

The Future of Manufacturing

Opportunities to drive economic growth

A World Economic Forum Report
in collaboration with Deloitte Touche Tohmatsu Limited

April 2012



Project Consultative Group

The Project Consultative Group comprises members of the project Task Force (senior executives from Forum Partner companies) as well as members of the Forum's Global Agenda Council on Advanced Manufacturing, who served an advisory role to this project, providing their input through conference calls, individual interviews and a project workshop in London. The World Economic Forum would like to express its gratitude to all the members of the Project Consultative Group.

Task Force

- **Peter Bosch**
Head of Strategy, Production and Logistics
Volkswagen AG
- **Mairead Lavery**
Vice-President, Strategy, Business Development and Structured Finance
Bombardier
- **Trevor Mann**
Senior Vice-President, Manufacturing, Purchasing, and Supply Chain Management, Nissan Europe
- **Jock-Mendoza Wilson**
Director, International and Investor Relations
System Capital Management
- **Fernando Musa**
Vice-President, Strategy and Productivity
Braskem SA
- **Edward Rogers**
Global Strategy Manager, Corporate Strategy
UPS
- **Rodolfo Sabonge**
Vice-President, Market Research & Analysis
Panama Canal Authority
- **Lisa Schroeter**
Director, International Policy
The Dow Chemical Company
- **Hemant Sikka**
Senior Vice-President, Operations - Head of Manufacturing, Automotive
Mahindra & Mahindra Ltd
- **Francisco Soares-Neto**
Vice-President, Manufacturing and Engineering
Embraer SA
- **Subodh Tandale**
Executive Director, Head of International Business
Bharat Forge Ltd
- **Andrew Weinberg**
Chairman, Strategy
Brightstar Corp.
- **Jeff Wilcox**
Vice-President, Engineering, Corporate Engineering and Technology
Lockheed Martin Corporation
- **Mike Yonker**
Vice-President, Product Engine Innovation
Nike Inc.

Global Agenda Council on Advanced Manufacturing

- **Odile Desforges**
Executive Vice-President, Engineering and Quality
Renault-SAS
- **Fadi Farra**
Head, Eurasia Competitiveness Programme
Organisation for Economic Co-operation and Development (OECD)
- **João Carlos Ferraz**
Vice-President
Brazilian Development Bank (BNDES)
- **Bernd Häuser**
Head, Corporate Department for Manufacturing Coordination, Production System Development and Investment Planning
Robert Bosch GmbH
- **Arun Maira**
Member, Manufacturing & Tourism
India Planning Commission
Global Agenda Council on Advanced Manufacturing Chair
- **Min Mu**
Director, Integrated Supply Chain
Honeywell
- **Jun Ni**
Director, Manufacturing Research Center, Professor, Manufacturing Science, Shien-Ming Wu Collegiate Professor of Manufacturing Science and Dean, University of Michigan, Shanghai Jiao Tong University Joint Institute; Global Agenda Council on Advanced Manufacturing Vice-Chair
- **Aloke Paliskar**
Global Head, Manufacturing
Mahindra Satyam Limited
- **Jean-Paul Rodrigue**
Professor, Global Studies and Geography
Hofstra University
- **Gerry P. Smith**
Senior Vice-President, Global Supply Chain
Lenovo
- **Daniel Viederman**
Chief Executive Officer
Verité

Contents

3	Executive Summary
6	Introduction
9	Section 1: Manufacturing's Globalization
33	Section 2: The New Calculus of Manufacturing
43	Section 3: Future Competition: Resources, Capabilities and Public Policy
78	Acknowledgements
80	End Notes

Executive Summary

John Moavenzadeh
Senior Director
Head of Mobility
Industries - World
Economic Forum

Ronald Philip
Senior Manager
World Economic
Forum

Craig A. Giffi
Vice-Chairman
US Leader,
Consumer &
Industrial Products
Deloitte United
States (Deloitte LLP)

Amish Thakker
Project Manager
Deloitte United
States (Deloitte
Consulting LLP)

Over the past several decades, the globalization of the manufacturing ecosystem has driven more change and impacted the prosperity of more companies, nations and people than at any time since the dawn of the Industrial Revolution. Nations around the world have taken part in and benefited from the rapid globalization of industry and expansion of manufacturing. Globalization of manufacturing has been a key driver of higher-value job creation and a rising standard of living for the growing middle class in emerging nation economies. This has dramatically changed the nature of competition between emerging and developed nations as well as between companies. Recent research confirms manufacturing has been immensely important to the prosperity of nations, with over 70% of the income variations of 128 nations explained by differences in manufactured product export data alone.

A number of factors have enabled this rapid globalization, including a significant change in geopolitical relations between East and West, the widespread growth of digital information, physical and financial infrastructure, computerized manufacturing technologies, and the proliferation of bilateral and multilateral trade agreements. These factors, along with others, have permitted the disaggregation of supply chains into complex global networks allowing a company to interact in the design, sourcing of materials and components, and manufacturing of products from virtually anywhere – while satisfying customers almost anywhere.

While digital technology and free trade proliferation will continue to enable the flattening of the world and the globalization of manufacturing supply chains, the dominant factors that shaped the disaggregated supply chains we find today will not be the same as those that carry us through the next several decades. The global environment is changing. Many emerging economies used by multinationals as locations of low-cost labour, have developed significant manufacturing and innovation capabilities permitting them to produce increasingly advanced manufactured products. At the same time, these economies have begun to experience a corresponding escalation in wages and costs, following in the footsteps of their developed nation counterparts. Greater prosperity and higher wages are helping drive an increased ability, and desire, to consume by these growing middle classes, making them much more an exciting market of new consumers and much less a source for low-cost labour.

With the seeds planted by these multinationals, and the opportunity to serve these new markets, powerful new competitors are growing every day. This will profoundly reshape manufacturing supply chains over the coming several decades. But this reshaping will also be influenced by complex macroeconomic and geopolitical challenges, including exposure to currency volatility, sovereign debt pressures and emerging protectionist policies of many countries to gain access to emerging and prosperous new markets. All of these factors are driving more localized manufacturing supply chains.

While we expect the forces that initiated this rapid globalization to continue, we also see some clear and important new trends emerging that will define manufacturing and competition over the next 20 years. These trends will require the attention and collaboration of policy-makers, civil society and business leaders:

- **The infrastructure necessary to enable manufacturing to flourish and contribute to job growth will grow in importance and sophistication and be challenging for countries to develop and maintain.**

Investing in effective infrastructure has been essential for emerging nations to be included as a potential location by multinationals and thus participate in the benefits derived from the globalization of manufacturing. This trend will intensify in the future. Reinvestment in maintaining competitive infrastructure will become critical for developed nations to keep pace. Public funding support for infrastructure development will be a challenge for developed nations given the expected long tail on sovereign debt issues. Effective public-private partnerships will be essential to address this. While infrastructure alone will not lead directly to best-in-class manufacturing, a serious lack of infrastructure or a steadily decaying infrastructure will negatively impact a nation's manufacturing competitiveness and create serious obstacles for the supply chain networks of global multinationals.

- **Competition between nations to attract foreign direct investment will increase dramatically raising the stakes for countries and complicating the decision processes for companies.**

Annual foreign direct investment (FDI) inflows for manufacturing more than doubled to average US\$ 350 billion from 2006 through 2009, and manufacturing accounted for 26% of global FDI projects in 2010, generating 1.1 million jobs. FDI is a means to bring manufacturing and research facilities to a country, building infrastructure in public-private partnerships and leveraging the multiplier effect of manufacturing on service jobs across the nation. As public funding challenges mount, the competition between nations for FDI will increase dramatically. Membership in the World Association of Investment Promotion Associations has increased by 2.5 times since 2001. For companies, the myriad of potential investment options will be increasingly hard to differentiate and navigate. But investments in the wrong location and not contributing enough to truly advance a company's global competitive capabilities will have long lasting negative consequences and be increasingly hard to unwind.

- **Growing materials resources competition and scarcity will fundamentally alter country and company resources strategies and competition, and serve as a catalyst to significant materials sciences breakthroughs.**

Demand for rare earth elements increased sixfold from 2009 to 2010, with China supplying 95% of global demand. In the short term, countries and companies react to rising scarcity and prices of materials, such as rare earth elements, by stockpiling or hedging. In the longer term, success will be marked by discoveries of alternative elements, investing in latent supply access, breakthroughs in materials sciences and more efficient practices governing the use of materials.

- **Affordable clean energy strategies and effective energy policies will be top priorities for manufacturers and policy-makers, and serve as important differentiators of highly competitive countries and companies.**

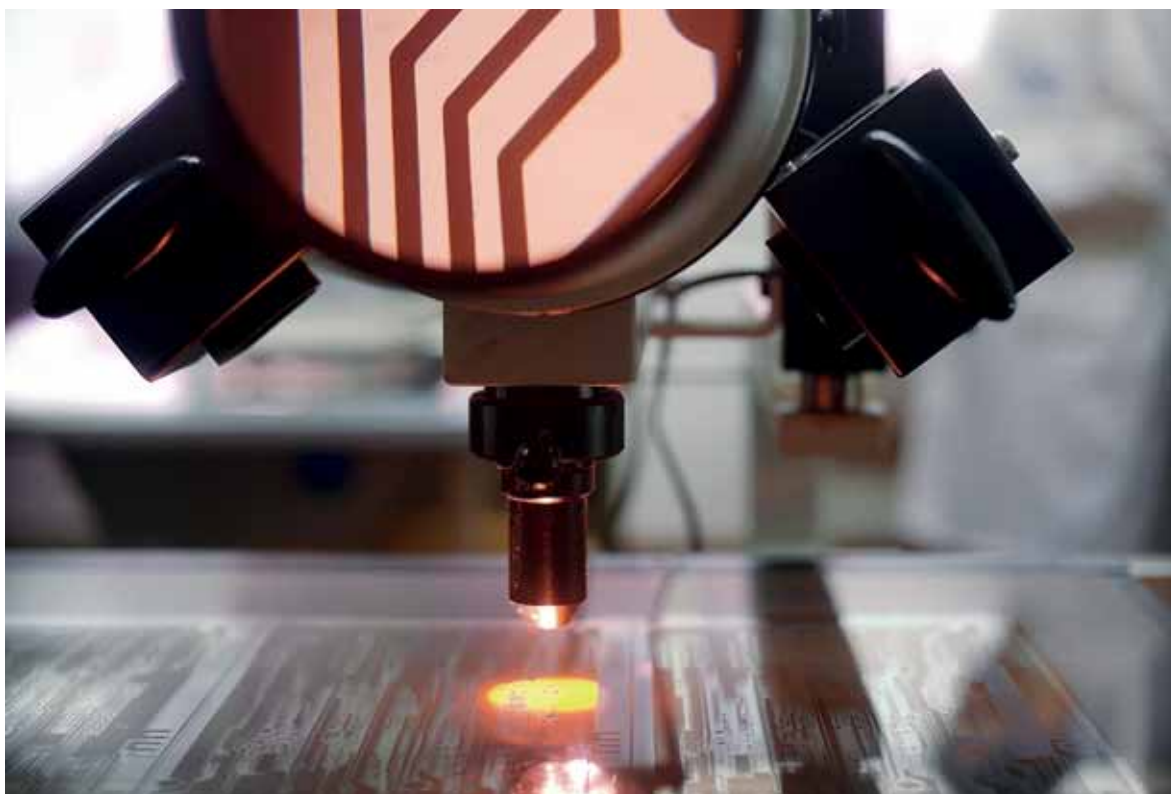
By 2035 the US Energy Information Administration expects world energy consumption will more than double, from a 1990 baseline, to roughly 770 quadrillion Btu, and outpace the increase in population over the same time period. Demand for and cost of energy will only increase with future population growth and industrialization. Environmental and sustainability concerns will demand that nations respond effectively and responsibly to the future energy challenge. All nations will be seeking competitive energy policies that ensure affordable and reliable energy supply. All manufacturing sectors will be forced to seek new ways of manufacturing, from energy efficient product designs to energy efficient operations and logistics. Collaboration between company leaders and policy-makers will become an imperative to solve the energy puzzle.

- **The ability to innovate, at an accelerated pace, will be the most important capability differentiating the success of countries and companies.**

Companies regarded as more innovative grew net income over two times faster and their market capitalization nearly two times faster from 2006 to 2010 compared to their non-innovative counterparts. Countries that are more successful at fostering innovation perform better, whether looking at GDP or GDP per capita. Companies must innovate to stay ahead of competition, and must be enabled by infrastructure and a policy environment that better supports university/research lab breakthroughs in science and technology and investment budgets that permit dedicated pursuits. In the 21st century manufacturing environment, being able to develop creative ideas, addressing new and complex problems and delivering innovative products and services to global markets will be the capabilities most coveted by both countries and companies. But even more essential for innovation to flourish will be access to a workforce capable of driving it.

- **Talented human capital will be the most critical resource differentiating the prosperity of countries and companies.**

An estimated 10 million jobs with manufacturing organizations cannot be filled today due to a growing skills gap. Despite the high unemployment rate in many developed economies, companies are struggling to fill manufacturing jobs with the right talent. And emerging economies cannot fuel their growth without more talent. Access to talent will become more important and more competitive. Today's skills gap will not close in the near future. Companies and countries that can attract, develop and retain the highest skilled talent – from scientists, researchers and engineers to technicians and skilled production workers – will come out on top. In the race to future prosperity, nothing will matter more than talent.



- The strategic use of public policy as an enabler of economic development will intensify resulting in a competition between nations for policy effectiveness and placing a premium on collaboration between policy-makers and business leaders to create win-win outcomes.

With competition increasing for so many resources and capabilities, and with the prosperity of nations hanging in the balance, policy-makers will be actively looking for the right combination of trade, tax, labour, energy, education, science, technology and industrial policy levers to generate the best possible future for their citizens. Despite many instances of failed industrial policies in history, policy-makers are increasingly turning to intervention in an attempt to influence outcomes and accelerate manufacturing sector development with several G20 countries, including China, India and Brazil, recently coming out with industrial policies. This means that policy-makers, in a complex global network of interdependencies, will need to carefully pull the right levers, at the right time in a balanced approach and mindful of unintended consequences. Companies will need to be more sophisticated and engaged in their interactions with policy-makers to help strike the balanced approach necessary to enable success for all.

In the future, nations will increasingly compete with each other to drive high-value job creation and harness the advantages of a globally leading manufacturing innovation ecosystem.

Manufacturing companies – current powers and new entrants – will engage in an intensifying, talent-driven innovation competition to dominate profitable markets for new and existing customers. As this unfolds, both government policy agendas and manufacturing company strategies will be shaped by growing competition around common resources and capabilities. The involvement of policy-makers in shaping outcomes will steadily grow and require stronger collaboration with business leaders to achieve success.



Andreas Renschler, Member of the Board of Management, Daimler and Chief Executive Officer, Daimler Trucks and Daimler Buses, Daimler AG and Robert Z. Lawrence, Albert L. Williams Professor of Trade and Investment, Harvard Kennedy School, Harvard University share comments in Davos-Klosters

Project Methodology

With a call to action from stakeholders at the 2011 Annual Meeting, in January 2011 the World Economic Forum's Mobility Industries team initiated the Future of Manufacturing project to address how the global manufacturing ecosystem is evolving. The project explored the pivotal drivers of change, today and in the future, to generate insights and a platform for informed dialogue between senior business leaders and policy-makers.

For this first phase of the project, the objective was to create a "data-driven narrative" regarding the state of the global manufacturing ecosystem and the factors that would be most likely to shape the future of competition for both countries and companies. The final report provides the foundation and launching point for more specific, recommendations oriented research efforts in a second project phase. The report was developed using an iterative process with the relentless support of global project stakeholders.

The project team, made up of manufacturing industry experts from the World Economic Forum and Deloitte LLP, used a combination of primary and secondary research including an extensive review of key academic and industry literature, select interviews with more than 30 manufacturing business, academia, and policy leaders, and numerous virtual Task Force calls. This effort also benefited from gaining invaluable feedback from other concurrent World Economic Forum project teams, including the Forum's Global Agenda Council on Advanced Manufacturing. Industry, policy, and academic stakeholders also interacted during seven face-to-face global workshops in the following locations:

- New York, USA: 7 April 2011
- Rio de Janeiro, Brazil: 27 April 2011
- Dalian, China: 15 September 2011
- Abu Dhabi, UAE: 11 October 2011
- Mumbai, India: 12 November, 2011
- London, UK: 1 December 2011
- Davos, Switzerland: 27 January 2012

These workshops allowed for more substantive dialogue and exchange of expert perspectives, and included critical region and country specific manufacturing industry challenges and opportunities, which helped shape this report.



Rob Davies, Minister of Trade and Industry of South Africa, Ricardo Hausmann, Director, Center for International Development, Harvard Kennedy School, Harvard University, and Siegfried Russwurm, Member of the Managing Board and Chief Executive Officer, Industry, Siemens share comments in Davos-Klosters

Introduction

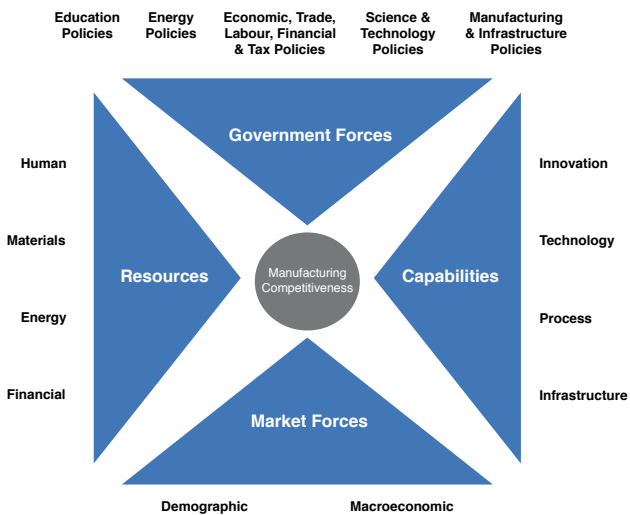
Over the past several decades, manufacturing has experienced significant change as rapid globalization shifted a significant proportion of manufacturing capacity from developed to emerging economies and substantial new markets and new competitors emerged. The globalization of manufacturing was enabled by a combination of forces coming together simultaneously, including a significant change in geopolitical relations between east and west, the widespread growth of digital information, physical and financial infrastructure, computerized manufacturing technologies, and the proliferation of bilateral and multilateral trade agreements.

These factors, along with others, have permitted the disaggregation of supply chains into complex global networks allowing a company to interact in the design, sourcing of materials and components, and manufacturing of products from virtually anywhere – while satisfying customers almost anywhere.

The manufacturing industry is of great interest to investors and business leaders hoping to take advantage of the opportunities presented by rapid globalization and the significant growth of the middle class in emerging markets, as well as serving high-value customers in developed markets with innovative new products and services.

Policy-makers, still coping with the aftermath of the financial crisis and hoping to stimulate high-value job growth and create sustained economic recovery, are keenly interested in the benefits of having a globally competitive manufacturing industry. While the changes that have occurred in the recent past are important to understand, it is the future of competition in the manufacturing industry that has the most interest to both business leaders and policy-makers.

Figure 1: Global Manufacturing Competitiveness Framework



Source: Adapted from Deloitte and Council on Competitiveness: What separates the best from the rest? Deloitte Touche Tohmatsu 2011

The Future of Manufacturing project represents a nearly 12-month collaboration among senior manufacturing executives, policy-makers, and subject matter experts. It is intended to provide a foundation upon which more detailed research will take place. Our research delved into how the global manufacturing ecosystem is evolving and the trends most impacting global manufacturing competitiveness in the future, as depicted in the framework shown in Figure 1, including market forces, such as macroeconomic and demographic forces, as well as the key resources and capabilities where competition will occur for both companies and countries in the future. Finally, we conclude with a brief look at the role of public policy and its impact on the manufacturing competitiveness of nations and businesses. The research is complemented by insights from seven project workshops at various global locations.

This report comprises three sections:

- **Section 1: Manufacturing's Globalization** identifies the key drivers of the change that have occurred over the past 20 years and the impact and implications for manufacturers that have resulted. In addition, we explore whether manufacturing still matters, looking at some compelling new research, and conclude without question that yes, manufacturing does indeed matter.
- **Section 2: The New Calculus of Manufacturing** explores some of the most important recent trends that will alter the nature of manufacturing's globalization over the next few decades and how this will again change manufacturing supply chains.
- **Section 3: Future Competition: Resources, Capabilities and Public Policy** examines the key areas where both countries and companies will face the most intense competition in the future, and where both policy-makers and business leaders will need to collaborate in the development of the solutions necessary to benefit both private enterprises and the well-being of nations.



Section 1:

Manufacturing's Globalization

Since the dawn of the Industrial Revolution, manufacturing has been transformative for countries and companies. Those who could harness its power have achieved great prosperity and profitability. High paying middle-class job creation, driven by manufacturing following World War II, established major industrial powers in North America, Western Europe and Asia, with the United States, Germany and Japan emerging as the major global manufacturing leaders and reaping the rewards: steady GDP growth, a prosperous middle class, and a rapidly growing services sector fuelled in large part by the multiplier effect of the manufacturing innovation ecosystem.

More recently, however, over the past several decades, a rapid globalization has occurred in the global manufacturing ecosystem driving more change and impacting the prosperity of more companies, nations and people than at any time in the last 100 years. A significant amount of manufacturing has moved from developed nations to emerging economies and this rapid global expansion of manufacturing has dramatically changed the competitive landscape for manufacturers. Nations around the world have taken part in and benefited from the rapid globalization of industry and expansion of manufacturing. Recent research confirms manufacturing has been immensely important to the prosperity of nations, with over 70% of the income variations of 128 nations explained by differences in manufactured product export data alone.¹

Globalization of manufacturing has been a key driver of higher-value job creation and a rising standard of living for the growing middle class in emerging economies, including China, India, South Korea, Mexico and Brazil. Developed nations have benefited from lower-cost products driven by the lower wages used for production in emerging markets. But this has also dramatically changed the relationship between emerging and developed nations, creating competition as well as co-dependency.

In this section, we explore a number of the key factors that have helped shape the current global manufacturing ecosystem, including the widespread growth of digital information infrastructures and computerized manufacturing technologies, and the proliferation of bilateral and multilateral trade agreements, providing a better understanding of globalization from a manufacturing perspective as well as defining our launching point for considering the future of manufacturing. But first, we seek to understand whether “manufacturing still matters” to the economic development and prosperity of nations before exploring significant recent changes and contemplating the future of manufacturing.

Does Manufacturing Still Matter?

Manufacturing's share of global value added has declined steadily over the past nearly 30 years as the global value added of services has grown. In 1985, manufacturing's share of global value added was 35%. By 2008, it had declined to 27%. Services grew from 59% to 70% over the same period. This trend has largely been driven by developed country economies with typically higher wages. According to a recent United Nations Industrial Development Organization (UNIDO) report, this can be explained by the decrease in relative prices of consumption goods, in conjunction with the simultaneous growth of the demand for services.

An added explanation is the often-cited multiplier effect of manufacturing on services jobs. The US Department of Commerce, Bureau of Economic Analysis indicates that manufacturing has a higher multiplier effect on the US economy than any other sector with US\$ 1.40 in additional value added in other sectors for every US\$ 1.00 in manufacturing value added. If manufacturing is having a multiplier effect on services while simultaneously reducing the prices of manufactured goods, services should indeed be growing more rapidly, assuming manufacturing is also growing.

Economic Complexity and Manufacturing

The debate has carried on over the past 30 years regarding the relative importance of manufacturing versus services. The great recession of 2008-2009 caused many policy-makers and business leaders to carefully examine the real value added of “making things” and the impact of manufacturing and manufacturing innovation on economic growth and job creation. Recent research from Harvard and MIT by Ricardo Hausmann and César Hidalgo provides a compelling case that manufacturing does indeed matter. Using export trade data for only manufactured goods from 128 countries over the past 60 years, they can explain a significant portion (over 70%) of the income variations in countries using their definition of Economic Complexity.²

For a more detailed discussion of Hausmann's and Hidalgo's research, please see their essay – “Economic Complexity and The Future of Manufacturing” – on the following pages. In their research, economic complexity is directly related to manufacturing knowledge and capabilities and they demonstrate that once a country begins to manufacture goods, thus building knowledge and capabilities, its path to prosperity becomes much easier. Furthermore, they show that the more complex the goods and the more advanced the manufacturing process, the greater the prosperity.

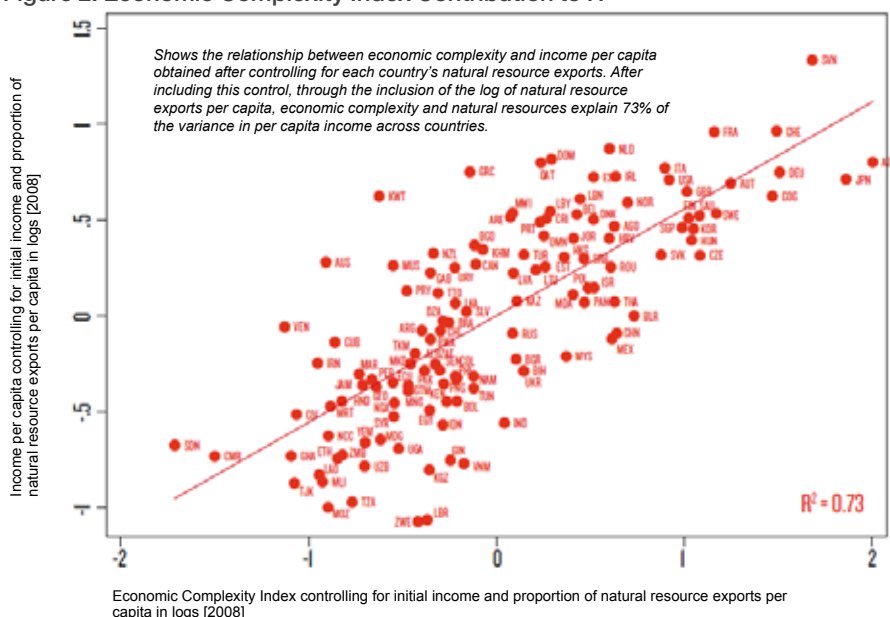
This research looks at both the composition and quantity of a nation's manufacturing. Hausmann and Hidalgo have created a measure of the sophistication of an economy based on how many products a country exports successfully and how many other countries also export those products. They argue that sophisticated economies export a large variety of “exclusive” products that few other countries can make. To do this, these economies have accumulated productive knowledge and developed manufacturing capabilities that others do not have. Manufacturing capabilities can be combined in different ways to produce different products and create different networks, some more sophisticated or complex than others.

