive ones such as powder metallurgy will maximize material yield. The circular economy concept will promote lease over sale, turning consumers into users, driving a shift from planned obsolescence to the continual evolution of long-lived product platforms, and tightening the reciprocity between producer and customer.

- **Frugal innovation.** In the fastest-growing markets for manufactured goods—developing economies—company R&D budgets and government research spending tend to be far lower than in advanced economies. For example, India’s national R&D budget was around \$14 billion in 2010—a year when Microsoft, Pfizer, and Intel each spent \$8 billion to \$10 billion on R&D. In this environment, frugal innovation changes the business model by emphasizing shorter launch cycles, innovation through commercialization, and reverse-engineered innovation. The concept is closely associated with Indian *jugaad* and Chinese *shanzhai* innovation models.¹⁰² Compared with advanced-economy companies, developing-economy companies are more comfortable in putting a new product or service on the market quickly and improving performance in subsequent generations (i.e., innovation through commercialization). Global manufacturers believe that innovating through commercialization is a competitive edge in emerging markets, and many companies are bringing these innovations back to developed markets.¹⁰³

The innovations in materials, information technology, production, and business processes apply not only to large global manufacturers, but also to smaller enterprises. Indeed, from product design to rapid prototyping and digital fabrication, manufacturing tools and services are becoming far less costly and more accessible, lowering barriers for small and medium-sized enterprises (SMEs) and entrepreneurs.¹⁰⁴

Online factory services, for example, allow designers and innovators to contract out prototyping and production, ordering a single unit or tens of thousands. “Makerspaces”—shared production facilities built around a spirit of open innovation—are proliferating around the world. In China, the first makerspace (Xinchejian) opened in 2010; the next year, Shanghai’s municipal government announced plans to open 100 government-funded makerspaces. In the United States, makerspace communities are flourishing in several cities, and

102 “Jugaad” refers to a makeshift arrangement, while “shanzhai” refers to copycat innovation. Both terms relate to the approach of adapting successful foreign products or business models to local markets, innovating, and bringing products to market quickly. See Gordon Orr and Erik Roth, “A CEO’s guide to innovation in China,” *The McKinsey Quarterly*, February 2012, for more on China’s innovation landscape.

103 Glenn Leibowitz and Erik Roth, “Innovating in China’s automotive market: An interview with GM China’s president,” *The McKinsey Quarterly*, February 2012.

104 See Chris Anderson, *Makers: The new industrial revolution* (New York: Crown Business, 2012).

the concept is being introduced even in schools. Students in more than 1,000 schools now have access to makerspaces supported by DARPA.

At the same time, crowdfunding websites such as Kickstarter and Quirky are opening doors for many more new ideas for manufactured products to come to life. Internet marketing also opens up new avenues for manufacturing entrepreneurs. This virtual ecosystem can accelerate manufacturing growth in both advanced and emerging economies and further blur the boundary between manufacturing and services.

This long-term opportunity, however, comes with near-term challenges. First there is a scale issue; it is still difficult to beat mass production costs. Also, while new methods promise greater flexibility, many still are very limited. As we have noted, additive manufacturing technologies are still constrained by cost, speed, reliability, and range of materials that can be used. As a result, current uses are concentrated in prototyping highly complex components, mainly for automotive, aerospace, industrial plastics, and medical devices—along with some “personalized” consumer products, mostly labor-intensive items such as toys, apparel, and jewelry. Therefore, the impact of these technologies on the broader manufacturing sector may not be noticeable for a while.

It also remains to be seen how much impact the opportunity to gain market exposure and distribution on the Internet will have for entrepreneurs and SMEs. Small and medium-size businesses typically under-invest in innovation and technology, which might be a more important factor in their growth.¹⁰⁵ Additionally, the SME sector remains under pressure: in the United States, new business creation declined by nearly 25 percent between 2007 and 2010, and business startup growth remains weak due to capital constraints, demand uncertainty, and reduced investor appetite for risk.

AN INCREASINGLY VOLATILE AND UNCERTAIN WORLD

Five of the ten most financially costly natural disasters in recorded history took place in the past five years. Raw material price volatility has increased by more than 50 percent in recent years and is now at an all-time high. Long-term shifts in global demand are accompanied by significant upswings and downswings in demand, driven by changes in customer preference, purchasing power, and events such as quality problems. Logistics breakdowns, natural disasters, or supplier insolvency can all interrupt the normal function of supply chains.

The growth of global value chains has increased exposure of many companies to the impact of natural disasters, as Japan’s earthquake and Thailand’s flooding have demonstrated. Many manufacturing companies are being forced to reassess the balance between efficiency gains from globally optimized value chains and the resilience of less fragmented and dispersed operations.

Catastrophic events are not the only sources of uncertainty facing manufacturing companies. As global growth recovers and central banks ease off emergency measures, there is a risk that the cost of capital will rise. Manufacturers also face fluctuating demand and commodity prices, currency volatility, and various kinds of supply-chain disruptions that chip away at profits, increase costs, and force

105 Stephen J. Ezell and Robert D. Atkinson, *International benchmarking of countries’ policies and programs supporting SME manufacturers*, Information Technology and Innovation Foundation, September 2011.

organizations to miss market opportunities. All of these issues have become more acute in recent years as rising volatility, uncertainty, and business complexity have made reacting to—and planning for—changing market conditions more difficult than ever.¹⁰⁶

Demand volatility

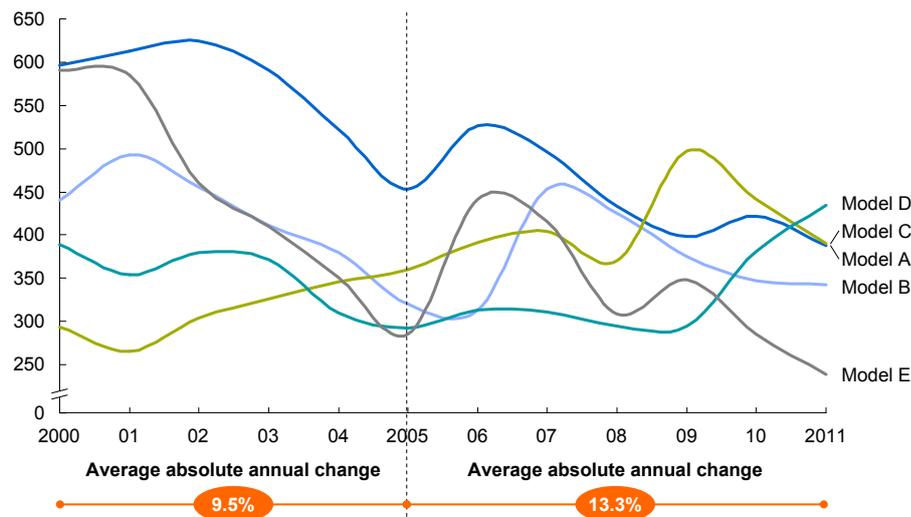
Demand can fluctuate wildly, while changing customer tastes or the emergence of disruptive technologies can permanently alter a company's market (Exhibit 66). With the projected addition of 1.8 billion consumers to the global consuming class by 2025 and the associated fragmentation of demand for manufactured goods, demand volatility likely will increase. The combination of rapid growth in global consumption, SKU proliferation as a result of demand fragmentation, more demand for capital investments, and demand spikes due to unexpected and disruptive events is likely to mean continued or increasing demand volatility for global manufacturers.

Exhibit 66

Auto demand is becoming more volatile

Sales of selected vehicles in individual market segment

Thousand



SOURCE: IHS Automotive; McKinsey Global Institute analysis

All manufacturing segments are exposed to demand volatility. In some industries, such as electronics and semiconductors, short product cycles and sudden shifts in demand are routine. Large capital goods sectors, such as aerospace, motor vehicles, equipment, and machinery, are exposed to demand uncertainty through business cycles, changes in government spending, and other macroeconomic factors. In the case of consumer goods, manufacturers must accommodate a wider range of consumer preferences and produce variations that appeal to local tastes. In consumer products, there seems to be no end to demand for variation. By 2011, mobile phone makers were introducing more than 1,100 varieties of handsets every year.

In food and beverage industries, volume volatility is relatively low, but there is significant fragmentation of local tastes and preferences, resulting in SKU

¹⁰⁶ Mike Doheny, Venu Nagali, and Florian Weig, "Agile operations for volatile times," *The McKinsey Quarterly*, May 2012.

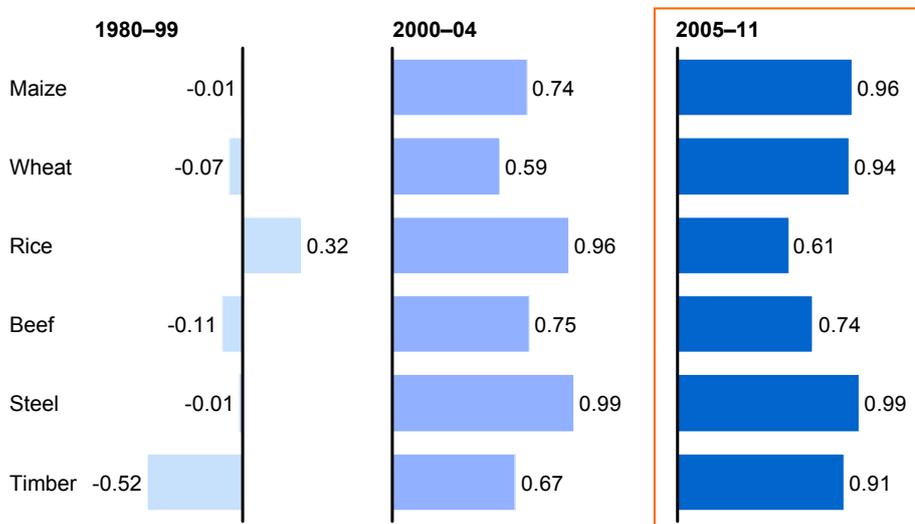
proliferation. Variations in baked goods, beverages, cereal, and candy all rose more than 25 percent a year in the mid-2000s; the number of SKUs at large North American grocers exceeded 10,000 by the end of the decade. Since the 2008–09 recession, the popularity of private-label goods has added more SKU complexity and added uncertainty in food and beverage demand.¹⁰⁷ Finally, unexpected events contribute to demand volatility. For example, in pharmaceuticals, sales volumes for vaccines can swing fivefold from one year to the next, depending on the level of disease threat. In the past decade, the avian flu and swine flu outbreaks drove explosive demand and significant shortages.

Commodity price volatility

Rising commodity prices have wiped out price declines of the 20th century. In addition, resource prices are becoming increasingly interlinked, and these linkages are resulting in more volatile prices; shortages in one commodity now rapidly spread to other resources and drive up prices globally. In the past decade, volatility in commodities such as oil, wheat, cocoa, and PET (polyethylene terephthalate) for plastics has exceeded one standard deviation over the average price.

Just as with commodity price increases, volatility in commodities disproportionately affects industries in which raw materials make up the majority of total factor costs (Exhibit 67). The consumer packaged goods (CPG) industry in the United States has historically passed on price increases to consumers—in the recovery from US recessions in the early 1980s and early 1990s, CPG product price growth exceeded raw material price growth. However, more recently CPG manufacturers have had less success passing on commodity price increases. From 1998 to 2008, product prices increased 15 percent but raw materials increased 40 percent. These trends are also evident in industries such as metals and plastics, in which raw materials make up a substantial share of total factor costs.

Exhibit 67
New linkages mean that commodity prices now show significant correlation with oil prices
 Correlation with oil prices



SOURCE: McKinsey Global Institute analysis

107 McKinsey US Consumer Sentiment and New Normal survey, September 2011.

The ongoing debate about extracting shale gas and “tight oil” in the United States is a prime example of commodity uncertainty. Shale gas helped reduce the price of US natural gas from \$13 per million BTUs in 2005 to less than \$2 per million BTUs in early 2012. This shift in energy cost has the potential to rewrite the economics of industries such as basic metals, paper and pulp, mineral products, chemicals, and rubber and plastics. In these industries energy costs can be 10 to 30 percent of value added. These industries account for 22 percent of jobs and 28 percent of value added in the US manufacturing sector.

Cheap energy can stimulate local production for the domestic market, as with Nucor’s decision to locate a \$750 million direct-reduced iron plant in Louisiana. If enough demand for steel could be met domestically and the United States could close its trade deficit in steel products (\$17 billion in 2011), the industry could create 20,000 new jobs—equivalent to 5 percent of employment in basic metals. Furthermore, the development of shale gas has raised expectations that US-based steelmakers may become far more successful exporters to developing economies where global demand growth has shifted.

The potential benefit of shale gas is not limited to manufacturing: it is also expected to have an impact in power generation, transportation, and energy exports. At \$3 per million BTUs, natural gas competes well with coal, oil, nuclear, wind, and solar power for generating electricity. The share of US electric power generated by gas has already risen from 20 percent in 2008 to 28 percent today, and by 2030 natural gas could fuel 40 percent of power generators. With gas prices equivalent to \$18-a-barrel oil, it may be economical to retrofit diesel trucks to use gas. Finally, with gas averaging \$10 per million BTUs globally, exporting liquid natural gas may be attractive.

Still, there is uncertainty about how best to exploit the benefits of low-cost gas for manufacturing and the wider economy. Regulatory issues need to be clarified, particularly around greenhouse gas emissions, air quality, land use, and water availability and contamination. New infrastructure and skilled workers will be needed to develop distribution networks. Ongoing public policy debates will have to resolve whether to export natural gas, use it to transform the domestic transportation industry, or use it to subsidize domestic manufacturing. Finally, the economics of shale gas will have to be clarified for specific industries. Other factors such as capital intensity, transportation costs, and market proximity also play a role in deciding the footprint of energy-dependent industries. For example, for steel plants with basic oxygen furnaces that use energy from coking coal, the change in landed costs due to cheaper electricity may not be enough to affect a sticky global footprint: nearly 85 percent of long steel (used in construction) and 70 percent of flat steel (used in automobiles and white goods) is produced locally for domestic consumption.

Currency fluctuations

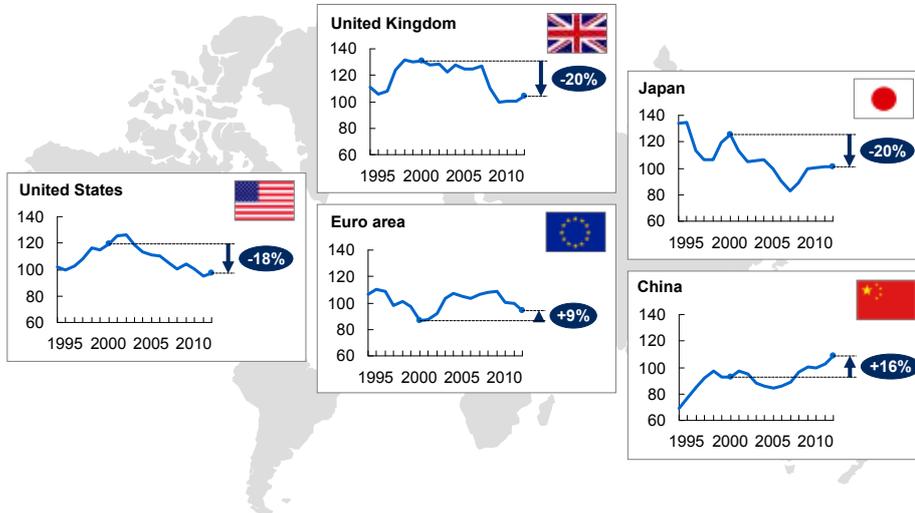
For companies in major manufacturing regions such as China, Europe, India, and Japan, currency has played a historical role in the location of some manufacturing industries, and continues to do so. Japanese automakers have long shifted production out of Japan because an unfavorable exchange rate penalized exports. Currency plays a smaller role in globally traded high-value products such as semiconductors or regional processing industries such as food (Exhibit 68).

Exhibit 68

Shifting currency movements over time and across countries add to uncertainty in the global manufacturing environment

● Change since 2000

Real effective exchange rates, 1994–2012, annual averages
100 = 2010



SOURCE: BIS real effective exchange rate, broad measure; McKinsey Global Institute analysis

Companies in automotive, machinery, and equipment manufacturing have used their global footprints to hedge against such volatility—and in so doing, have increased the regional or local nature of their footprints. With its recent US plant expansions, Honda will have the capacity to make nearly two million vehicles a year in North America, up from 1.3 million in 2010.¹⁰⁸ Nissan’s goal is to make 85 percent of the vehicles it sells in North America in North American plants by 2015.

Supply-chain risks

Given the complexity of supply chains in global manufacturing sectors, skill in managing supply-chain risk will be an increasingly important differentiator. “In our industry, the competitor that’s best at managing the supply chain is probably going to be the most successful competitor over time; it’s a condition of success,” notes former Caterpillar Chairman and CEO James W. Owens.¹⁰⁹ Yet more than two-thirds of global executives in a recent McKinsey survey acknowledged that supply-chain risk had increased since the 2008 recession. Executives in developed Asian countries reported the most concern: 82 percent said their companies’ supply-chain risks will increase in the next five years.¹¹⁰

Supply-chain concerns affect all manufacturing industries, even those with local footprints. These concerns are driven by the shift of consumption to developing economies, growth of local supply networks in these markets, higher demand and commodity volatility, the potential global impact of local quality problems, and regulatory action related to environmental and labor standards, health, and safety.

108 Mike Ramsey and Neal E. Boudette, “Honda revs up outside Japan,” *Wall Street Journal*, December 11, 2011.

109 Yogesh Malik, Alex Niemeyer, and Brian Ruwadi, “Building the supply chain of the future,” *The McKinsey Quarterly*, January 2011.

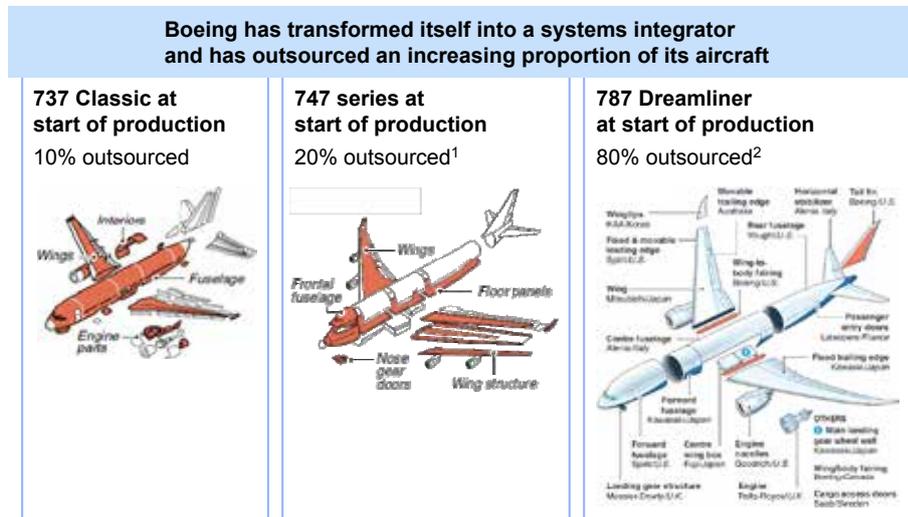
110 “McKinsey Global Survey results: The challenges ahead for supply chains,” *The McKinsey Quarterly*, November 2010.