While complexity is normally something manufacturing organizations try to avoid, complex economies based on sophisticated networks of manufacturing knowledge, capabilities, and product sets are a good thing.

Hausmann and Hidalgo not only show that income or prosperity and sophistication or economic complexity rise in tandem, but also that the linkage between manufacturing, economic complexity and prosperity is highly predictive, with economic complexity being much better at explaining the variation in incomes across nations compared to any other leading indices (Figure 2). Economic complexity, and therefore manufacturing, is closely related to a country's level of prosperity: the more advanced manufacturing capabilities and more advanced product sets, the higher the prosperity.

Importantly, they demonstrate that economies find it easier to master new products that are similar to ones they already make. It is easier to graduate from assembling toys to assembling televisions than to jump from textiles to aerospace. They call the feasibility of these jumps “adjacent possibilities.” In their maps of the industrial landscape of a nation, similar products using similar knowledge and capabilities are more closely related than others and cluster tightly together while unrelated products stand apart. Using their maps you can see that an economy that already exports a few products in the tightest clusters can diversify quickly, hopping from one closely related product to the next. Manufacturing knowledge and capabilities can breed new knowledge and capabilities and thus new, more advanced products when the right jumps are made.

Figure 2: Economic Complexity Index Contribution to R³



Source: Hausmann, R., Hidalgo, C.A. et al. (2011) The Atlas of Economic Complexity: Mapping Paths to Prosperity. Available at: <http://www.cid.harvard.edu/documents/complexityatlas.pdf>

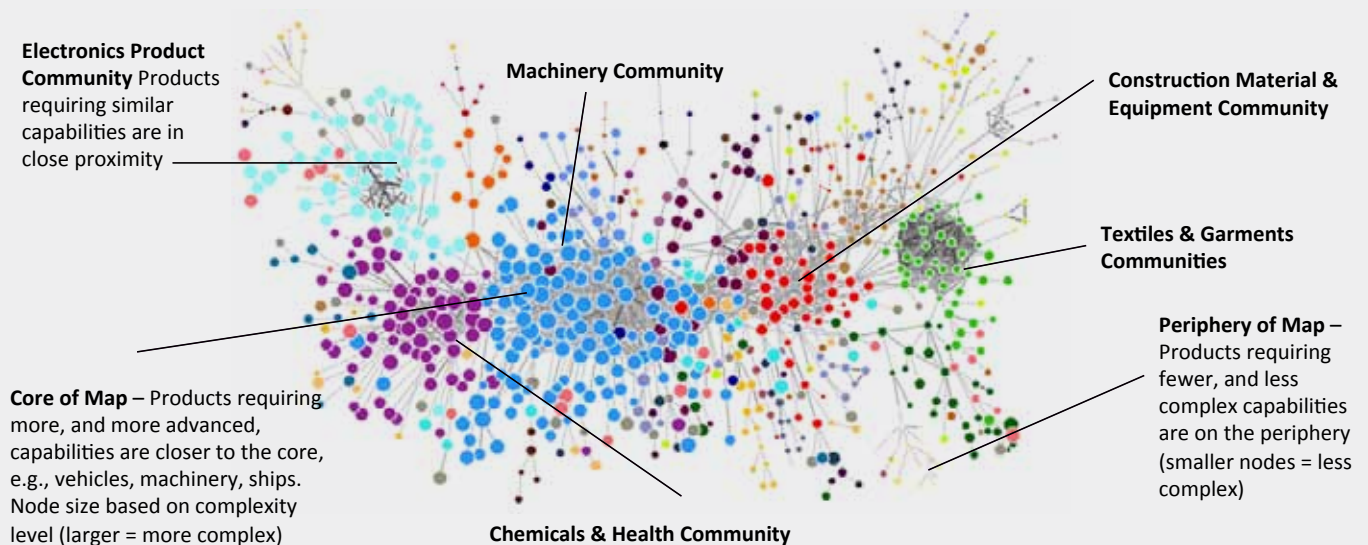
Product Space Network

Reading Tree Maps and Product Space Maps

Tree Maps (rectangles) represent the composition of the country's economy with each colour rectangle depicting a separate product being exported and with the size of the rectangle representing the percentage that product constitutes of total country exports. Product Space Maps on the other hand appear as complex network nodes. Products requiring fewer and less complex capabilities are on the periphery of the map and are smaller and typically less connected to other nodes. The centre or core of the Product Space Map contains products requiring more advanced capabilities, such as complex machinery and automobiles. At the core, the nodes are larger and typically more connected, indicative of the higher complexity level of such products. In the Product Space Map, only the nodes with dark/black rings around them represent the products that country is exporting. The Product Space Map is the same for every country, much like a map of the world. Only the nodes circled in black change, depicting that country's unique combination of products being manufactured for export.

Finally, their product maps, displayed in colourful detail for 128 countries showing development over time, in *The Atlas of Economic Complexity, Mapping Paths to Prosperity*, illustrate that a very large number of economies are growing their manufacturing capabilities and the sophistication of their product sets and thus advancing the complexity of their economies. It is possible to slide backwards, particularly for developed nations that do not keep developing their manufacturing knowledge, capabilities and product sets. However, almost all nations are moving forward (albeit at different rates), suggesting not only that manufacturing matters, but that a very large number of nations are becoming competitors for manufacturing products and advancing their manufacturing knowledge and capabilities. Based on their research, one conclusion seems very clear: a great competition is underway between most nations – both emerging and developed – for the benefits that their economies can derive from manufacturing.

Product Space Network



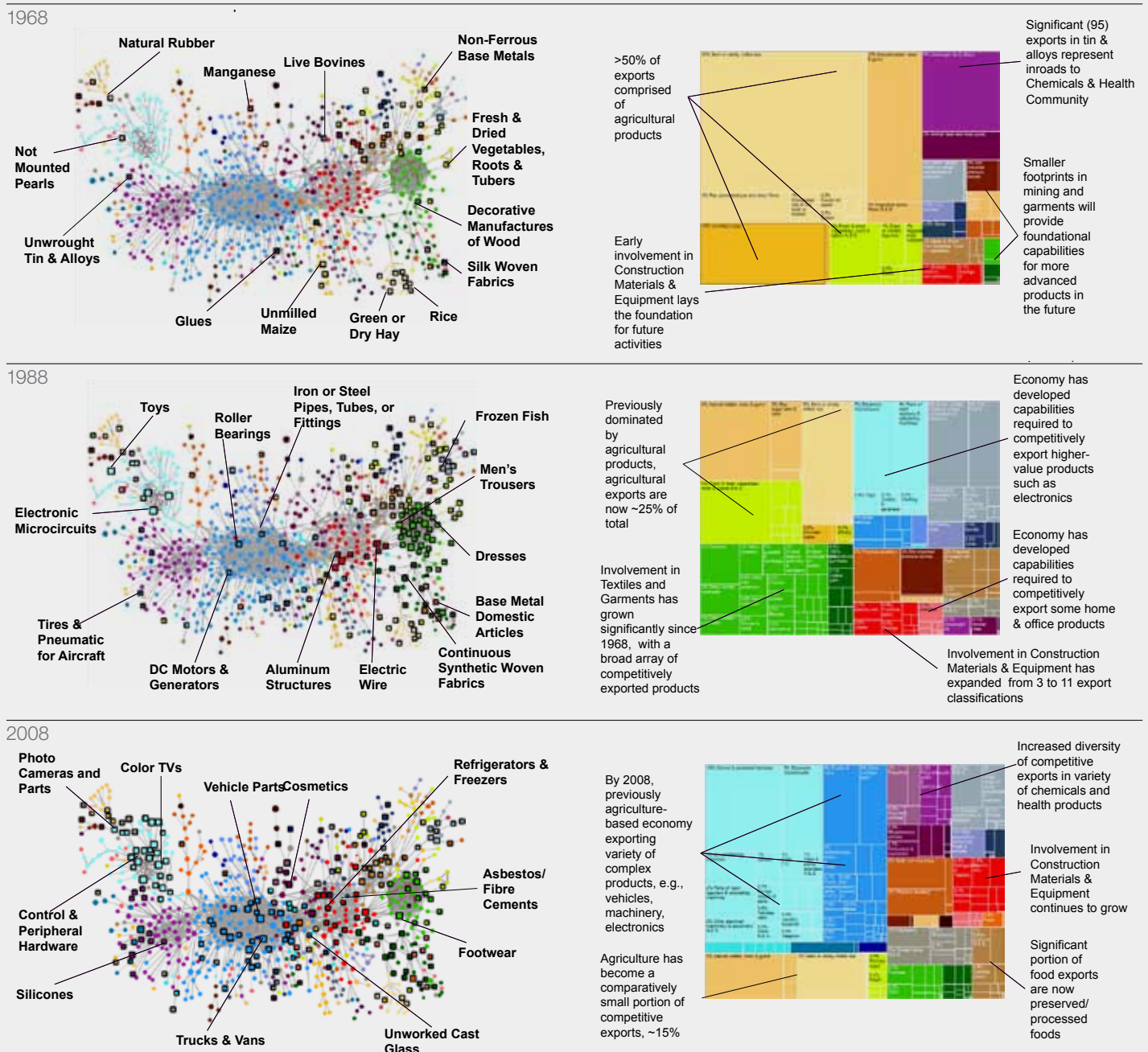
Economic Complexity in Action: Thailand as a Case Example

Using Thailand as an example, representing one of the fastest growing economies since 1968, Hausmann's and Hidalgo's very visual Product Space Maps and Tree Maps show the state of that economy in 1968, 1988 and 2008 (Figure 3) and clearly demonstrate growing economic prosperity, increasing economic complexity, more advanced manufacturing capabilities, and more advanced products for export.

- In 1968, competitive exports reflected lower complexity and clustered around the periphery of the Product Space Map. Competitive positioning, while focused on agricultural economy, did include the capabilities that would ultimately drive the economy toward more advanced products.

- By 1988, competitive exports reflected an increased complexity and entry into key high-complexity product communities (e.g. electronics, machinery, construction material and equipment, and aircraft). Positioning in 1988 enabled entry into increasingly valuable industries and prepared Thailand for an improved role in producing and exporting more complex, higher-value products and participating in higher value chains.
- In 2008, competitive exports reflected considerably higher complexity as evidenced by dozens of products being exported from the core of the Product Space Map. Knowledge accumulation and capability development have allowed Thailand to develop an increasingly complex economy now competitively manufacturing and exporting complex machines and electronics.

Figure 3: Thailand Product Space and Tree Map



Essay – Economic Complexity and The Future of Manufacturing

by Ricardo Hausmann and César A. Hidalgo

The product space can be used to predict the evolution of an economy because countries are more likely to start exporting products that are connected in the product space to the ones that they already export. We care about the structure of the product space because it affects the ability of countries to move into new products. Products that are tightly connected share most of the requisite personbytes (the amount of knowledge a person can know), and it is easier for countries to diversify following the links in the product space. A highly connected product space, therefore, makes the problem of growing the complexity of an economy easier. Conversely, a sparsely connected product space makes it harder.

In our analysis we find that most manufactured goods are network hubs, meaning that they tend to be connected to many other goods. This is a strong difference between manufacturing and other activities like mining, oil and gas, and agriculture. At the lower end of manufacturing, garments constitute a highly connected cluster in the product space. A country that is successful at making a few kinds of garments will find it relatively straightforward to diversify into others. A similar pattern is observed for higher-end products such as machinery, electronics, chemicals and pharmaceuticals. This is so because the productive knowledge required to make some of these products is relatively similar, making them adjacent in the product space. Manufacturing creates a set of stepping-stones, or a stairway to development, that provides a more continuous progression of rungs than other economic activities.

This is one of the reasons why most of the sustained growth miracles of the past 60 years have been manufacturing miracles. Think of Japan, Korea, China, Thailand or Turkey. This is also the reason why so many resource-rich countries have had trouble transforming their natural wealth into a self-sustaining growth process. The personbytes required to successfully extract minerals do not lend themselves as easily for alternative use. It is also the reason why so many developing countries are not catching up: their productive knowledge is in very peripheral, poorly-connected products, making it hard for them to advance.

This is not to say that manufacturing is easy. Quite the contrary. It is hard to get started because efficient manufacturing requires a large network of connected activities, and their personbytes. Materials need to be able to get in and out, through ports, airports and roads. People with a diverse set of skills need to be able to go to work and back, a fact that requires good urban transportation and an experienced, capable and intellectually diverse population. Power needs to be generated and made available. Water and water treatment needs to be provided. Worker and environmental safety must be assured. Security needs to be adequate. Appropriate sections of a city need to be authorized to host different activities and infrastructure.

The list goes on: finance, labour training, custom services, telecommunications, day-care facilities, etc. This manmade ecosystem cannot pre-exist the development of manufacturing. It needs to co-evolve with it. Moreover, while many of the inputs that a manufacturing plant needs can be purchased from other private firms, many elements of the ecosystem are either provided by or under the control of governments.

A laissez-faire disregard of the government-provided requirements for competitive manufacturing, justified under the often repeated prohibition against “picking winners”, is bound to guarantee that a country will end up losing the march towards prosperity by making public-private cooperation impossible in constructing the productive ecosystem.

The Atlas of Economic Complexity places each country in the product space. It presents what it is currently able to do and which activities lay in the “adjacent possible.” We measure how far is each non-existent activity from the current knowledge set of the country, which should affect how challenging it would be to move in that direction. We also measure how potentially profitable each of these activities are, relative to the current set of successful exports and how strategic each move would be, in terms of how many other options would a successful move open up.

Ultimately, we view economic development as a social learning process, but one that is rife with pitfalls and dangers. Countries accumulate productive knowledge by developing the capacity to make a larger variety of products of increasing complexity. This process involves trial and error. It is a risky journey in search of the possible. Entrepreneurs, investors and policy-makers play a fundamental role in this economic exploration. Manufacturing, however, provides a ladder in which the rungs are more conveniently placed, making progress potentially easier.

Today, the improvement of transportation and telecommunication services has allowed production chains to be split up geographically. This means that to get going, locations need to have fewer personbytes in place than in the past. Design, procurement, marketing, distribution and manufacturing need not be done in the same place, meaning that places with few personbytes can more easily get their foot through the door and then add functions more gradually. This has made much more of the manufacturing space accessible to more countries, with the concomitant reduction of manufacturing jobs in the advanced countries.

Our guess is that this process is bound to continue at an accelerated pace, as more and more middle-income countries get into a position where they can occupy more of the product space, as China, Thailand and Turkey have done. For the advanced countries, inventing new products at an accelerated pace, and controlling the international networks that help put together these products, is what will allow them to maintain their currently high level of income, albeit with a potential increase in inequality

By providing maps, we do not pretend to tell potential explorers where to go, but to pinpoint what is out there and what routes may be shorter or more secure. We hope this will empower these explorers with valuable information that will encourage them to take on the challenge and thus speed up the process of economic development. Maps are available at atlas.media.mit.edu.

Ricardo Hausmann is Director of Harvard's Center for International Development and Professor of the Practice of Economic Development at the Kennedy School of Government.

César A. Hidalgo is Assistant Professor at the Massachusetts Institute of Technology (MIT) Media Laboratory, the Asahi Broadcast Corporation Career Development Professor, and a faculty associate at Harvard's University Center for International Development.

Implications For and of Economic Complexity Research

Hausmann's and Hidalgo's work has numerous implications in the context of manufacturing and the linkage to economic growth. For countries:

- The advancement of manufacturing capabilities is directly linked to increasing economic prosperity for a nation and its citizens. Proper positioning and movement within the product space determines the ability to accelerate economic development.
- Many emerging economies are primed for rapid growth, enabled by the complex economic infrastructures they have developed and the manufacturing knowledge and capabilities accumulated. Emerging nations should focus on directing policy and investing resources in building capabilities and in product groups that are the "adjacent possibilities."
- Developed nations must also continue to advance their manufacturing capabilities and knowledge in order to innovate, create ever more sophisticated economies, and to stay competitive.

For companies, this research also has significant implications.

- As globalization and economic development make an increasing array of locations appear attractive, better understanding the ability of a country to make the next "adjacent possible" step to ongoing competitiveness, including the critical development of human capital and infrastructure among other factors, will be needed.
- As more countries develop advanced manufacturing capabilities, more competitors are being created that will someday rise up and challenge today's market leaders, requiring ongoing investments in innovation and new products and new markets to maintain and improve competitiveness.
- While the growth of advanced research and manufacturing hubs in emerging markets creates new sources for both talent and customers, the higher costs typically seen in developed countries will surely follow into these new complex economies.

For both countries and companies, there are broader implications.

- Viewing existing capability sets through the economic complexity lens can create a competitive advantage for companies and countries that understand how to use the information and navigate through the "product space."
- As nations and companies build increasingly advanced manufacturing capabilities, strategic decisions will become more complex and carry more risk for both countries, from a policy perspective, and companies regarding everything from location decisions to joint venture partners and sourcing and supply chain networks.
- The proverbial "bar" will continue to be set higher and higher as advanced manufacturing capabilities disseminate globally.

The Globalization of Manufacturing and the Rise of a New Global Middle Class

A growing population is creating the foundation for new demand centres in emerging economies

During the second half of 2011, the global population surpassed the 7 billion mark, representing considerable growth from 1950, when the population stood at 2.5 billion. Should current rates of growth continue, the United Nations projects, on a medium fertility variant, that world population could exceed 8.9 billion inhabitants by 2050.²

Much of the growth is expected to take place in the developing world

Currently, 82% of the global population lives in the developing world, and through 2020 will account for 96% of the projected 766 million increase.⁴ Asia and Africa, which account for 75% of the global population today, are forecast to make up 78% of the total by 2050.⁵ As the population grows, it will also get older and increasingly urban.⁶

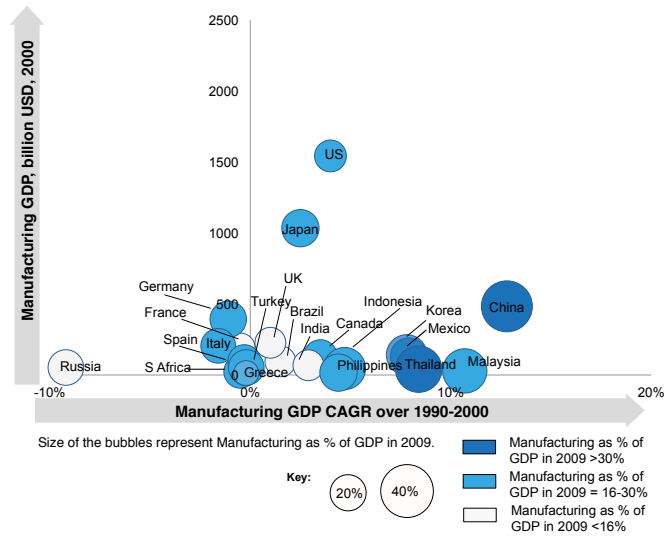
Manufacturing is helping drive significant GDP growth in the developing world

Economic growth, as represented by GDP, has been due in part to the growth of manufacturing in emerging countries. With the exception of Germany, manufacturing growth in developed nations, including the United States, Japan, the United Kingdom and Canada slowed considerably between 2000 and 2009 compared to the 1990 to 2000 period, while manufacturing growth accelerated in most other nations in the world, particularly in China. While Japan's manufacturing GDP held steady in absolute terms, and the United States actually increased, China passed all other nations in the world to become the world's largest manufacturer in terms of GDP (Figures 4 and 5).

Donald Hepburn at Chatham House has recently authored a study, "Mapping the World's Changing Industrial Landscape,"⁷ which highlights the global shift in manufacturing over the past 20 plus years, including the following.

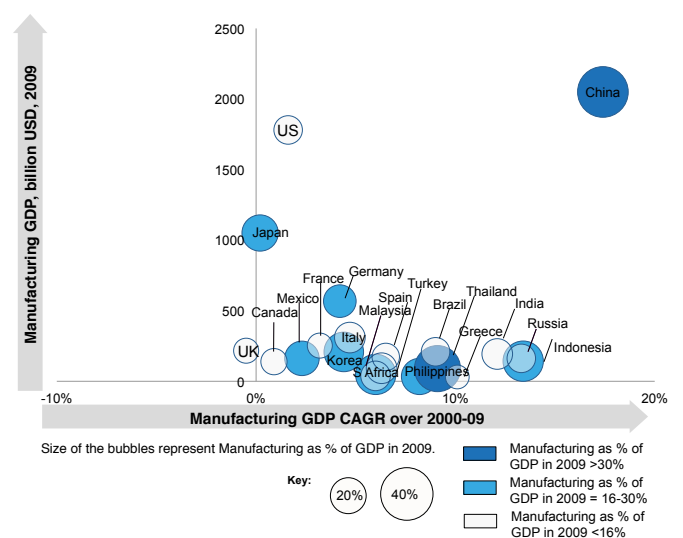
- The dramatic shift of manufacturing to developing countries due in part to the rise of domestic industries as well as the relocation of industries from the developed world as multinationals sought low cost labour rates to provide them with a cost advantage in global markets. On the whole, shares of world manufacturing value added have moved towards developing countries, at the expense of industrialized countries (Figure 6).
- The very rapid growth in value added in developing countries from 2000–2007 across all sub-sectors of manufacturing as opposed to developed nations (Figure 7).

Figure 4: Manufacturing GDP CAGR, 1990-2000



Source: United Nations Conference on Trade and Development, The World Bank

Figure 5: Manufacturing GDP CAGR, 2000-2009



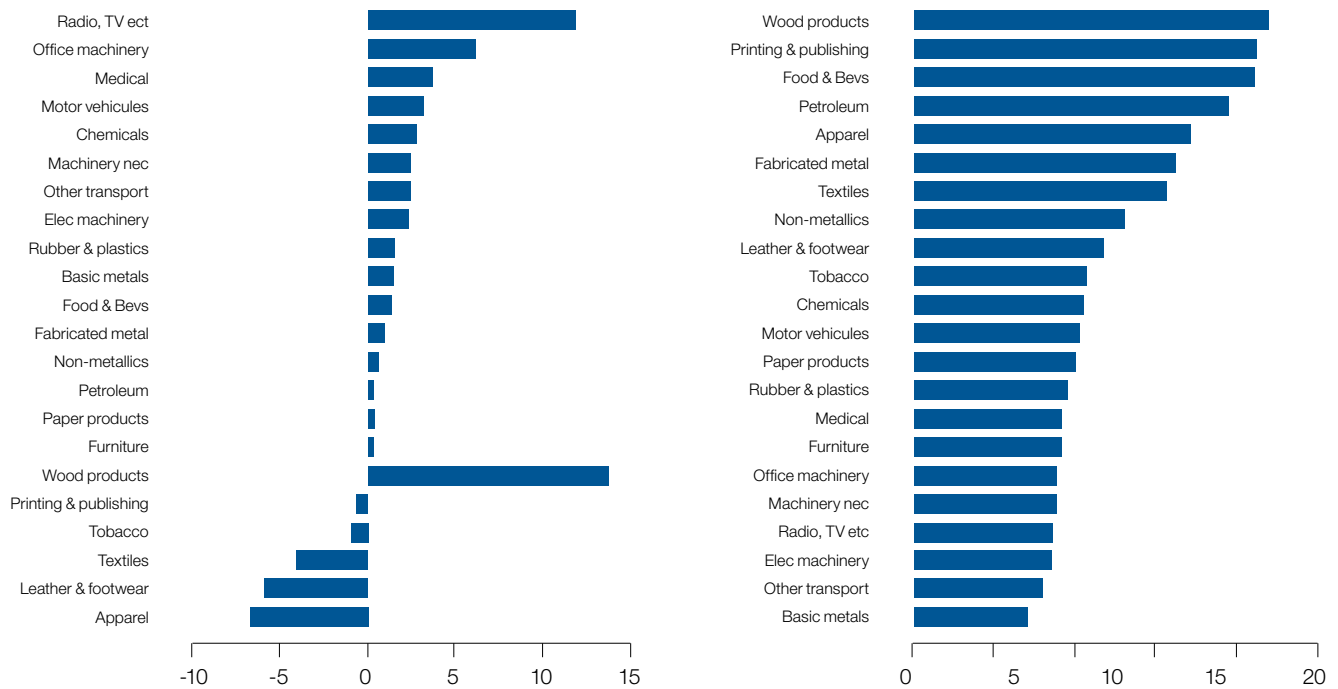
Source: United Nations Conference on Trade and Development, The World Bank

Figure 6: Share of World Manufacturing Value Added (%)

	1995	2000	2005	2008e
Industrialized countries	80.2	79.1	74.6	72.2
Developing countries	19.8	20.9	25.4	27.8

Source: UNIDO (2009) from Hepburn, D. (2011) Mapping the World's Changing Industrial Landscape. Chatham House, Briefing Paper. Available at: http://www.chathamhouse.org/sites/default/files/0711bp_hepburn.pdf.Pg. 3

Figure 7: Growth in Value Added, 2000-2007



Source: Hepburn, D. (2011) Mapping the World's Changing Industrial Landscape. Chatham House, Briefing Paper. Available at: http://www.chathamhouse.org/sites/default/files/0711bp_hepburn.pdf.Pg. 6

- Share of world manufacturing value added by sector demonstrates developing countries increased their share of manufacturing value added in 22 International Standard Industrial Classification (ISIC) categories (Figure 8). Particularly rapid growth (more than 10% a year) occurred in base metals (e.g. steel), other transport (e.g. railway rolling stock, ships, aircraft), TVs, machinery (both office and factory), furniture and medical equipment.
- The dominance of Asia during this period, which grew four to five times faster than Latin America – Asia and Latin America account for most of developing-country manufacturing.
- The significant growth in Fortune Global 500 represented by BRIC companies since 1995, when there were only six, to 2000, when there were 18, finally to 2010, when there were 67 BRIC companies on the list of 500.