The costs of supply-chain risks are rising in many sectors. Highly publicized quality issues in supply chains of industries ranging from automotive to pharmaceuticals have cost companies billions of dollars. Some local and global food brands incurred sales and reputation costs when melamine contamination was found in Chinese-made infant formula. And an elaborate new supply chain that Boeing devised to feed outsourced components and subassemblies to its 787 Dreamliner assembly plant turned out to be unwieldy (Exhibit 69). The ambitious effort had to be simplified, pushing back delivery by four years. According to one study, firms that announce production or shipment delays resulting from supply-chain glitches experience 10 percent declines in share prices on average.¹¹¹

Exhibit 69

Large aircraft makers such as Boeing have outsourced more of their manufacturing programs

Parts built by Boeing in-house



1 Estimated.

2 The number is a rough estimate due to integration of Vought plant into Boeing.

SOURCE: International Association of Machinists and Aerospace Workers; Boeing; Reuters; McKinsey Global Institute analysis

Location risk

The number of loss-related natural disasters has risen by 3 percent annually over the past 30 years, according to insurance statistics, from roughly 400 incidents per year in the early 1980s to as many as 1,000 per year in the past decade (Exhibit 70). Economic losses due to these events have also increased substantially, from nearly \$75 billion in 1980 to \$380 billion in 2011. The insurance industry recorded 820 loss-relevant events in 2011 alone, with more than 80 percent of these events affecting the world's major manufacturing regions: the Americas (35 percent), Asia (29 percent), and Europe (18 percent).¹¹² The worldwide impact of the 2011 Fukushima earthquake on supply chains demonstrated how the effects of a local disaster can spread. For example, damage to a primary supplier of metallic paint additives affected the color options available from major global automakers for several months. The earthquake also destroyed a key facility of one of the world's largest manufacturers of custom

111 Kevin B. Hendricks and Vinod R. Singhal, "The effect of supply chain glitches on shareholder wealth," *Journal of Operations Management*, volume 21, number 5, December 2003.

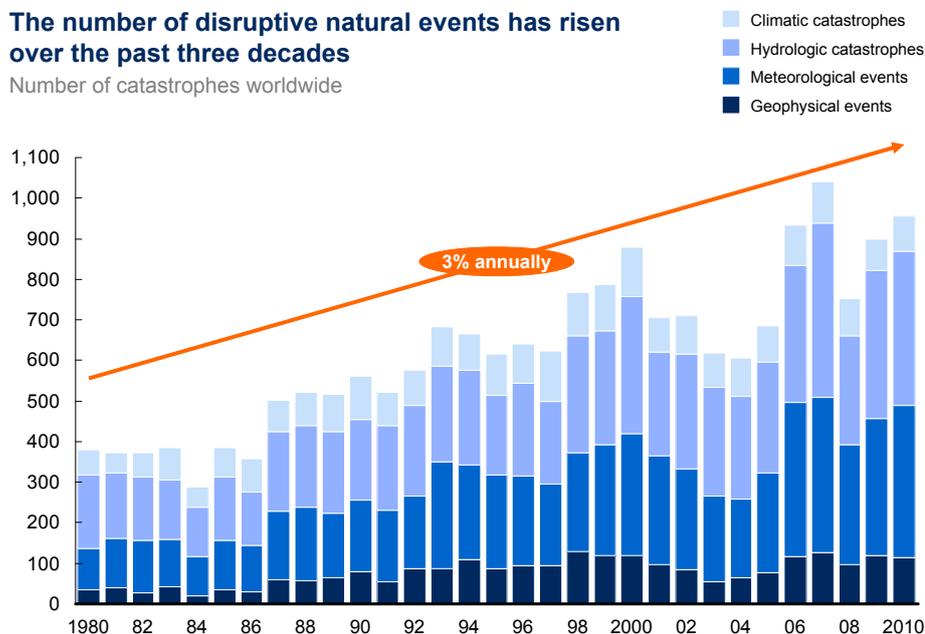
112 Christophe Courbage and Walter R. Stahel, eds., "Extreme events and insurance: 2011 annus horribilis," *The Geneva Reports—Risk and Insurance Research*, Number 5, March 2012.

microcontrollers. The specialized nature of these components made it hard for customers to obtain substitutes and led to significant shortages on global markets for more than three months.

Exhibit 70

The number of disruptive natural events has risen over the past three decades

Number of catastrophes worldwide



SOURCE: Munich Re; McKinsey Global Institute analysis

Manufacturing industries can be vulnerable to location risks not just because of their global supply chains but also because of concentration and single-sourcing in their supply chain. For example, in the pharmaceuticals manufacturing industry, up to 30 percent of company revenue can be traced to a single production site; up to three-quarters of revenue for some blockbuster drugs are at risk due to single-sourcing somewhere along the supply chain. Even in such global industries, there is little to be gained by sourcing critical components from multiple suppliers if they share a single source further up the chain.

Uncertainty in capital costs and access to capital

Over the past 30 years, costs of capital in most countries have converged, financial markets have globalized, and risk premiums in developing countries have fallen. Capital became plentiful, and long-term interest rates declined, largely as a result of falling investment in infrastructure and machinery; since the 1970s, global investment as a share of GDP fell from 26.1 percent to a recent low of 20.8 percent in 2002. This decline in demand was a key contributor to the three-decade-long fall in real interest rates that helped feed the global credit bubble.¹¹³

In a long era of cheap capital—still evident in today’s low interest rates—manufacturing companies have not had to prioritize capital efficiency. This may not seem like a risk now, but if and when global growth recovers and central banks are no longer focused on stimulating growth, the cost of capital will start to rise. When this swing may occur is uncertain, but fundamental trends make

113 *Farewell to cheap capital? The implications of long-term shifts in global investment and saving*, McKinsey Global Institute, December 2010. Also see *The emerging equity gap: Growth and stability in the new investor landscape*, McKinsey Global Institute, December 2011 (www.mckinsey.com/mgi).

such a swing all but inevitable. Rapid urbanization across Africa, Asia, and Latin America is increasing the demand for real estate and infrastructure development and manufacturing investment.

By 2030, we project that global investment demand could reach levels not seen since the postwar reconstruction of Europe and Japan. Global savings, however, are unlikely to rise in step—spending will rise as populations age, and even China plans to encourage more domestic consumption. Increased expenditure to address or adapt to climate change will play a part. As a result, the world may soon enter a new era of scarce capital and rising real long-term interest rates that could constrain investment and ultimately slow the global economic growth rate by as much as one percentage point.¹¹⁴

When it does, it will favor companies that are capital-efficient, that have locked in long-term capital financing, and that have the benefit of high credit ratings and large balance sheets to use capital as a competitive strength in the market. Companies across all five manufacturing segments are affected by higher capital costs. Meanwhile forces such as aging and the growing wealth of emerging economies could reshape global capital markets and reduce the role of listed equities, creating a potential \$12 trillion “equity gap.” The imbalance between the supply and demand for equity will be most pronounced in emerging economies, where companies need significant external financing to grow and to capitalize on the demand for investment. In the United States and several other advanced economies, investor demand for equities is likely to exceed what companies will need, partly because many companies in mature economies generate sufficient profits to finance their growth.

In an environment of rising interest rates and shrinking equity financing, companies in capital-intensive manufacturing industries must think carefully about how to meet their capital requirements to exploit growth opportunities—for example, sourcing capital globally by listing in markets where investor demand for equities is strong, or through private placements of equity shares. Companies should evaluate ways to boost capital productivity and reduce working-capital requirements and liquidity risks in the supply chain, and also consider the potential of suppliers to be a source of capital. Manufacturers with access to financing may be able to compete by offering sophisticated credit solutions to customers.

□ □ □

The next decade will bring new constraints and challenges to the global manufacturing industry. It will be critically important for manufacturers and policy makers who want to support manufacturing sectors to understand the nature of these changes and their dynamics. In many ways, these trends represent a new era for manufacturing that requires new approaches to policy. We find a growing mismatch between demand and supply footprints, driven by demand shifts to emerging markets, demand fragmentation, and customization. An era of decreasing factor costs is giving way to one of talent and resource scarcity. Government policies promoting deregulation and market efficiency are threatened by proactive policies to shore up domestic manufacturing.

114 Richard Dobbs and Michael Spence, “The era of cheap capital draws to a close,” *The McKinsey Quarterly*, February 2011.

4. Implications for manufacturing companies

The future of manufacturing belongs to the companies that can craft the strategies and build the capabilities to succeed in a new phase of global competition. New technologies and innovations as well as new sources of demand provide the opportunity. It is up to manufacturing leaders to seize it.

Manufacturing companies will need new thinking and new muscle. They will be challenged to make big bets on long-term trends while also becoming more agile and responsive to near-term opportunities and shocks. To place those bets, manufacturers need to find new ways to answer core strategic questions: What is the optimum footprint for design, manufacturing, and service? Who are the best partners and how does the company collaborate with them to create the most competitive network? How does the company gather information and use intelligence to inform decisions and operations? How does the enterprise develop and retain talent?

The result of this rethinking of operating strategy very likely will be a new kind of manufacturing company—a truly global organization that reaches around the world to build and sell products and services to diverse customer bases. Successful manufacturing companies will be networked intelligent enterprises that rely more on data and analytics to drive decisions and manage complexity. Leaders of 21st-century manufacturing organizations will manage across functional silos and across their companies' boundaries to collaborate seamlessly with partners and suppliers. Manufacturing companies will need new knowledge, new capabilities, and a new conviction to act.

As important as what manufacturers will do to create effective strategies and execute successfully is what they will not do. Leading companies will abandon simplistic single-point projections. They will not clone the same strategies they used in advanced economies or in other developing economies to enter new emerging markets. And, unless they are competing in the most low-skill labor-intensive types of manufacturing, they will not base footprint decisions on wage rates alone. Instead, they will use a “total factor performance” approach that takes into account all variables and considers the scenarios for how these factors evolve over time.

In this chapter we discuss four requirements for manufacturing companies for the next phase of global competition.

- **Getting granular.** Manufacturers must understand the context as it relates to their group and industry and develop a highly detailed, granular understanding of new market requirements to craft appropriate product and footprint strategies.
- **Building agility.** To respond adequately to the opportunities and challenges that will arise, manufacturers need to be able to move quickly and anticipate shifts in trends. Companies will need to be flexible and fast, and at the same time resilient—able to commit to strategies to capture long-term opportunities.

- **Adopting new approaches and capabilities.** Companies will need to learn new ways of generating market insights and, increasingly, will need to rely on an ecosystem of suppliers and partners that must work as a seamless organization. They will use a “total factor performance” approach to determine footprints and will continue to raise productivity, including in their use of resources.
- **Investing in organizational change and talent.** To operate in a more complex environment and to do so with speed and agility, companies need to remove organizational barriers and build new management capabilities and mindsets. And they need workers with the right skills.

BUILD STRATEGY AND FOOTPRINTS ON GRANULAR KNOWLEDGE OF MARKETS, TRENDS, AND OPPORTUNITIES

First, companies need to take a careful reading of where their industries stand in the new context. Crafting a specific strategic response to the new global manufacturing environment will require not only a clear understanding of a particular industry’s needs (e.g., its labor, energy, or innovation intensity), but also a grasp of how the new trends play against those requirements and potentially redefine sources of competitive advantage. The appropriate response to the inexorable shift of demand to developing economies will not be the same for automakers as it is for food processors.

Broadly speaking, all global manufacturing companies need to be present in Asia in much more substantive ways to capture the growth opportunity. But they will need to do so in ways that work for their segments, industries, and companies. For some companies, it may mean shifting production, development, or marketing functions to new locations—or all three. Food processors, for example, need to be on the ground in all phases of manufacturing. They build competitive advantage through strong brands, in-market supply, and retail relationships. For them, supply footprints must closely follow demand shifts.

In consumer electronics, the key requirement will be gaining market intelligence to serve new kinds of customers, even if they never build a plant in-market. Hundreds of millions of new consumers in developing economies have very different needs than customers in advanced economies. For example, some emerging-market consumers demand low-cost, feature-rich mobile phones. Others want limited-capability, entry-level handsets.

Companies across industries will have to invest in the process of collecting and using regional and local market insights, especially to compete in non-premium segments. More companies may rearrange R&D footprints, consolidating core hardware and operating system development centrally while dispersing customer insight and application development to new frontiers so that market intelligence can be turned into features and models more rapidly.

In some manufacturing groups, the impact of trends may be more muted. For example, the primary metals industry (part of the energy- and resource-intensive group of industries) is confronted by surging demand in Asia, higher energy costs, and volatility in the price and availability of raw materials such as iron ore and bauxite. But there is little expectation that the industry footprint or its sources of competitive advantage will shift dramatically. For example, even though higher energy costs are a consideration, energy accounts for only about 10 percent of

total costs in primary metals such as steel, so a superior energy-cost position is unlikely to alter the industry footprint; the locus of demand will be a more important factor.

Turn granular understanding into tailored strategies

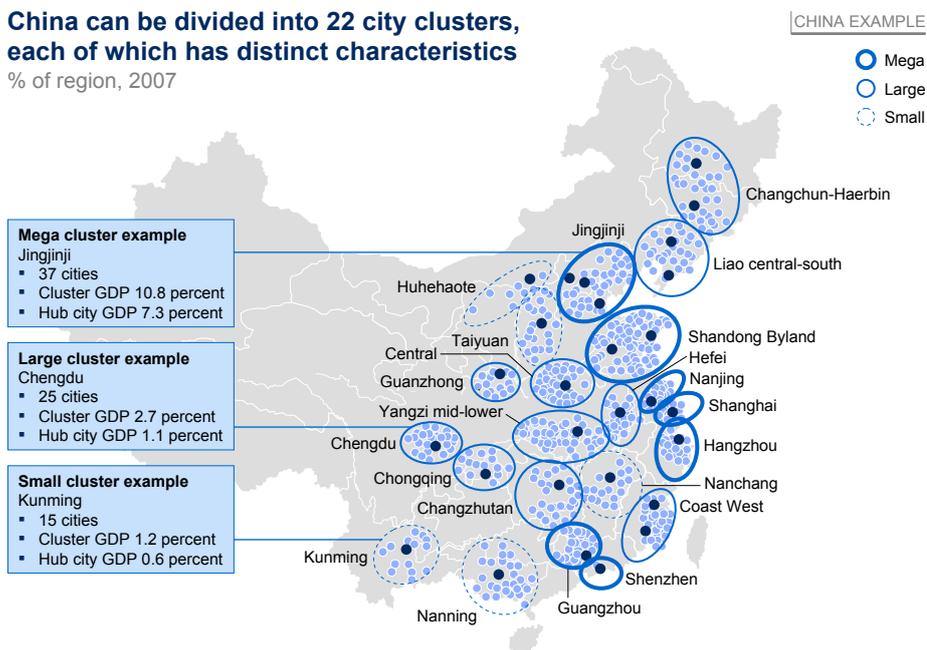
Once companies understand the overall context, to generate appropriate and adequate strategic responses they will need to understand the trends and opportunities in a far more detailed and granular way—not just at the company or regional level, but even at the business unit and (in some cases) down to the SKU level.

Granular data and on-the-ground observation allow companies to dig below the surface and uncover the insights that will enable them to tailor products and supply-chain strategies to specific sub-segments of markets. Traditional research methods can miss new opportunities, particularly in developing economies that have demographics, market structures, and distribution systems that are unfamiliar. A McKinsey study found, for example, that segmenting the Chinese market on a single-country or even on a regional or city basis was not adequate. By analyzing consumer characteristics, demographics, government policies, and other factors, the study identified 22 distinct market clusters that can be targeted independently (Exhibit 71).

Exhibit 71

China can be divided into 22 city clusters, each of which has distinct characteristics

% of region, 2007



SOURCE: McKinsey Insights China; McKinsey Global Institute analysis

In recent years, some companies have started to embrace a “granularity of growth” approach to markets. This involves looking for niches and underserved sources of demand that can be more profitable than broader markets where more competitors are present. However, few companies have mastered the cross-functional routines to consistently translate granular market understanding into granular operations strategies. In this next era of manufacturing, getting to this micro view of manufacturing strategy will be a key differentiator.

A granular view can help get past superficial views of average behavior and determine not-so-obvious market insights—such as what consumers really mean, rather than what they say (see Box 4, “Do consumers care where a product is made?”). In India, Frito-Lay succeeded by being highly selective about its market niches. It developed new brands and offerings based on deep, local consumer insights and built its own distribution network and supply chain to market its Indian portfolio.

Box 4. Do consumers care where a product is made?

Consumer markets are increasingly global, yet consumers continue to say they favor products made “at home.”¹ That’s what they say. But when it comes to actual purchase decisions, this sentiment gives way to more important considerations: brand value, price, quality, features, convenience, and performance. Local preferences clearly matter in food, where consumers equate “local” with “fresh” and have strong national and regional tastes. This keeps the industry’s footprint highly local. But in electronics and apparel, consumers focus on performance, innovation, style, and brand reputation, no matter what the source. In automobiles, where consumers do state a country-of-origin preference, they actually buy on price, quality, and features.

For products where the perception of value is very deeply associated with the country of origin—Swiss watches, German automobiles, Italian suits—consumers remain faithful even after much of the content is no longer sourced in the country of association.² In the United States, many foreign automobile brands have higher domestic content than famously American cars; the Toyota Avalon has 85 percent US/Canadian-made parts, versus as little as 55 percent for some iconic US brands.³

What are the implications for companies? Manufacturers can employ the power of country of origin to cultivate and strengthen their brand identity, even when products are not strictly domestic. We see companies such as Audi, Chanel, and Victroinox (Swiss Army) using country of association to convey brand images of quality, precision, performance, or luxury. We also see companies successfully creating country associations wherever they manufacture. GE, for example, uses the “We are the GE in Germany” campaign to emphasize its commitment there. Manufacturers should identify where they can create positive associations (e.g., in design or in craftsmanship or quality) with countries of origin and use those insights to differentiate their products.

1 In a *New York Times* poll of US consumers in November 2011, 86 percent of respondents thought that it was very important or somewhat important that the products they buy are made in the United States.

2 For a watch to be considered “Swiss-made,” only 51 percent of its value has to originate in Switzerland; in 2007 a proposal was made to raise the standard. BMW’s X3 and X6 SUVs, sold worldwide, are made in South Carolina, not in Germany.

3 American Automobile Labeling Act (AALA) annual report, US National Highway Traffic Safety Administration, 2012.

In another case, a consumer products company struggled for several years to create a viable business plan to enter an emerging market. It had been attempting to define the product and supply-chain design for the emerging market using the approaches (and people) that had served the company well in advanced economies. After repeated attempts and limited progress, the company finally invested in highly detailed local research into what customers really wanted and used that insight as the starting point for defining what a successful local supply chain should look like. Researchers interviewed consumers in shops and in their homes to understand what they were willing to pay for, how they would use the product, and what brand value they associated with the product. This helped the company discover what feature and price points would be acceptable.

The interviews also uncovered an unexpected insight: packaging was critically important, because consumers expected to reuse the container for other purposes. Being on the ground also yielded another critical insight: by observing how the local competition operated, the multinational learned that to meet local standards it didn't have to use imported ceramic tiles for clean rooms in its plants. Local manufacturers used locally sourced tiles, which were of sufficient quality and available at a fraction of the cost. Getting granular finally allowed this company to successfully launch into this new market.