Figure 8: Share of World Manufacturing Value Added, by Sector (%)

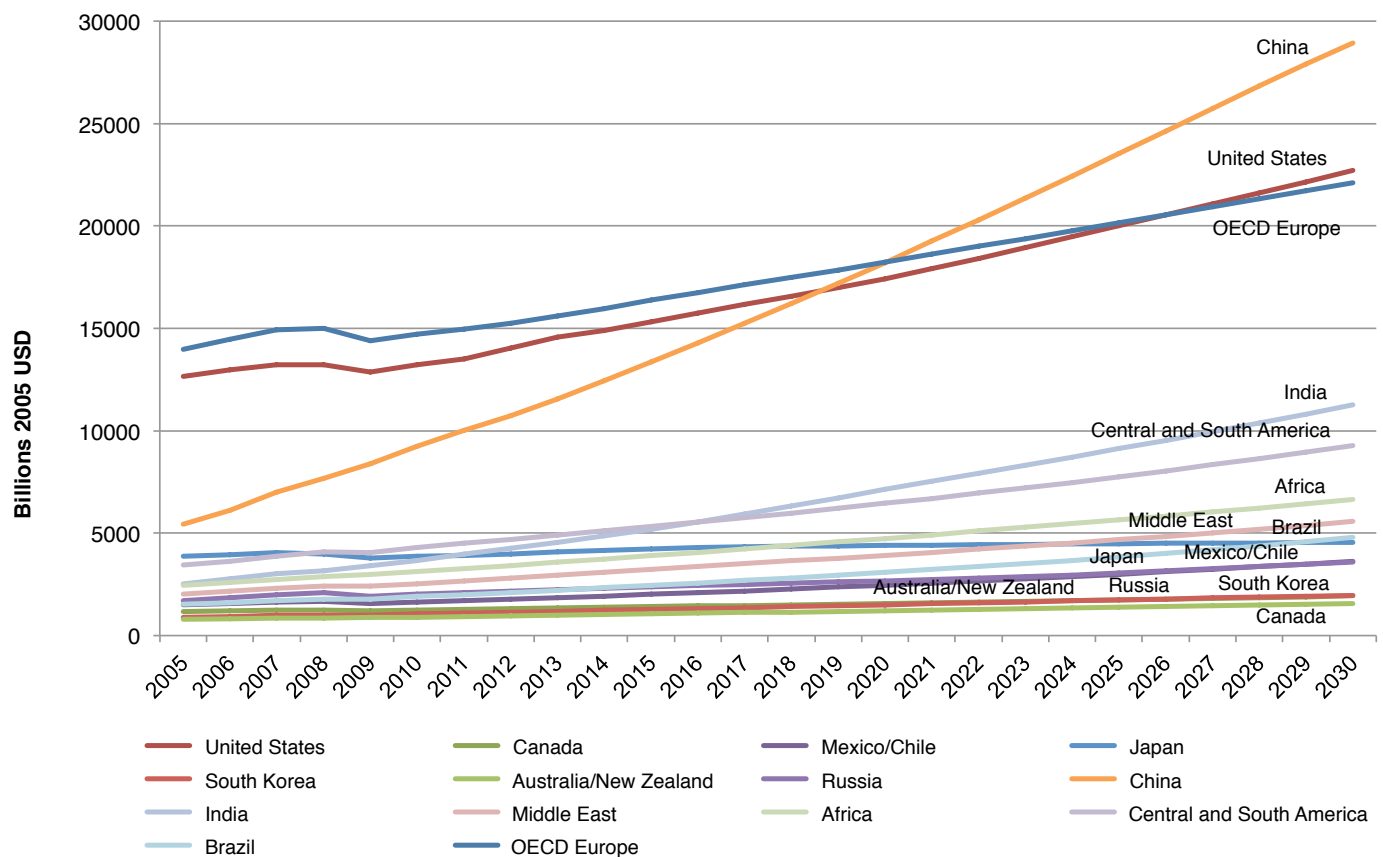
ISC	Industry	Industrialized Countries		Developing Countries	
		2000	2007	2000	2007
15	Food & Bevs	70.0	62.1	30.0	37.9
16	Tobacco	40.4	27.2	59.6	72.8
17	Textiles	54.0	35.5	46.0	64.5
18	Apparel	63.9	40.8	36.1	59.2
19	Leather & footwear	54.2	32.8	45.8	67.2
20	Wood products	84.3	78.9	15.7	21.1
21	Paper products	83.0	74.2	17.0	25.8
22	Printing & publishing	90.9	86.4	9.1	13.6
23	Petroleum	58.8	48.5	41.2	51.5
24	Chemicals	75.9	68.8	24.1	31.2
25	Rubber & plastics	74.7	63.9	25.3	36.1
26	Non-metallics	70.9	61.0	29.1	39.0
27	Basic metal	72.6	50.0	27.4	50.0
28	Fabricated metal	85.0	78.8	15.0	21.2
29	Machinery nec	85.9	75.8	14.1	24.2
30	Office machinery	91.4	87.8	8.6	12.2
31	Elec machinery	77.8	58.9	22.2	41.1
32	Radio, TV etc	89.4	87.2	10.6	12.8
33	Medical	91.1	87.7	8.9	12.3
34	Motor vehicles	70.0	62.1	30.0	37.9
35	Other transport	40.4	27.2	59.6	72.8
36	Furniture	54.0	35.5	46.0	64.5

Source: Hepburn, D. (2011) Mapping the World's Changing Industrial Landscape. Chatham House, Briefing Paper. Available at: http://www.chathamhouse.org/sites/default/files/0711bp_hepburn.pdf. Pg. 4

Prosperity is leading to the growth of a new middle class in emerging economies.

By 2030, China will account for a greater portion of the global GDP, expressed in purchasing power parity, than both the United States and Organisation for Economic Co-operation and Development (OECD) Europe (Figure 9). India and South America will also see their shares grow during that period.⁸ Indeed, a World Bank report suggests that by 2025, six emerging economies – Brazil, China, India, Indonesia, South Korea and Russia – “will account for more than half of all global growth.”⁹

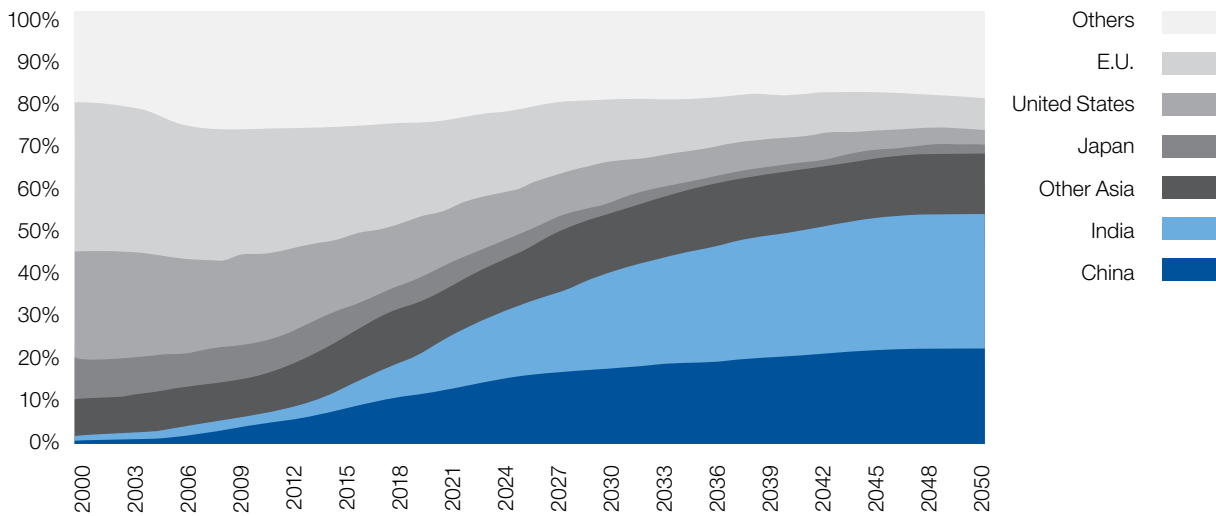
Figure 9: GDP by Region, 1990-2030, Expressed in Purchasing Power Parity, Reference Case



Source: United States Energy Information Administration. (2011) Annual Energy Outlook 2011. Available at: www.eia.gov/forecasts/archive/aeo11/

Accompanying this shift in GDP will be the development of a new middle class in emerging economies. This is especially true in China and India, where manufacturing has played a key role in increasing levels of prosperity. Today, India and China account for a mere 5% of global middle class consumption, while Japan, the United States, and the European Union cover fully 60%.¹⁰ By 2025, those numbers are expected to equalize; by 2050, they will be flipped¹¹ (Figure 10). Middle-class demand is expected to grow from US\$ 21 trillion in 2009 to US\$ 56 trillion by 2030, with 80% of that growth coming from Asia.¹²

Figure 10: Shares of Global Middle-Class Consumption 2000-2050



Source: Kharas, H. (2010) The Emerging Middle Class in Developing Countries. OECD Development Centre, Working Paper. Available at: <http://www.oecd.org/dataoecd/12/52/44457738.pdf> Pg. 28-9

According to a recent World Bank report, “Global Development Horizons 2011 – Multipolarity: The New Global Economy”, the changes will be felt everywhere: “In many big, emerging economies, the growing role of domestic demand is already apparent and outsourcing is already under way,” said Hans Timmer, the World Bank’s director of development prospects. “This is important for the least developed countries, which are often reliant on foreign investors and external demand for their growth.”¹³ The report also noted the following.

- The growth of the new global middle class is underway and started with multinational corporations (MNCs) building overseas, which ultimately sparked wage growth, and created an environment conducive to developing the manufacturing capabilities that will enable countries to continue to develop their economies.
- The report also highlights the diversity of potential emerging economy growth poles, some of which have relied heavily on exports, such as China and South Korea, and others that put more weight on domestic consumption, such as Brazil and Mexico. With the development of a substantial middle class in emerging countries and demographic transitions underway in several major East Asian economies, stronger consumption trends are likely to prevail, which in turn can serve as a source of sustained global growth.

As noted in the Chatham House report, growing populations and incomes in developing countries will account for most of the rising global consumer spending. Larger workforces will also keep fuelling the developing world’s emergence, while rapid innovation may help the developed world move up the value chain even as its pre-eminence is being challenged.

The geographical shift of the middle class has implications for supply chains

The rise of demand centres in Asia, along with the typical costs that accompany more developed nations, will likely increase localization of production. Increasingly expensive logistics are leading some companies, such as Caterpillar in China, to turn to more localized production.¹⁴ The erosion of labour-cost advantages is leading to more capital-centric production. One company, Foxconn, has announced plans to use more robots to cope with rising labour costs.¹⁵ The implication of these rapidly growing middle-class population projections is that supply chains will need to respond to growing demand and rising costs in the developing world – especially as those population centres mature and hundreds of millions of their citizens begin to enter the higher-consumption middle class and become a driving force behind the flow of manufactured goods around the world.¹⁶

Free Trade Proliferation Helps Open the Door to Rapid Manufacturing Globalization

Bilateral free trade agreements serve as substitutes for a new global accord

In order to enable complex economies to grow, access to global markets and the free movement of products are essential to drive prosperity for countries. Businesses depend on open access to markets to leverage their product innovations, serve new customers and grow. Most countries, however, have been better at recognizing the benefits of agreements than putting them into action. In fact, before 1980 very few regional trade agreements (RTAs) existed.

Beginning in 1948, the General Agreement on Tariffs and Trade (GATT) provided the rules for much of the world's trade and for almost half a century the basic principles remained untouched. During this time, very few "free" trade agreements (FTAs) were necessary. The GATT later became the World Trade Organization (WTO). The WTO's Uruguay Round of the 1980s and 1990s involved 123 countries and covered nearly all aspects of trade, in a single, simple system providing much needed updates to the increasingly dated rules under GATT.¹⁷

As trade growth became more important and sophisticated, the Uruguay Round began to show its deficiencies leading to the current round of WTO negotiations, the Doha Development Round. Unfortunately, for a variety of reasons, this round of negotiations largely stalled and led countries to take other measures to continue the pursuit of increasing trade, which became so important to their economic growth. Bilateral and regional free trade agreements became the substitutes for an effective global accord.

Bilateral and regional agreements have taken precedence and proliferated

Frustrated with the slow pace of multilateral talks and the formation of a global accord, many countries have turned increasingly to smaller bilateral or regional agreements to boost trade. Looking at a few historical snapshots in time, the proliferation is most evident post 2000 (Figure 11).

What started as a trickle has become a near explosion in FTAs and RTAs. The benefits, especially in absence of a multilateral agreement, are clear. Signatories gain access to each other's markets, which has demonstrably improved trade in many cases and been an important driver of GDP growth for many nations. As FTAs have grown dramatically since 1980, both imports and exports have grown in near lock step as shown for Brazil, China, Germany, India, Japan and the US (Figure 12).

Figure 11: Snapshots in Time – Regional Trade Agreements for Six Target Countries

1980



Note: This chart excludes connections for focus countries' accession to GATT membership (1948)

2000



Note: This chart excludes connections for focus countries' accession to GATT membership (1948) and WTO membership (1995)

2010



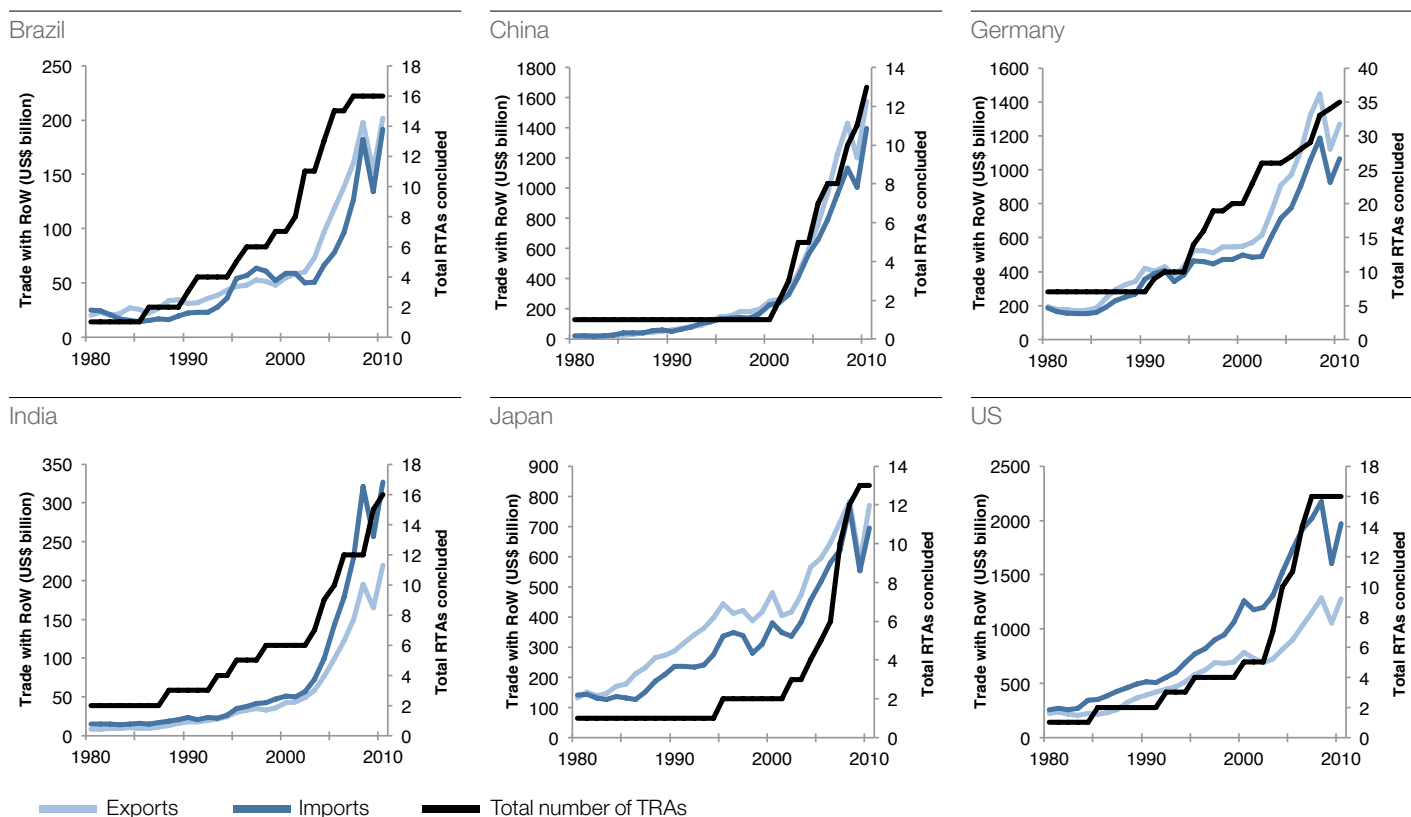
Note: This chart excludes connections for focus countries' accession to GATT membership (1948) and WTO membership (1995)

■ RTAs in pipeline

■ RTAs concluded

Sources: Participation in Regional Trade Agreements, WTO; Foreign Trade Information System, SICE; Department of Commerce, India; Ministry of Economy, Trade & Industry, Japan; Office of the United States Trade Representative; China FTA Network, Ministry of Commerce, PRC

Figure 12: Growth in Import/Export Closely Follows Growth in RTAs



Sources: Statistics database, WTO; Participation in Regional Trade Agreements, WTO; Foreign Trade Information System, SICE; Department of Commerce, India; Ministry of Economy, Trade & Industry, Japan; Office of the United States Trade Representative; China FTA Network, Ministry of Commerce, PRC

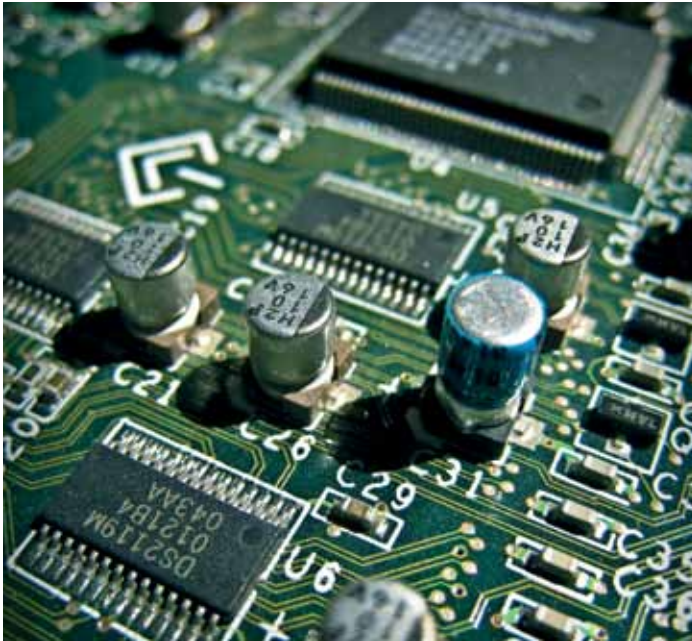
An agreement between Singapore and the United States, for example, is the principal reason why Singapore is now the tenth largest export market for the United States with exports exceeding US\$ 29 billion and registering a year-on-year growth of 31% in 2010.¹⁸ Another example: trade between Guangxi (China's south region) and ASEAN countries ballooned to US\$ 3.99 billion in 2008 up from US\$ 630 million in 2002, when the initial China-ASEAN framework agreement was signed.¹⁹

Trade agreements and growth in manufacturing's contribution to GDP are closely linked

The overall trend though, for both developed and emerging economies, is an increase in RTAs with a rise in manufacturing contribution to GDP (Figure 13). Although trade is an important aspect of economic activity, and has clear linkages to both manufacturing exports and manufacturing GDP, trade agreements are less of a guaranteed driver of economic expansion and more an enabler for countries and companies that strategically use them. However, formal agreements alone do not guarantee trade growth. For example, in 1980, China and India had similar manufacturing exports. At the time, India had the greater number of regional trade agreements. Yet, by 2010, Chinese manufacturing exports were significantly higher than India's, although it still lags in the number of regional FTAs enacted.

Despite rapid growth, bilateral FTAs and RTAs are less desirable than a single, global accord

The most obvious drawback to bilateral and regional agreements is that exporters must deal with regulatory divergence and fragmentation with multiple sets of rules and administrative requirements and will never enjoy the predictability and market integration and harmonization promised by multilateralism. Furthermore, regional agreements are sometimes signed for political rather than economic reasons; some nations will try to influence the market or will themselves be influenced by powerful domestic companies or political interests. One sector may be favoured over another, or companies from one country may enjoy benefits not available to more competitive counterparts from other countries, allowing inefficient firms to become entrenched. Economies too small to extract concessions from their bigger bilateral negotiating partners fare particularly badly. What's more, some agreements offer free trade in name only. Certain countries have a number of agreements that, on merit, do not qualify as free trade. Though they can provide their own unique benefits and potential justifications, bilateral and regional FTAs have not served as stepping-stones to a comprehensive, global agreement. In fact, some feel they distract governments from the multilateral agenda and serve as a convenient excuse for its failure.



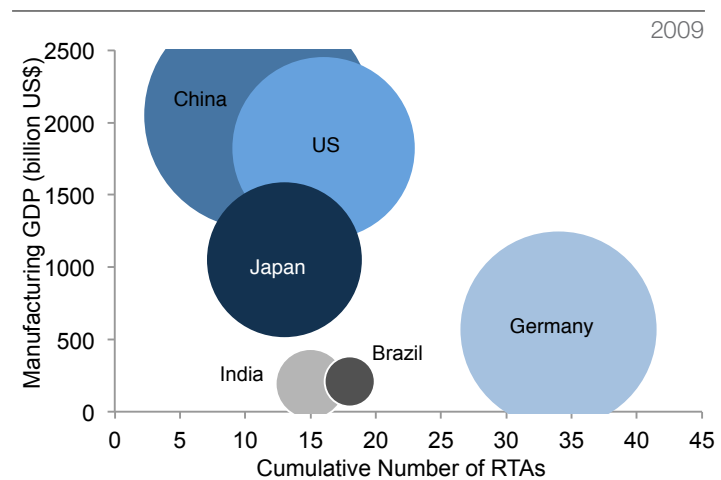
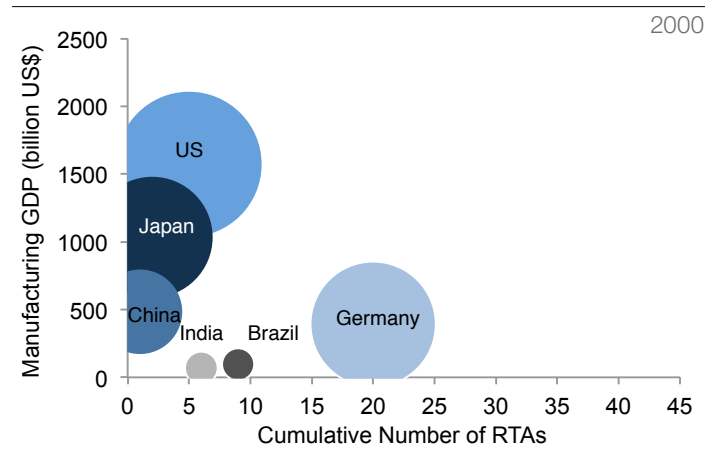
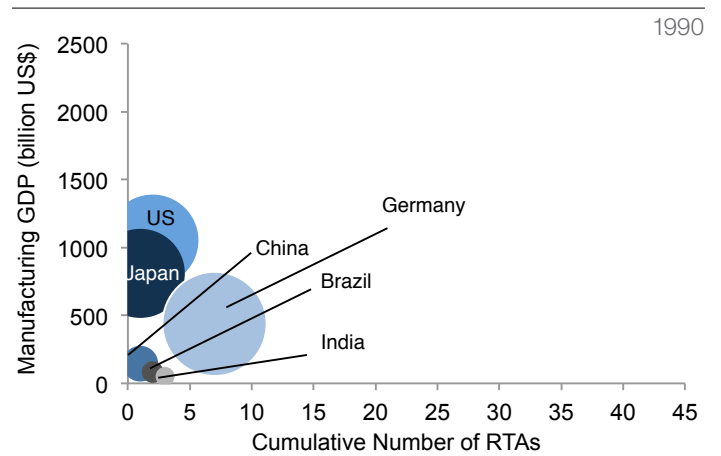
Companies want a fair and efficient system of trade that levels the playing fields and reduces barriers to trade

Both policy-makers and business leaders recognize that lower barriers are vital to the competitiveness and viability of exports. Because of its important linkage to and effect on a country's economy, trade policy will continue to be of critical importance and scrutiny.

As global competition increases, and the focus on manufacturing's contribution to jobs and GDP grows, there will be increasing tension between opening and protecting markets. Chief executive officers as well as government officials have an increasingly vested interest in getting involved in the negotiations. Countries are taking different strategic approaches and there are decisive solutions. Most are trying to balance the approach between free, open, market-based economies and measures that enable their domestic companies to flourish.