Getting granular is not just about emerging markets. A medical devices manufacturer lost 15 points of market share in North America over three years to a low-cost competitor because the rival had a better understanding of what a particular segment—community hospitals—required. Product engineers at the share-losing company had assumed that, as in other market segments, these hospitals wanted the latest products with the greatest precision. It learned, however, that prior-generation technology was good enough and that customers were concerned about lifecycle costs, not just product costs. The company's marketing department used these insights to tailor performance specifications and pricing to the community hospital sector. Engineers and marketers collaborated to solve the problem and introduce the right type of product and a new technology strategy.

In both the emerging-market and medical products cases, companies found that creating the right strategy for the specific segment requires granularity of focus. Companies can't do this from a distance—it needs to be done locally, and it requires analytical rigor to see past the "tyranny of averages" and develop insights into sub-industries, product segments, and micro-markets. To make the right portfolio choices at a granular level, companies need to collaborate and share insights across their functional silos.

The lesson here is that "copying and pasting" proven approaches into new strategies will rarely succeed. This is particularly true as companies venture further into unfamiliar territories. Nevertheless, many companies—particularly risk-averse ones—continue to use the copy-and-paste model when establishing new overseas production, ignoring not only the particulars of local market demand, but also variation in worker skills, supply quality, and supply-chain reliability across different emerging markets.

Before committing to strategy, companies must drill down further to understand how they can pursue new market opportunities and navigate the challenges of the new environment. Companies must have a clear understanding of how their

specific products and services can compete in different markets. Selling steel and glass for automobiles is very different from selling steel and glass for construction.

Understanding what constitutes value in new markets and coming up with the solution that sells can be more challenging than manufacturers expect. John Deere, for example, entered the Indian market with its lightest, 55-horsepower American tractor, knowing that Indian farms are small and require only low-power tractors. It quickly found that even that model was too much for a market where the average farm is only three acres (in the United States, farms average more than 400 acres and Deere sells many 500-hp tractors). In response, Deere solicited input from 2,000 local customers and introduced 36- and 41-hp models that were designed in India for Indian requirements.¹¹⁵ In Africa, Nokia learned that consumers had a very different concept of what was valuable in a mobile handset. It had to be affordable, but it also had to have a built-in flashlight, an FM radio, and a waterproof case. Companies across all five segments of manufacturing have made similar adjustments to their products—and to their design and production processes—to fit into new markets.

Not only do companies need to develop a granular understanding of market requirements, they must also apply this knowledge in an end-to-end way (thinking about how the new perspective on markets and trends affects each step in the value chain) and in organizational terms. The understanding of specific opportunities and the impact of trends must exist across the organization; it is no longer possible to hand off the business strategy to the manufacturing group. Commercial and operations functions need to collaborate and remain closely aligned to craft the strategic response to these trends.

Take a granular, total factor performance approach to footprint design

Part of the end-to-end strategy is footprint design. As noted in the previous chapter, in all but a few manufacturing sectors, such as apparel or footwear, a simple labor cost analysis has become a misleadingly narrow basis for determining production footprints. Indeed, in many manufacturing industries, hourly labor is as little as 5 percent of total cost, while in many modern plants the white collar payroll may be as much as 50 percent of cost. Yet some companies continue to use a simplistic labor cost model to guide footprint decisions.

We find that leading companies look at footprint decisions in a multi-dimensional way. In addition to labor and transportation expenses, they consider all factors that affect how much it costs to make products and get them to where they need to be at the right time and in the correct quantities and at a competitive price—knowing that these variables will be changing continuously. This total factor performance approach also looks at forces such as currency swings and the potential impact of evolving labor markets. All contingencies are considered: Could the company be locked into a particular location or committed to a certain level of employment even if changes in wages or other costs undermine the economics? Will greenhouse emissions rules dictate use of smaller plants and raise transportation costs? What technological breakthroughs might cause the company to regret this decision? (For more on footprint and network design see “New operations capabilities to meet new opportunities and challenges” below).

¹¹⁵ “Small is beautiful for John Deere,” Bloomberg Businessweek, September 22, 2011.

BUILD AN AGILE APPROACH TO INVESTMENTS AND BUILD AN AGILITY AGENDA FOR OPERATIONS

As manufacturers craft strategies in response to the trends we described in Chapter 3, they will be challenged to balance the need to make long-term investments with the need to manage near-term volatility and uncertainty. For example by using a portfolio of small investments, companies can reduce risk. In addition to building financial agility, manufacturing companies need to build agility across strategy and operations—by adopting an “agility agenda.”

Make big bets and hedge against uncertainty

The shift of global demand toward emerging markets will unfold over the next 10 to 20 years or longer. Similarly, many new technologies, such as nanomaterials or big data, are only slowly beginning to transform manufacturing processes. Some of these trends will no doubt accelerate at some point, but many others will develop over decades.

To plan adequately for a trend such as the emergence of 1.8 billion new consumers, mainly in developing economies, companies must be able to plan far into the future and commit to long-term investments, even in the face of short-term performance pressures and uncertainty. Near- and medium-term volatility can be managed by using a portfolio approach—implementing the long-term strategy with smaller chunks of capital, more modular designs, and with flexible technologies, plants, processes, and labor arrangements. This makes each strategic choice along the way less critical, less permanent, and less costly to reverse or redirect.

The auto industry is a prime example of the challenge. Carmakers are wrestling with two massive, long-term forces—the shift of demand to developing economies and a transition to new power train technologies. As they plot their paths, leaders of Hyundai’s automotive business say they now set long-term strategy over 30- to 50-year time horizons, asking themselves today what it will take to be the leading car company in 2050. Toyota’s leaders share this long-range mindset, and carmakers in Western advanced economies also are looking far ahead to see what their goals should be in a world of shifted demand, rising energy costs, and, in all probability, greater environmental constraints. BMW, for example, is making a big bet on a new i3 brand of “megacity” electric vehicles due out in late 2013. The design addresses the need for fuel-efficient cars and also aims to satisfy the unique transportation requirements of consumers in growing cities in Asia and elsewhere—an enormous market opportunity. Moreover, the project advances BMW knowledge in electric power trains, batteries, and lightweight composites, which can be transferred to other model lines.

Even as they make these long-term bets, car companies are challenged to deal with uncertainty and complexity in the near term. Demand is surely shifting to emerging markets, but the pace varies widely by market and product, requiring granular and timely market intelligence. Factors of production are also in flux. Commodity costs, for example, are moving in unpredictable ways, so although auto companies experienced a clear upward trend in prices before the recession, they cannot factor in a smooth rise in the coming years. The only clear trend seems to be more volatility. Several commodities have experienced price swings that exceeded one standard deviation in the past few years. Regulation is another factor that is difficult to predict. Many countries are offering incentives to promote

auto manufacturing, but there are also instances of countries unexpectedly changing the rules to the detriment of some companies.

Placing long-term bets in the face of such uncertainty makes the job of the strategist more challenging, requiring companies to build new analytical muscle. Too many manufacturing companies use point forecasts, do limited what-if testing of strategic decisions, and fail to make the links between macroeconomic trends and practical considerations such as plant location decisions.

Successful companies have made the leap from a conventional, short-term focus in strategy development to an awareness of multiple alternative futures and are prepared to face each future eventuality. One automobile manufacturer built agility into its strategic planning to preempt the effects of anticipated volatility. Planners segmented product lines and parts to evaluate reaction time in the case of sudden shifts or other disruptions and simulated output under different demand assumptions to estimate the range of possible impact. They then identified places where agility needed to be improved and used that information to prioritize actions in manufacturing stages, supply-chain design, and forecasting to protect an estimated two to three percentage points of EBIT that was at risk.

The good news is that useful data and increasingly powerful tools are available to create alternate future scenarios and build agile strategies to accommodate them. Leading chief operating officers need to learn these scenario-planning tools, know them well, and build new organizational capabilities to use them effectively. Without such tools, decision makers fall back on outdated strategic planning practices and companies risk placing confidence in a single, clear, yet almost certainly erroneous “prediction” of the future or making difficult calls using “gut instinct.” Agile strategy is also reversible. Agile companies make big directional bets, but by deploying smaller chunks of capital, using more modular designs, and adopting more flexible technologies, plants, and labor arrangements, they also make their commitments more reversible. If things do not go as planned, shifting to an alternate strategic scenario is not as costly.

Create an agility agenda

Agility is required not just in strategy but also in all phases of operations. And these days, agility in operations goes far beyond simply ensuring business continuity in the face of risk. It is also about exploiting opportunity, raising the speed and responsiveness, and building resilience to daily shocks. Agility is a popular buzzword and the concept is on the radar of most executives. Yet relatively few companies have made much progress in building agility into strategy and operations.

Agility comes in many flavors and is exercised in different ways, according to the situation or the needs of the particular company. To build agility to handle uncertainty, companies will need to understand the nature of the uncertainties that could affect their strategies and operations—are they most exposed to resource price volatility or to transportation bottlenecks?

Fortunately, even if the sources of operating uncertainty seem infinite, there is only a handful of ways in which they will be manifested: supply disruptions, internal disruptions (e.g., equipment breakdowns, severe weather), spikes in demand, dips in demand, and input volatility. To mount an agile response to spikes in demand, for example, a consumer product company may find that the ability to flex demand across the portfolio is less useful than developing the flexibility to rapidly accommodate mix shifts, new product launches, and promotional responses. The company may need to invest in some fixed capital to provide this flexibility.

Another useful guide in crafting agile operations is to think about four tactics that any agile response should include: pre-emption, detection, building response strength, and capturing opportunity (See Box 5, “The four steps to agile operations”).

Box 5. The four steps to agile operations

Pre-emption involves design and operational choices that can insulate a company’s operations from disruptions. Food companies, for example, have adopted recipes and processes that allow them to switch between liquid, ingot, crystal, and powdered sugar types so that a shortage in any single variety will not affect production. Similarly, automakers have designed catalytic converter blocks that can use different mixes of platinum, palladium, and rhodium to protect them from supply shocks in any of those metals.

Detection refers to investments in sophisticated monitoring systems to spot potential problems early. One high-tech company, for example, installed a sophisticated early-warning system based on close observation of supplier delivery performance to identify potential glitches in the supply of critical parts.

Response strength can be enhanced by delineating clear decision rights, supported by playbooks that define specific interventions, along with the precise conditions that will trigger the responses. One manufacturer of commercial vehicles uses changes in its forward order book to adjust its cost dynamically to reflect shifts in demand. When orders rise, the company automatically responds with lean efficiency enhancements to maintain margin; when they fall, the company suspends some production lines and consolidates plants and functions if orders fall sharply.

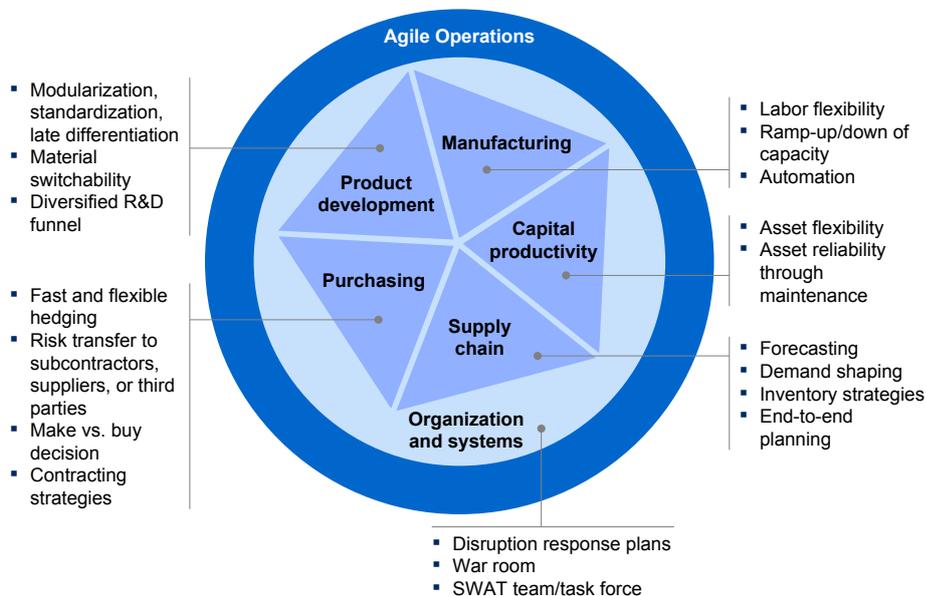
Opportunity capture refers to the ability to use volatility to gain advantage. A chemicals manufacturer evaluated alternative feed stocks and changes in its product formulation to handle price volatility—and found it could save 25 percent of its material costs.

Agile strategies can and should be applied across the manufacturing value chain. This means thinking about agile approaches not only to supply chains, but also to development, purchasing, and capital productivity (Exhibit 72).

Exhibit 72

Implementing agile operations in manufacturing

NOT EXHAUSTIVE



SOURCE: McKinsey & Company

Agility in product design and platforms is essential for competitive manufacturing operations. A medical device manufacturer reduced ramp-up time for new product variations by 75 percent, while lowering capital costs by 40 percent, through “platforming”—developing more sharable components and designs that could be used across product families. The company also phased in a manufacturing process that allowed more flexibility in meeting demand spikes for specific product variations.¹¹⁶

Modular product designs also increase flexibility. Volkswagen, for example, uses the modularized approach to build different cars under the same brand for different geographies. This system allows the carmaker to sell a €12,300 VW Polo in Europe and use the same platform for a €7,000 model in India. In a recent McKinsey Global Survey of heads of high-performing innovative companies, 57 percent said that their R&D strategies are to focus on creating shared product platforms rather than developing local or standardized global products.¹¹⁷

Purchasing agility is a critical value driver in most industries, but especially for those in the energy- and resource-intensive group and in regional processing. A common problem for many companies in these industries is their siloed approach to managing raw material volatility. Agile companies manage commodity risks with a combination of external methods (risk transfer) and internal measures (risk mitigation). External methods include transferring risk to suppliers via

116 Mike Doheny, Venu Nagali, and Florian Weig, “Agile operations for volatile times,” *The McKinsey Quarterly*, May 2012.

117 See McKinsey Global Survey 2012 report “Organizing for the future.” The online survey was conducted in April 2012 and received responses from 1,283 executives representing a wide range of regions, industries, functional specialties, tenures, and company sizes.

contracting, to financial markets via hedging, and to customers via pricing and demand shaping. Internally, companies can seek to improve flexibility in product specification; reduce inventory, scrap, and waste; and establish a clear view of the total risk profile across the organization.

Finally, companies also can achieve agility through collaboration across the value chain. In the metals industry, raw materials can represent 70 percent of costs, so manufacturers are exposed to the risk of price changes in ore and other raw materials. To become agile, metals manufacturers may seek to diversify their resource risks through acquisitions or strategic partnerships with suppliers of technology, or by purchasing other suppliers that allow for flexibility in raw material inputs (e.g., ore/coal versus scrap/electric versus ore/natural gas). In the steel industry, three global mining concerns have the combined market presence and power to effectively set prices for sea-bound ore. This has led to renewed vertical integration in order to secure strategic access to key raw materials and to buffer price volatility.

NEW OPERATIONS CAPABILITIES TO MEET NEW OPPORTUNITIES AND CHALLENGES

Business-as-usual approaches and current standard practices clearly will not be adequate. Companies will need new capabilities and competencies to address the challenges and opportunities in the new era of manufacturing. To operate effectively in this environment, we see that companies will need to execute competitively across ten critical domains that fall under three major strategic thrusts: developing insights that drive new business opportunities; building agile, resilient networks and ecosystems; and maintaining a focus on productivity.

Figuring out how to operate in the new environment is an even larger challenge than this lengthy list implies. Essentially, it is asking companies to step back and question all their assumptions about how they craft strategy, build products, and go to market. In even the best-run organizations, successful methods quickly become fixed, and momentum and mindsets keep those methods cemented in place. Overcoming this inertia is not easy. Companies need to move beyond what they know now and ask what they need to know in the next five years—and make sure they get granular, actionable answers that address their companies' specific needs. In almost every case, the answers also will make clear just how much manufacturing companies will need to invest in new capabilities.

Gather new sources of insight that translate into new sources of value

1. Develop customer and supply-chain insights; apply end-to-end intelligence

Information-driven intelligence—based on big data and advanced analytics—creates new opportunities for competitive advantage across the value chain. Companies can tap customer insights in more detail, identify product opportunities sooner, and get innovations and variations to market faster. They can use real-time information to fine-tune capacity and create unprecedented transparency and information flow in the supply chain to identify weaknesses and shortfalls. By monitoring machinery, they can prevent or work around potential outages before they happen.

For example, in chemical plants and oil refineries, sensors and telematics devices that monitor noise, temperature, vibration, and other factors are used

to gather the data to predict breakdowns or safety risks. All kinds of companies can streamline maintenance strategies by using similar analytical techniques, allowing them to move from preventive maintenance plans that require replacement schedules that are often too conservative to more efficient predictive maintenance. Big data has also enabled new inventory optimization models, which have helped John Deere realize \$900 million in savings over two years. Coca-Cola Enterprises used big data for a new vehicle routing system that helped save \$45 million annually.¹¹⁸ MGI estimates that manufacturers can cut product development and assembly costs by as much as 50 percent and save up to 7 percent of working capital by integrating big data into their operations.¹¹⁹

For successful adoption, big data and analytics strategies must be intertwined with overall strategy. Drugmaker Astra Zeneca, for example, was frustrated by its inability to get beyond a discussion of drug price with “payers” (the insurance companies, care providers, and health services that decide which drugs will be prescribed). Big data provided the solution: by scouring electronic medical records, the company was able to show that total cost of care for patients using its product was lower because they had fewer office and emergency room visits. That changed the conversation.

Such results are only possible when the organization—not just the IT experts—has the training and tools to apply big data techniques.¹²⁰ Companies must also size the opportunities that big data has in their industries and the threat that arises if competitors jump ahead in this new competitive capability. Once the size of the opportunity is understood, then the company can identify the resources that will be needed, align on the strategic choices, and then address the organizational implications. For many organizations, big data will present a talent challenge—finding both the technical talent to run the data systems and the managers with the knowledge to translate the information into strategies, product designs, and process improvements.

2. Segment and design to value—in products and business models

Earlier we discussed the need for companies to get granular in their understanding of the strategic context as demand shifts and fragments. It was a carefully researched segmentation strategy, which included a distribution approach tailored to the market, that helped Frito-Lay capture more than 40 percent of the Indian branded-snacks market. The company tweaked mass global brands such as Lays and Cheetos to match local tastes, but also created Kurkure, a successful cross between traditional Indian-style street food and Western-style potato chips. Attractive pricing, a local feel, and scalable international packaging were key to the product’s success.¹²¹

118 Loren Troyer et al., “Improving asset management and order fulfillment at Deere & Company’s C&CE Division,” *Interfaces*, volume 35, number 1, January/February 2005. Also see Goos Kant, Michael Jacks, and Corné Aantjes, “Coca-Cola Enterprises optimizes vehicle routes for efficient product delivery,” *Interfaces*, volume 38, number 1, January/February 2008.

119 Big data: The next frontier for innovation, competition, and productivity, McKinsey Global Institute, June 2011 (www.mckinsey.com/mgi)

120 Dominic Barton and David Court, “Making advanced analytics work for you: A practical guide to capitalizing on big data,” *Harvard Business Review*, October 2012.

121 Yuval Atsmon, Peter Child, Richard Dobbs, and Laxman Narasimhan, “Winning the \$30 trillion decathlon: Going for gold in emerging markets,” *The McKinsey Quarterly*, August 2012.