Therefore, left to their own devices, some nations may try to influence the market too much or be too influenced by domestic companies and politics – hence the need for a global standard and enforcement of the agreements. But in the absence of a Doha-like agreement, RTAs are likely to continue to grow in the future. Despite various approaches, most agree that we need to have and enforce a global fair trade agreement that eases and streamlines the process and ability to move goods globally. Participants in the project workshop in Davos in January 2012 stressed that in this age of disaggregated supply chains, it was critical to reduce barriers to trade, to enable fluidity of flows along global supply chains.

Figure 13: Manufacturing Contribution to GDP has Grown Alongside Trade Agreements



Key: Size of the bubble represents manufacturing exports in US\$



Y-axis represents manufacturing contribution to country GDP in billion USD at current prices

Source: UNCTAD, Participation in Regional Trade Agreements, WTO; Foreign Trade Information System, SICE; Department of Commerce, India; Ministry of Economy, Trade & Industry, Japan; Office of the United States Trade Representative; China FTA Network, Ministry of Commerce, PRC

Exponential growth of digital infrastructure is expanding opportunities for new entrants and increasing pressure for existing firms

Digital information technologies have allowed decoupling of research, engineering and manufacturing capabilities

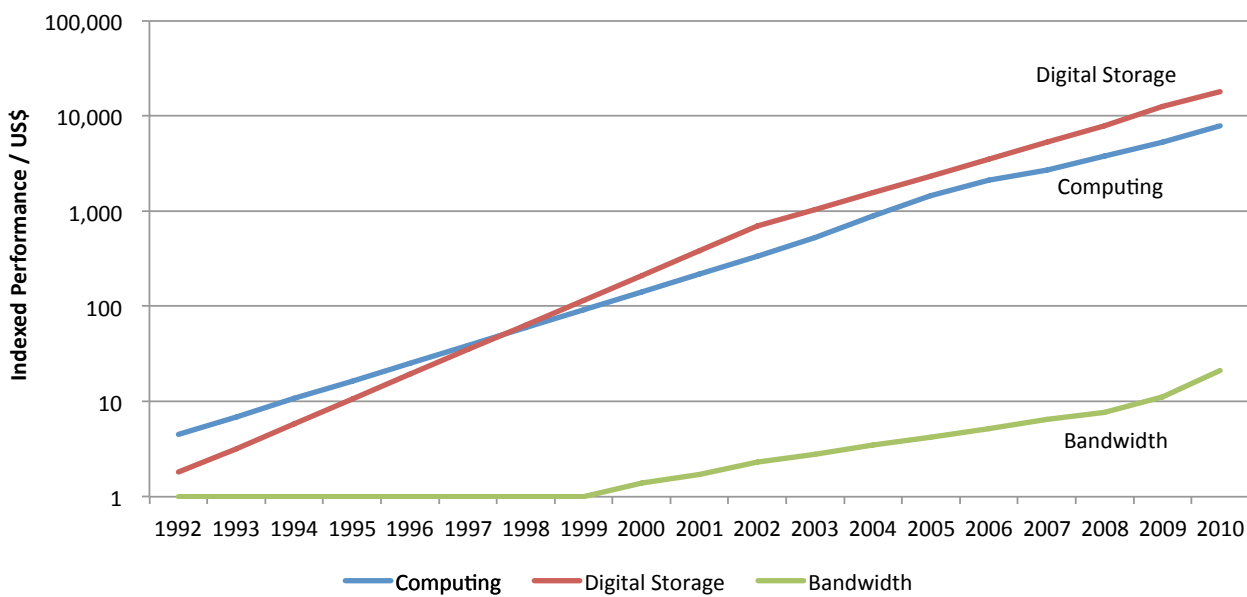
Over the past several decades, digital technology has become ubiquitous, transforming manufacturing processes in large and small companies across the world. Broadly defined, digital manufacturing is “the use of advanced computing technologies to employ modelling and simulation techniques for engineering, testing, or design purposes.”²⁰ The dramatic increase in computing power and capabilities has allowed widespread application of computer-aided design, engineering, and manufacturing (CAD, CAE, and CAM), and has further allowed for a physical decoupling of research from engineering, and engineering from manufacturing. That is, research can be conducted in one place, engineering in another, and manufacturing in a third, with many suppliers collaborating in the design, engineering and manufacturing processes, all in different global locations, and with all participants linked by digital technology infrastructures.

Exponential growth of the digital infrastructure is expanding opportunities for new entrants and increasing pressure for existing firms

The fast moving, relentless evolution of a new digital infrastructure is reducing barriers to entry and movement of new competition. The exponentially advancing price/performance capability of computing, storage, and bandwidth is contributing to an adoption rate for the digital infrastructure that is two to five times faster than previous infrastructures, such as electricity and telephone networks. The cost of 1 million transistors has steadily dropped from over US\$ 222 in 1992 to US\$ 0.13 in 2010, levelling the playing field by reducing the importance of scale and thus increasing opportunities for innovation.

Similarly, the cost of 1 gigabyte (GB) of storage has been decreasing at an exponential rate from US\$ 569 in 1992 to US\$ 0.06 in 2010, and the cost of 1,000 megabits per second (mbps), which refers to data transfer speed, dropped 10 times from over US\$ 1,197 in 1999 to US\$ 47 in 2010, allowing for cheaper and more reliable data transfer (Figure 14). The exponential drop in price/performance of elements of the digital infrastructure have allowed for smaller, less well capitalized manufacturing firms to compete in arenas previously not attainable to them.

Figure 14: Price Performance Curves for Elements of Digital Infrastructure



Source: Deloitte analysis

The rapid spread of digital information technologies has enabled broader access to advanced manufacturing technology around the world

Early computer-aided manufacturing was proprietary technology created by aerospace and automotive companies in a small handful of developed countries in the 1960s and 1970s.²¹ By the 1980s, with the introduction of the PC and computers faster and more affordable than ever, a number of digital modelling companies emerged to tap into the growing commercial demand across a variety of industries.²² One early – and current – market leader, Autodesk, was founded in 1982 to develop a CAD programme at a price tag of US\$ 1,000 that would run on a PC. AutoCAD was born, and by 1985, Autodesk sales were over US\$ 27 million.²³ The overall market for the digital-modelling industry has shown similar strong growth over time, and is projected to continue steady growth despite the global financial crisis according to the 2012 Worldwide CAD Market Report by Jon Peddie Research.²⁴

During its early years, a small handful of countries in the developed world made and used digital modelling technology for manufacturing with the US, Germany, France, and Japan being leaders. Today, this technology is no longer the exclusive property of large multinationals or developed countries: the number of countries using this technology has expanded from a small handful to a truly global scale. Asia-Pacific has overtaken the Americas as the fastest-growing market for digital modelling products (Figure 15). Revenues within the sector in the Americas grew by over US\$ 800 million between 2004 and 2010. During the same period, revenues in the Asia-Pacific market grew by nearly US\$ 2 billion (Figure 16).²⁵ Worldwide trade in machinery and transport equipment has also grown, complementing the spread of digital technology.²⁶

Digital information and computerized manufacturing technology allows for easy, exact replication of manufacturing processes

Increased access to technology means that a company can replicate its production capabilities in practically any location with skilled talent, supporting infrastructure, and favourable policy. Twenty years ago, this sort of capability and process replication was not possible without major obstacles and barriers. These computer-controlled processes are not vulnerable to the same vagaries as the artisanal skills of machine operators a generation ago. With the explosion of digitization, literally everything can be identical. Manufacturing facilities can be relocated to emerging or developed nations as needed, allowing manufacturers to disaggregate supply chains.

Figure 15: Total Revenue Across Global Markets for Top Digital Modelling Companies

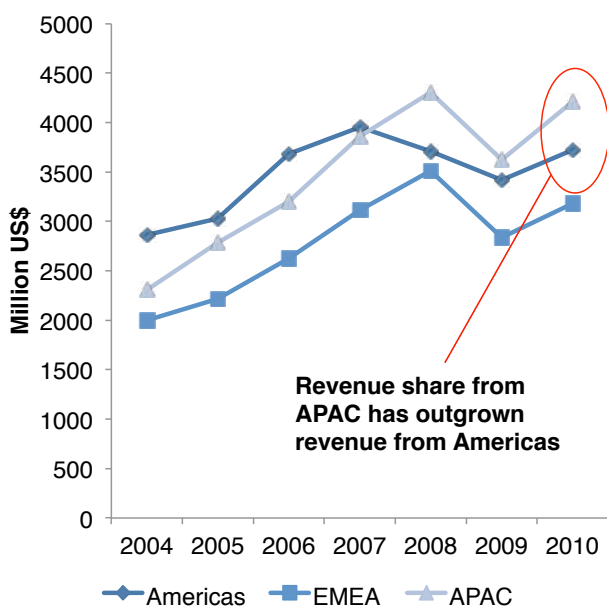
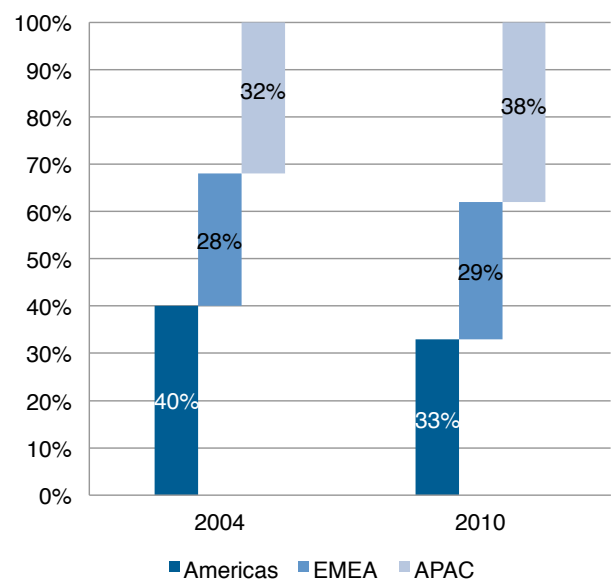


Figure 16: Global Revenue Sources of Top Digital Modelling Companies



Note: Graphs are based on data for eight of the top 10 companies in the CAD industry which together account for more than 60% of revenues in the industry for 2010. Data includes total revenue of all companies involved in CAD/CAM, which includes revenues from non-CAD operations.
Source: Deloitte analysis based on annual reports of top digital modelling companies

Case Studies: Copy Exact

Intel's "Copy Exactly!" Strategy²⁷

In the 1990s, Intel faced growing competition from Japanese and South Korean chipmakers that had flooded the market with cheap, high-quality memory chips. Intel's response was a Copy Exactly! strategy that minimized the time for technology transfer and ensured that quality and product yields were not compromised. Digitization allowed the company to match its manufacturing site to its development site at all levels, from equipment to process, and data collected at a number of levels was compared with data from R&D sites to get an exact match.

A123 Mimics "Copy Exactly!" Strategy to Import Capabilities²⁸

A123, a US company that makes lithium-ion batteries, has recently repatriated its manufacturing operations after years of producing in South Korea and China. To facilitate the move, the company also used a "copy exactly" strategy. South Korean operations were replicated on a larger scale in the United States with the help of a team of South Korean engineers who were extremely familiar with the production process.

Companies are developing increasingly sophisticated ways to leverage digital technology

New technologies and innovative processes will continue to be embedded in manufacturing. Model-based definition (MBD) and additive manufacturing (such as 3-D printing) are two examples of cutting edge applications of digitization that are further transforming supply chains and processes. Such technologies can be disruptive forces that propel companies or countries outside a conventional progression up the value chain because the barriers to manufacturing (requiring investment in infrastructure) are effectively removed. For example, following the basic steps in Figure 17, a small mom-and-pop shop in Anytown, United States, can create a 3-D computerized model of a toy and then send it to a 3-D printer locally or even around the world to China for production.²⁹ MBD and additive manufacturing change the concept of economies of scale by providing the ability to customize at no incremental cost and produce fewer items at lower cost than with assembly-line production.³⁰

MBD uses a fully annotated 3-D digital model as the master, providing a seamless flow of the digital thread through the product life cycle.

Figure 17: Additive Manufacturing Technologies



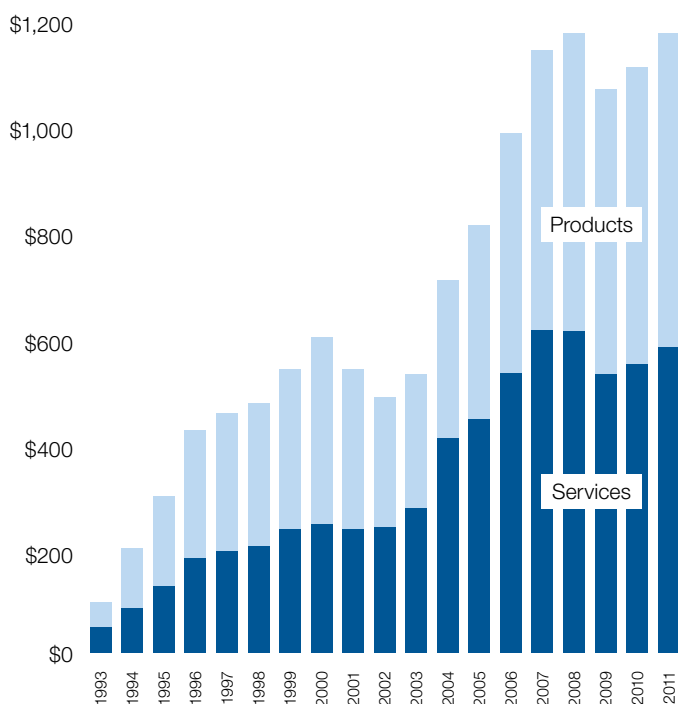
Sources: Campbell, T., Williams, C., Ivanova, O. & Garrett, B. (2011) Could 3D printing change the world? Atlantic Council, Strategic Foresight Report. Available at: http://www.acus.org/files/publication_pdfs/403/101711_ACUS_3DPrinting.PDF

Additive manufacturing (AM) is another example of the way companies are leveraging digital modelling to achieve economies of scope as well as scale. AM builds products layer by layer – additively – rather than by subtracting material from a larger piece of material.³¹ Its use is aggressively and consistently growing; over its 23-year history, AM revenues and services have a compound annual growth rate (CAGR) of 26.2% (Figure 18).³²

The technology has proven to have a variety of applications across a number of industries. “While the technology is still in its infancy, innovators have proven how versatile it can be, such as using 3-D printers to make bicycles out of nylon, concrete, chocolate, and even transplantable organs that will one day save human lives.”³³

Digital technology will continue to be a significant driver of transformation for manufacturing organizations in the future. “Smart product” with embedded software on advanced computer chips integral to the products function and capabilities will become increasingly commonplace. And “smart processes” further enabled by advanced software and digital technologies will continue to alter the productivity and quality of production processes for many decades to come. The implications for the type of human capital required, financial capital required, innovation capabilities possible, and the very nature of competition will be profound.

Figure 18: Estimated Annual Revenues (in millions of US\$) from Additive Manufacturing Products and Services



Sources: Wohlers Associates. (2011) New Industry Report on Additive Manufacturing and 3D Printing Unveiled. Press Release, May 16. Available at: <http://www.wohlersassociates.com/press54.htm>



The Shift Index

In the midst of economic uncertainty, when it is all too easy to fixate on cyclical events, there is real danger of losing sight of deeper trends. Short-term cyclical thinking risks discounting or even ignoring powerful forces of longer-term change. The Shift Index³⁴ is an attempt to express a clear and comprehensive view of the deep dynamics associated with globalization.

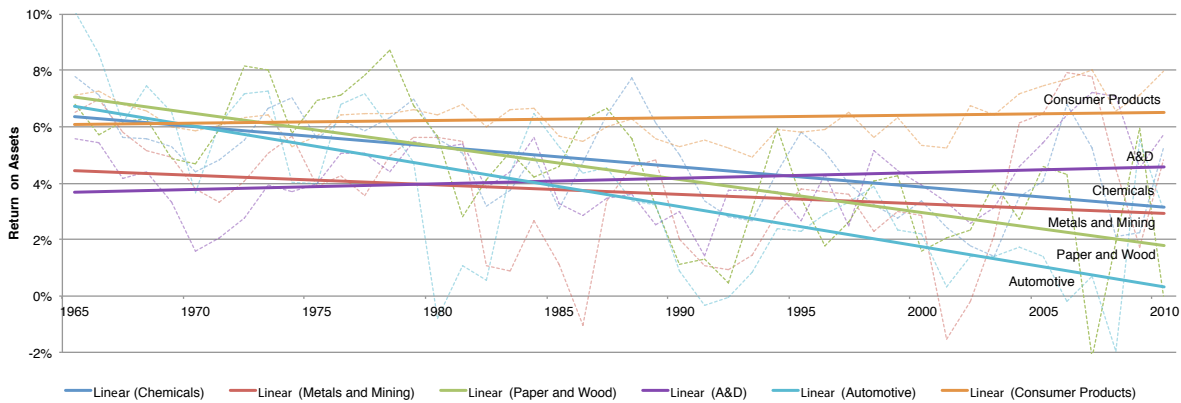
The Shift Index, developed by John Hagel and John Seely Brown at Deloitte's Center for the Edge, consists of three indices and 25 metrics designed to make longer-term performance trends more visible and actionable. The Shift Index framework embodies the three waves of transformation in the competitive landscape: foundations for major change; flows of resources, such as knowledge, that allow firms to enhance productivity; and the impacts of the foundations and flows on companies and the economy.

While the current Shift Index analysis is limited to the United States, given that it is the largest world economy, and the largest manufacturing economy in the developed world, we believe it to be a leading indicator for other developed economies around the globe. Long-term data trends of some metrics included in the Shift Index, such as Return on Assets, Firm Performance Gap, and Topple Rate on the US manufacturing sectors may provide insights to similar trends manifesting in other developed economies today.

The Big Shift is driving declining performance in most manufacturing sectors in the US

Globalization, as driven by the dual forces of the exponential growth of digital infrastructures, and increasing public policy liberalization is at the core of the “Big Shift” (See the essay by John Hagel and John Seely Brown). These forces are increasing pressure on most manufacturing sectors in developed economies and especially so in the US. Looking at the long-term trends in Asset Profitability from 1965 to 2010 (see Figure 19), all but two sectors have seen dramatic rates of performance erosion. With the exception of the Consumer Products sector, the rate of decline is highest for those sectors that initially had high asset profitability. The Metals and Mining, Chemical, Paper and Wood, and Automotive sectors saw a trended decline of ROA on 30%, 49%, 75% and 92%, respectively. The ROA trend for the Consumer Products sector, and Aerospace and Defense increased slightly by 6.7% and 25%, respectively. Lower investments and rationalization of assets, layoffs, and sticky price increases in recent times have led to an increase in ROA in the Consumer Products sector in the last few years and levelling the trend over time. The relative high-barriers to entry due to capital requirements and the influence of government contracts have allowed the Aerospace & Defense sector to increase its ROA trend over time.

Figure 19: Long-Term Asset Profitability Trends by US Manufacturing Sector (1965-2010)

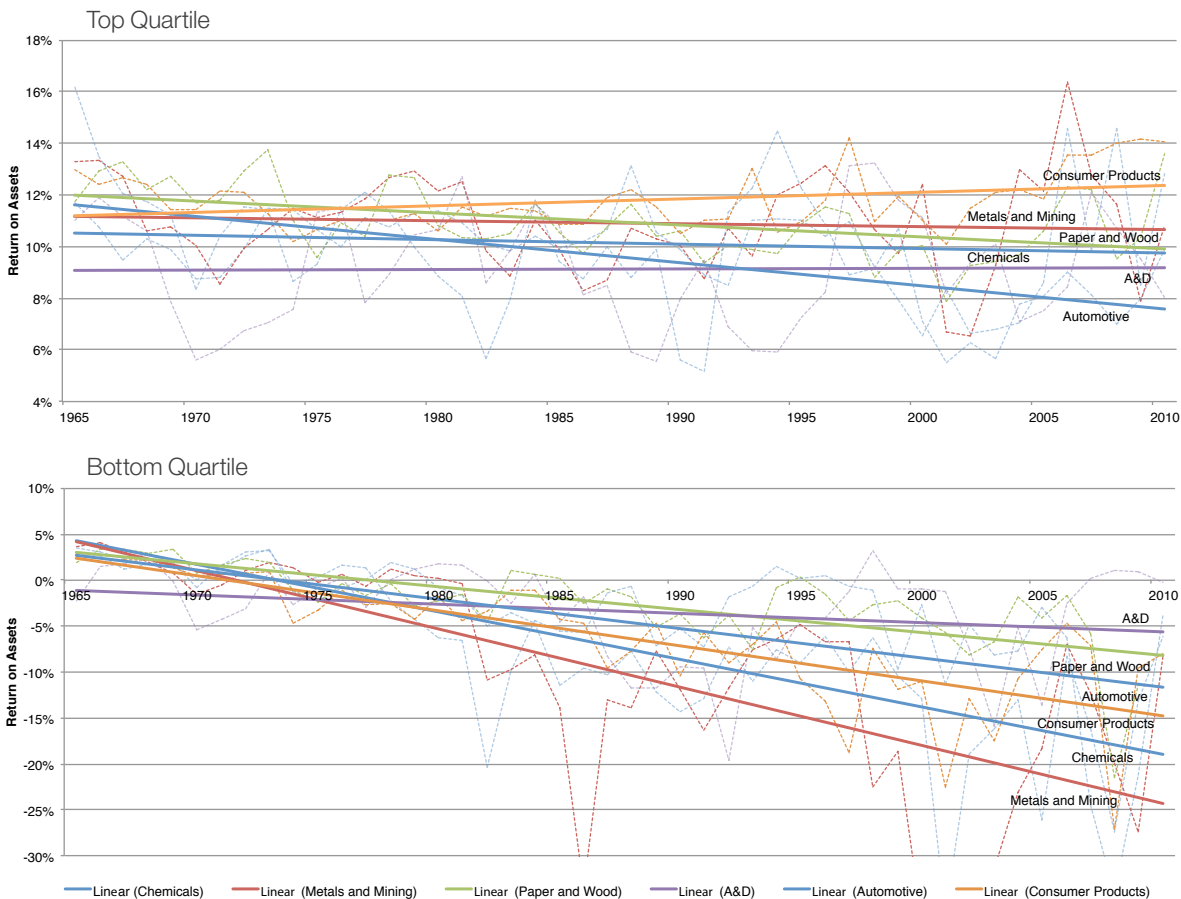


Source: Deloitte analysis

In US Manufacturing, winning companies are barely holding on, while losers experience rapidly deteriorating performance

The ROA Performance Gap for US manufacturing firms shows a bifurcation of winners and losers. This finding is by no means new. What is surprising, however, is how little winners have gained during the past 45 years. Technology has enabled firms to leverage talent in new and innovative ways and cut costs from operations on an unprecedented scale. However, even top quartile performers have failed to convert these advances into ROA gains. Only two of the sectors (Aerospace & Defense and Consumer Products) had their top performing firms maintain or grow their performance; all other sectors showed declining performance for the even their top quartile (Figure 20). As expected, these same trends were amplified in the lower quartiles of each of these sectors – driving an increasing distance between the winners and losers in each sector.

Figure 20: ROA Performance Trends for Top and Bottom Quartiles of US Manufacturing Sectors (1965-2010)



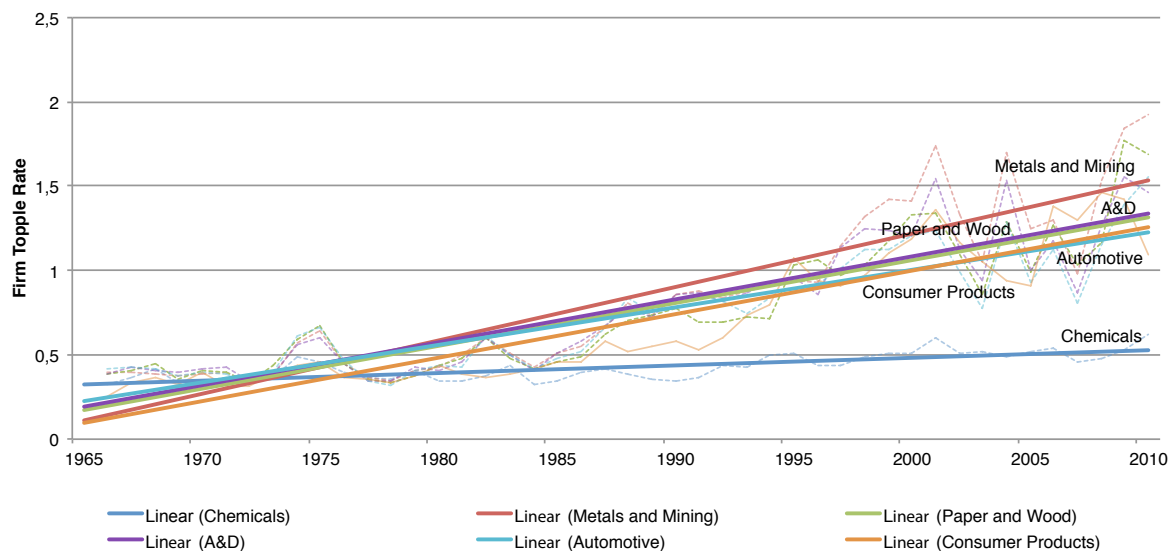
Source: Deloitte analysis

Large manufacturing firms are losing their leadership positions at an increasing rate

The Topple Rate metric tracks the rate at which big companies (with more than US\$ 100 million in net sales) change ranks, defined in terms of their ROA performance. This metric is a proxy for the ability to sustain a competitive advantage in the world of the “Big Shift.” Not only have most manufacturing sectors demonstrated declining ROA over the past four decades, the large firms within these sectors have been losing their leadership positions at an increasingly faster rate (Figure 21). Between 1965 and 2010, the topple rate for large firms in the manufacturing sectors increased, with the chemicals sector increasing from 0.32 to 0.52 (62% increase) and the metals and mining sector increasing from 0.08 to 1.47 (1,700% increase), as competition exposed low performers and ate away at their returns.

The Shift Index and its key components with a focus on ROA performance over time and Topple Rates, suggests that the rapid globalization of manufacturing, while opening up emerging market economies and leveraging resources in low cost wage locations, has also made it difficult to sustain an operating competitive advantage for the large multinational manufacturing organizations coming out of developed economies. In the future, we see this trend gaining increasing attention from business leaders and investors.

Figure 21: Long-term Topple Rate Trends by US Manufacturing Sector (1965-2010)



Source: Deloitte analysis

Essay – The Big Shift and Manufacturing

by John Hagel and John Seely Brown

To understand the future of manufacturing, we need to explore a much broader set of dynamics that are reshaping the global business economy. These powerful forces have been playing out for decades and will continue to unfold over many decades ahead, shifting the basis of competition in profound ways. We call these forces and the trends they set in motion the “Big Shift.” Business leaders and policy-makers get so caught up and consumed by short-term events that they often lose sight of these much more powerful long-term developments.

The Big Shift is driven by two forces – the global spread of ever more powerful digital technology infrastructures and long-term public policy trends towards greater economic liberalization. Unlike any other time in history, we are confronting the evolution of a new form of technology infrastructure that shows no signs of stabilizing. In contrast to previous technologies like the steam engine, electricity and the telephone, digital technology continues to deliver exponential price/performance improvements over decades, leading to ever more powerful infrastructures. As the most recent example, look at the emergence and deployment of cloud computing. It creates a new generation of infrastructure that we are just beginning to harness.

In economic terms, these two forces are reducing barriers to entry and barriers to movement on a global scale. In other words, competition is intensifying and economic pressure on companies is mounting.

But something even more fundamental is occurring – the basis of competition is shifting as well. We are moving from a world of stocks to a world of flows. What does this mean? In the past, companies achieved scale and profitability by acquiring proprietary knowledge stocks, aggressively protecting those stocks and efficiently extracting the value from those stocks and delivering it to the marketplace.

That model is now challenged. In a world where change is speeding up, knowledge stocks depreciate in value at an accelerating rate. In this new world, companies and other institutions need to become more adept at tapping into a broader range of more diverse knowledge flows so that they can refresh their knowledge stocks at a faster and faster rate. This shift is easily stated but very challenging to navigate.

The challenge is highlighted by one of the metrics that we chose for the Shift Index, an index we developed to both characterize the dimensions of the Big Shift and to quantify the movement of the US economy along these dimensions. This metric focuses on ROA for all public companies in the U.S. as a fundamental indicator of performance. Since 1965, ROA for all public companies has steadily eroded – it is now only 25 percent of what it was then. This erosion in profitability has occurred despite consistent and, over decades, significant improvement in labor productivity. Pressure continues to mount and there is little evidence that companies have figured out how to respond effectively to these competitive pressures.

When we look more narrowly at US companies involved in various forms of manufacturing, we see a similar pattern of performance erosion. Depending on the specific manufacturing sector involved, we see declines in ROA ranging from 34% to 96% between 1965 and 2010. The rates of decline were fastest in sectors that initially had the highest ROA while the declines were more modest in sectors that had lower profitability at the outset. Only one sector, Aerospace and Defense, saw a modest improvement in ROA over this time period.

Even if we focus only on US companies in the top quartile of ROA performance in their respective manufacturing sectors, we find that these “winners” generally experienced erosion in profitability over the more than four decades covered by the Shift Index, albeit a more modest erosion than the overall average of all companies in the sector.

Not only did profitability erode for these winners, but topple rates increased significantly. Topple rates are a measure of sustainability of ROA performance, focusing on the rate at which companies shift ranks in ROA performance. Over this same period topple rates more than doubled in most of the manufacturing sectors, suggesting that the companies that achieved higher levels of profitability had much greater difficulty in sustaining this performance.

One way to describe the challenge for companies is that they are caught in a pincer movement. On one side, they face more and more powerful customers armed with greater information about products and vendors than ever before. These customers find it easier and easier to access vendors wherever they are and to switch from one vendor to another whenever one vendor disappoints. On the other side, companies face knowledge workers who are increasingly essential for competitive success. These knowledge workers have much greater bargaining power to extract more cash compensation for their services, given greater visibility on other employment options in an increasingly competitive labor marketplace.

While our data only covers US companies (including their global operations), we suspect that these broad patterns of mounting pressure and erosion in performance will be reflected throughout most countries. The two forces driving the Big Shift – digital technology infrastructures and economic liberalization – are playing out on a global scale, with few companies immune from their effects.

So far, the evidence suggests that companies have experienced the Big Shift as a source of mounting pressure, leading to eroding profitability. But there is another dimension of the Big Shift. The forces discussed earlier – rapidly evolving digital technology infrastructures and economic liberalization in public policy – have a second order effect. They unleash a flood of knowledge flows on a global scale that become more diverse and richer with each passing year.

For companies narrowly focused on protecting existing knowledge stocks, these knowledge flows can be very threatening. On the other hand, when companies develop the institutions and practices that can effectively tap into these proliferating knowledge flows, threat can transform into opportunity. Now, there is an opportunity to learn faster and drive more rapid performance improvement than ever before by harnessing these knowledge flows.



For example, manufacturing companies have long operated in broader networks encompassing suppliers and various forms of distribution channels to reach the end consumer. The trend over the past several decades has often been for large companies to reduce the number of participants in their networks in an effort to drive greater efficiency and enhance bargaining power. Their focus has largely been on cost reduction which is by its very nature a diminishing returns game – each new increment of cost reduction takes far more effort and time than the previous increment.

More flexible and powerful digital infrastructures make it easier and more cost effective to coordinate larger and more diverse networks on a global scale. As a result, we are likely to see a reversal of the trend towards fewer participants. Now, there is an opportunity to expand networks to tap into deeper specialization and enhance flexibility of business operations in the face of increasingly volatile economic environments.

More importantly, these same infrastructures will make it easier to build sustained relationships throughout the network that can help to drive more rapid learning and performance improvement by mobilizing different skill sets and perspectives. Increasingly, the focus is likely to shift from narrow cost reduction to a broader set of innovations designed to deliver more value to the marketplace. Rather than facing the increasing pressure of diminishing returns performance, companies have the opportunity to harness network effects to generate increasing returns, where the learning and performance improvement increases as more participants join the networks.

We are still in an early stage of the Big Shift. Mounting competitive pressure will force reassessment of traditional approaches to manufacturing. As companies become more adept at leveraging distributed capability on a global scale and participating in more diverse knowledge flows, we are likely to see pressure transform into opportunity. Companies and governments that understand the fundamental forces reshaping our global economy will be the most likely to reap the rewards of the Big Shift.

John Hagel III, director at Deloitte Consulting LLP, has nearly 30 years of experience as a management consultant, author, speaker and entrepreneur. John has helped companies improve their performance by effectively applying information technology to reshape business strategies.

John Seely Brown (JSB) serves as the independent co-chairman of the Silicon Valley-based Deloitte LLP Center for Edge Innovation. JSB is a prolific writer, speaker and educator, and has published more than 100 papers in scientific journals and authored or co-authored five books.

Globalization and Disaggregated Manufacturing Supply Chains

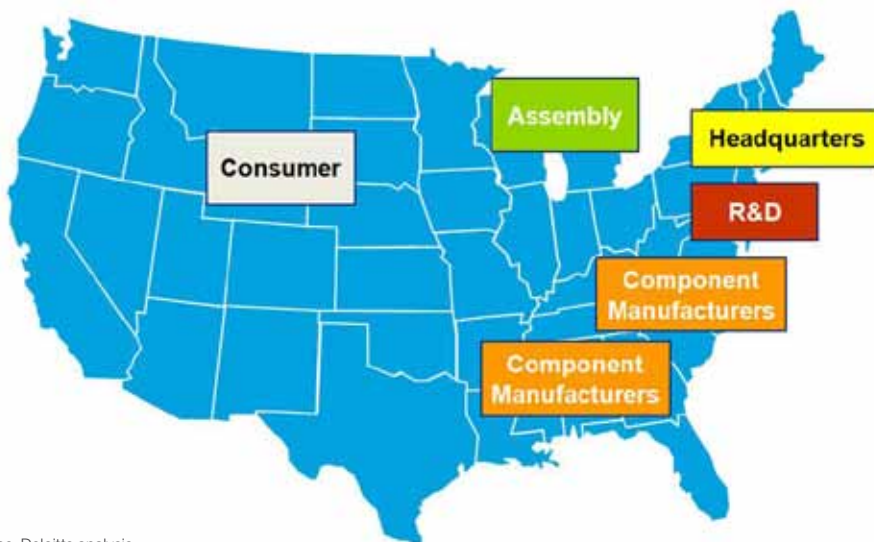
Trade proliferation and global access to digital technology have been key drivers of the expansion and disaggregation of today's supply chains

A number of factors have enabled this rapid globalization or "big shift," including a significant change in geopolitical relations between east and west, the widespread growth of digital information infrastructures and computerized manufacturing technologies, and the proliferation of bilateral and multilateral trade agreements. These factors, along with others, have permitted the disaggregation of supply chains into complex global networks allowing a company to interact in the design, sourcing of materials and components, and manufacturing of products from virtually anywhere – while satisfying customers almost anywhere. The term "disaggregated" refers to the separation and splitting apart of the manufacturing value chain into different locations or countries. Figure 22 represents a local supply chain, where the full product lifecycle takes place in a single country. Figure 23 shows the disaggregated supply chain.



Daniel J. Brutto, President, UPS International shares his insights in Davos-Klosters

Figure 22: Illustration of a Local Supply Chain



Source: Deloitte analysis

Figure 23: Illustration of a Disaggregated Supply Chain



Source: Deloitte analysis

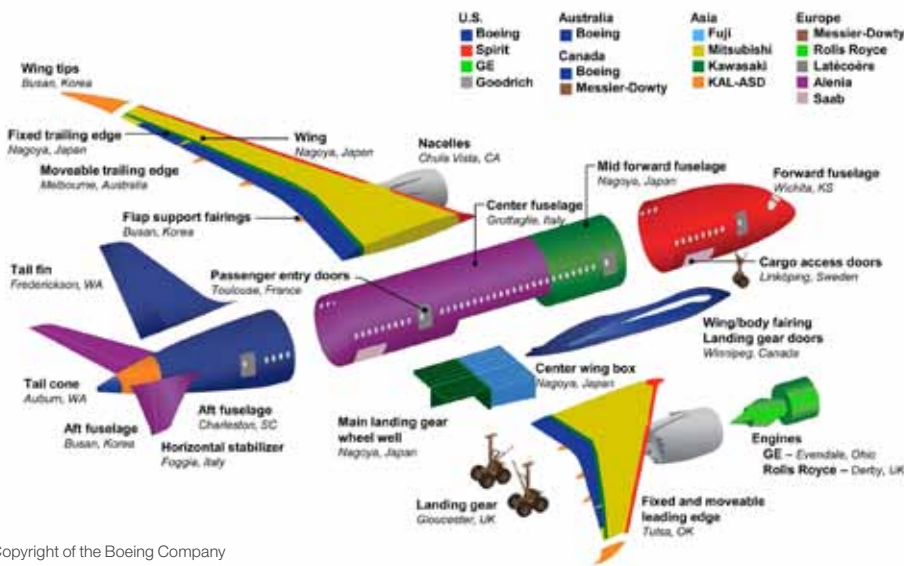
No longer is a product designed, produced and sold in a single country or even a single region.³⁵ Facilitated by access to digital information and open trade routes, a company can procure materials at the lowest price in one location and ship them to a location with low labour rates, as engineers in yet another location make product design decisions.

The Boeing's 787 Dreamliner (Figures 24 and 25) illustrate the concept of disaggregation, showing that the many activities required to bring a product to the consumer are now being performed in different countries.³⁶ The Dreamliner is manufactured with components from 287 suppliers across 22 countries, creating a complex global network that would not have been possible or desirable several decades ago.³⁷

The supply chain for the Apple iPod is also an example of a disaggregated supply chain. iPod components come from multiple geographies, including Japan, the United States, South Korea and Taiwan. Like other multinationals, Apple seeks to minimize its cost basis through global sourcing. Out of the total value of the iPod, Apple captures the greatest portion of the value created (36%), followed by suppliers of major components in Japan (12%), the US (3%), South Korea (0.4%) and Taiwan (2%).³⁸ How is the supply chain for the small iPod so diverse, complex and global? The answer points back to trade policy: WTO's Information Technology Agreement (ITA), which entered into force in 1997, eliminated tariffs on information technology products with a few exceptions.³⁹ This agreement is plurilateral, meaning any of the WTO members can adhere to it. Currently, over 70 countries are included, which comprise roughly 97% of world trade in information technologies, making the global explosion of technology possible.⁴⁰

The level of disaggregation varies by industry and by product within industry. But with the big globalization in manufacturing, as more manufacturing has moved away from developed to emerging nations, more industries have evolved to build far-reaching, global supply chains.

Figure 24: Disaggregated Supply Chain: The Boeing 787 Dreamliner Example

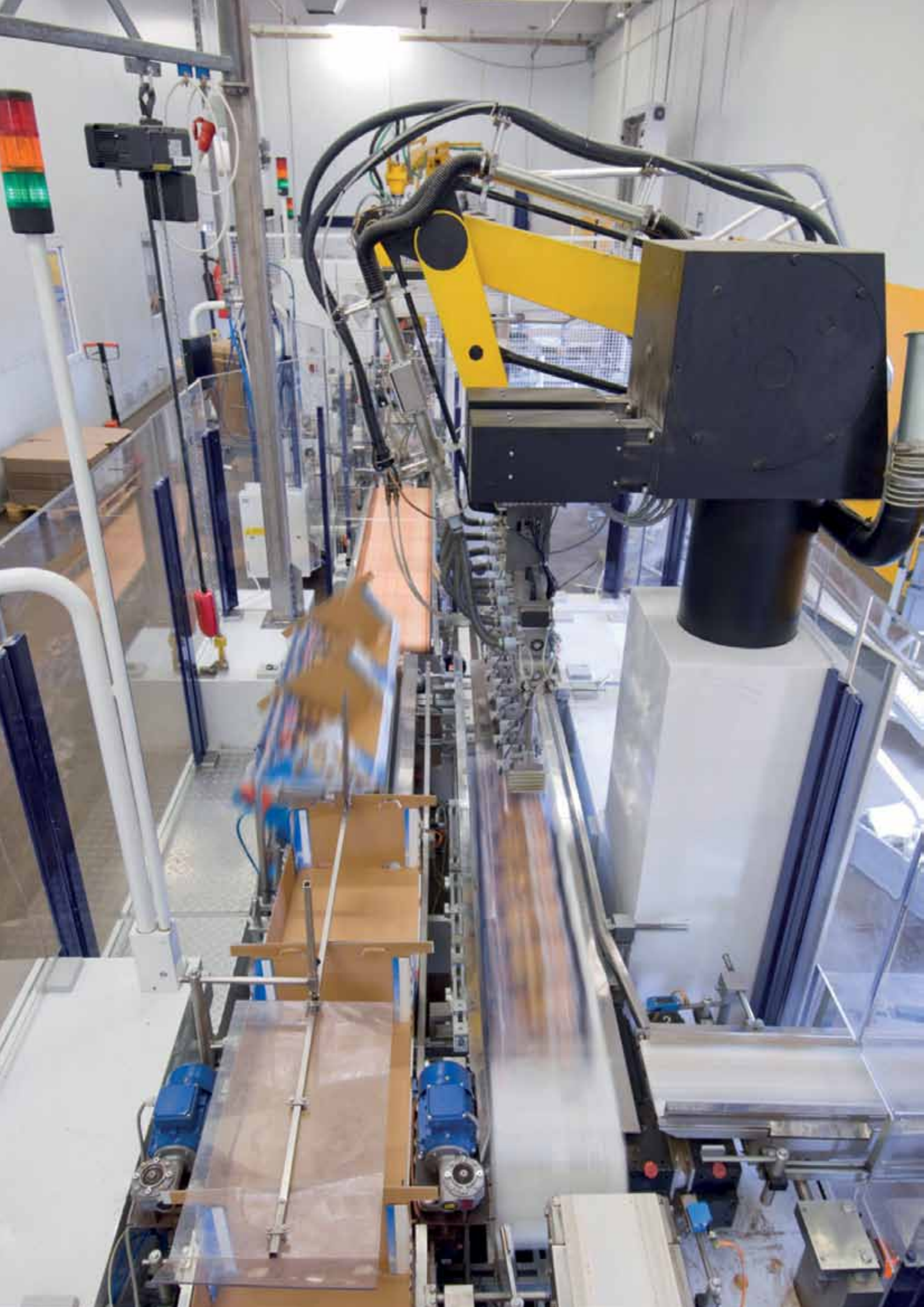


Copyright of the Boeing Company

Figure 25: 287 Suppliers Across 22 Countries: The Boeing 787 Dreamliner Example



Source: Deloitte analysis



Section 2:

The New Calculus of Manufacturing

In this section we transition from the trends and factors that have shaped the rapid globalization of manufacturing, and what we have today in terms of global manufacturing value chains, to a discussion of a few of the most important recent trends that will alter the course of manufacturing's globalization over the next few decades, and how this new calculus will again change manufacturing supply chains.

Global supply chains leave companies increasingly exposed

Free trade and digitization have fundamentally reshaped manufacturing value chains. A company might be able to produce anywhere, sell anywhere, and trade with anyone. The question then becomes: does it make sense to produce in a given location? This changed environment exposes companies and countries to competitive forces that are not necessarily new, but are becoming more complicated and difficult to mitigate. As companies elect to trade and build in new markets, they are exposed to factors that naturally accompany globalization. Three in particular will prove to be especially challenging for manufacturers and policy-makers alike:

1. The politics that give rise to protectionism that distorts open and free trade
2. Rising labour rates in emerging economies and the fading of labour-rate arbitrage being used today to lower overall supply chain costs
3. Exposure to foreign currency fluctuations that can cause significant and unexpected cost anomalies in supply chains

Protectionism is on the Rise

Protectionism has risen in response to the global economic crisis and political pressure

Policy-makers are facing enormous pressure from business leaders and ordinary citizens to address the effects of the global recession. In many cases, policy-makers have manipulated domestic factors (lowering interest rates and cutting budgets) as much as possible – from a political perspective or in real terms – and must resort to restricting foreign competition to protect national industries, investment and employment.⁴¹ The soft macroeconomic environment paired with election cycles in a number of countries contributes to growing rhetoric and action around protectionist measures as political leaders seek to gain popular favour.⁴²

In late 2008, trade scholars predicted that the economic slowdown would result in a growing number of WTO-consistent trade barriers.⁴³ This prediction proved to be true. Governments around the world have enacted over 1,200 “beggar-thy-neighbor”⁴⁴ policies since the first G20 crisis-related summit occurred in November 2008.⁴⁵ During this same time period, new trade liberalizing measures were also implemented, but the growth in protectionist policies outpaced liberalizing policies,⁴⁶ as countries scrambled for ways to find jobs for their citizens and maintain economic activity. The EU 27 (collectively) has contributed most to the rise in protectionism since 2008, with China close behind.⁴⁷ See Figure 26 for a list of the top 10 countries that have taken the most discriminatory measures in total and by number of product categories, sectors and trading partners affected. China and the EU 27 were also top targets of discriminatory measures taken by other jurisdictions.⁴⁸

Sectors are impacted differently by the measures countries are taking to protect national interests and jobs. Five of the top seven sectors and 15 of the top 20 sectors most affected by discriminatory policy measures around the world are manufacturing sectors. Some of the heaviest hit include basic chemicals, basic metals, transport equipment, special purpose machinery, and fabricated metals.⁴⁹ When it comes to the range of product categories, current protectionist policies have not approached the same level as those in the 1930s post-depression era, but are still alarming when it comes to the overall products affected. In the 1930s, the United States increased tariffs on practically all product categories.

Currently, if the EU 27 countries are regarded as a single jurisdiction, it has implemented discriminatory measures imposed on over one-quarter of all possible product categories.⁵⁰ This suggests a more strategic application of discriminatory practices as a prelude to the future.

Protectionist measures have grown increasingly complex and difficult to measure over time.

Protectionist measures have evolved over time. Countries are moving away from transparent policy instruments such as tariffs and towards measures that are less regulated by international trade rules.⁵¹ Just as there is variation across industries and countries in terms of degree of protectionism, there is also diversity in terms of types of policies enacted.⁵² See Figure 27 for types of protectionist measures implemented. Since the 2008 G20 Summit, bailouts and state aid were the most frequently cited instances of policies designed to discriminate against foreign commercial activity.

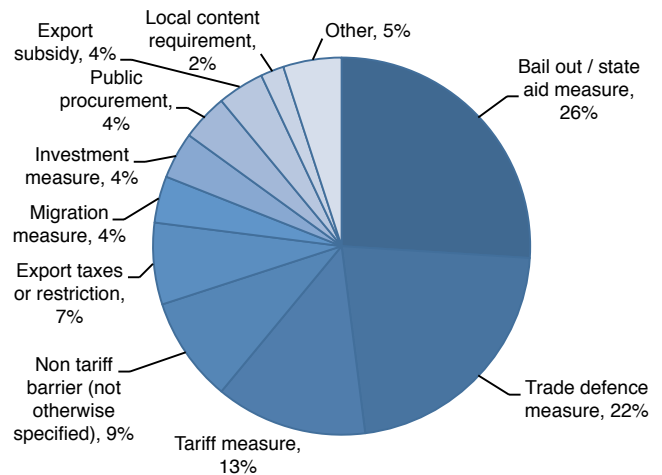
The increasing diversity of protectionism makes it difficult to measure the number of protectionist policies, as well as measure the true impact or harm of a particular policy. Some policies reveal themselves to be discriminatory only in practice, perhaps even in a way that is unintended. Others conceal discrimination within public safety concerns or environmental promotion. For example, one nation recently revealed a plan to promote 50 domestic firms that export green products by offering financial support through 2015 equivalent to approximately US\$ 37 billion.⁵³ Geographies or time frames may be restricted, also adding some type of restriction to free trade. Another nation recently restricted import of food to a selected number of seaports for all of 2011 and 2012, rather than allow the importation of food through any seaport.⁵⁴ Added to the complexity of monitoring global protectionism is the political noise accompanying these policies, which may magnify or distort the true impacts.

Figure 26: Countries/Jurisdictions Ranked by (Almost Certainly) Discriminatory Measures in Total and by Number of Product Categories, Sectors and Trading Partners Affected

Rank	Ranked by number of measures imposed	Ranked by number of product categories affected	Ranked by number of sectors affected	Ranked by number of trading partners affected
1	EU 27 (242)	Vietnam (927)	Algeria (62)	China (195)
2	Russian Federation (112)	Venezuela (786)	EU 27 (58)	EU 27 (181)
3	Argentina (111)	Kazakhstan (729)	China (47)	Argentina (175)
4	UK (59)	China (698)	Nigeria (45)	Germany (161)
5	Germany (58)	Nigeria (599)	Kazakhstan (43)	India (154)
6	India (56)	EU 27 (550)	Germany (42)	UK (154)
7	China (55)	Algeria (476)	US (42)	Belgium (153)
8	France (51)	Russian Federation (439)	Ghana (41)	Finland (153)
9	Brazil (49)	Argentina (429)	Indonesia (40)	Indonesia (151)
10	Italy (47)	Indonesia (388)	Russian Federation (40)	France (150)

Source: Evenett, S.J. ed. (2011) Trade Tensions Mount: the 10th GTA Report. London: Centre for Economic Policy Research. Available at: <http://www.globaltradealert.org/gta-analysis/trade-tensions-mount-10th-gta-report>. Pg. 30

Figure 27: Top 10 Measures Used to Discriminate Against Foreign Commercial Interests Since the First G20 Crisis Meeting in November 2008



Source: Evenett, S.J. ed. (2011) Trade Tensions Mount: the 10th GTA Report. London: Centre for Economic Policy Research. Available at: <http://www.globaltradealert.org/gta-analysis/trade-tensions-mount-10th-gta-report>. Pg. 31

The growing number of preferential trade agreements (PTAs) also has hidden discriminatory effects

The growing number of preferential trade agreements (PTAs) adds to the complex web of factors leaving countries torn between free trade and protectionism. The WTO reports that the number of PTAs has grown four times over the past two decades, to approximately 300 active agreements in 2011, and shows no sign of shrinking in number.⁵⁵ Historically, nations formed PTAs to avoid high tariffs. As average tariffs have been decreasing, nations are entering into PTAs for a broader array of factors, including services, investment, intellectual property, technical barriers to trade, and dispute settlement.⁵⁶ Experts suggest that the rise in complex, global, cross-border production networks has driven the need for deeper integration – and resulted in the need for certain international standards, which are being defined in PTAs.⁵⁷

Many of the “non-tariff policy commitments in PTAs are largely non-discriminatory, at least in intent, and pose no threat to the multilateral trading system.”⁵⁸ The result, however, is far more complicated. There may be consequences associated with these policy areas that amount to protectionism and discriminatory trade policies: a PTA may lock a government into a particular regulatory regime, making it more difficult to move towards multilateral liberalization.⁵⁹ With supply chains and production networks becoming more global, policy-makers will be increasingly challenged to establish the right level of standards from a safety, legal and environmental perspective, while also permitting the growth of national businesses that have established far-reaching supply chains. Discriminatory measures, both unintended and intended, are creating friction in the global movement towards opening trade.