Recognizing the challenges and opportunities of the new environment, leading manufacturers are developing new ways to define next-generation products and business models. These leaders invest in new research and data to gain deeper insights into their customers, competitors, and supply bases to define value and gain insights into how to achieve it. This design to value (DTV) process yields better products, faster time to market, happier customers, higher margins, and, ultimately, a stronger ability to innovate.

From food and beverage companies to makers of autos, medical products, and industrial equipment, DTV approaches have boosted product margins by 20 to 25 percent, while helping companies increase share and reach new segments. Leaders in DTV go beyond conventional cost reduction (i.e., “value engineering”) and find ways to bring added value, not just reduce cost. With 1.8 billion new consumers on the horizon, it is critically important to understand what new kinds of buyers require. As we saw above in the cases of the John Deere tractors and the Nokia mobile phones, even in relatively poor areas, a value product is not simply a stripped-down version of the company’s standard model. Emerging consumers—not unlike today’s customers—have very clear ideas about what they expect to get for their money and what features (or services) are worth paying extra for.

This requires a rigorous effort to get granular insights into what value means to customers. Getting granular is not just about identifying what is important to consumers, but quantifying how important things are (i.e. how much are they willing to pay for a particular feature or service, and how it ranks against other choices). This means market research is not just for marketing any more. Engineering, supply chain, service, and sales, for example, need to jointly determine which features, prices, and service attributes should be tested with consumers to generate actionable insights for their future product and business model designs.

In a similarly granular and cross-functional way, leading companies are analyzing how well their own products and their competitors’ products are delivering value, often through side-by-side teardowns and product testing. A company that sells equipment to the CPG industry brought together experts from across all functions for a teardown of a competitor’s products alongside its own. They identified more than 1,000 ideas for improving the company’s design and removing cost. The company implemented 80 percent of the ideas within two years, reducing the cost of goods sold for this product by more than 25 percent. In another instance, tear-downs helped a maker of medical products identify 80 percent of the factors that put its design at a cost disadvantage. It then figured out how to bridge the gap without compromising the features that its research showed were most valued by users.

Leading companies also are now moving beyond designing the product to value and applying the cross-functional methodology to their service and supply-chain offerings, too. This allows companies to quantify the key “break points” where differences really matter to customers. When one US food manufacturer segmented its retailers by service expectations, it found that a large group of customers would prefer a longer delivery time, if they could get lower cost. For another group, express service could be a compelling competitive differentiator.

Ultimately, companies apply DTV principles to their entire business models. A medical products company had done a great job in unearthing customer insights and translating them into products, features, and services. But it found that

there was a disconnect with the purchasing process, where sales and marketing materials did not convey the value message and the sales process did not provide customers with the kind of data they valued for decision making. By taking this DTV approach across the integrated business model (products, supply chain, and sales and marketing), the entire organization is aligned and working together to deliver what customers value.

3. Use insights and analytics to enable service offerings

As we have noted, manufacturers are called upon to provide more after-market services. Such services can have great benefits to the manufacturer, including smoothing cyclical sales, providing a higher-margin revenue stream, and establishing a new depth of involvement in customer operations that can lead to more sales opportunities. In some segments, manufacturers already generate more revenue from services than from product sales. For example, in enterprise computing, services account for 80 percent of vendor revenue. Additionally, by providing services, equipment manufacturers can harvest deeper insights into customer needs that can help define product improvements.

Traditional maintenance and repair are still core services, but manufacturers also have more advanced offerings, such as total cost of ownership services. These are aimed at helping customers maximize utilization and provide a simple way to understand and manage the full cost of using equipment. A classic example is aircraft engine manufacturers offering their products for an hourly rate that includes use of the engines and related services.

A third service approach is to help customers improve their operations by using the manufacturer's products more effectively. Some medical equipment manufacturers, for example, now supply automated analysis tools that combine diagnostic data with knowledge of clinical best practice to optimize patient treatment plans, helping health care providers deliver better service to their patients and manage equipment costs. GE Locomotives offers RailEdge, a service that looks at traffic on the system, route conditions, and other factors to optimize scheduling to help railroads stretch capacity and improve efficiency.

To deliver such services, manufacturers need to understand customer business needs and invest in the ability to capture the data that enable the services. As noted in our discussion of big data, it is increasingly possible to access real-time information about the health, performance, and usage of the installed equipment. For example, based on its deep understanding of its customer needs, John Deere developed a service that uses sensor data from farm equipment to advise customers how to improve yields. General Electric sees so much potential in this type of data-enabled service for buyers of industrial equipment that it has invested in a 400-engineer software development center in California to create new service applications.¹²²

Such high-value services often demand a broader and more intimate understanding of customer needs than is needed to sell a product and may require manufacturers to engage different parts of the customer organization. Manufacturers also must understand what value is at stake (i.e., what the customer is willing to pay for) and develop appropriate models for selling the service—as a yearly subscription, on a per-use basis, or with performance-driven contracts.

¹²² Kate Linebaugh, "GE Makes Big Bet on Software Development," *The Wall Street Journal*, Nov. 17, 2011.

To maximize the financial and strategic payoff from service businesses, companies will need to make big commitments. Some leading companies have created dedicated service businesses and invested in new data systems and other capabilities. Moreover, they have taken steps to build cooperation across the organization to develop new services (e.g., by tapping into sales force knowledge) and harvest additional benefits that come from intimate service connections, including ideas for better features and sales leads.

Build collaborative global networks, with a premium on agility, speed, and segmentation

4. Network design and footprint: Take a “total factor performance” approach

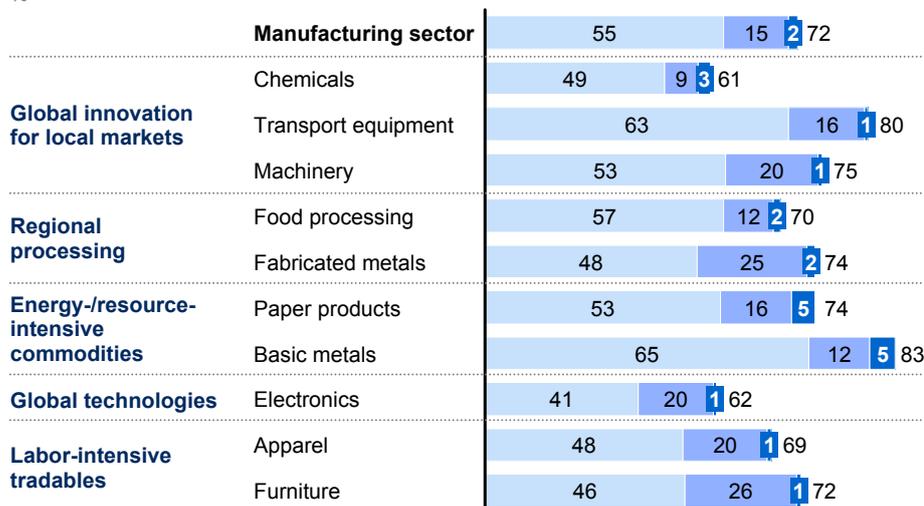
To an alarming degree, manufacturing companies continue to indulge in herd behavior when it comes to deciding where to establish their production footprints and how to arrange their supply chains—following each other to low-cost locations or letting themselves be guided by incentives that can lock companies into undesirable locations or environments. One major multinational manufacturer based its footprint decisions in part on the percentage of global spending that is in low-cost countries. Another company used silo-based metrics: purchasing staff were measured on piece price, while the logistics staff were measured on transportation costs.

With shifting and fragmenting demand and rising factor costs, it is more important than ever to treat network and footprint design as a strategic decision that will affect a company’s choices for many years. Yet even as footprints must enable long-term strategies, they must also be adaptable. There will be disruptions and it is a given that conditions change over time—any low-cost location will eventually become more costly as economies become wealthier. Companies should also put labor cost in perspective: in many manufacturing sectors, labor is less than 20 percent of cost (Exhibit 73). Therefore, labor cost arbitrage alone cannot be a guiding principle in most manufacturing sectors.

Exhibit 73

Labor arbitrage cannot be the only guiding principle since labor costs vary widely—even within industries in the same groups

Factor costs as share of sales in select US manufacturing industries
 %



NOTE: Numbers may not sum due to rounding.

SOURCE: US Census Bureau’s Annual Survey of Manufactures, 2006; McKinsey Global Institute analysis

Among the other major considerations for footprint decisions now is the shift of demand to developing economies. These countries are not just places to build things, they are markets. Companies in sectors in which production is closely tied to the local market (e.g., regional processing, global innovation for local markets, and even some industries within the energy- and resource-intensive commodities group) have a particular need to tailor footprints to market opportunities. An analysis of US multinationals shows that sales by their affiliates in local markets grew at 6 percent annually in the past decade, while consumption of manufactured goods in emerging markets grew at twice that rate. In large markets such as India and China, consumption of manufactured goods is projected to grow at 12 to 15 percent annually (in nominal terms) through 2025.

The process of choosing where, when, and how to enter markets, and where to invest in capacity is becoming extremely complex and involves knowledge across the value chain—in distribution, sourcing, and even financing. Moreover, the solution that works in one product line or brand and in a particular market may not work for others, but efforts across groups must be coordinated to avoid conflicting and overlapping efforts. One multinational consumer products company found that several of its business units had separately negotiated entry strategies for expansion in India, building multiple capital investments in the same city and region. To avoid this kind of costly, duplicated effort, a machinery manufacturer created a step-by-step playbook for market entry that standardized how the company would decide and execute market-entry strategies and required commercial, operations, and product development teams to collaborate in any market entry plans.

In an environment of greater risk and volatility, leading companies are using a dynamic, risk-adjusted process to make footprint and network decisions instead of using point forecasts. This involves assessing the total risk-adjusted landed cost of product manufacturing and the lifecycle costs associated with the manufacturing location decisions (i.e., what it will cost to maintain and eventually exit a facility). Decisions made this way consider the “total factor performance” of every option.

Using a risk-adjusted network design approach helped one pharmaceuticals manufacturer deal with demand swings in the sterile injectable product segment, which generates 10 percent of total revenue. The company was planning new capacity, but volatile demand made it difficult to develop accurate forecasts for production and determine the appropriate amount of capacity required and in which locations. By implementing a risk-adjusted approach to its network capacity planning that accounted for predictable and less predictable supply and demand risks, the company optimized network capacity and inventory around a more fully informed view of net present value of its investment and took actions to reduce risk using both demand and supply levers.

As companies evaluate their production network decisions, they will also review R&D location decisions. In Chapter 1 we discussed the different considerations that companies use to locate production and R&D activities and we noted that the factors that guide R&D and production footprint decisions are not the same. Just as when they design production footprints, when companies locate R&D functions, they need to understand in a detailed manner how factors such as talent pools and cost, as well as proximity to customers, supply chain, and industry clusters will determine appropriate location.

While many companies continue to co-locate R&D at a lead factory site, we also see a desire by manufacturers to decentralize R&D. According to the McKinsey Global Survey, a majority of executives believe their R&D organizations should employ a more decentralized model, with individual R&D sites operating as nodes in a global network, and 38 percent say their companies plan to increase offshoring of their global R&D activities. While there has been much recent discussion of companies bringing manufacturing activities and processes closer to home (to increase operating flexibility, for example), the survey suggests that R&D offshoring will continue. Just 18 percent of respondents say they plan to increase “onshoring” in the next three to five years; 24 percent say they plan more “nearshoring.”

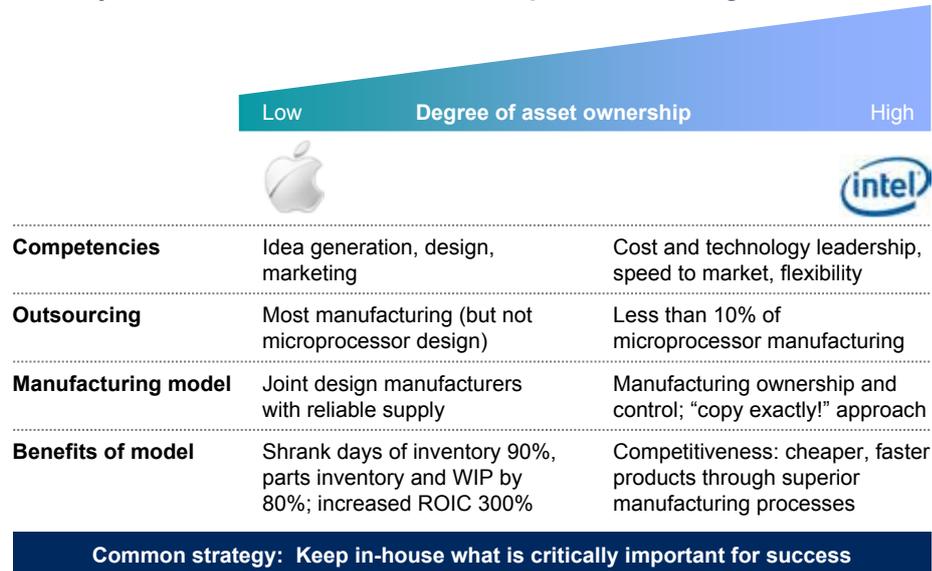
5. Vertical integration and outsourcing: Create an “integrated” organization, whether you own it or not

Integration is not about ownership; it is about control. Whether a process remains in-house or is outsourced will remain open to debate, but control must remain constant, allowing companies to maintain expertise in all core capabilities. All functions—whether they are inside or out—appear as part of a vertically integrated whole with a common alignment of program objectives. It is easier said than done. Boeing, which ran into serious difficulties when it attempted a new level of outsourcing for its 787 Dreamliner program (see Chapter 3), invested in a “war room” to monitor the hundreds of partners in its supply ecosystem and maintain control over the entire manufacturing process.

In such an ecosystem, outright ownership may not be possible, but control over critical processes, knowledge, and intellectual property is essential. We know of companies that lost touch with core production know-how by outsourcing work without maintaining control. A consumer products manufacturer that outsourced and offshored production achieved cost efficiency in the short term, but was caught off-guard when a vertically integrated competitor used its production capability to innovate with new materials and introduce a new class of products in the market.

There are no perfect formulas for what should be outsourced and what should be kept inside. Successful companies can operate at both ends of the ownership spectrum: Apple has largely outsourced its manufacturing and some design; in contrast, Intel has kept manufacturing and development almost entirely in-house (Exhibit 74). When outsourcing, companies must maintain control, trust, and collaboration; good ideas from any source need to be captured.

Vertical integration matters to innovation as well. In the McKinsey Global Survey, fewer than half of executives say their central functions and satellites collaborate very effectively or extremely effectively with one another; fewer than one-quarter say the same about satellite-to-satellite collaboration, which is needed for a dispersed R&D model. Whether or not their organizations collaborate effectively, respondents say that the most important capabilities for fostering successful collaboration are the right mindsets and greater transparency on R&D strategy.

Exhibit 74**Specialization versus integration: Industry leaders use different strategies, but they all control what is critical for competitive advantage**

SOURCE: McKinsey Global Institute analysis

6. Technology investment: Partner with suppliers, researchers, and service providers, and rebuild production prowess

In Chapter 3 we highlighted the robust pipeline of innovations in materials, products, and processes that will influence the future of manufacturing. Companies are pressured to make bets on these technologies today, but in many industries it is unclear what the dominant technology will be. In some cases, it is not even clear how a technology choice today will be affected by changes in the regulatory environment. As a result, conventional supplier relationships are giving way to supplier-manufacturer partnerships and joint ventures that cover technology portfolios. Risk-sharing with suppliers is becoming more common, and outsourcing is increasingly driven by the need for flexibility, not for competency or cost reasons.

The auto industry provides an example. The industry has relied on stable dominant technologies—the internal combustion engine and steel structures—but these technologies are challenged by the shift to new power trains and lighter materials, which is driven to a significant degree by government mileage and emissions regulations. Steel, cast iron (engine blocks), and light metals make up nearly three-quarters of the material mix in today's average small family car, with steel alone contributing more than half of the mix. In the Volkswagen XL1, a high-mileage prototype, carbon fiber makes up 20 percent of overall weight and a combination of light metals makes up an additional 25 percent. A larger portfolio of materials will mean that carmakers will need to master more technologies, with implications for product design, part manufacturing processes, line handling processes, and material combinations and joining processes.

To maintain coverage of developments in technology and supply, companies must manage a portfolio of relationships with suppliers and research institutes while insourcing selected, high-value-adding technologies. In the automotive industry, a new ecosystem is evolving to support the transition to lightweight materials and electric power trains, which no carmaker can manage independently. So

carmakers are now juggling portfolios of technology options and partnerships and deciding which functions to insource.

Finally, after many years of under-investing in production technology, many companies are reversing course. They recognize that innovation in production methods is still a basis for differentiation and competitive advantage.

7. Regulations and quality: Get it right from the start, internally and externally

In almost all industries, policy makers and regulators need to be part of the modern manufacturing company's ecosystem. As we discussed in the previous chapter, around the world, policy makers are increasingly active in the manufacturing sector, attempting to attract investment, regulating products and services, and sometimes controlling access to markets.

As a result, regulatory and compliance strategy has taken on new importance, especially for those segments where regulatory intervention limits plant migration and footprint evolution; nobody wants to risk being trapped with uncompetitive capacity. This is a common problem for industries in the global innovation for local markets and energy- and resource-intensive commodities groups, because governments often feel they have a strategic interest in maintaining jobs in auto factories or steel mills. Frequently, they protect local employment with measures such as preferential financing and subsidies.

While companies recognize the growing importance of developing a comprehensive regulatory strategy, few have done so. In a recent *McKinsey Quarterly* survey of global executives, 65 percent said they expect regulatory oversight to increase and half predicted that government intervention will reduce operating income over the next three to five years.¹²³ However, only 20 percent of respondents said they believe they are managing the external environment successfully today.

In this environment, companies have an even greater motivation to shape regulation. This means not only building relationships with regulators and government officials, but it also means connecting with all relevant stakeholders (e.g., consumer groups and non-governmental organizations) and allying with companies that face the same regulatory issues. By working with policy makers, for example, companies have been able to shape compliance rules so that they can meet reporting requirements without taking on costly overhead. Policies also can be designed to promote productivity by encouraging sharing of operational best practices. Policy makers can also encourage research in the areas of productivity and automation and help promote quality, improve industry infrastructure, and provide transparency into government requirements. Finally, companies and regulators can work together to ensure that the regulatory environment doesn't limit innovation.

In addition to working with regulators, stakeholders, and allies to influence the path of regulation, companies can pre-empt regulators by avoiding problems that draw regulatory action. Investments in quality, safety, and environmental compliance in their products and plants can go a long way toward lightening the regulatory burden. Industries such as aerospace and auto manufacturing have

123 Need to insert reference here. McKinsey Quarterly.

realized that investing in quality not only reduces the opportunities for regulatory action, it also eliminates errors that can be very expensive to correct if they continue down the production chain or, worse, into the marketplace. Product recalls have cost the food processing industry hundreds of millions of dollars, with negative sales impact lasting more than a year.

Obey the productivity imperative

8. “Lean” is not dead

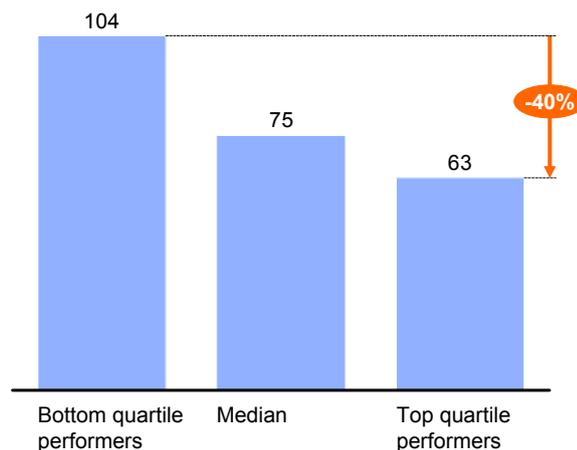
“Lean” manufacturing techniques have driven productivity and efficiency gains in a range of industries, from autos to pharmaceuticals. Lately, there has been concern about supply chains being “too lean” and unable to withstand shocks. We find that lean and agile are not mutually exclusive—in fact, they are mutually reinforcing. Lean is about eliminating waste, variability, and inflexibility in the value chains. Moreover, the lean movement is far from finished, and shifting demand to developing economies raises the need for productivity improvement.

In some industries, the efficiency of manufacturing operations still varies widely, highlighting the opportunity for improvement. Despite productivity gains in the pharmaceuticals industry, for example, a performance gap of up to 40 percent still exists between the least efficient and most efficient players (Exhibit 75). This matters a great deal for companies facing global competitors. For example, only the highly productive pharmaceutical plants in advanced economies are still cost-competitive in their home markets on a landed cost basis versus plants in low-cost nations.

Exhibit 75

Lean is not dead: In some industries, a 40 percent gap in productivity performance still exists between top and bottom performers

Conversion cost comparison for pharmaceuticals manufacturers in advanced economies
Unit conversion cost¹ (¢ per product unit)



¹ Includes all costs associated with final dosage form for pharmaceutical solids: production and non-production labor, utilities, and depreciation costs.

SOURCE: McKinsey POBOS database; McKinsey Global Institute analysis

In the food processing industry, while individual companies have adopted lean practices, the industry has had significantly slower productivity growth than the overall manufacturing sector in the European Union, Japan, the United Kingdom, and the United States. Labor productivity in the US food processing industry was 35 percent higher than in the manufacturing sector overall in 1970, but by 2007 labor productivity was 13 percent lower than in manufacturing overall.

9. Resource productivity: Build a circular economy in manufacturing

As we discussed in Chapter 3, price increases since 2001 have wiped out the declines in resource costs of the past century. Prices are not expected to rise at the same rate in this decade but are likely to be more volatile, making it harder for companies to set prices, disrupting long-term planning, and eating into profits. Through resource productivity strategies, manufacturers can cushion the shocks from resource price moves and improve efficiency. Depending on their levels of resource dependency, manufacturers may need to devote as much effort to resource optimization as they have to lean and other performance improvement initiatives in the past.

Resource productivity efforts span production, product design, value recovery, and supply-circle management, and can unlock significant value. Our experience suggests that manufacturers could reduce the amount of energy they use in production by 20 to 30 percent and might be able to design 30 percent of the material out of products, increasing their potential for recycling and reuse.

In production, efficiency gains often come from rethinking standard processes with an eye toward energy savings, by using “value-stream mapping” techniques, for example, to analyze energy or material consumption at every production stage. Using such analysis, one chemical company changed its process to release heat more quickly during polymerization, which allows evaporation to start sooner and reduces the energy used in the drying stage by 10 percent.

Resource-conscious product design can cut the amount of material used in a product or use less costly or recycled materials. A shampoo manufacturer, for example, redesigned its bottles so that they were thinner but still met strength criteria. The redesign reduced material consumption by 30 percent and cut the time to produce the bottle by 10 percent. In addition, by redesigning the cap, the company made the bottle easier to recycle. As a bonus, the new design allows more bottles to be packed in a carton, saving shipping costs (and energy).

Finally, manufacturers also can make better use of resources through recovery and recycling. In the emerging “circular economy,” manufacturing companies will maximize the reuse of materials and minimize the energy and environmental damage caused by resource extraction and processing. The circular economy requires a different view of raw materials. A mobile phone, for example, would be designed with the entire lifecycle in mind, with parts and materials chosen for eventual separation and recycling (Exhibit 76). Materials from end-of-life products, particularly technical materials, are gathered in uncontaminated streams for redistribution efficiency.¹²⁴

Other circular tactics include recovering more waste material at production sites and extending the operating lives of products with in-service upgrades and refurbishing programs that reduce the need for new materials. The value of adopting circular economy production techniques is substantial, with gains flowing to companies, consumers, and economies. One study estimates that

124 Technical materials are those that are obtained from non-renewable sources, such as metals or fossil-fuel-based plastics, and that cannot be renewed or recycled using biological processes.

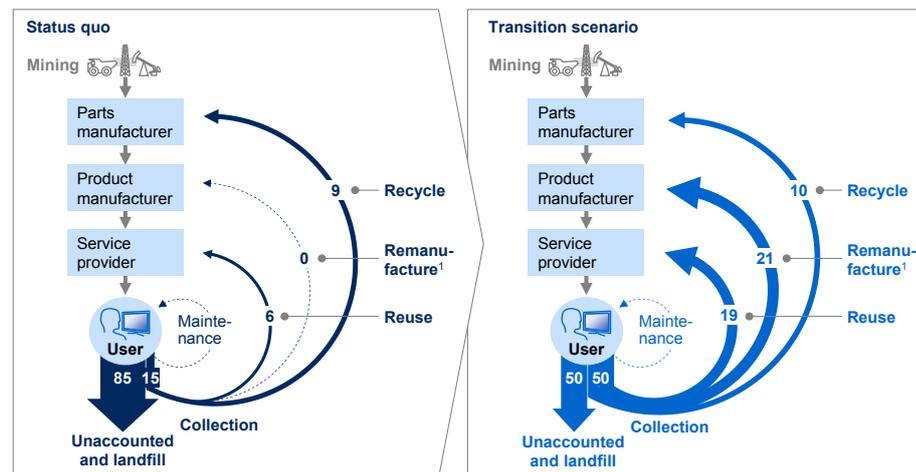
circular economy techniques could save up to \$380 billion annually in the European Union.¹²⁵

Exhibit 76

Mobile phones: Reuse and remanufacturing as a viable alternative to recycling

ESTIMATES

End-of-life product flows based on 2010 EU figures
Percentage of total end-of-life devices



¹ Remanufacturing, here refers to the reuse of certain components and the recycling of residual materials.
SOURCE: Gartner; EPA; Eurostat; UNEP; Ellen MacArthur Foundation circular economy team

10. Capital productivity: Revisit the automation/labor trade-off

Even when large manufacturing companies have ready access to capital and borrowing costs are low, making the most of capital is an important strategic consideration. This affects everything from footprint decisions to determining what processes must be owned.

One of the key questions about capital efficiency is whether or not to invest in more automation, especially as the trade-off between automation and labor continues to shift. Wages are rising in low-cost manufacturing centers and talent is becoming scarce, while automation is becoming more affordable and is now capable of better precision and consistency than humans. But the relative inflexibility of most automation solutions, especially in an environment that rewards agility and modularization, is pushing toward more adaptive, labor-oriented solutions. Companies that can strike the balance between automation and the flexibility needed to build the next generation of products will enjoy significant competitive advantages. One aerospace company found that newly available automation capabilities could reduce quality defects and improve ergonomics in its assembly processes. A beverage distributor recently found that it may now be economical to install automated picking machinery in more locations.

The capital-labor trade-off is also apparent in factory design and layout. Toyota's Global Body Line template combines a highly automated assembly line and a

¹²⁵ Towards the circular economy: Economic and business rationale for an accelerated transition, Ellen MacArthur Foundation, January 2012. The \$380 billion estimate is based on a pioneering stage, where reuse is limited. The research includes an "advanced scenario," in which improved recovery and reuse technologies, infrastructure, and higher customer acceptance are in place, and savings rise to \$630 billion annually.

more labor-intensive paint shop component. The line requires significantly less floor space, ceiling height, and site preparation than was needed for the standard Toyota plant design of five years ago. Construction, maintenance, and refit costs are 50 percent lower, and energy costs are 35 to 40 percent less because ceilings are lower, lines are shorter, and conveyors are simpler. The paint shop uses a balance of labor and automation appropriate to the market location and the maturity of the economy. Downstream assembly processes always have a high level of labor content regardless of geographic location.

MAKE THE RIGHT INVESTMENTS IN THE ORGANIZATION TO SUCCEED

To address the challenges they face in a sustainable way, manufacturers will need to consider how they are organized internally and whether they have the talent to operate successfully in this environment. Companies operating in diverse, fast-moving global markets can't afford to have organizational barriers stand in the way of collaboration and knowledge sharing. They also will be at risk if they can't compete for the talent to bring their products and strategies to life.

To operate this way, companies also need agile leadership. This means speedy decision-making and preparing for what to do when the company encounters volatility or disruptions. Well-defined contingency plans should be specified well in advance of the events, with "triggers" set ahead of time to ensure companies know, as soon as possible, when disruptions are severe enough to warrant action. Leading organizations do this as a matter of routine. For example, NASA, the US space agency, conducts a year's worth of simulations to anticipate possible contingencies. This allows NASA management to think through the many things that might go wrong and develop standard responses. Even if an unanticipated event occurs, familiarity with the "normal" response plan and capabilities can help identify a course of action more quickly.

Agile leadership also requires a decision-rights approach that establishes clear lines of decision authority for when volatile conditions arise, avoiding conflicts or delays as leaders try to agree on who can make the call to take action. Finally, agile leaders clearly articulate their intent regarding trade-offs. For example, leaders can make clear their preference for designing for innovation versus lead time and can ensure that all functions along the manufacturing value chain are aligned with that intent.

Structuring the organization to meet global aspirations

Global manufacturing companies find organizational structure challenging because there are no simple solutions. Rather, they are confronted with an endless series of trade-offs; the notion of a set organizational strategy is illusory, and companies that have focused on standardizing structures and processes may find it difficult to achieve the nimbleness and flexibility to respond to local market opportunities. Another challenge arises for companies that have created self-contained, vertically integrated businesses. The benefit of these structures is that decisions can be made quickly and complexity is minimized. The downside, which is now more apparent, is that such structures create silos that make it harder to find and share knowledge across boundaries to exploit new opportunities and mitigate risks. In a McKinsey survey of global business

executives, fewer than half felt that ideas and knowledge were freely shared across divisions, functions, and geographies within their companies.¹²⁶

Several other issues further complicate the organizational picture. For example, the right organizational trade-off in a dynamic, high-growth market where decisions need to be made quickly may not be the same as for a company operating in a stable, mature market. This contrast may exist between different businesses in the same company. And the legacy and culture of the organization also matters; companies that have grown through acquisitions may have strong and independent silos that pose a challenge to collaboration, while companies that have grown organically may need to focus on standardization and being able to adapt processes quickly for local tailoring.

Organizational needs change over time, too. When companies enter rapidly growing new markets, local decision making is needed for issues such as product innovation, marketing, and choosing partners and suppliers. But as the local business grows and matures, more of the decision making may be standardized and globalized. Regional structure can work if markets, suppliers, or competitors are also regional, but companies need to ensure that these structures are not duplicating activities that can be done better and more efficiently at the global or local scale.

Companies that make the right trade-offs for their situation can achieve substantial competitive advantage over local incumbents and other global competitors. With a granular understanding of opportunities and risks, they will know when to standardize and exploit scale and when to tailor their approach to local preferences; how to integrate closely with the ecosystem; and how to push for productivity and efficiency while nimbly translating new opportunities to sources of value.

Human capital: Arming the company for an escalating war for talent

In Chapter 3 we discussed the talent challenge facing manufacturers. In the coming years, advanced economies will have a rising need for high-skill production workers in advanced economies, engineers who have the training to work in cross-functional specialties (e.g., electric power trains in autos), and workers familiar with new materials, processes, and information systems. Companies that can maintain or improve access to highly skilled talent, particularly in R&D-intensive industries such as chemicals, will have a competitive advantage.

To fill their talent pipelines, companies are working individually or with other companies to partner with universities and community colleges on training. Efforts include industry coalitions that provide scholarships for students in relevant specialties and working with educators to tailor curricula to specific needs. Siemens, for example, found that its US gas turbine plant in Charlotte, NC, suffered from a shortage of qualified workers. Working with the local community college, Siemens is implementing an apprenticeship program in which students are paid to attend class part-time and work part-time in the factory, similar to the German work/study apprentice system. Apprentices who graduate from the program with degrees in “mechatronics” (mechanical engineering,

¹²⁶ Structuring your organization to meet global aspirations: Perspective on global organizations, McKinsey & Company, May 2012. www.mckinsey.com/client_service/organization/latest_thinking/perspectives_on_global_organizations.

systems design, and electronics) are qualified for employment with Siemens in Charlotte. Working with a job-matching firm, Siemens is also finding that returning military veterans provide a good source of talent once they have the proper technical skills.

Similar examples are found around the world. Cisco's Europe and Emerging Markets program hires sales representatives from local countries, training them for a year in Amsterdam. Nestlé provides technical assistance and training programs to coffee and cocoa farmers in Southeast Asia; these training programs are sometimes given through government partnerships, and the company also provides farmers with plants developed for the local environment. And Intel has established elementary education and higher education improvement initiatives with governments in developing countries, focusing on specialized course work meant to fill local educational gaps.

Access to R&D talent is a growing concern. In the McKinsey Global R&D survey, executives said they were concerned that their R&D personnel are already "oversubscribed." As R&D organizations continue to globalize and disperse, the talent-allocation challenge may become greater, and survey respondents confirm that they are concerned with this issue.

Aging is another challenge and some industries are at risk to lose their most highly skilled and knowledgeable employees to retirement in the next two decades. To turn that demographic trend into an advantage, some companies are creating apprenticeships and hiring retirees to train new employees. One US shipbuilding company is addressing this issue with an in-house apprenticeship system in which workers who will retire in the next ten years teach technical skills to younger workers.

In addition to technical skills, global manufacturers face a shortage of leadership talent, particularly in developing economies. According to one survey of senior executives, 76 percent believe their organizations need to develop global leadership capabilities, but only 7 percent think they are currently doing so very effectively.¹²⁷ Attracting and retaining leaders in developing economies requires different solutions than are used to develop technical talent. In China, GE works with the government to select two dozen executives each year to attend its leadership program in the United States.

Companies must create leadership opportunities for high-fliers in emerging markets, even if they haven't spent time working in a developed economy.¹²⁸ In Brazil, the mining giant Vale SA found that it lacked managerial talent and needed to train current workers as well as build a talent pipeline. It approached public universities in the states in which it had operations, and together they created graduate programs in disciplines directly related to its business. University professors teach the curriculum, and Vale executives work as part-time teachers and consultants. Vale has also invested \$12 million in professional training centers outside the company to reach an additional 19,000 people and has agreements with 200 schools and universities in Brazil.

127 Pankaj Ghemawat, "Developing global leaders," The McKinsey Quarterly, June 2012.

128 Martin Dewhurst, Matthew Pettigrew, and Ramesh Srinivasan, "How multinationals can attract the talent they need," The McKinsey Quarterly, June 2012.



The opportunities that are emerging for manufacturers will not be easy to exploit. Manufacturing companies will be competing in new markets, responding to fragmenting consumer demand, and implementing new technologies—all in an environment of heightened risk and uncertainty. They will work with new tools like big data analytics and learn new ways of doing things, such as designing their products and production systems for a “circular” economy. It points to an era of great challenge and exciting possibilities—and exceptional rewards for organizations that summon the conviction to act.

5. Implications for policy makers

In the wake of the Great Recession, governments around the globe are under enormous pressure to find ways to reignite growth. Facing weak domestic demand, many policy makers have shifted focus to exports and to manufacturing. This has led nations to consider more active measures to support specific industries and sectors, and in many nations there is growing enthusiasm for industrial policy. As a result, we see increasing intensity in the already fierce competition among governments to attract and retain manufacturing companies and activities.

Yet, as governments double down on manufacturing supports, they risk adopting policies that could actually make their economies less competitive. As we have shown throughout this report, manufacturing has evolved in ways that render increasingly irrelevant and ineffective any approaches aimed primarily at maintaining or creating large numbers of production jobs in advanced economies. Advanced economies have good reasons to pursue growth and job creation. They also have good reasons to promote the health of manufacturing industries that drive innovation, productivity, and trade. But they must understand where jobs and manufacturing initiatives converge in today's environment and where they may be in conflict.

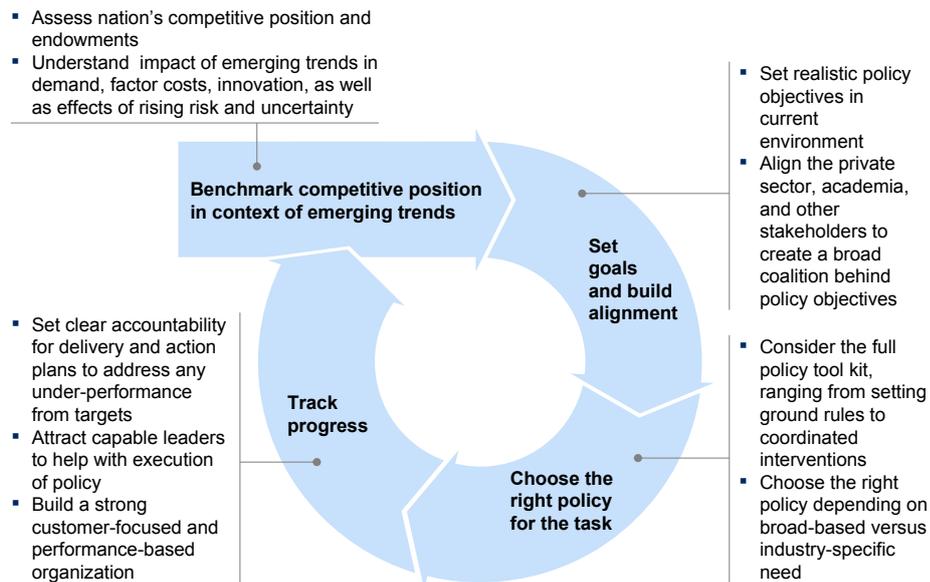
In this chapter we conclude our analysis of the future of manufacturing with recommendations for how nations can develop policies and address the particular circumstances of their economies and the manufacturing industries they have or can attract. We do not prescribe specific strategies, nor do we offer a list of "do's and don'ts." We do not attempt to settle the questions about what constitutes appropriate policy—or whether policy interventions are even warranted. We do provide policy makers a framework and approach for designing and implementing effective manufacturing strategies for today's environment, with examples of how nations have reinvented manufacturing sector strategy.

CRAFTING MANUFACTURING POLICY FOR THE NEW ENVIRONMENT

Now more than ever, policy choices should be made in a systematic, strategic way. Exhibit 77 lays out a four-step process that is designed to ensure that policy is fact-based, specific, flexible, and measurable. The best practices described here are drawn from the experiences of Singapore, South Korea, Ireland, and Finland, among others. We offer these lessons while acknowledging that the challenges for large economies are far more complex, given the wide variations in resources, infrastructure, and labor forces that can exist among diverse regions.

Exhibit 77

Best practice for developing manufacturing policy in today's environment



SOURCE: McKinsey Global Institute

The process begins with a clear understanding of the nation's current competitive position, which informs the decision about overall goals and approaches (i.e., what types of interventions the government will adopt). Once there is consensus and support for the direction, the next step is to establish specific targets, track progress against those targets, and build the capabilities to achieve the overall goals. Finally, as the circular design of the chart emphasizes, this is an ongoing process: as goals are achieved and as circumstances change, policy makers will once again benchmark their economies and industries and update their fact bases to determine whether current goals and the policies to reach them remain relevant.