Taken together, the discriminatory trade actions and degree of sophistication being used, including targeting specific sectors, products, and trading partners as well as disguising the discrimination as safety, environmental or other supposedly non-discriminatory policies, implies both a more strategic application as well as steadily increasing protectionism through increasingly complex approaches. There is no reason to believe success using these more complex approaches will result in anything but proliferation as opposed to curtailment. While clearer standards, with a greater level of detail to combat the newer and more complex discrimination approaches would be beneficial, the most likely scenario is that governing bodies will not be able to keep pace with the degree of sophistication being used and the trajectory it is taking.

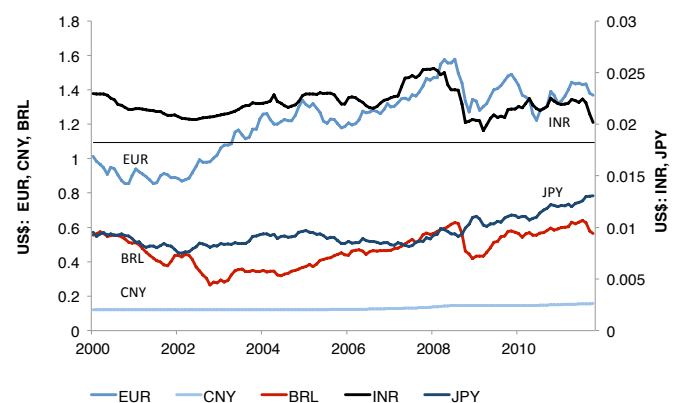
The big shift in globalization will certainly continue into the future, and liberalized trade will be an important element of the future of manufacturing. But the more striking aspect of the next 20 years will be a trade environment characterized increasingly by the intervention of policy-makers, with very strategic objectives, using more and more sophisticated techniques. This is likely to contribute to more regionalized or localized production, more closely matching consumption patterns, and a reshaping of the wide-open, disaggregated supply chains initially enabled by the rapid globalization of manufacturing.

Exposure to Foreign Exchange Rate Fluctuations Grows

As trade has expanded and supply chains have disaggregated, countries and companies have been increasingly exposed to currency volatility

The ubiquity of digital technology and proliferation of free trade agreements have allowed companies access to markets, production facilities and suppliers in new geographies. While these new locations yield opportunities for growth, value creation and innovation, companies confront a host of challenges – not necessarily new challenges, but felt more acutely. The disaggregation of supply chains, which results in the spread of various aspects of production across the world, leaves companies more vulnerable to foreign exchange rate fluctuations. Over the past decade, major currencies have demonstrated high degrees of fluctuation resulting in significant supply chain cost swings for manufacturers with global operations and globally disaggregated supply chains (Figure 28). Participants in project workshops from Brazil and Japan highlighted the challenges that their appreciating currencies were placing on production in their home countries.

Figure 28: Currency Volatility: US\$ per Unit of Currency



Source: Deloitte analysis using data from Oanda

There is a strong relationship between exchange rate exposure and a country's economic openness, defined as Trade/GDP or (Exports + Imports)/GDP. Research from University College, Dublin, analysed the foreign currency exposure of 3,788 companies in 23 developed countries and found that economic openness leads to higher levels of currency exposure.⁶⁰ This includes both direct transactional exposure and indirect exposure that arises when suppliers or competitors are exposed. Even for a company with no foreign transactions, the global trend towards disaggregation means that indirect exposure can affect a company from deep within its supply chain.



Artur Aparecido Coutinho, Executive Vice-President and Chief Operating Officer, Embraer SA shares his insights in Rio de Janeiro, Brazil

This research also found that currency exposure impacts industries differently and requires different mitigation strategies: the more competitive and the less differentiated the product, the greater the exposure to exchange risk.⁶¹ As a result, the industries with the highest currency exposure are metals, services, commodities, and construction/building products (Figure 29). Firms in the manufacturing categories with highest exposure have little flexibility to pass exchange rate costs to customers.⁶² On the opposite end of the spectrum are non-durable manufacturing, chemicals, and utilities. For all companies, managing longer-term direct and indirect exposure requires a strategic combination of financial and operational matching.⁶³

Despite variations by industry, currency volatility appears here to stay

The policy and macroeconomic factors that contribute to increasing currency volatility show every indication of persisting in the future. Currency volatility is positively correlated with more flexible exchange rate regimes (e.g. floating currencies), higher central bank intervention and increased economic uncertainty, while greater national economic wealth reduces currency volatility. As Figure 30 shows, global trends impacting each of these factors point to ongoing currency volatility. Experts anticipate that developing countries will continue moving away from pegged currencies, especially as poorer countries gain access to global capital.⁶⁴

At the same time, developed countries – even those with flexible currency regimes – have taken increasingly interventionist measures to stabilize economies and protect national industries. Given the size of the US economy, the “revival of fiscal activism” by the US Federal Reserve⁶⁵ impacts foreign central banks’ decisions, and perpetuates the symbiotic relationship between intervention and volatility. In countries with high exchange rate volatility, central banks intervene more aggressively.⁶⁶ Finally, the sovereign debt crisis contributes to ballooning deficits and economic uncertainty. The average of public debt as a percentage of GDP for the G7 countries crossed the 100% mark in 2010. For the first time in 60 years some advanced economies face the threat of sovereign default, which could push the world into recession.⁶⁷

Figure 29: Industries Ranked by Mean Absolute Currency Exposure (1993-2003)

	Mean Absolute Exposure	Median Size (\$USm)	No. of Firms
Most Exposed			
Metals manufacturing	0.60	239	108
Services	0.59	226	525
Commodities	0.56	195	182
Construction & building products	0.49	177	318
Electronics manufacturing	0.46	229	429
Textile, clothing and footwear	0.46	65	165
Low-tech durables manufacturing	0.46	237	847
Telecoms, media and info	0.45	493	177
Wholesale, retail & transportation	0.41	357	333
Non-durables manufacturing	0.41	283	261
Chemicals	0.36	636	291
Utilities	0.31	1,509	152
Least Exposed			

Source: Hutson, E. & Stevenson, S. (2010) Openness, hedging incentives and foreign exchange exposure. *Journal of International Business Studies*, 41(1):105-122



Gary Chu, President, Greater China, General Mills China and Takahisa Miyauchi, Executive Vice-President and Group Chief Executive Officer, Chemicals, Mitsubishi Corporation sharing insights in Dalian, China

Figure 30: Policy and Macroeconomic Factors Correlated with Currency Volatility

Factor	Description	Correlation with Currency Volatility	Likelihood of this Continuing
Policy / Domestic Factors			
Floating currency	The way a country manages its currency in relation to other currencies matters: countries with free-floating currencies experience higher intra-month exchange rate volatility than countries with pegged exchange rates	↑ Increased Volatility	↑ IMF experts predict that the number of pegs in the developing world will diminish over the coming years, as poorer countries gain access to global capital, eroding the durability of pegs
Higher levels of central bank intervention	Even in countries with a free-floating currency, the central bank may intervene by: <ul style="list-style-type: none"> • Trading the domestic currency • Changing the domestic real interest rate Research suggests a symbiotic relationship between volatility and intervention	↑ Increased Volatility	↑ U.S. has moved towards short-term fiscal and monetary interventionism; this affects foreign central bank decisions
Macroeconomic Factors			
Greater national wealth	Broad-based wealth and prosperity may stabilize the exchange rate; financial and currency crises are more common in poor countries	↓ Reduced Volatility	↑ Lingering effects of the sovereign debt crisis will continue to negatively impact national wealth, resulting in higher volatility
Increased economic uncertainty	Higher stock market volatility is correlated to higher exchange rate volatility	↑ Increased Volatility	↑ Economists predict that recessions will be more frequent during the coming years than they were in the quarter century leading up to the credit crunch

* Researchers from the Bank of Israel and the School of Business Administration at Bar-Ilan University looked at the daily volatility of the exchange rate between the U.S. Dollar and 43 other currencies between 1990 and 2001 and identified key factors correlated with increased currency volatility.

Sources: Deloitte analysis

Benita, G. & Lauterbach, B. (2007) Policy Factors and Exchange Rate Volatility. International Research Journal of Finance and Economics

Husain, A. M., Mody, A. & Rogoff, K.S. (2004) Exchange Rate Regime Durability and Performance in Developing Versus Advanced Economies. Available at: http://www.carnegie-rochester.rochester.edu/April04-pdfs/regimes_cr.pdf

Taylor, J.B. (2011) A Slow Growth American Can't Lead the World. The Wall Street Journal, November 1. Available at: <http://online.wsj.com/article/SB10001424052970204394804577009651207190754.html>

Mattich, A. (2010) Currency Volatility is here to stay. The Wall Street Journal Source Blog, July 5. Available at: <http://blogs.wsj.com/source/2010/07/05/currency-volatility-is-here-to-stay/>

Case Study: Expectations Point to More Volatility for the Yuan⁶⁸

Even the yuan, which is pegged to the dollar within a very narrow range, is expected to show more volatility in the future. Until recently, investors viewed the yuan as a good bet to rise in value. However, the downturn in Europe and the weak recovery in the United States, China's two largest trading partners, have prompted concerns that reduced export demand will lead the People's Bank of China to slow or halt currency appreciation as a means of limiting job losses. In response, some companies have begun to hedge against yuan volatility.

The CFO of Trina Solar predicted that the company would "do more options trades to smooth [the company's] cost structure and minimize the impact of foreign-exchange fluctuations." Meanwhile, the head of business development for HSBC Holdings PLC indicated that many Hong Kong exporters that receive yuan as payments are starting to use options to manage their exposure to the currency.

Countries and companies are reacting to currency volatility, reshaping supply chains and trade

Many emerging economies are reacting to support national industries while companies face difficult short- and long-term decisions. In late 2011, Brazil's soaring currency, along with its declining infrastructure and vast bureaucracy, led to shrinking industrial output.⁶⁹ Brazilian automakers were forced to implement mandatory vacations for workers as more and more Brazilians are purchasing imports (25% in 2011 versus 5% in 2005).⁷⁰ Brazilian President Dilma Rousseff announced a manufacturing stimulus package and measures intended to weaken the currency.⁷¹ In addition to implementing domestic policy, Brazil has raised the exchange rate issue to a wider audience.

The Wall Street Journal reported in November 2011 that the WTO agreed, at Brazil's request, to look into China's policy of pegging the yuan to the US dollar to determine whether the peg "amounts to an unfair export subsidy that should be fought with tariffs on Chinese-made goods."⁷² While complaints about China's currency policy are not new, this is the first time the WTO will formally address in a dispute settlement the question of whether the policy is in violation of an article against countries using currency policy to "frustrate other countries that were expecting market access."⁷³

Developed nations with strong currencies are seeing their manufacturing competitiveness erode and domestic economies crippled

Switzerland, Australia, and Japan have also witnessed their currencies strengthen in relation to other global currencies, which has caused exporters to struggle. The strength of the Australian dollar is being blamed for the closure of steel mills.⁷⁴ Swiss companies have similarly cited the strength of the franc for recent layoffs.⁷⁵ In Japan, Nintendo has blamed the strong yen for its first expected annual loss in 30 years,⁷⁶ and Sony has reported similar currency-related struggles.⁷⁷ In response, the Bank of Japan intervened in October 2011 with close to US\$ 100 billion (the biggest single intervention in Japanese history) to try to weaken the yen and protect Japanese automotive and electronics industries (Figure 31).

The reactions from industry have revealed different approaches companies are taking in an environment where the only certainty is that volatility will continue. Toyota suggests that it will take a long view and is committed to continuing to produce in Japan, citing history and the high cost of relocating operations. Honda and Nissan, on the other hand, will shift production. Honda has already announced plans for new plants in Mexico,⁷⁸ and Nissan has commented, "There is 'no way' the company can plan any new projects in Japan as long as the currency continues to soar."⁷⁹

Figure 31: Japanese Officials Intervene to Protect National Industries



Source: Monahan, A. & Shah, N. (2011) Doubts Cloud Tokyo's Yen Intervention. The Wall Street Journal, November 1. Available at: <http://online.wsj.com/article/SB10001424052970204528204577009152325076454.html>

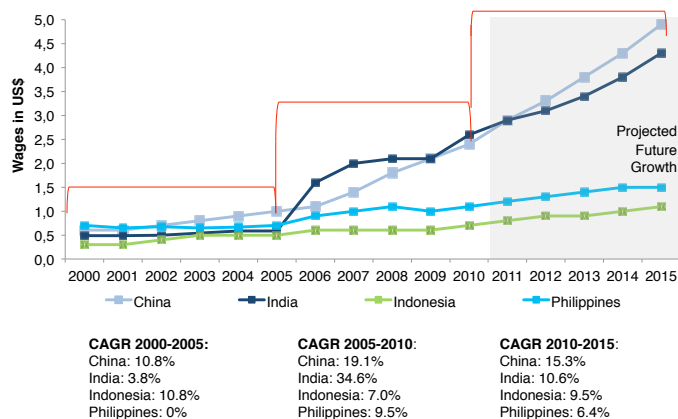
Labour Rate Arbitrage is Fading

Average hourly wages in emerging economies are rising rapidly

As the middle class grows and pressure increases to attract and retain skilled talent in countries that have historically been sources of low-cost labour, companies are paying higher salaries. Wages in China and India have been rising at an accelerating rate. From 2000 to 2005, wages in China and India grew at CAGRs of 10.8% and 3.8%, respectively. Over the next five years, those rates rose to 19.1% and 34.6%. Projections suggest that wages will continue to show strong growth from 2010 to 2015 at CAGRs of 15.3% in China and 10.6% in India (Figure 32).⁸⁰

Similar increases have occurred in Indonesia and the Philippines. From 2000 to 2005, wages in Indonesia grew at the same CAGR experienced in China for the same time period, 10.8%. Between 2005 and 2010, Indonesia's wages grew at a 7.0% CAGR, while in the Philippines wages grew at a 9.5% CAGR. Projections for these emerging nations from 2010 to 2015 suggest CAGRs for wages of 9.5% in Indonesia and 6.4% in the Philippines.

Figure 32: Average Hourly Wages in Emerging Economies



Source: Deloitte analysis based on data published by the Economist Intelligence Unit. Extracted November 15, 2011.

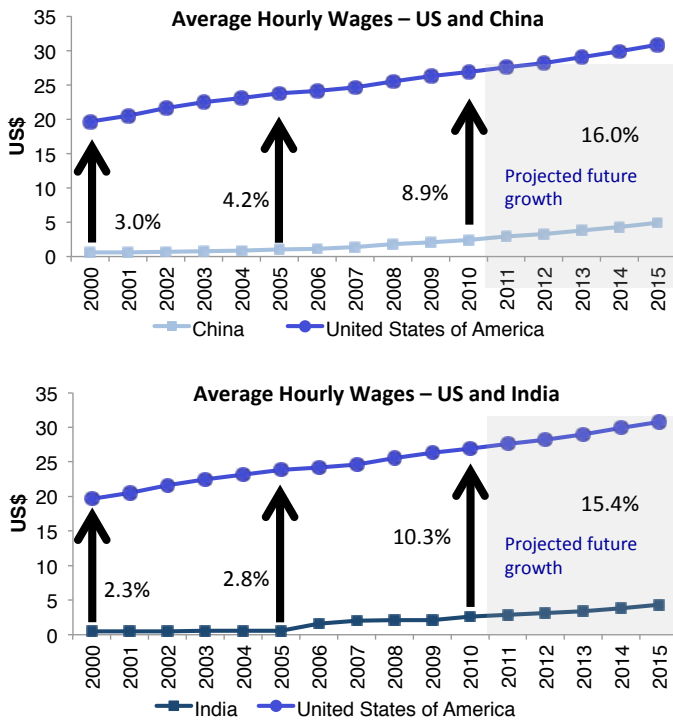
The gap between the wages in developed and emerging nations is closing rapidly

Chinese labour costs soared in 2011, despite a slowdown in the broader economy. Twenty-one of China's 31 provincial-level divisions raised minimum wages by an average of 21.7%. This comes on the heels of comparable hikes over the past two years.⁸¹ The picture in India is similar: on average, salaries increased by 12.9% in 2011, slightly better than the 11.7% registered in 2010.⁸² In 2000, the hourly wage rate in China was 3% of the hourly wage rate in the United States. In 2015, that gap is expected to close to 16%.⁸³ In India, wages are projected to be 15.4% of the wages in the US, up from 2.3% in 2000 (Figure 33).

What is true for China and India is generally true for the rest of the developing world, where the average hourly wage was a mere 2% of the US average in 2000 and is expected to climb to 9% by 2015 (Figure 34). Given that the pace of wage growth is expected to continue,⁸⁴ the gap between developing and developed countries is shrinking, as developed world salaries remain steady.

Finding countries with a labour-cost advantage is increasingly difficult. Luxury handbag-maker Coach announced in January that it would reduce its reliance on China in favour of increased production in Vietnam and India. In another example, Bangladesh raised its minimum wage by 87% late last year, yet Bangladeshi apparel factories still struggle to find enough workers to meet ever-rising numbers of orders. Vietnamese wages are rising as quickly as China's.⁸⁵

Figure 33: Average Hourly Wages in the United States, India and China



Source: Deloitte analysis based on data published by the Economist Intelligence Unit.

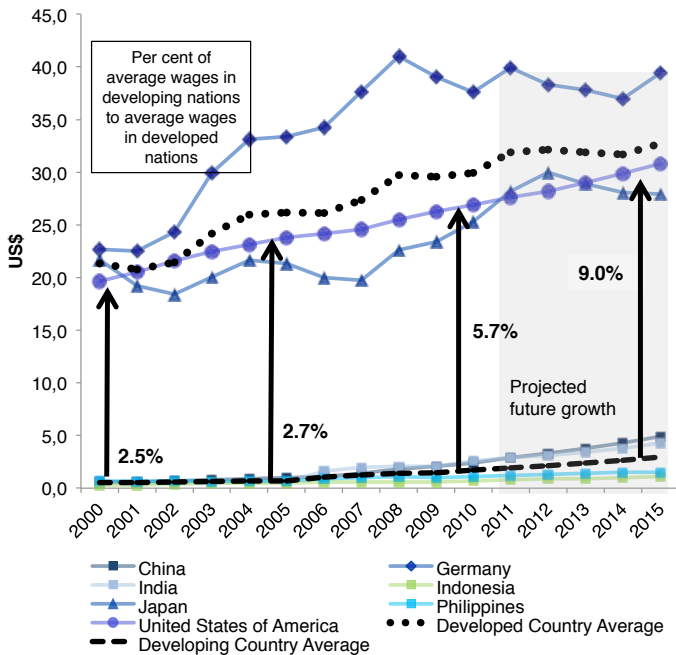
While the gap between wages in the United States and both China and India can still be considered large today, the rate at which they are closing is very rapid.

A recent analysis by The Boston Consulting Group suggests a combination of economic forces is fast eroding China's cost advantage as an export platform for the North American market and concludes that by sometime around 2015 – for many goods destined for North American consumers – manufacturing in some parts of the United States will be as economical as manufacturing in China. One of the key reasons for this shift is related to a shrinking gap in fully burdened labour rates.

Wage and benefit increases of 15-20% per year at the average Chinese factory will slash China's labour-cost advantage over low-cost states in the US, from 55% today to 39% in 2015, when adjusted for the higher productivity of US workers. Because labour accounts for a small portion of a product's manufacturing costs, the savings gained from outsourcing to China will drop to single digits for many products.⁸⁶

For manufacturers considering long-term commitments to new facilities in emerging country locations, and always focused on keeping costs low to remain competitive, the rapid escalation of labour costs and other associated costs will have a significant impact on their supply chain decisions over the next 20 years.

Figure 34: Average Hourly Wages in Developing Economies



Source: Deloitte Analysis based on data published by the Economist Intelligence Unit.

As global labour-rate arbitrage fades, the course of manufacturing's globalization will be altered

Having lost the cost advantages of production in China and other low-cost countries, companies will focus on transforming internal cost structures and shifting production to hedge against labour-rate increases.

The middle classes in China and India are growing more prominent, with consequences to both demand and supply. With respect to demand, the growing middle class creates a vast new market for a range of goods, including big-ticket items. On the supply side, the shrinking pools of low-cost labour mean that companies will be challenged to find ways to add value other than by using cheap labour. Companies will also struggle with higher worker turnover, as people have more employment options in low-cost locations.

To address these changes, some companies, such as Foxconn, are moving to greater automation in their Asian operations as a means of reducing labour costs, part of what Alvin Kwock, head of hardware technology research at JPMorgan, identifies as “a broad automation push among China-based manufacturers” and a signal that “the cost of labour is no longer lower than the cost of capital.”⁸⁷

While some companies will always be on the lookout for low-cost labour (and some are starting to look to Africa), the lowest cost is a constantly moving target, and it is unlikely that production shifts will be as dramatic as they have been over the past two decades. Some companies are focused on localizing production, not only because of the shrinking wage gap but because all costs to manufacture – energy, transportation and inventory – are rising. Localizing production is a hedge against currency volatility by establishing a cost base where products are sold. For some companies, localization aligns with growing demand centres in emerging markets. For others, including many in the United States and Europe, localization means moving production facilities back home. Given high unemployment, these companies are being welcomed home with open arms.⁸⁸



Baba N. Kalyani,
Chairman and
Managing Director,
Bharat Forge, India
shares his insights in
Mumbai, India



Arun Maira,
Member, Planning
Commission, India
shares his insights in
Mumbai, India



Section 3:

Future Competition: Resources, Capabilities, and Public Policy

The rapid globalization experienced over the recent past has established many new and formidable manufacturing competitors, both companies and countries. The rapid rise in productive knowledge or the know-how of manufacturing combined with rapidly developing new markets has intensified the competition for both the resources and the capabilities necessary for success.

In some cases, such as with the Earth's natural resources, this competition could play out as a win-lose scenario, as there are only so many resources and not enough to go around if shared and equitable solutions do not prevail. In other cases, such as the competition for talented human resources, win-win scenarios can play out as nations and companies all contribute to advancing the skills and capabilities of their people to ever-higher levels.

Countries will intensify their efforts to build leading manufacturing sectors – more competitive than their counterparts around the world – because manufacturing will increasingly be an essential path to attract investment, spur innovation and create high-value jobs. Both the leaders of developed and emerging economies are trying to create the most compelling environments upon which to develop a highly-skilled workforce and build a sustainable innovation engine that raises the standard of living for their people, with a particular emphasis on the important middle class.

Established manufacturing enterprises and rapidly emerging new entrants are also competing fiercely in open markets to create and sustain the most competitive businesses possible.

For them, the 21st century presents enormous business opportunities, whether in developed nations or emerging economies. But this also means they will fiercely compete for resources and superior capabilities in a wide variety of areas.

As we look to the future, there are a number of key areas where both companies and countries will effectively share in the intensifying competition for manufacturing supremacy, where they both will have a critical stake in the outcome, as it will be a fundamental driver of either their success or their failure. While there are many areas where they are in complete control of their own destinies, here we have focused on those areas where they have a shared role and interest in the future competition.

In this section we explore the competition to develop infrastructure and attract foreign direct investment, the competition for materials resources and energy, and the competition to develop their innovation capabilities and talented human resources they will require to drive their success. The final area we explore is the competition to develop or influence public policy impacting manufacturing, as policy-makers increasingly seek to shape the factors most likely to drive prosperity for their nations. In all of these areas of shared interest in the drivers of competitiveness, business leaders and policy-makers must come together to deliberate and collaborate to ensure the best possible outcome for all stakeholders.

Competitive Infrastructure Will Increase in Importance for Emerging and Developed Nations

The infrastructure necessary to enable manufacturing to flourish and contribute to job growth will grow in importance and sophistication and be challenging for countries to develop and maintain

Investing in effective infrastructure has been essential for developing nations to be included as a potential location by multinationals and thus participate in the benefits derived from the globalization of manufacturing. This trend will intensify in the future. Reinvestment in maintaining competitive infrastructure will become critical for developed nations to keep pace. Public funding support for infrastructure development will be a challenge for developed nations given the expected long tail on sovereign debt issues. Effective public-private partnerships will be essential. While infrastructure alone will not lead directly to best-in-class manufacturing, a serious lack of infrastructure or a steadily decaying infrastructure will cause nations to fall out of contention and create serious obstacles for the supply chain networks of leading companies.

To compete in global manufacturing, nations must have quality infrastructure

As nations compete for FDI and strive to support national industries and innovations, the race to build enabling, effective infrastructure will intensify. As part of the 2010 Global Manufacturing Competitiveness Index, over 400 CEOs were asked to rank the drivers of global manufacturing competitiveness: infrastructure was rated fifth out of 10 factors. Although it trailed behind talent and innovation and costs of labour, materials and energy, infrastructure is a very important consideration for executives.⁸⁹

Infrastructure helps determine the type of activities that can be undertaken in a country, as well as the capabilities and sectors that a country can develop. Well-developed infrastructure encourages connectedness and economic activity between nations and within a nation. Information technology and telecommunication networks are critical for daily business operations, for both small companies and large multinationals. Effective modes of transportation including highways, railways, waterways and ports, and airfields and air traffic control are all necessary to move manufactured inputs and finished goods to consumers. Companies, particularly manufacturers, also depend on a reliable supply of affordable electricity to support operations.⁹⁰

Inadequate infrastructure is a concern in many emerging economies, though China has made significant improvements

Since 2005, the World Economic Forum has based its competitiveness analysis on the Global Competitiveness Index (GCI), which measures countries on the basis of 12 pillars of economic competitiveness. The GCI, like the economic theory of stages of development, assumes that economies in the first stage compete on the basis of their factor endowments – primarily low-cost labour and natural resources. To be competitive, a country at this stage of development must meet four basic requirements: institutions, infrastructure, macroeconomic environment, and health and primary education.⁹¹ Many emerging countries struggle with these foundational pillars of an enabling business environment.