1. UNDERSTAND THE NATION'S STARTING POINT AND THE FORCES AFFECTING RELEVANT MANUFACTURING SEGMENTS

Good manufacturing policies are grounded in facts—performance and benchmarking data that establish a nation's starting point in global competition and an objective assessment of how trends in demand and other factors are influencing diverse manufacturing industries within the economy.

We begin with a realistic diagnosis of what strengths a nation or region brings to the game, as well as the weaknesses it needs to overcome and opportunities that can be exploited. A nation's comparative advantages are influenced by its endowments—its natural resources, the quality of its labor force, its energy, transportation, and finance systems. China's large and rapidly growing domestic market has been a magnet for a broad set of industries, while Mexico's location across the border from the United States provides advantaged access to the large US consumer market. Strong engineering capabilities have enabled both Germany and Japan to sustain leadership in a number of specialty technical markets, while Singapore has benefited from its location at an important trade juncture.

Natural endowments help explain the mix of manufacturing industries in which countries are likely to specialize and compete. A nation's revealed competitive advantage (RCA)—a measure of its trading strength—is linked to specific endowments that are relevant to particular manufacturing groups. Exhibit 78 shows that nations that are endowed with competitive labor costs have strong RCA in labor-intensive tradables industries. Exhibit 79 shows that countries that are endowed with good innovation capabilities—and whose wage rates are at least relatively competitive—have strong RCA in global technologies/innovators industries (e.g., consumer electronics).¹²⁹

While certain physical endowments (e.g., iron ore and gold deposits, or geographic proximity to large markets) are immutable, many attributes evolve over time, reflecting the impact of government policy and company actions. The depth of a nation's talent pool or the quality of its infrastructure is often a direct outcome of its policies; regulatory efficiency reflects government's internal capabilities.

Endowments also shift as nations become wealthier. As incomes rise and low-cost labor is no longer a significant advantage, a nation's manufacturing mix shifts from labor-intensive industries to more capital-intensive industries and finally to those that are R&D-intensive. Singapore and Taiwan, two of the "Asian tigers," followed this pattern and explicitly planned for the sequence in their industrial strategies, building the capabilities that they needed in order to succeed beyond labor-intensive manufacturing. For example, both nations invested in creating a skilled labor force with strong engineering capabilities and introduced strong intellectual property protection.¹³⁰ China's diminishing RCA in labor cost and emerging RCA in innovation and technology appears to mirror what occurred for Singapore and Taiwan, but potentially on a much larger scale.

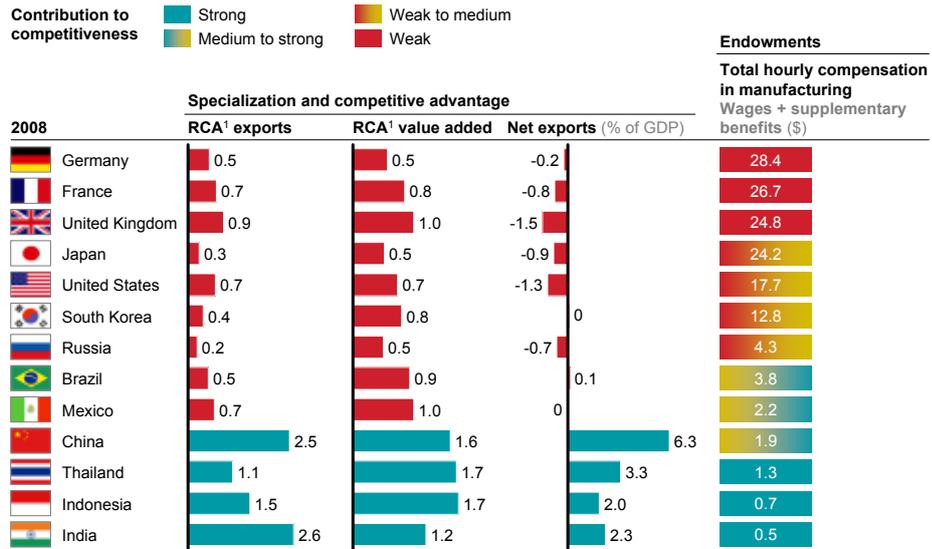
129 Data from 2008 are used to ensure comparability across countries. While the trade balance and other indicators may have changed since then, especially for fast-growing countries, the analysis nonetheless helps illustrate the point that revealed competitive advantage is linked to specific endowments that are relevant to particular manufacturing groups.

130 The large literature on the Asian industrial policy includes John Weiss, *Export growth and industrial policy: Lessons from the East Asian miracle experience*, Asian Development Bank Institute discussion paper number 26, October 2005.

By themselves, however, good endowments do not guarantee strong performance and competitive advantage. How nations use their endowments and how they develop new capabilities often matter more. Japan, for example, lacks endowments of domestic energy assets, but government policy has compensated for this gap by helping its manufacturing industries develop more energy-efficient production technologies—creating a new endowment in the process.

Exhibit 78

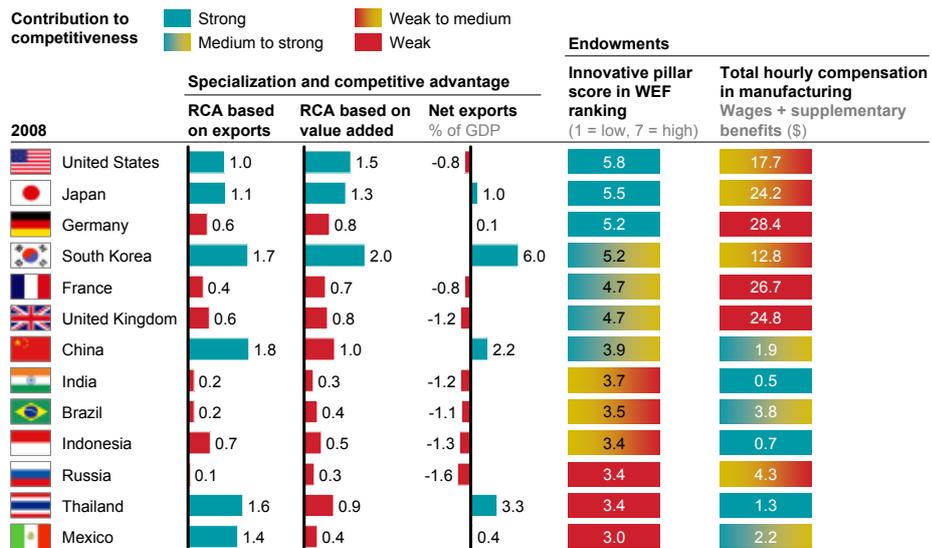
Labor cost determines advantage in labor-intensive manufacturing



1 RCA = A country's Revealed Competitive Advantage, a measure of its trading strength. SOURCE: OECD; World Bank; IHS Global Insight, February 2012; IMD; World Economic Forum (WEF) Global Competitiveness Report 2008–2009; McKinsey Global Institute analysis

Exhibit 79

Innovation capability is the key advantage in the global technologies/innovators segment



SOURCE: OECD; World Bank; IHS Global Insight, February 2012; IMD; WEF Global Competitiveness Report 2008–2009; McKinsey Global Institute analysis

Policy makers also need a fact-based understanding of how the trends shaping global manufacturing—from energy and wage costs to demand shifts and emerging technologies—are likely to affect their nations, regions, and industries. In the previous chapter, we discussed how these trends compel manufacturing companies to rethink their business and operations strategies. These trends matter for governments, too. Knowing how the trends will alter company requirements for talent or infrastructure will help policy makers identify measures and priorities to avoid gaps, by creating new programs in higher education or investing in deepwater ports, for example. Here we examine in greater detail the implications of the major trends on government policy.

Demand: Work with trends, not against them

Until the past decade, globalization of manufacturing was driven largely by cost arbitrage—essentially the search for low-cost production locations. Today, however, a more important driver for multinational manufacturing companies is to match production footprints to patterns of demand growth. At the same time, an increasingly diverse global customer base creates demand for a broad set of localized, tailored products, also driving the need for proximity to customers.

These shifting demand trends affect all manufacturing industries, although to differing degrees and on different timelines, and conventional policy is not adequate to deal with them. Indeed, because of these demand shifts, a policy focus on retaining production jobs at home through subsidies or other measures can be costly for national treasuries and counter-productive for manufacturers. In industries where all or part of the supply chain needs to be located close to demand, such as those in the regional processing or global innovation for local markets groups, the shift of demand to emerging markets will pull production footprints in the same path. In these industries, efforts to dictate local production are simply an expensive way to delay inevitable shifts in global production footprints.

At the same time, however, because these industries rely on proximity to customers and markets, the production needed for local markets is unlikely to move from where it is already established. In fact, industries in the regional processing and global innovation for local markets groups continue to grow (in value added) in advanced economies. And, while manufacturing employment as a share of total employment in advanced economies fell by 14 percentage points from 1995 to 2007, in these segments employment contracted by just 5 and 7 percentage points, respectively.

To help their manufacturers make the most of emerging demand trends, governments have several options. They can continue to provide financing for exports to developing economies (e.g., through agencies such as export-import banks). They can also play a role in connecting their exporting manufacturing companies to fast-growing markets by upgrading shipping or air-freight infrastructure, negotiating trade and commercial agreements, or helping to attract skilled talent through student exchange programs or new immigration rules. Governments can also help industry develop knowledge that will enable companies to succeed in new markets. Just as they have created government institutes to advance technical knowledge (in microelectronics or biotechnology, for example), governments can establish research programs that focus on developing customer insights in emerging markets that can feed market information back to domestic producers. Commercial diplomacy can play a

role, too, not only in attracting foreign investors, but also in obtaining market information for domestic producers, including small companies that can't afford to develop their own market intelligence.

Innovation: Continue to support research and enable creation and diffusion

Historically, manufacturing innovation has been the largest contributor to productivity growth across economies. The productivity imperative for both companies and governments is stronger today than ever.¹³¹ As we discussed in Chapter 3, a pipeline of emerging technologies and applications has the potential to raise the productivity of labor, capital, and resources used in manufacturing.

Governments have many ways to encourage innovation that benefits a broad range of manufacturers. They can support basic research in fields such as robotics and materials, and they can help nurture markets for new technologies through purchasing and policy decisions. From semiconductors to mobile telephony, governments have provided critical early demand for innovations—and they continue to do so in many fields.¹³² For example, the US Navy has been an early customer for emerging energy-saving technologies.¹³³ And the US Department of Defense has historically supported a wide range of basic, applied, and advanced technology research.

Governments also shape consumer markets with incentives: both the German and US governments, for example, have given tax breaks to purchasers of energy-efficient vehicles to help speed adoption. In China, the national government offers financial incentives for regional and local governments that provide supports for companies in emerging industries such as wind or solar power.

Standards setting is another tool that governments can use to help commercialize innovation. Auto mileage standards and regulations on carbon emissions can provide the catalyst for products such as electric vehicles or the adoption of green manufacturing techniques. Today, additive manufacturing (evolving techniques for building parts or prototypes out of powders or resins) is potentially a valuable production technology, but companies need assistance with qualification and standardization of processes—a role government can fill. Similarly, clarity on environmental and health regulations would help bring nanotechnology into manufacturing. And big data can become a cross-cutting enabler of innovation in production processes, product development, and customer insights in manufacturing, but clear guidelines and standards are needed to allow companies to easily create value out of data (for example by mining trillions of bytes of consumer data, including location data), while maintaining privacy protections for citizens and data security for industry.

131 For further reading on the productivity imperative, see these McKinsey Global Institute reports: *Growth and renewal in the United States: Retooling America's economic engine*, February 2011; *Why Europe lags behind the United States in productivity*, October 2010; *Beyond the boom: Australia's productivity imperative*, August 2012; *The archipelago economy: Unleashing Indonesia's potential*, September 2012 (www.mckinsey.com/mgi).

132 *How to compete and grow: A sector guide to policy*, McKinsey Global Institute, March 2010 (www.mckinsey.com/mgi), includes a detailed discussion of the role different governments played in the early stages of semiconductor industry growth, among other examples.

133 See "State, business and US Navy highlight progress in clean energy and job creation during Navy Week at State Capitol," California Energy Commission press release, July 19, 2012.

Effective government policy to encourage innovation in manufacturing focuses on outcomes and performance goals, not on specific technological solutions. Auto fuel efficiency standards are an example: the government states a mileage goal and a target year for reaching it, and industry responds with designs that drive innovations in engines and lightweight materials; nobody dictates how the goals must be reached.¹³⁴

While governments have traditionally focused more on basic research (the “R” of R&D), support for commercial development (the “D”) may be increasingly important, for two reasons. First, customers in emerging markets are more cost-conscious and diverse, requiring companies to be increasingly skilled at customizing products and squeezing out costs. Being a technology leader may be necessary, but it is no longer sufficient in many growing markets. Winning manufacturers will be those that can deliver the technology with sufficient features at the right price.

Second, many promising technologies fail to turn into commercial products to drive new demand and productivity, because small companies frequently do not survive the capital-intensive phase of initial production (see Box 6, “The ‘valley of death’ in commercializing innovation”). Increased funding for early-stage development could improve the prospects for commercialization of innovations. It can be provided directly by government to innovators through grants or indirectly through financial intermediaries. For example, the European Investment Fund, which was established in 1994, provides risk financing for SMEs. By December 2010, the fund had invested more than \$30 billion in 351 venture capital funds, guaranteed 193 loans, and supported five microfinance operations, promoting SME innovation in areas such as drug development and technology.

Government commitments to buy pre-commercial versions of new products can also help young companies commercialize their ideas. Another approach is to buy innovation and development services in such a way as to share the risks and benefits of designing, prototyping, and testing a limited volume of new products and services with suppliers. Finally, information and market data should be shared early in the innovation process among industry, investors, researchers, academics, and the public sector to improve chances of successful commercialization. One example of this is the EU’s “Nano2Market” initiative that brings together various European industry associations, universities, and scientific institutes to promote technology transfer in nanotechnology developments.

134 *Increasing global competition and labor productivity: Lessons from the US automotive industry*, McKinsey Global Institute, November 2005 (www.mckinsey.com/mgi).

Box 6. The “valley of death” in commercializing innovation

The road from basic research to commercialization can be long and risky—with a “valley of death” in between. The valley appears when funding for research runs out and companies can’t fund the more expensive phases of proof of concept and initial production.¹ In many cases, companies find themselves in the valley when government R&D funding tapers off and private funders are not willing to step in until the company has proven that the technology works as expected and can be made efficiently. In other words, investors wait until risks are lower and rewards are more likely to be realized. Part of the problem is that investors frequently lack sufficient information or understanding to evaluate whether an innovation is technologically or commercially viable. This information gap encourages would-be funders to withhold capital or demand a higher risk premium.

The valley of death phenomenon is evident in many advanced economies, including Germany and the United States. Both countries have strong public funding for basic research and industry-led research capabilities. But both struggle to commercialize new concepts.² In China and India, frugal innovation models are more common; entrepreneurs do not attempt to create a perfect product before launch. “When the Chinese get an idea, they test in the marketplace,” explains Kevin Wale, former president of GM China. “They’re happy to do three to four rounds of commercialization to get an idea right.”³

Governments can help companies avoid the valley of death in three ways. First, they can make public money available through loans or equity investments for middle-stage funding, which could transfer the risk of commercialization to the public sector and give entrepreneurs a chance to prove their concepts and survive long enough to attract private investment. Second, as a purchaser, government can drive commercialization and set standards for product specifications. Finally, government can foster collaboration among technologists, researchers, investors, business leaders, and regulators to promote information sharing that will reduce risk and encourage private investment.

1 See, for example, George S. Ford, Thomas M. Koutsky, and Lawrence J. Spiwak, *A valley of death in the innovation sequence*, *An economic investigation*, September 2007.

2 *Highlights, OECD science, technology, and industry outlook 2006*, Organisation for Economic Development and Co-operation, December 2006; also see Federal funds for research and development: Fiscal years 2004–06, National Science Foundation, NSF 07-323, June 2007.

3 Yuval Atsmon, Peter Child, Richard Dobbs, and Laxman Narasimhan, “Winning the \$30 trillion decathalon: Going for gold in emerging markets,” *The McKinsey Quarterly*, August 2012.

Factor costs: Rise to the talent challenge and base energy decisions on hard facts

There are two areas where government actions can make a great deal of difference in helping manufacturers cope with shifts in factor costs: providing access to a qualified labor force and ensuring a reliable and inexpensive supply of energy.

The skill challenge is already apparent in many manufacturing sectors and is expected to get worse. With the increasing speed and complexity of manufacturing industries, the need for more high-skill workers is growing and shortages of workers with training in technical and analytical specialties are appearing. Industries such as autos and aerospace anticipate shortages of engineers as older workers retire. Across many advanced economies and in China, aging will constrict the supply of workers with college degrees and the technical skills that are increasingly critical to manufacturing. Access to talent is already an important factor in location decisions of manufacturers in industries in the global technologies/innovators and global innovation for local markets segments. In the US auto industry, 70 percent of executives surveyed by the Original Equipment Suppliers Association, a trade group representing auto parts makers, said they had trouble finding engineering and technical talent in 2011, up from 42 percent in 2010.¹³⁵ The Association of German Engineers (VDI) has declared that the talent shortage could impede R&D efforts, with the mayor of Leipzig describing the situation as “unprecedented.”

The talent issue is not limited to advanced economies. The engineering group SAE-China has blamed a shortage of engineers for weaknesses in technology and innovation across the nation. In India, Vinod Dasari, managing director of automaker Ashok Leyland, has stated that “talent acquisition is a huge challenge in the last two years and it’s worsening now.”¹³⁶ Managing this human capital challenge effectively can help nations enhance competitive advantage.

In addition to continuing efforts to improve public education, particularly in teaching math and analytical skills, policy makers can help steer students into the appropriate fields. This can be done by providing accessible and clear information about what workers at different skill levels or in specific occupations can expect to be paid, and how quickly new graduates are likely to be employed. The data should also include information about what occupations have the lowest rates of layoffs and where in the country (both geographically and by industry sector) demand for workers with specific skills and experience is strongest. In countries such as the United Kingdom and the United States, engineering and technical students are not attracted to manufacturing because, as they have indicated in surveys, they perceive the sector to be in decline.¹³⁷ Governments can help erase this misconception and raise the profile of the sector by explicitly recognizing and celebrating successes more prominently.

135 See *Engineer shortage threatens advanced powertrain development*, Society of Automotive Engineers, SAE 2012 World Congress report, April 2012.

136 See “Talent shortage a bottleneck for China’s auto industry,” *People’s Daily Online*, July 18, 2011; also see Sudha Menon, “Auto companies going all out to overcome talent shortage,” *LiveMint/Wall Street Journal*, June 13, 2007.

137 See *The public’s view of the manufacturing industry today*, Deloitte Touche Tohmatsu and US Manufacturing Institute, September 2011; also see remarks by Vince Cable, UK secretary of state for business, innovation, and skills at the Manufacturing Summit, in London, March 2011.

Governments can also work with industry and educational institutions to ensure that skills learned in school fit the needs of employers. To prepare young people for emerging manufacturing jobs, governments can develop vocational training that leads to industry-wide and nationwide certification and can ensure that emerging technology research connects with companies that can commercialize the results. The developing economies whose labor-intensive sectors may be threatened by the next round of wage arbitrage (i.e., the shift to Africa, South Asia, and other emerging low-wage locations) are likely to fare better in the medium term if they avoid fighting the trend with wage subsidies and instead focus on building the skills, networks, and infrastructure that will enable them to move up the value chain and compete for higher-paying and more highly skilled jobs.

The other factor cost that governments can help manufacturers cope with is energy. Many nations face the prospect of rising energy costs. In Western Europe, for example, greenhouse gas emissions targets are beginning to affect fuel prices. Some nations, by contrast, are in the enviable position of finding new and inexpensive resources, such as shale gas.

In both cases, understanding the underlying economics of energy-intensive industries is critical for making the right policy choices. Where energy prices are likely to rise, the good news is that manufacturing companies have already made good progress in reducing energy consumption per unit of output in the past three decades, making energy costs a small share of cost in many, but not all, manufacturing sectors. By identifying the exceptions, governments can target support to industries or regions where higher energy prices will have a substantial impact on competitiveness.

Once government understands the industries that are most vulnerable to rising energy costs—and before any policy decisions can be made—policy makers must also be aware of what overall impacts and unintended consequences their policies might have. For example, by directing support to energy-intensive manufacturing industries, the government would in effect provide a special subsidy for those companies, which might affect investment and returns in industries that don't benefit. A broad policy to encourage conservation by both businesses and consumers might wind up hurting some manufacturers but might bring large benefits to the overall economy, as has been the experience in California.¹³⁸

Risks and uncertainty: Don't add to the risks or create barriers to company agility

Globalization flourished from the early 1990s until the global financial crisis began in 2007, during what some economists called the Great Moderation. This was a period of muted business cycles and low volatility, when governments forged new trade agreements and companies spread their operations globally in search of optimized locations for each step in manufacturing value chains. Now the Great Moderation has given way to a time of great uncertainty. Government policy itself—or a lack thereof—contributes to the uncertainty and risk. Both by

¹³⁸ California's stringent energy-efficiency regulations and higher electricity prices have increased manufacturing costs. However, University of California Berkeley economist David Roland-Holst finds that California's energy-efficiency policies have been a boon for the California economy overall, creating 1.5 million jobs as the \$56 billion savings from lower electricity consumption have been spent on goods and services that generate more jobs than energy use would.

taking more aggressive steps to support manufacturing sectors and by failing to provide sufficient clarity about the intent of regulation and policy, governments have added to confusion and risk in some cases. Argentina shocked the energy sector when it expropriated the operations of Spanish oil and gas company YPF in early 2012, the first major expropriation in more than a decade. In another highly controversial move, India authorized a local drug manufacturer to produce a generic version of Bayer's Nexavar cancer treatment and required Bayer to license Nexavar to the local manufacturer.

Meanwhile, lack of clarity about energy and environmental policies has raised uncertainty about energy costs in several developed and emerging nations. And there is rising concern about the direction of corporate tax rates in countries that are struggling to address their debt problems, particularly where new governments might reverse current policies. Complexity and uncertainty—real or perceived—make companies reluctant to invest; timely, clear signals about government priorities and policies reduce uncertainty and allow companies to move ahead with investment.¹³⁹

Uncertain or unclear regulations are not the only way that governments can limit the agility of their manufacturing sectors. Government can also slow down business with regulatory inefficiency. Labor laws that make firing workers costly will make it increasingly difficult to attract companies that are seeking to build the type of agile, flexible global operations we describe in the previous chapter. Many governments recognize that this kind of hindrance represents a potential barrier to growth and have worked hard to simplify regulatory processes. Saudi Arabia, for example, established a high-profile “10 by 10” initiative in 2006 that aimed to make the economy one of the ten most competitive in the world by 2010, based on the World Bank's Doing Business rankings. By identifying the biggest bottlenecks and costs and systematically simplifying process flows, the nation advanced 15 places in just two years, reaching 11th place in 2012. Similarly, Vietnam jumped ten places by simplifying the process for launching a business, streamlining permitting, and reducing tax rates.

Finally, governments can take steps to mitigate some forms of volatility. An example of this is Germany's labor market arrangements, which have reduced volatility in employment. For example, the Kurzarbeitergeld system, created in the 1970s, permits employers to apply for subsidies to keep workers on the payroll during a temporary downturn. A more recent “mini job” program targeted young workers and unemployed older workers, providing jobs for 15 hours per week at a set pay rate. In combination with Germany's well-known workforce training and apprenticeship programs, these German labor arrangements serve to dampen the volatility in labor inputs, especially during economic downturns and recoveries.

2. SET REALISTIC POLICY GOALS AND BUILD BROAD ALIGNMENT BEHIND THEM

In today's fragile global economic environment, governments are under intense scrutiny for what they do—or don't do—to enable growth. Ensuring that they don't add to uncertainty with erratic policy is a first step. But successful policy will depend on both credible action and the ability to align private-sector investors and get them to pull in the same direction.

139 *An economy that works: Job creation and America's future*, McKinsey Global Institute, June 2011 (www.mckinsey.com/mgi).

Step one is setting appropriate economic goals. As we noted in Chapter 1, manufacturing makes disproportionate contributions to productivity, exports, and innovation. To reach these economic goals, governments need policies that are based on a granular understanding of how different manufacturing sectors work and how possible initiatives would affect their performance. Not all manufacturing companies are likely to become major exporters. So, providing incentives to all manufacturing firms—including the non-exporters—as a means to boost exports is costly and potentially ineffective. At the same time, the rising role of services in global trade means that the best policy for exports or innovation may not be just manufacturing policies, but those that address specific service sectors, too. Between 2000 and 2011, services exports grew slightly faster than goods exports in most advanced economies. Policy makers should not rule out any tradable sectors that have export potential, whether they provide goods or services.¹⁴⁰

Sustaining global competitiveness in high-skill, innovative manufacturing industries—from aerospace to electronics—is another goal for many governments. Cutting-edge innovation tends to occur in a few clusters that are home to major manufacturing companies, leading research universities or institutions, an established talent pool, and an ecosystem of specialized suppliers and service providers (e.g., California’s Silicon Valley and Taiwan’s Hsinchu region).

Governments that want to sustain or develop innovation clusters need to consider a portfolio of actions that are coordinated across the full value chain, including component suppliers and specialized service providers (e.g., design, research, legal, and engineering firms, and investment banks). In many industries success is difficult, if not impossible, without the participation of leading global companies that have industry know-how and established innovative capability. To attract such companies to the cluster, the policy portfolio may also need to include specialized education, research incentives or grants, and perhaps commitments for public-sector purchasing or investment support. MGI research, however, shows that multinational investments were related less to monetary incentives or taxes and more to improvements in business climate, talent, and infrastructure.¹⁴¹

Policy makers must also be realistic about what they can achieve with manufacturing industry strategy. As we have shown, manufacturing has changed in ways that make approaches that are aimed primarily at large-scale job creation in advanced economies increasingly ineffective and costly at a time of tight government budgets. Manufacturing can continue to grow and contribute to value added and export growth, and it will continue to be a critical source of innovative businesses and productivity-enhancing devices and equipment. And all of these achievements will help create new jobs—but not in the volumes or at the same skill levels as seen in previous decades.

Technology has made manufacturing more capital-intensive and less labor-intensive, particularly in advanced economies where labor is expensive. Overall, manufacturing companies need fewer hands on the shop floor, but more service workers in R&D, product development, market research, sales, marketing, and other fields. In R&D-intensive industries in the United States, such as semiconductors, medical equipment, and precision equipment, more than half of

140 *Trading myths: Addressing misconceptions about trade, jobs and competitiveness*, McKinsey Global Institute, May 2012 (www.mckinsey.com/mgi).

141 *Growth and competitiveness in the United States: The role of its multinational companies*, McKinsey Global Institute, June 2010 (www.mckinsey.com/mgi).

employment is already in service-type jobs. In this environment, then, measures such as subsidies to maintain production jobs do not address the way that jobs are created by the manufacturing sector in advanced economies today (see Box 7, “Job creation and manufacturing”).

Box 7. Job creation and manufacturing

Job creation is a top policy priority for most governments around the globe today. So is maintaining a healthy manufacturing sector. In some places—such as in developing economies that are still building their industrial bases and bringing their people out of rural poverty—policies that promote manufacturing may also be effective in creating jobs. In advanced economies, this is not necessarily the case. As we showed in Chapter 1, the share of manufacturing jobs in total employment declines in all nations after they reach a certain level of wealth (about when per capita incomes reach \$10,000 at purchasing power parity), dropping to 8 to 20 percent of jobs in advanced economies, from about 25 to 35 percent in middle-income nations. Today, service sector industries create eight out of ten net new jobs globally. The clear message: if the primary goal of policy is job creation, a plan that focuses on manufacturing alone is unlikely to live up to expectations.

This is not to say that all efforts to generate manufacturing employment are bound to fail. In individual cities and small regions, manufacturing industries make a huge difference for local employment. Manufacturing helps drive aggregate demand across a region or city, which is why municipalities, states, and provinces are willing to “pay to play,” offering large subsidies to attract or retain manufacturing companies.

In some industries, these investments promise desirable additional benefits. Autos and consumer electronics plants function as an anchor for a range of suppliers, spreading the benefits of any subsidy across the local economy. We also find that tradable services (for example, business services such as accounting) or headquarters activities can also stimulate job growth and provide broad economic impact. On the other hand, the most innovative kinds of manufacturing—sectors such as clean tech, biotech, or nanotech that local governments are eager to attract—often represent very small employment opportunities, currently about 0.5 percent or less of employment across major economies. Moreover, local governments that contemplate making extraordinary concessions to attract production facilities should study the mixed record of sustained benefits.¹

1 For example, the costs of clean-tech subsidies in Europe have been estimated to far exceed average salaries, ranging from \$240,000 per solar industry job created in Germany to more than \$750,000 per wind power job in Spain (www.instituteeforenergyresearch.org). In the 1990s, Brazilian state governments competing to host new auto plants offered subsidies of more than \$100,000 for each assembly job created, which led to both overcapacity and financial stress for local governments. For detail, see *New horizons: Multinational company investment in developing countries*, McKinsey Global Institute, October 2003 (www.mckinsey.com/mgi).

A critical step is to build alignment around the economic goals that policy makers propose. Governments at all levels have increased the odds of success by building solid private-sector support before committing to goals. Indeed, goals that cannot win support of non-governmental stakeholders probably need to be reconsidered. When there is alignment by companies, workers, investors, and communities, manufacturing strategies can have great impact.

The German success in sustaining global automotive leadership, for example, depends in no small measure on broad support from federal and regional governments, public agencies, leading auto and auto parts companies, research institutions, employees, and the public. France's sectoral plans are developed in close collaboration between the government and industry, and South Korea's national government supported joint R&D activities among domestic businesses. In the United States, the President's Council on Jobs and Competitiveness and the National Advisory Council on Innovation and Entrepreneurship both included private-sector leadership. Collaboration is key to successful economic development at the city level, too. In Latin America, for example, strong private-public collaborations have contributed to the above-average growth of Medellin in Colombia and Monterrey in Mexico. Tiny Oulu in Northern Finland built a global mobile technology cluster through close collaboration between city government, local universities, and Nokia.¹⁴²

3. CONSIDER THE FULL POLICY TOOL KIT—AND CHOOSE THE RIGHT INSTRUMENT FOR THE JOB

For most policy goals, the spectrum of available public policy interventions ranges from a hands-off approach to becoming a central actor in a particular sector. We find it useful to think about the policies in four categories that are arranged according to increasing intensity of intervention. In order of intensity, the intervention models are as follows:

- **Setting the ground rules and direction.** Government sets the regulatory environment (i.e., labor, capital-market, and general business regulations) and lays out broad national priorities and road maps.
- **Building enablers.** Without interfering directly in the market, governments can help enable sector growth with hard and soft infrastructure investments: educating and training a skilled workforce, supporting R&D and basic research, and upgrading highways and ports.
- **Coordinating interventions.** Governments can create favorable conditions for local production through coordinated multi-agency actions at the national, regional, and sector levels—such as providing investment support or by shaping demand through public purchasing or regulation.
- **Playing the principal actor.** At the interventionist end of the policy spectrum, governments establish state-owned or -subsidized companies, fund existing businesses to ensure their survival, and actively restructure industries.

Whether national growth strategy involves direct government action or coordinated interventions for a particular industry, or a more restrained role—setting the conditions for overall economic success and then getting out of the

¹⁴² *How to compete and grow: A sector guide to policy*, McKinsey Global Institute, March 2010 (www.mckinsey.com/mgi).

way—is largely a political decision. Singapore and Hong Kong, for example, have both achieved rapid economic growth but have taken opposite approaches to economic strategy; Singapore has relied on intensive government interventions, while Hong Kong has let market forces lead. Policy makers must operate within the limits of a nation’s culture, stage of development, and budgetary constraints—and within the bounds that the global trading community will abide.

We have seen governments use very different mixes of policies across manufacturing industries (Exhibit 80), ranging from setting directions to taking an active role as owner and manager of companies or projects. In food manufacturing, for example, food safety regulation in the European Union and the United States has taken a new direction in the past decade, shifting from a focus on inspection to prevention and encouraging best manufacturing practices, accountability, and traceability at every step of the value chain. To upgrade farming techniques and provide worker training, the Indian government has adopted structural reforms that enabled contract farming and joint ventures with global food manufacturers. Switzerland’s coordinated interventions provided domestic support for its food manufacturers, especially in dairy products. And Singapore, through the state-owned Temasek investment company, developed an integrated food production zone in China’s Jilin province in partnership with the state-owned enterprise Jilin Sino-Singapore Food Zone Development Company.

Exhibit 80

Government policy actions vary widely across countries and industries

ILLUSTRATIVE

	Degree of intervention			
	Low			High
	Setting the ground rules and direction	Building enablers	Coordinating interventions	Playing the principal actor
Global innovation for local markets	Fuel economy standard for new automobiles	Tax credits, loans, and subsidies for auto R&D	Incentives to upgrade to fuel efficient models	Government loans and bailouts of carmakers
Global technologies/innovators	Safety certification for all electronics sold in EU	R&D packages for semiconductor firms	Oulu mobile handset cluster initiative	Early government investment in chip maker
Regional processing	Preventive food safety and quality controls	Raise food production via training, technology	Coordinated food export cluster support	Joint food production zone in northeast China
Energy-/resource-intensive commodities	Regulatory norm for very high-quality steel	Power co-generation projects for steel plants	Integrated steel demand strategy	Assumption of pensions and plant closing costs
Labor-intensive tradables	Duty-free garment imports from Bangladesh	Government delegations sent to new markets	Duty drawback policy for garment industry	Restructuring and debt relief for garment makers

SOURCE: McKinsey Global Institute analysis

Interventions in the left half of the tool kit tend to be well suited for broad-based policies and initiatives that boost competitiveness across the economy, not just a few sectors. Such interventions would include effective regulation, creation of a strong talent pool, and subsidies to R&D and other innovation activities that benefit broad swaths of the economy, including services. Focusing government research funding on early-stage research with broad applications—“commons R&D”—is likely to have much larger long-term benefits than support for specific technical solutions that may not end up being the most commercially attractive solutions.

Policies that create a level playing field across all industries and companies also reduce the risk of unintended constraints or distortions. For example, fast-track regulatory compliance processes for foreign companies or export enclaves are sector-spanning—if they are thoughtfully designed. Mexico's *maquiladora* program is an example of where the regulatory framework limited the impact of a free-trading zone. Because the program required companies to import at least 75 percent of their intermediate inputs (e.g., parts) to qualify for reduced tariffs, a network of local component suppliers and service companies failed to spring up around the assembly plants. Moreover, while allowing foreign exporters into its export segments, Mexico sheltered the rest of its economy from global competition; as a result, a relatively small number of companies, most of them foreign, dominate Mexican exports. Many of these exporters, at least in the *maquiladora* regime, generate value added primarily from intermediate imports, not domestic inputs from Mexico.¹⁴³

As policies move further toward the interventionist side of the scale, effective government actions become more tailored to specific industries. Coordinated interventions, for example, require an in-depth understanding of what drives business competitiveness in different manufacturing industries. Ireland became an important global hub for pharmaceuticals by understanding the key factors required by the industry, such as access to technical talent and favorable corporate tax rates. Both nations have also sustained their leadership by continuously monitoring where they stand compared with other nations on these metrics.

Finally, there is the direct approach, in which governments buy, build, or control manufacturing enterprises. The history of such interventions is uneven, at best. In some industries, state-owned companies have succeeded in becoming global leaders in performance (typically resource- and energy-rich industries with established technologies, cost-based competition, and relatively slow speed of change).¹⁴⁴ In steel, South Korea's state-owned POSCO became a leading global steel producer, but many other state-owned steel companies lagged far behind. Trade barriers protected these other companies from competition and provided favorable access to raw materials but also reduced competitive pressure and the incentive to improve.

4. TRACK PERFORMANCE AND BUILD EXECUTION CAPABILITIES

Designing effective policies is no guarantee of success: execution often matters more than the choice of policies. Execution becomes even more critical with interventionist policies that require specific sector knowledge and the skills within the government to translate sector growth strategies into effective actions. Singapore and Ireland have set the global bar for operating highly effective agencies to attract foreign investors. Both have built capable organizations that have many of the hallmarks of an effective private-sector sales force. Singapore's Economic Development Board (EDB), established in 1961, started by rigorously identifying areas of strength and weakness and used this assessment to establish

143 Diana Farrell, Antonio Puron, and Jaana K. Remes, "Beyond cheap labor: Lessons for developing economies," *The McKinsey Quarterly*, February 2005.

144 *How to compete and grow: A sector guide to policy*, McKinsey Global Institute, March 2010 (www.mckinsey.com/mgi).

national industrial policy priorities—including removing barriers against company expansion and investment.

Early on, the EDB focused its efforts on attracting relatively low-skill, labor-intensive operations of multinational companies. It used a systematic approach of identifying potential investor companies, cultivating relationships with those companies, seeking to understand their decision processes, and then developing tailored packages to attract businesses to Singapore.

Over time, EDB's focus has shifted to more skilled manufacturing and services, and the efforts to promote Singapore have become increasingly sophisticated. Today, the leaders of Singapore's EDB are paid CEO-level salaries. Entry-level EDB salaries that are 5 percent higher than in the private sector ensure that they attract people with high skill levels and relevant industry experience that allow them to engage in complex interactions with the private sector.

Ireland has long focused on attracting foreign direct investment, pursuing key investors over a prolonged period—a decade or more in some cases. Intel and Microsoft were early anchor investors. IDA Ireland, founded in 1949 as Industrial Development Authority, is the key agency leading this effort. To seal the deal with Intel, within five weeks the agency interviewed 300 Irish engineers who were living abroad and presented the US company with a list of 85 qualified candidates. IDA Ireland has 16 international offices on four continents. Although it is a government agency, IDA Ireland has developed its own customer-focused and performance-based culture. The agency assesses its staff on the basis of outcomes, not targets.



As the global economy continues to recover from the Great Recession, growth strategies are critically important. The damage inflicted on national balance sheets by the debt crisis makes it more important than ever to spend public funds wisely; in this environment, ineffective policies and ill-conceived investments by governments will be doubly costly. Healthy manufacturing sectors will play an important role in moving advanced economies ahead and sustaining the momentum of developing economies. But policy makers must be realistic about what manufacturing can contribute and think clearly about what their goals are. Smart, innovative companies—in manufacturing and in services—will drive employment and competitiveness. Policy makers can help that happen, but only if they approach the challenge with a thorough understanding of their in-going position, with consensus on what the goals are and the best methods for achieving them, and by following through with careful execution.