The following chart shows the factors that business executives from BRIC nations participating in the World Economic Forum’s Executive Opinion Survey saw as the most problematic for doing business in their economy, both in 2006 and 2011 (Figure 35). In 2006, infrastructure was cited as one of the top-three concerns for two of the four BRIC nations – China and India. In 2011, infrastructure was also cited as a top concern for two BRIC nations – Brazil and India – but executives no longer saw China’s infrastructure as one of its primary issues.⁹² This was corroborated in the project workshops. Participants in our project workshop in India cited the lack of infrastructure and the challenges in land acquisition as a key barrier to scaling up manufacturing sector growth in India. In our workshop in China, participants expressed concerns about China’s increased push towards locating manufacturing capacity in the Western regions of the country, which would potentially lead to increased logistics costs and lead times.

Figure 35: Problematic Factors for Doing Business in BRIC Countries in 2006 and 2011: Inadequate Infrastructure

	2006	2011-12
Brazil	Tax rates Tax regulations Inefficient government bureaucracy	Tax rates Tax regulations Inadequate supply of infrastructure
Russia	Corruption Tax regulations Inefficient government bureaucracy	Corruption Inefficient government bureaucracy Crime and theft
India	Inadequate supply of infrastructure Inefficient government bureaucracy Restrictive labour regulations	Inadequate supply of infrastructure Corruption Inefficient government bureaucracy
China	Corruption Inadequate supply of infrastructure Access to financing	Inflation Access to financing Inefficient government bureaucracy

Source: Rahul, S., Rahul, M. & Sahay, A. (2009) An assessment of competitiveness of BRICS nations with special focus on India. Abhigyan. 27(1): Table VII



In the past five years, China has made substantial progress on a number of infrastructure fronts. In 2005, only nine of every 100 people were Internet users; by 2010, that number shot up to 34 of 100.⁹³ Paved roads as a per cent of total roads increased from 41% in 2005 to 54% in 2008.⁹⁴ In 2006, China made a commitment to invest 1.5 trillion yuan (US\$ 190 billion) in rail construction through 2010⁹⁵; by 2011, China's standard and high-speed rail lines totalled more than 91,000 km.⁹⁶ Although China recently announced some railway construction spending cuts in response to concerns about debt and safety of trains, China continues to make plans for more and more sophisticated infrastructure. According to *The Telegraph*, China plans to "create the world's biggest mega city by merging nine cities to create a metropolis twice the size of Wales with a population of 42 million."⁹⁷



Cui Dianguo, President, China CNR Corporation Limited (CNR)
 Andrew Weinberg, Chairman, Strategy, Brightstar Corporation and
 Sam Hsu, Senior Vice-President and General Manager, Ecolab
 participating in a discussion in Dalian, China

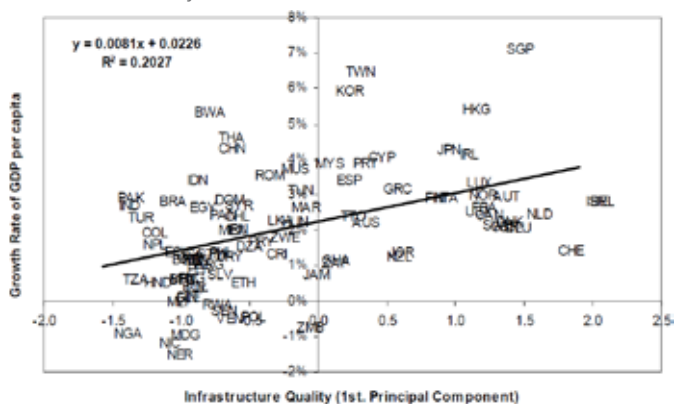
“

Over the next six years, around 150 major infrastructure projects will mesh the transport, energy, water and telecommunications networks of the nine cities together, at a cost of some 2 trillion yuan (£190 billion). An express rail line will also connect the hub with nearby Hong Kong.⁹⁸

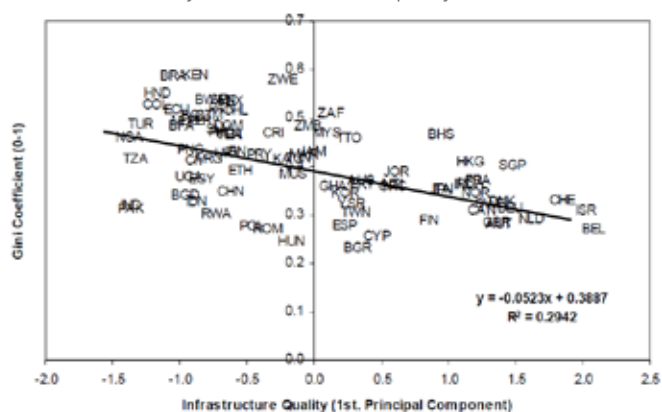
”

Figure 36: Infrastructure Quality

Infrastructure Quality versus Economic Growth



Infrastructure Quality versus Income Inequality



Source: Calderón, C. & Servén, L. (2004) The Effects of Infrastructure Development on Growth and Income. World Bank Policy Research Paper. Available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=625277. Pg. 9, 42-3

Infrastructure quantity and quality are drivers of economic growth and income equality

Countries considered to have the most competitive infrastructure have higher GDP per capita (Figure 36). Experts have demonstrated that the quantity of infrastructure has a significant positive effect on long-run economic growth. Additionally, infrastructure quantity and quality have a negative impact on income inequality, which means that investment in infrastructure reduces poverty and facilitates the rise of the middle class.⁹⁹

Researchers have also shown that a country's stage of development influences the level of impact of public capital spending on infrastructure. Returns to public investment diminish with income. While there is evidence that public capital spending on infrastructure has a positive return, regardless of national income, it is most impactful in poorer and fast-growing nations.¹⁰⁰ Research by Shenggen Fan and Connie Chan-Kang estimated that each kilometre of road extension in low-potential rain-fed areas in India resulted in a reduction of 10 people in the poverty headcount; Fan and Chan-Kang estimated economic rates of return in the hundreds or thousands of per cent.¹⁰¹

While infrastructure alone will not lead directly to best-in-class manufacturing, a serious lack of infrastructure or a steadily decaying infrastructure will cause nations to fall out of contention and create serious obstacles for the supply chain networks of leading companies. The challenge for emerging nations is to develop new infrastructure. The challenge for developed nations, is to refurbish old infrastructure that is sometimes in serious disrepair and to keep pace with the advantages inherent in new, modern and often specialized infrastructure targeted toward certain sectors being built in emerging nations. As the global industrialization expands, emerging countries are not building "old" infrastructure; only new infrastructure is being erected and global business could be easily seduced.

Lingering effects of the debt crisis will impact nations' abilities to strengthen infrastructure

Public funding support for infrastructure will be a challenge for developed nations given the expected long tail on sovereign debt issues. Nations are finding ways to cut spending in order to reduce deficits that have ballooned due to borrowing and economic stimulus projects (including some national infrastructure projects). In many cases, countries are forced to cancel or postpone projects, or make a choice between projects. For instance, Portugal, whose debt was over 90% of GDP at the end of 2010,¹⁰² announced in June 2011 the cancellation of its €3.3 billion Madrid-Lisbon high-speed rail line.¹⁰³ The Economy Minister Alvaro Santos Pereira explained the cancellation was to "make room for building railway lines that help take Portuguese goods to export destinations."¹⁰⁴

Effective public-private partnerships targeted at strategic projects will be essential to address this issue. Spain and France are attempting to use more private finance to maintain their infrastructure investment.¹⁰⁵ Experts predict that private finance will step in to cover economic infrastructure that is paid for by users, but social infrastructure that relies on government as a payer is more likely to see reduced investment.¹⁰⁶ In the UK, for example, the government cut budgets for school and social housing,¹⁰⁷ but announced £30 billion (US\$ 46.3 billion) of new public and private money for civil infrastructure such as railways, roads, and broadband connections.¹⁰⁸

Competition for Foreign Direct Investment is Increasing

Competition between nations to attract FDI will increase dramatically, raising the stakes for countries and complicating the decision processes for companies

FDI is a means for bringing manufacturing and research facilities to a country, building infrastructure in public-private partnerships and leveraging the multiplier effect of manufacturing on service jobs across the nation. As public funding challenges mount, the competition between nations for FDI will increase dramatically. For companies, the myriad of potential investment options will be increasingly hard to differentiate and navigate. But investments in the wrong location, thus potentially not contributing enough to truly advance a company's global competitive capabilities, will have long lasting negative consequences and be increasingly hard to unwind.

The last decade has seen an increase of FDI into manufacturing

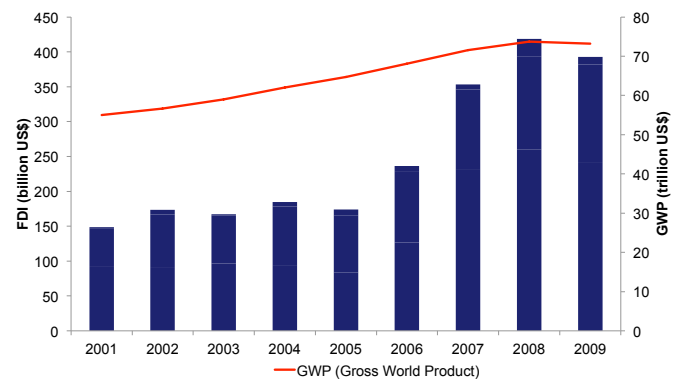
FDI flows have markedly outpaced flows of goods and services. From 1990 to 2006, global cross-border inflows of FDI rose by an average of 12.4% annually, versus 7.7% growth in total exports of goods and services and 5% overall economic growth.¹⁰⁹ Since 2003, FDI flows have grown even faster, by an average of 30% annually.¹¹⁰ FDI has brought millions of jobs, technology transfer, improved skills, greater competition, and stronger fiscal positions to many countries. In coming years, strong growth is expected in the automotive, industrial machinery and equipment, metals and chemicals, renewable energy, and natural resource sectors.¹¹¹ Slower growth in FDI is expected in business services, financial services, and food and beverages.¹¹²

After averaging US\$ 170 billion from 2001 through 2005, FDI inflows for manufacturing more than doubled to an average of US\$ 350 billion from 2006 through 2009 (Figure 37).¹¹³ In 2006–2008, leading into the global recession, the average annual growth rate was 35%.¹¹⁴ In 2010, manufacturing accounted for 26% of global FDI projects.¹¹⁵ Manufacturing FDI projects generated 1.1 million jobs in 2010, an increase of 25% over the previous, admittedly sluggish, year.¹¹⁶ For manufacturers making these investments they are typically seeking new market opportunities and/or operational efficiencies. Often they are looking to mitigate cross-border trade barriers. FDI can also be about strategic positioning relative to competitors.¹¹⁷ It is another example of the larger trend of value-chain fragmentation – the desire to locate the constituent components in their optimal environment.¹¹⁸

Global manufacturing companies are sitting on large cash reserves

By slowing spending, the economic crisis left many companies holding cash (Figure 38). India's top 500 companies have cash reserves amounting to US\$ 96 billion.¹¹⁹ The top 100 global manufacturing companies are holding more than US\$ 700 billion in cash and equivalents, up from about US\$ 400 billion in 2005.¹²⁰ Also, cash and equivalents as a percentage of revenue has spiked up to 12% after four years of decline from 2005 through 2008.¹²¹ The opportunity to marry these idle funds with latent manufacturing capacity amid the right conditions – that is, consistent, transparent industrial policy – is readily apparent.

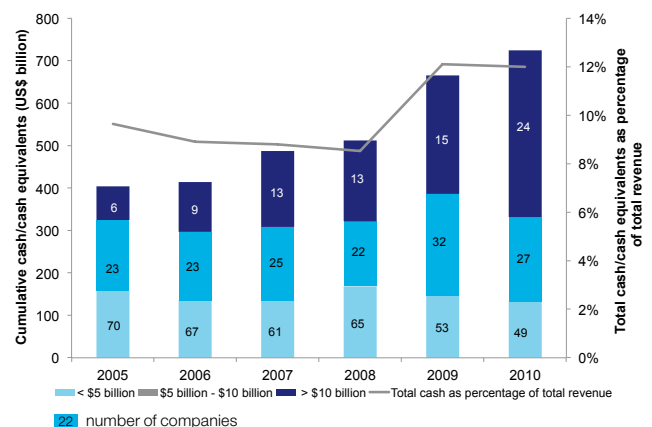
Figure 37: Foreign Direct Investment in Manufacturing (2001–2009)



Note: Total world FDI inflows in manufacturing are estimated averages

Source: UNCTAD; The Conference Board Inc.

Figure 38: Trends in Cash Holdings: Top 100 Global Manufacturing Companies

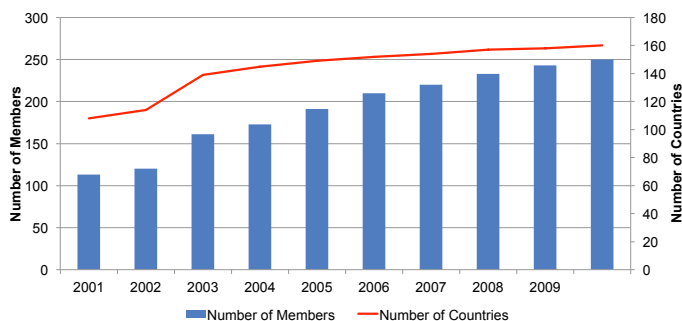


Source: Industryweek. (2012) IW 1000: The World's Biggest Manufacturers. Available at: <http://www.industryweek.com/section.aspx?sectionid=40>

Global competition for FDI is increasing as more countries seek the benefits

The global appetite for FDI in manufacturing remains strong. Few countries are willing to refuse FDI into any sector, with the exception of certain industries, such as media, where there are significant foreign ownership restrictions.¹²² Competition for FDI is increasing. Membership in the World Association of Investment Promotion Agencies has increased by 2.5 times to 250 since 2001 (Figure 39). Countries seek FDI to create jobs, tax revenues, and demand for goods and services domestically. Similarly, by bringing these operations within their borders countries are also supporting the advancement of their labour force's productive capabilities – learning to be more efficient and operate new technologies and systems.

Figure 39: Individual Agency Membership in World Association of Investment Promotion Agencies

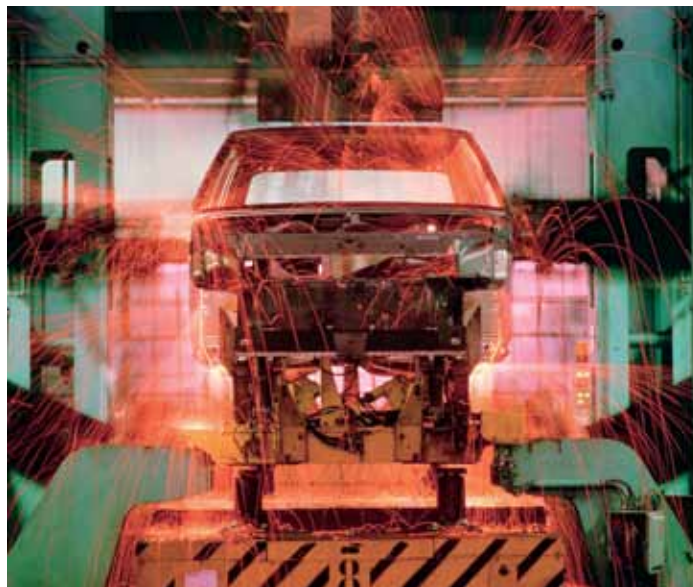


Note: Count of Investment Promotion Agencies is not exhaustive, as not all agencies are members of the WAIPA

Source: World Association of Investment Promotion Agencies. (2012) 2001-2010 WAIPA Annual Reports. Available at: <http://www.waipa.org/reports.htm>

CASE STUDY: The Korea Trade-Investment Promotion Agency (KOTRA) and Invest KOREA

KOTRA acts like many of its global counterparts. Through its investment promotion arm, Invest KOREA, it prepares detailed information on the various benefits of investing in South Korea: market conditions, technology and infrastructure, labour performance, and metrics on quality of life. It also offers incentives in the form of cash grants and site location support. In the latter case, the government secures and develops land that it then leases to foreign companies that meet specific requirements. KOTRA further supports foreign interests by reducing or eliminating rents on state properties and offering the services of project managers to ensure a smooth and rapid settlement in South Korea. According to the organization's annual report, KOTRA's efforts helped attract FDI of US\$ 13 billion in 2010, a 13.8% increase over the previous year. At the same time, global FDI flows increased by a mere 0.7%.¹²³



FDI is also increasingly controversial

Despite the rapid growth and increasing competition for FDI, it is also becoming increasingly controversial. Sovereign wealth funds and other foreign investors are sometimes considered risks to national security, economic prosperity, and even political stability. According to the Council on Foreign Relations, over the last two years, at least 11 major FDI recipients (countries that together received 40.6% of all world inflows in 2006) have approved or are seriously considering new laws that could restrict certain types of FDI, or expand government oversight of cross-border investments.¹²⁴ In many of these countries, high-profile transactions are increasingly disputed. "In February 2008, for example, the joint bid for 3Com Corporation by Bain Capital, a U.S. private equity company, and Huawei, a Chinese technology company, was withdrawn after objections were raised by the US government."¹²⁵ Other examples include the following.

- The Chinese government conducts a rigorous review of many foreign investment transactions, involving five state agencies, and has specific restrictions on news agencies, broadcasting and programming, and mining and processing of certain minerals.¹²⁶
- In Germany, the Ministry of Economics and Technology reviews "certain foreign investments, particularly those from state-owned entities." The reviews largely cover industries directly related to national security (e.g. weapons manufacture) but also include banking, and private television broadcasting among others.¹²⁷
- The Committee on Foreign Investment in the United States, enabled by the Foreign Investment and National Security Act, examines FDI in the interest of national security – a process that has become "much tougher and more regulator." Specific instances of foreign attempts to invest in oil and shipping ports have created backlashes in the US Congress.¹²⁸
- Recent legislation in Russia formalized the evaluation of foreign investment transactions involving companies engaging in activity of strategic importance to the country's defence, national security, and other industries. In several ways the Russian system mirrors its US counterpart, although in addition to national security concerns, specific attention is also paid to economic factors, such as "whether the target company has more than a 35% share of a particular commodity."¹²⁹

Essay – The Benefits Multinational Companies Have Brought to Global Manufacturing

by Matthew Slaughter

Multinational companies have long been central to global manufacturing for several reasons. In dozens of countries, multinational firms have long accounted for an outsized share of manufacturing capital investment, research and development, and exporting. As a result, productivity growth – the only source of sustainable increases in standards of living for any country – has around the world long been faster in manufacturing than in services.

Despite the common assertion that multinationals in manufacturing simply “export job” out of host countries, research has found that expansion abroad by these firms has tended to complement their home-country operations. More international investment and employment in foreign affiliates has to date tended to create more home-country parent investment and jobs as well. One recent study carefully analysed all US multinationals in manufacturing from 1982 to 2004. Each additional US\$ 1 in an affiliate’s employee compensation generated an average increase in its parent compensation of about US\$ 1.11. And each additional dollar in an affiliate’s capital investment generated an average increase in its parent’s investment of about US\$ 0.67.

A distinguishing feature of the integration of the global economy over the past generation has been, paradoxically, the disintegration of manufacturing production. Manufacturing companies increasingly operate within elaborate global production networks in which final products are made in many stages spanning many countries, linked together primarily by the international trade and investment of multinational companies. Several forces – advances in communication technology, fast economic growth in emerging markets – have helped expand global production networks in manufacturing. These networks have benefited not just the multinationals at their core, but also the broader global economy – suppliers, consumers, and workers.

Perhaps the canonical example of the integral role of multinational companies in today’s global manufacturing networks is information technology. About 30 years ago IT firms, thanks both to competition at home and opening borders around the world, began to establish and expand global production networks. Stages of production that had once been bundled now migrated abroad (e.g. hard-disk drives to Singapore) all linked together via international trade and investment. Today the breadth of these IT-manufacturing networks can be best summarized by the words on the back of any sleek iPhone: “Designed by Apple in California, Assembled in China.”

A critical force in solidifying and expanding the globalization of IT production was comprehensive policy liberalization. Signed in 1996, the Information Technology Agreement eliminated over the next decade all tariffs in dozens of signatory countries in hundreds of IT capital goods, intermediate inputs, and final products. Indeed, to this day IT remains the only industry with a comprehensive free-trade agreement in the World Trade Organization.

The globalization of IT hardware driven by multinational companies has helped boost average living standards in dozens of countries. Cause and effect run in many directions between global engagement and productivity. The ITA offers a textbook example of the benefits trade and investment liberalization can deliver: a competitive spur to price declines and productivity gains in firms, benefitting not just the firms themselves but also firms and consumers worldwide via lower prices and new varieties.

The policy challenge multinationals in manufacturing present to government leaders.

The spread of global production networks means that manufactured products made in their entirety in a single country are increasingly rare. It is vitally important that policy leaders have a comprehensive understanding of this reality and the attendant benefits that the global production networks of manufacturing multinationals can bring.

But not all do. Indeed, over the past decade a protectionist drift has emerged towards the foreign direct investment of multinational companies. In 2000, just 2% of all the national FDI policy changes tracked by the United Nations were restricting multinational companies. But this share climbed steadily over the decade, reaching 32% by 2010.

What accounts for this protectionist drift in FDI policy? One important force has been the emergence of new source countries and companies for investment. FDI from non-traditional countries such as China, India, and the Middle East is growing due to sustained, rapid economic growth in these countries, high energy prices, and the ongoing pattern of global imbalances. Government ownership and control of multinational firms has been a second important force behind the protectionist drift. Of the top 100 multinational companies in the world, 19 are government owned – up from five just five years ago. Of the top 100 developing-country multinational companies, 28 are government-owned. Third, foreign investment is increasingly flowing to more sensitive sectors of the economy, including assets considered “critical infrastructure” like ports, airports, energy and telecommunications. And fourth, the severity of the world financial crisis and related great recession has compelled many governments to protect domestic “national champions” against foreign competitors.

What might be the consequences of new FDI restrictions? In a growing number of countries and industries, new FDI restrictions have led to some proposed transactions being denied – and have also deterred other potential investments through a less-visible but still important “threat” effect. They have also impaired the quality of many transactions as well. New policies that mean longer, more complex, and more regulated transactions can mean deals of lower economic value.

Leaders of national governments that want to boost the standard of living for their citizens are thus confronted with an increasingly important challenge. The multinational companies at the heart of manufacturing’s ever-widening global production networks have ever-widening choices for where to locate their high-knowledge, high-innovation, high-wage jobs and related activities. To attract and retain these companies, government leaders cannot just liberalize FDI policies in terms of market access and national treatment. Rather, they must go far beyond traditional FDI-policy considerations to meet a deeper set of national-competitiveness issues critical to the success of these companies: worker skills, public infrastructure, efficient immigration, and corporate taxation.

Government leaders who can provide to global multinationals a constellation of competitive strengths – high and rising worker skills, efficient and modern infrastructure, simple and low-burden taxation – will be leaders whose countries create and expand key nodes in world manufacturing. Doing this amidst the spreading protectionist pressures will require imagination and courage not unlike the imagination and courage that spawned the ITA and all its benefits.

Matthew J. Slaughter is the Associate Dean of the MBA Program and the Signal Companies’ Professor of Management at the Tuck School of Business at Dartmouth. He is also currently a Research Associate at the National Bureau of Economic Research; a Senior Fellow at the Council on Foreign Relations; a member of the academic advisory board of the International Tax Policy Forum; an academic advisor to the Deloitte Center on Cross-Border Investment; and a member of the U.S. State Department’s Advisory Committee on International Tax Policy Forum.

Competition for Earth's Materials Resources Will Drive Scarcity and Innovation

Growing materials resources competition and scarcity will fundamentally alter country and company resources strategies and competition, and serve as a catalyst to significant materials sciences breakthroughs

In the short term, countries and companies react to rising scarcity and prices of materials, such as rare earth elements, by stockpiling or hedging. In the longer term, success will be marked by discoveries of alternative elements, breakthroughs in materials sciences, and more efficient practices governing the use of materials.

As demand increases, competition for Earth's resources will intensify

Some resources will be under more pressure than others. Of particular interest are the rare earth elements (REEs) and other materials elements that are critical to making high-tech, energy-efficient, and stronger products such as wind turbines, solar energy collectors, and electric cars. While the 17 elements that comprise the group of REEs are a main focus, they are not the only elements from the periodic table that are critical to these types of products. Other elements including platinum group elements and elements with photovoltaic conductivity properties are important to high-tech, energy-efficient, and stronger products, such as lithium, cobalt, gallium, indium, and tellurium, which are considered critical.¹³⁰ The term "rare earth" may be somewhat misleading, because not all of these elements are necessarily scarce but are elements that are more difficult or expensive to extract from the Earth. It is perhaps more accurate to think of REEs and the other materials resources in terms of criticality.

New products are driving the demand for critical elements today

A sampling of the products using critical elements shows how strong demand is likely to grow.

1. **High-tech products:** Computer hard drives, mobile phones, cameras, portable X-ray units, flat-panel displays, and fibre-optic data transmission rely on critical elements in increasingly large quantities. Intel estimates that computer chips contained 11 mineral elements in the 1980s, 15 elements in the 1990s, and may rely on up to 60 elements in the coming years. General Electric reports that its products use 70 of the first 83 elements in the periodic table. As new technologies and engineered materials emerge, so does the prospect of rapid spikes in demand for some minerals that had previously found only limited use.¹³¹
2. **Energy-efficient products:** Products such as stadium lights, energy-efficient light bulbs, glass additives, hybrid electric motors and batteries, and wind turbines are more prominent as countries work to address energy efficiency goals and reduce their carbon footprints. The current crop of more efficient, spectrally complete, and visually pleasing lamps uses phosphors containing different concentrations of lanthanum, cerium, europium, terbium, and yttrium to achieve various lighting effects. Phosphors represent a significant portion of the cost of an LFL (linear florescent lamp, commonly used in industrial or commercial buildings) or CFL (compact florescent lamp, designed for residential buildings). Phosphors accounted for 7% of all REE usage by volume and 32% of the total value in 2008.¹³²
3. **Stronger products:** These include products used in defence, such as micro-alloyed steels, superalloys, and air and space vehicles and parts, but also medical and dental products and glass additives.