Appendix: Technical notes

1. Calculation of the mix effect in Sweden's manufacturing growth
2. Calculation of the difference of the share of manufacturing in Germany versus the United States
3. Calculation of the contribution of productivity, demand changes, and trade to job shifts and losses

1. CALCULATION OF THE MIX EFFECT IN SWEDEN'S MANUFACTURING GROWTH

We use a dynamic shift–share analysis to decompose growth in Swedish manufacturing gross value added (GVA) into three components, based on a method used by Barff and Knight for employment.¹⁴⁵

- **Growth in line with peer group.** Swedish manufacturing gross value added (GVA) in manufacturing industry i in year $t-1$ * growth in total manufacturing GVA in the EU-15 economies.
- **Industry mix effect** (referred to as “sector outperformance” in chart). GVA in Swedish manufacturing industry i in year $t-1$ *(growth in GVA in EU-15 manufacturing industry i in year t minus growth in total manufacturing GVA in EU-15 in year t).
- **Growth from outperformance relative to peer group.** Swedish manufacturing GVA in manufacturing industry i in year $t-1$ * (growth in Swedish GVA in manufacturing industry i in year t minus growth in EU-15 GVA in manufacturing subsector i in year t).

These components are calculated separately for each manufacturing industry and year. The total growth effect from a specific component is the sum of the annual contributions over the years in all manufacturing industries. Note that this summation of components leads to a small deviation from reported overall manufacturing sector growth that typically applies a Tornqvist aggregation of sectors.

We base the analysis on real gross value added derived from nominal gross value added and price deflator data from the EU KLEMS growth and productivity accounts. To avoid disproportionately high real value added data in electronics (and therefore in our overall manufacturing data) that would result from the hedonic deflators that reflect performance improvements, we use a deflator of “1” instead. This change does not affect the outcome of the analysis materially or the conclusions derived; unadjusted deflators would attribute 78 percent of outperformance to superior performance within each sector instead of 88 percent of outperformance to superior performance within each sector.

145 R. Barff and P. Knight, “Dynamic shift-share analysis,” *Growth and Change*, volume 19, number 2, 1988.

2. CALCULATION OF THE DIFFERENCE OF THE SHARE OF MANUFACTURING IN GERMANY VERSUS THE UNITED STATES

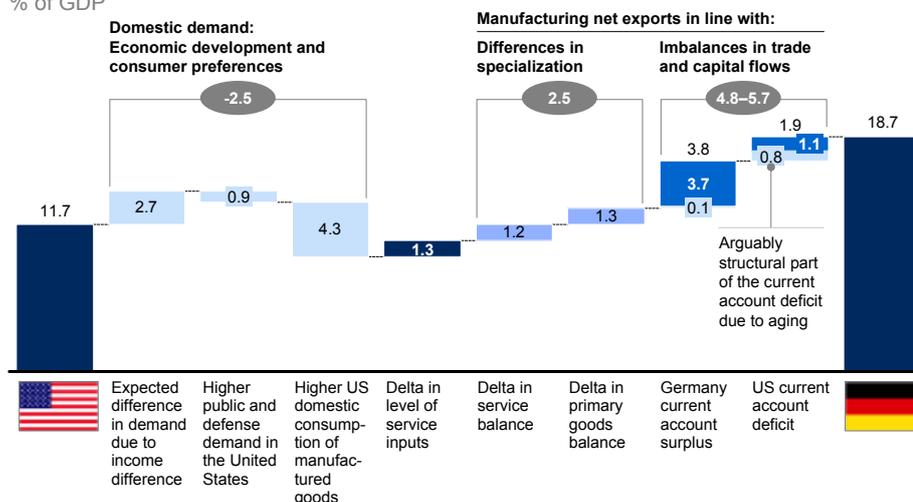
In this analysis, we decompose the impact that differences in net exports (which reflect current account imbalances and differences in specialization in manufacturing versus services or primary resources), use of service inputs, and domestic demand have on the share of manufacturing in an economy (Exhibit A1). Here we present a more detailed version of the disaggregation to supplement the description in Chapter 1.

Exhibit A1

The difference between US and German share of manufacturing reflects specialization, structural differences, demand, and Germany's vast current account surplus since the introduction of the euro

ESTIMATES

Difference in share of manufacturing in Germany versus United States, 2010
 % of GDP



SOURCE: OECD; Eurostat; BEA; Goldman Sachs; McKinsey Global Institute analysis

Impact that differences in net exports of manufactured goods have on the manufacturing value added in an economy

We use OECD mid-2000s domestic input-output tables to calculate final demand to value-added multipliers per sector, in order to understand what domestic value added is generated from additional final demand, split across manufacturing, services, and primary resource sectors. We calculate import content as the residual, since gross output must equal the sum of value added across the international value chain.¹⁴⁶ The value added multipliers per sector are then weighted by the export volumes per sector to yield the export value added ratios for manufacturing, services, primary resources, and imported content. We find that in the United States, each dollar of exports corresponds to an average of 49 cents in domestic manufacturing value added (44 cents for Germany), 32 cents in domestic service value added (24 cents for Germany), and 19 cents of import content (32 cents in Germany).¹⁴⁷

146 Alternatively, one could take the difference of total table versus domestic table multipliers as import content, but conceptually, the logic that total value-added multipliers should add up to 1 (without induced effects) seems more robust than using the total table multipliers, which are close to 1.

147 These numbers reasonably match those given for value-added content of exports in Robert Johnson and Guillermo Noguera, *The value-added content of trade*, extracted from voxeu.org on January 30, 2012.

We then calculate the net export impact of \$1 of export growth by subtracting the import content, or, to get the same result, determine the domestic manufacturing value added required to generate \$1 of net exports by dividing the domestic manufacturing value added share in exports by $(1 - \text{import content})$. In our analysis, a \$1 increase in net exports corresponds to 60 cents of additional domestic manufacturing value added for the United States (65 cents in Germany).

Applying 65 percent to Germany's manufacturing net exports of 9.9 percent of GDP in 2010, we estimate that net export growth produces a gain of 6.4 percentage points for manufacturing's share of GDP in Germany. Similarly applying 60 percent to US manufacturing net export growth of -2.9 percent in 2010, we get -1.7 percentage points as manufacturing's contribution to GDP in the United States.

Next we look at the sources of current account balances (the sum of the balances of trade in manufactured goods, primary resources, services, and the balance in income and current transfers). Solving for differences in current account balances (and in income and current transfers, which happen to be nil) versus differences in specialization between the two economies, we see that in 2010 the United States ran a surplus of 1.1 percent of GDP in services compared with a deficit of 0.9 percent in Germany, and a deficit in primary resources of 1.5 percent of GDP (3.6 percent in Germany).

Part of the current account balance relates to aging, because rapidly aging economies like Germany tend to save more and invest less (i.e., they run current account surpluses) than economies with a more balanced age structure like the United States. This structural imbalance is estimated as 0.1 percent of GDP for Germany and -1.4 percent for the United States.¹⁴⁸

Impact of different uses of service inputs in the production value chain

We find that \$1 in additional manufacturing final demand creates 24 cents in domestic service value added in the United States and 21 cents in Germany (i.e., US manufacturers are significantly more dependent on service suppliers). The 3 additional cents of domestic value added that are captured by service suppliers in the United States translates to a 1.3 percentage point difference in manufacturing share of GDP between the United States and Germany.

Impact of differences in final demand

The remaining difference in the shares that manufacturing contributes to GDP in the two countries is explained by differences in domestic demand. We decompose this difference into several components:

First, demand for manufactured goods varies according to wealth; richer economies tend to consume more services, as a share of GDP. US per capita GDP in 2010 was \$47,000 compared with \$37,000 in Germany (in purchasing power adjusted terms), according to the Conference Board. Adjusting for the domestic manufacturing value added share of output, the United States, therefore, would be expected to spend 2.7 percentage points less of GDP on manufactured goods than Germany. Actual domestic demand is higher than this

148 D. Wilson and S. Ahmed, *Current accounts and demographics: The road ahead*, Goldman Sachs Global Economics paper number 202, August 2010.

expected number, however, contributing positively to the US manufacturing share. Using input-output tables to separate manufacturing demand from public and defense sectors, we see that US demand by those sectors is substantially higher than in Germany. We finally calculate the residual as “higher relative consumption of manufactured goods in the United States.”

These calculations are approximate, but nonetheless help to illustrate the forces at play.

3. CALCULATION OF THE CONTRIBUTION OF PRODUCTIVITY, DEMAND CHANGES, AND TRADE TO JOB SHIFTS AND LOSSES

We use US Bureau of Economic Analysis (BEA) per-sector employment data (full-time equivalent jobs plus self-employed workers) for 2000 and 2010 and explain the change in employment over that period based on changes in final demand and productivity. We compute the impact from final demand changes on jobs using multipliers based on an input-output table from the BEA for 2000. For the productivity impact, we calculate the jobs needed to generate 2000 output at 2010 productivity levels. Finally, we show the residual impact as “other.”

Estimating jobs change from changes in final demand

Jobs multipliers based on input-output tables enable us to estimate the impact of a change in final demand on output and jobs by industry. We create an import-adjusted direct requirements table for 2000 from the original BEA table that includes imports, and then we develop an industry-by-industry domestic total requirements table following standard input-output methodologies. We then calculate the jobs multiplier table by adjusting the industry-by-industry total requirements table (i.e., output multipliers) for 2000 by the ratio of employment to gross output for each sector.

We then take final demand (final uses) from the BEA 2000 input-output table and split it into domestic final demand plus net exports. We do the same for the BEA 2010 input-output table, rebasing final demand and net exports into 2000 US dollars using BEA gross output deflators.¹⁴⁹ For computers and electronic products, we adjust the deflator to 1 (equivalent to using nominal values) to avoid hedonic deflation, because improvements in factors such as processing speed appear to be of limited relevance for production employment. We thus derive final demand in 2000, change in net exports, change in domestic demand, and final demand in 2010, all in 2000 US dollars.

We multiply the year 2000 job multiplier matrix with the vectors of (1) change in net exports from 2000 to 2010 to get the employment impact from net export changes, and (2) change in domestic demand from 2000 to 2010 to get the employment impact from domestic demand changes. We do not distinguish between changes in domestic demand for domestic or foreign suppliers, but we show all changes in consumption and investment in the United States as changes in demand and the respective changes in imports as part of net trade. For instance, if US consumers purchase more cars but import those cars from abroad, we would show a positive employment impact from demand but a negative impact from net trade in line with increased imports.

¹⁴⁹ The accuracy of the calculation could be improved even further by separately applying specific deflators for domestic demand, exports, and imports.

Estimating jobs change from changes in productivity

We use BEA value added and employment data by sector to calculate productivity (real value added per full-time equivalent including the self-employed) in 2000 and 2010, deflating 2010 value added to 2000 US dollars with BEA value added deflators. We then derive the number of full-time equivalent (FTE) jobs needed per sector when producing year 2000 output at 2010 productivity levels and compare this number with actual 2000 employment. Again, we adjust the deflator in computers and electronics products to 1 to avoid hedonic deflation that would lead to an oversized productivity impact. The use of unadjusted data would result in an increase of 0.5 million manufacturing job losses from productivity.

Residual

Finally, we calculate the residual to actual 2010 employment data. This residual has a number of interpretations: (1) the combined or multiplicative effect from the separate levers; (2) statistical discrepancies; and (3) changes in the structure of the value chain—for example, outsourcing that can lead to fewer jobs in a sector than are captured in the final demand or productivity numbers based on value added. The latter point merits further discussion. For instance, if health care buys more inputs (equipment) from knowledge-intensive manufacturing, this would mean a negative residual for health care and a positive one for manufacturing, due to increased intermediate demand without increased final demand.

Because we base the calculation on sector-level data, it can only partially account for outsourcing or offshoring within a sector. Consider the following example. Demand for products made by Company X is \$10 billion per year (gross output). Company X generates \$5 billion of value added from these products and employs 200,000 manufacturing workers. Purchases of intermediate goods and services make up the other \$5 billion and generate a further 200,000 jobs among suppliers. We illustrate three scenarios of outsourcing and offshoring, and how they would be reflected in our calculation:

- **Scenario 1.** Company X decides to outsource its human resources department domestically (equivalent to 10,000 jobs). Final demand and net trade would not change, as only intermediate demand alters. Our 2000 multipliers would show no changes due to final demand or net trade. There would be no impact on productivity. The residual to 2010 employment would mean that we show a minus 10,000 residual impact in manufacturing and a positive 10,000 residual impact in business services.
- **Scenario 2.** Company X decides to offshore half of its activities, equivalent to 100,000 jobs, to a low-cost country. Assuming these activities are as high in value as the ones remaining in the domestic economy, they would pay 50 percent of their value added, or \$2.5 billion, to their low-cost country operations, while intermediate inputs from suppliers remain unchanged. Accordingly, in this scenario, net trade would deteriorate by \$2.5 billion, which our analysis would translate into 50,000 jobs lost in Company X and another 50,000 among the suppliers. Because the supplier jobs would often be in a different industry (typically in services), our analysis would show a somewhat different industry mix for the jobs lost than what is happening in reality. The difference of 50,000 manufacturing job losses to the 100,000 specified in our scenario would show up as “residual” in our analysis, and, equivalently, the difference of minus 50,000 to the zero job losses among suppliers would show up as residual there.

- **Scenario 3.** This is the same as Scenario 2 but the 100,000 jobs Company X offshores lead to imports worth only \$1 billion rather than \$2.5 billion, assuming as an extreme scenario a 60 percent landed cost saving due to sourcing from a low-cost country (or a pre-selection of outsourced jobs to reflect only low-value activities). The job impact from net trade in the model in this scenario would be only minus 20,000 in manufacturing and minus 20,000 among suppliers, in line with the lower price for the imports. But because Company X retains the \$1.5 billion in cost savings as margin, there would be a significant measured productivity impact. After the offshoring, Company X would deliver \$4 billion in value added (\$5 billion minus \$1 billion of imports) with 100,000 jobs, or productivity of \$40,000 per worker, while previously it had a productivity of only \$25,000 per worker (\$5 billion in value added with 200,000 workers). Our model would show that Company X can deliver its pre-offshoring value added for the year 2000 of \$5 billion at a year 2010 post-offshoring productivity level of \$40,000 per employee, rather than \$25,000 per employee, or with 125,000 employees instead of 200,000, and therefore the model would show job losses related to productivity growth of 75,000 employees. Finally, the residual in our analysis would show the difference to actual job losses of an additional 5,000 jobs for Company X and a reduction of the loss by 20,000 jobs among the suppliers.

The last scenario is an extreme case, but it demonstrates the importance of understanding what portion of measured productivity growth may have been driven from cost savings when switching to offshore sourcing.

In a slightly different context, Houseman et al. have estimated that real value-added growth, and therefore growth in labor productivity, in manufacturing in the United States could be overstated by 0.2 to 0.5 percentage points a year due to an offshoring bias, because price deflators do not reflect price declines in inputs from changing suppliers (e.g., to offshored operations).¹⁵⁰ With the current import profile of the United States, they show that this is approximately equivalent to a 30 percent price advantage when switching to suppliers in developing countries. This bias suggests that 300,000 to 800,000 of the manufacturing jobs lost in the United States and attributed to productivity increases actually reflect price advantages from offshoring that do not properly get reflected in net export changes or value added deflators. In our analysis, we therefore identify the midpoint of 0.6 million as “offshoring-related efficiencies” within the productivity-related job decreases.

Several further angles help make these results plausible:

- **Assessment of productivity impact from changes in the composition of the value chain.** From 2002 to 2010, there was a 2.1 percentage point shift of employment out of assembly and into R&D at one end of the value chain and into sales and customer care at the other end. This change in composition was equivalent to a 0.1 percentage point annual increase in average real manufacturing wages from shifting to higher value added activities (Exhibit A2). This change is lower than we expected because the compositional shift was stronger from assembly jobs to similarly low-wage customer-care jobs rather than high-value R&D jobs. While wages can never be a solid proxy for productivity, the results still suggest that the impact of this kind of

150 Susan Houseman et al., “Offshoring bias in US manufacturing,” *Journal of Economic Perspectives*, volume 25, Number 2, Spring 2011.

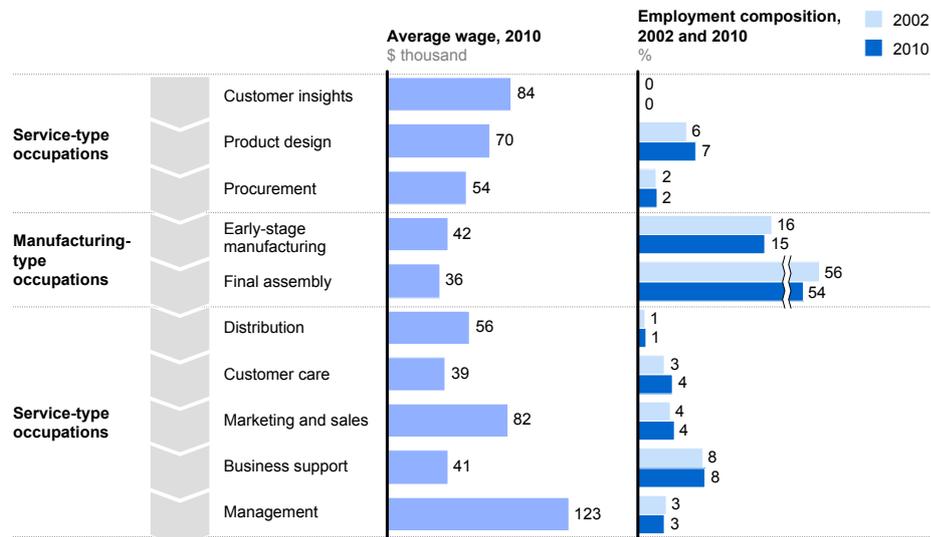
trade-related specialization on measured productivity growth may be small compared with the overall annual rate of productivity growth in manufacturing.

Exhibit A2

Repositioning along the value chain may have added around 0.1 percentage points to annual manufacturing productivity growth



% of total US manufacturing employment



SOURCE: BLS; McKinsey Global Institute analysis

- Analysis of productivity impact by sector.** Sectors that show the largest negative employment impact from productivity growth in our analysis are computers and electronics products (-1.1 million), machinery (-0.6 million), and wood products, electrical equipment, furniture, food, printing, apparel, chemical, and plastics (each around -0.2 million). Examples of outsourcing or offshoring assembly work are concentrated in computers and electronics products. For a scenario in which we assume all productivity growth in those sectors was related to offshoring (and offshoring did not drive productivity in other sectors) 1.1 million of the 4.8 million productivity impact would be related to offshoring.
- Analysis of Chinese processing exports.** In 2009, China's imported goods for processing were worth \$322 billion, and re-exported processed goods were worth \$587 billion, retaining a processing value added of \$265 billion—\$220 billion more than in 2000. Assuming that all of this processing could be done in the United States instead—at 1.5 times the Chinese cost—it would be equivalent to around 3.3 million US jobs. About 2.2 million of these jobs would correctly show up in the job decomposition analysis as job losses from trade (which did not materialize as other sectors and activities improved their net trade position accordingly). But 1.1 million jobs, in line with the assumed cost improvement achieved from offshoring, would be reflected as productivity gains in our analysis.

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