Criticality of materials resources defined

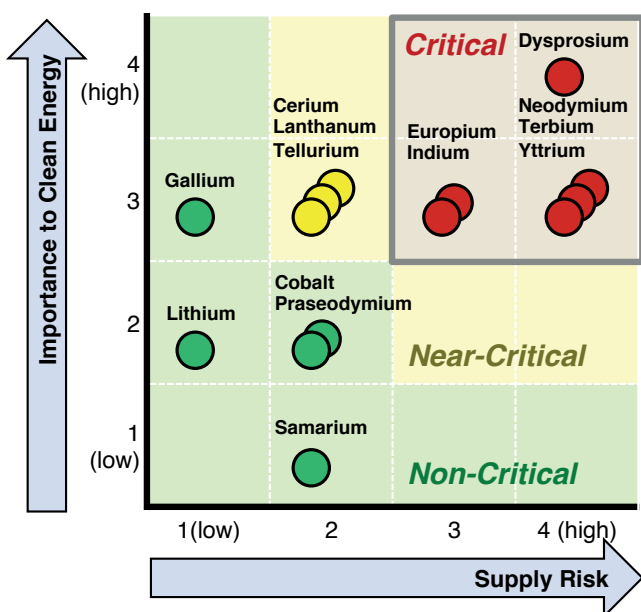
Criticality of material resources depends on the importance of their use, supply risk, and long-term developments. Importance is a function of whether there is demand for the material; those resources with few or no practical substitutes are clearly more important. Supply risk comes into play through availability, demand (a new use may overwhelm suppliers, especially when the material is a by-product), political factors (although even in a stable political environment, a single producer can become unreliable), and producer diversity (risk is higher when production is too concentrated). Finally, long-term developments – how long an element will be in demand, how many new sources are found, etc. – will also affect competition for materials (Figure 40).¹³³

Criticality impacts pricing and response strategies

Price fluctuations reflect the changing demand for critical resources. In fact, rare earth prices increased from about US\$ 10 per ton in 2009 to almost US\$ 60 per ton in 2010 as a result of Chinese government policies to restrict supply, a rebound in demand following the financial crisis, and consolidation of production and marketing channels.¹³⁴ Recent history focused on rare earths also highlights companies' reactions to decreased availability of a resource in demand. When availability is threatened, new sources are pursued.

Today, China dominates the REE market, supplying 95% globally. Control is tight, with the Chinese government implementing tax, quota, and administrative measures to keep prices for REEs at record highs.¹³⁵ It is precisely this tight control, which is leading many to view China as a risky supplier, that may prove the undoing of the near monopoly it has today of supplying REEs. Interestingly, only 37% of the estimated global supply is in China (Figure 41).¹³⁶

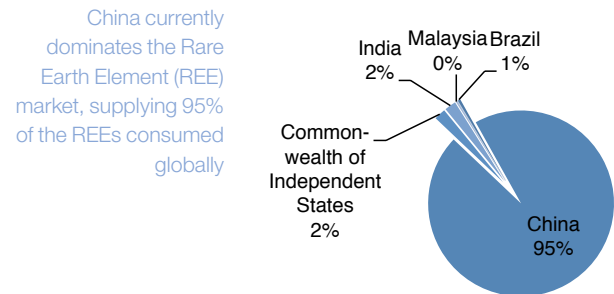
Figure 40: US DOE Critical Material Assessment Short Term (2010-2015)



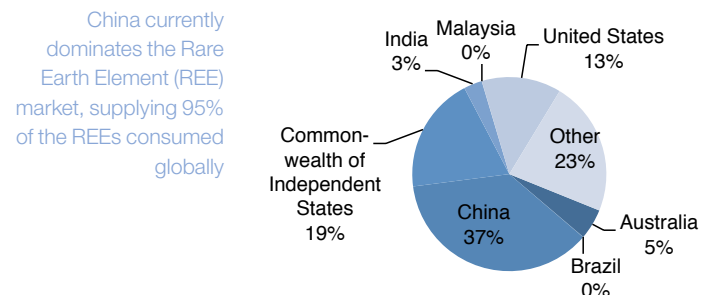
Source: US Department of Energy. (2010) Critical Materials Strategy. Available at: <http://cr.aiag.org/files/criticalmaterialsstrategy.pdf>.

Figure 41: Rare Earth Reserves

Per cent of REE Global Production as of 2009



Per cent of REE Global Reserves as of 2009

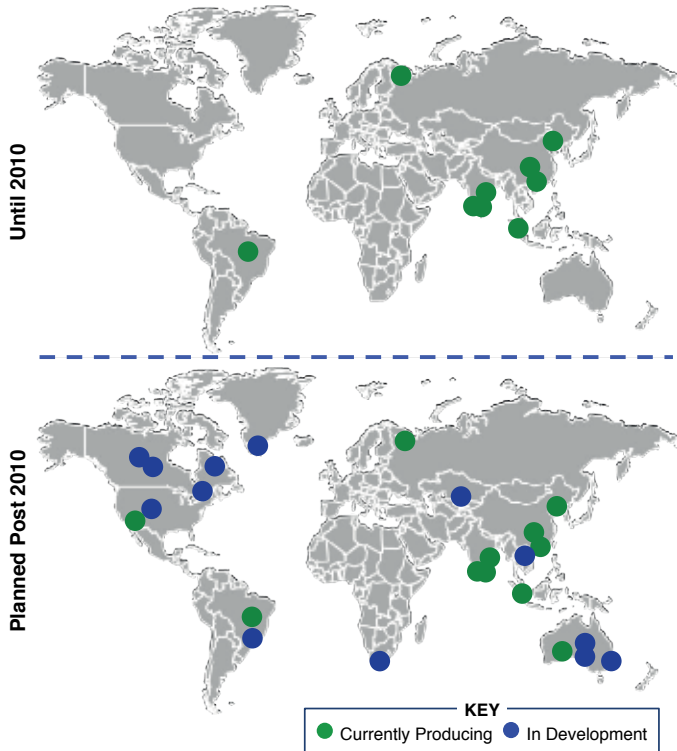


Source: Deloitte analysis based on:

Long, K.R., Van Gosen, B.S., Foley, N.F. & Cordier, D. (2010) The Principal Rare Earth Element Deposits of the United States – A Summary of Domestic Deposits and a Global Perspective. U.S. Department of the Interior, U.S. Geological Survey. Available at: <http://pubs.usgs.gov/sir/2010/5220/>.
Chen, Z. (2011) Global rare earth resources and scenarios of future rare earth industry. Journal of Rare Earths, 29(1):

In response to China's market dominance, many companies – both traditional miners and others who depend on REEs – are entering the business of producing rare earths. The number of mines is increasing dramatically, with over 200 projects under preparation and exploitation (Figure 42).¹³⁷ However, development of REE mines can take upwards of 10 years. Before the shovels can come out, there is a long process of prospecting, exploration, process development, feasibility studies, permits, construction, and commissioning.¹³⁸ Because the availability of the rare earths will not be eased immediately, companies must develop short- and long-term solutions to address the need for critical resources.

Figure 42: Increased Opening of Rare Earth Mines

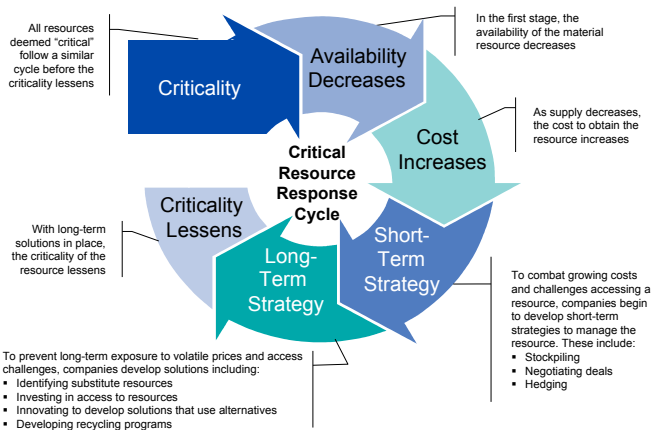


Source: Journal of Rare Earths, Science Direct

The status of a critical resource adjusts until eventually innovation eases criticality

Critical resources tend to follow a path of decreased availability and increased prices until innovative solutions are developed to lessen the need. The critical resource response cycle shows that material resource criticality drives innovation – the long-term strategy is almost always to find a substitute and find innovation (Figure 43). In reaction to the challenges early in the cycle, companies look for ways to avoid using the material resource. This opens the door for material science innovation.

Figure 43: Critical Resource Response Cycle



Source: Deloitte analysis

Innovation eases criticality

History has shown time and again that companies will proactively rethink production inputs and leverage ongoing scientific advancements, innovating in response to the need for a critical resource. Depending on which material resources are critical to a company's production, companies are reacting and innovating in various ways, including developing alternatives to the use of a critical resource and using recycling to decrease need for new sources.

Because critical elements are prominent in the hybrid-electric vehicles that are increasingly demanded in the market, Toyota and General Electric have taken different approaches to combating the challenge of using a critical resource. Toyota uses neodymium magnets in some of its vehicles, but has seen the price of this element skyrocket to US\$ 455 per kilogram from US\$ 19.45 in 2009. To counter this cost, Toyota entered into a joint venture with Tesla Motors to supply a RAV4 motor and battery pack that does not rely on permanent magnet technology. Engineers are also in the advanced stages of development of a more efficient induction motor than that being currently used in the hybrid Prius.¹³⁹

Another option is recycling. To counter the 10-fold increase in the price of rhenium, which helps steel retain its shape under high force and temperatures, General Electric started a global recycling partnership with other jet-engine makers to decrease the need for new materials and superalloys. The company also conducted research that identified the ability to adjust the mix of elements used in its jet engine blades to cut the rhenium content from 6% to 3%.¹⁴⁰ Proactive companies could look to identifying long-term strategies as soon as a material resource is identified as critical to shorten the time frame when the company has to react to decreased availability and high costs.



Toshiyuki Shiga, Chief Operating Officer, Nissan Motor Co., and Bob King, President, United Auto Workers (UAW) share comments in Davos-Klosters

Affordable Clean Energy Strategies will be a Critical Competitive Differentiator

Affordable clean energy strategies and effective energy policies will be a top priority for manufacturers and policy-makers and serve as an important differentiator of highly competitive countries and companies.

Demand for and cost of energy will only increase with future population growth and industrialization. Environmental and sustainability concerns will demand that nations respond effectively and responsibly to the future energy challenge. All nations will seek competitive energy policies that ensure affordable and reliable energy supply for all manufacturing sectors and will be forced to seek new ways of manufacturing, from energy efficient product designs to energy efficient operations and logistics. Collaboration between company leaders and policy-makers will become an imperative to solve the energy puzzle.

As the global population grows, demand for all forms of energy will continue to expand

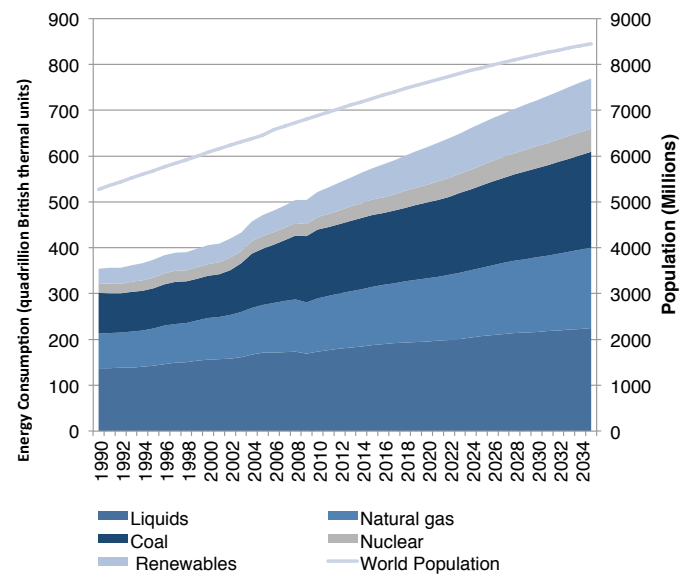
In 1990, total world energy consumption ran to about 354 quadrillion Btu. By 2035, the US Energy Information Administration expects world energy consumption will more than double to roughly 770 quadrillion Btu (Figure 44).¹⁴¹ In fact, the growth in energy consumption is expected to outpace population growth.

As emerging countries mature, consumption of energy is rising

One reason for the high growth in energy consumption is emerging countries (non-OECD nations) are consuming more energy as they make the shift to developed (OECD nations). Because economic development tends to be tied to growth in manufacturing, energy use is growing especially in the industrial sector. Industrial sector energy consumption, which already accounts for close to a third of total energy consumption worldwide, is expected to grow 50% by 2035, with 70% of that growth driven by emerging countries. By the same year, emerging economies will consume 71% of total delivered energy in the global industrial sector.¹⁴²

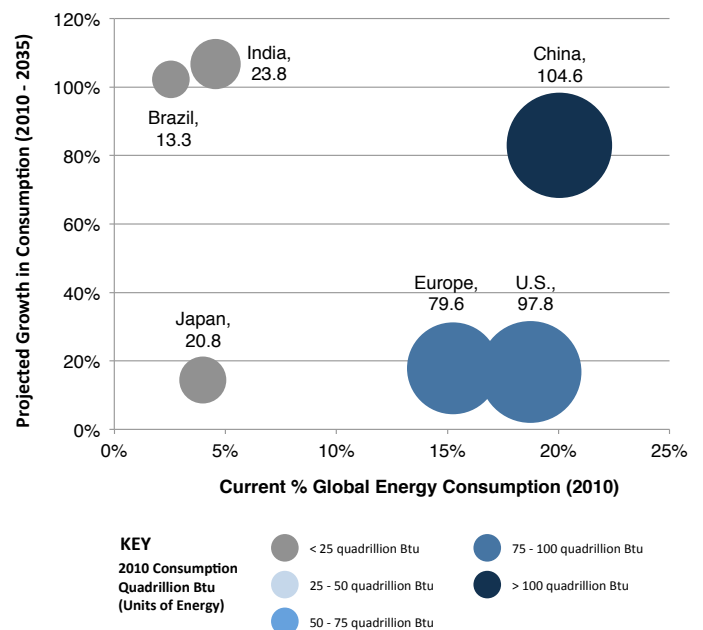
China is projected to be the largest driver of energy consumption growth (Figure 45). Currently accounting for 20% of global energy consumption, China is expected to become the world's largest consumer over the next 25 years. Meanwhile, energy use by developed countries is projected to continue to be relatively stable, increasing only 14% from 2005 to 2035.¹⁴³

Figure 44: World Energy Consumption Growth



Source: Deloitte analysis based on data from the U.S. Energy Information Administration (EIA) and World Bank

Figure 45: Energy Consumption by Country



Source: Deloitte analysis based on data from the US Energy Information Administration (EIA)

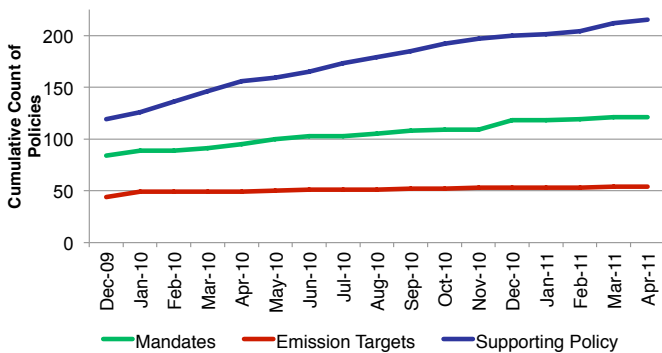
Emerging economies are projected to use more traditional fossil fuels, driving future growth in that fuel segment

The industrial sectors of emerging countries are projected to increase their use of liquid fossil fuels by 50% and of coal by 63% between 2008 and 2035.¹⁴⁴ Meanwhile, developed countries are expected to slightly reduce their dependency on liquid fuels and only marginally increase their use of coal. The challenge is the growth in the use of oil and coal, which are not only relatively expensive, but dirty. The push for renewables is in part a reaction to this challenge.

Growth in global energy consumption has led policy-makers to take an increasingly active role

Recent years have seen a steady increase in the number of climate policies, with over 390 policy announcements made globally since July 2008 (Figure 46).¹⁴⁵ Like companies, governments are interested in reducing energy usage, although they are also motivated by the need to reduce energy-related carbon emissions. At Copenhagen in 2009, countries made non-binding pledges to cut emissions and mitigate climate change, and over 80 countries submitted voluntary targets, action plans, or letters of commitment before the 31 January 2010 deadline.¹⁴⁶ Many governments have been active in trying to develop alternatives to carbon-producing energy. Globally, renewable-energy subsidies increased from US\$ 39 billion in 2007 to US\$ 66 billion in 2010.¹⁴⁷ Some view recent policies as inadequate to meet government pledges and mandates, and more measures may be taken to push the issue.¹⁴⁸

Figure 46: Increase in Global Climate Change Policy Announcements since 2009



Source: Deloitte Analysis based on data published by Deutsche Bank Climate Change Advisors Global Climate Change Policy Tracker 2011

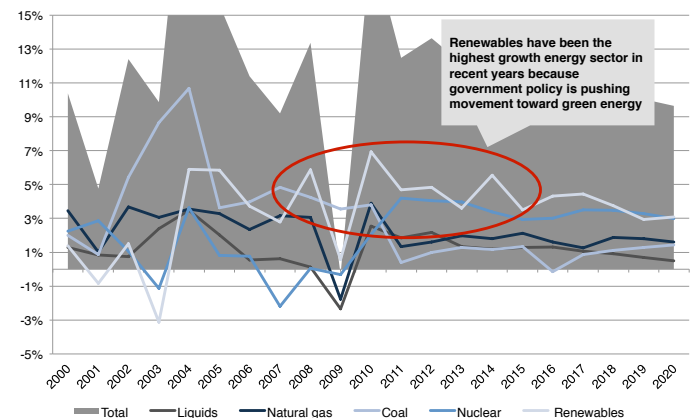
Renewables will be the highest-growth energy sector

Due in part to government subsidies, renewable energies, led by hydro and wind, are projected by the International Energy Agency to account for half of the new capacity installed between 2010 and 2035 to meet growing demand (Figure 47). Despite being expected to grow faster than any other source in relative terms, total supply of renewable energy is still not projected to reach the level of any single fossil fuel by 2035.¹⁴⁹ This has not discouraged the government of China from implementing policies that have made China the world leader in renewable energy, with 2010 investments reaching US\$ 48.9 billion (in comparison, all of Europe invested US\$ 35.2 billion and North America invested US\$ 30.1 billion in the same year).¹⁵⁰

Rising energy prices are making energy costs and consumption a top priority for manufacturers

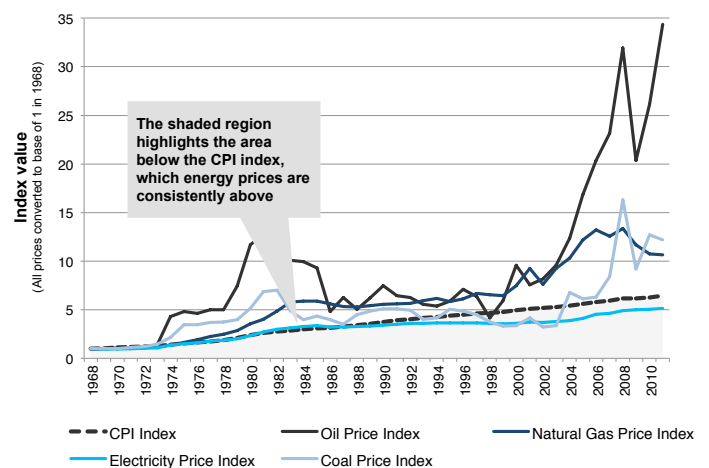
As energy consumption rises, prices are also rising at a faster rate than inflation. The price of oil, for example, grew at four times the Consumer Price Index in 2010. Natural gas and coal also outpaced inflation (Figure 48). For companies, energy costs are taking up a bigger portion of overall costs.

Figure 47: Annual Increase in World Energy Consumption by Fuel Type



Source: Deloitte analysis based on data from the U.S. Energy Information Administration (EIA)

Figure 48: Fuel Price Indices Increase Well Above Rate of Inflation



Source: Deloitte analysis based on data from the US Energy Information Administration (EIA) and World Bank Commodity Data.

The importance of managing energy consumption is clear for manufacturing companies. As energy costs escalate, reducing energy consumption is particularly critical for high-energy use sectors, those with a greater than 20% energy cost per dollar of value added.¹⁵¹ With an eye to future pressures, many companies that fall into this category have taken steps to cut energy use. Oil refineries have cut energy use by 30% since 1973. In the steel sector, where energy accounts for 15 to 20% of the cost of the end product, energy costs have been reduced by 45% since 1975. Recycling and waste-to-energy programmes have authored similar stories for aluminium and cement manufacturers.¹⁵²

Energy will be a key consideration in the way a company designs its products and supply chains and manages its operations

By reducing energy consumption through efficiency gains, companies can offset growing energy costs and decrease future energy dependence (Figure 49).

To this end, companies have a few options, including the following.

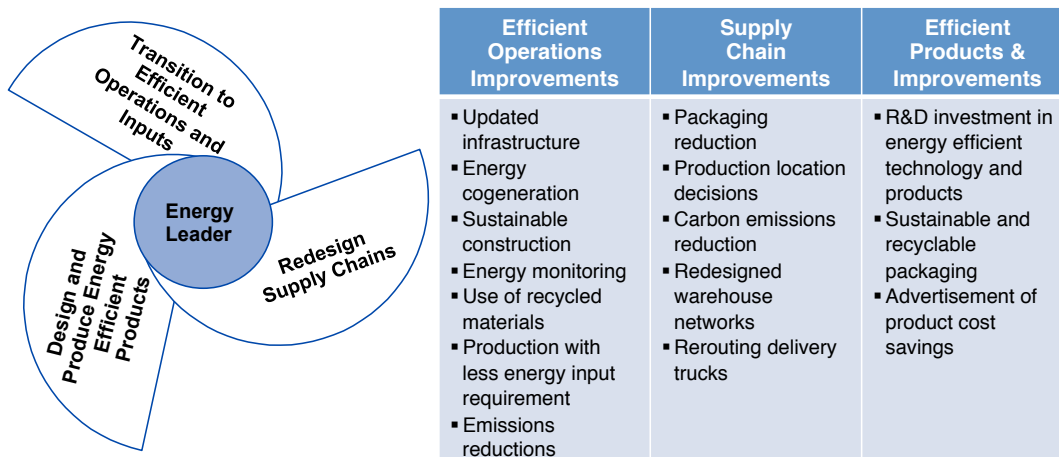
1. Companies can make their operations more efficient by installation of updated equipment, energy cogeneration, sustainable construction, energy monitoring, use of recycled materials, and choosing production methods that require less energy input. Unilever has won accolades internationally for its transition to energy efficient and sustainable business practices, which also improved the bottom line by reducing energy costs. A new aerosol manufacturing site in Mexico has solar lighting and heating, a water reuse system and high-efficiency equipment to achieve a 25% reduction in CO2 and a 40% reduction in water consumption per tonne of production compared to existing aerosol production sites. Unilever has been on a path to reduce energy use since 1995, and has set targets to continue that reduction through 2020, including a plan to meet 40% of its energy needs with renewables.¹⁵³

2. Companies may target supply chain improvements, such as packaging reduction, relocating production, and delivery rerouting (whether internally or externally by working with suppliers). Examples abound. Chocolate makers Hershey and Ferrero have entered into a North America-wide alliance to share warehousing, transportation, and distribution, meaning fewer trips to deliver their products.¹⁵⁴ Initiatives can extend to suppliers. In another example, after calculating that its suppliers produced five times the carbon footprint of its internal operations, UTC developed guidelines for suppliers that aim to reduce energy consumption.¹⁵⁵
3. Improving products to perform more efficiently not only helps a company to save money, but increases demand for the product among consumers. This can range from sustainable and recyclable packaging to energy-efficient products, such as those developed by P&G, Phillips, and Apple, which allow consumers to use less energy. P&G's advances in laundry detergent powder compaction have yielded transportation, retailer, and consumer benefits. After the entire portfolio of US and Canadian carton powder laundry detergents was compacted by 33%, the reduced packing required enabled a 6% reduction in the number of delivery trucks and 5% to 8% less fuel for transportation. The 28% less corrugates saves retailers shelf space and reduces the pallet and carton size. Finally, the product is a hit with customers. Not only did consumers react positively to the product being lighter to carry and easier to store, but consumers using the Coldwater formula can save 80% of the energy use per load of laundry.¹⁵⁶



Andrew N. Liveris, Chairman and Chief Executive Officer, The Dow Chemical Company shares his insights in Davos-Klosters

Figure 49: Energy Efficiency Solutions Framework



Source: Deloitte analysis

Competition to Innovate Escalates for Countries & Companies

The ability to innovate, at an accelerated pace, will be the most important capability differentiating the success of countries and companies in the future

Compared to their counterparts, companies regarded as more innovative and countries more successful at fostering innovation perform better, whether looking at market share or profitability for companies or growth in GDP or GDP per capita for nations. Companies must innovate to stay ahead of competition, and must be enabled by infrastructure and a policy environment that better supports breakthroughs in science and technology and investment budgets that permit dedicated pursuits. In the 21st century manufacturing environment that has emerged out of rapid globalization, being able to develop creative ideas, addressing new and complex problems, and delivering innovative products and services to global markets will be the capabilities most coveted by both countries and companies.

Innovation and a country's prosperity are tightly linked

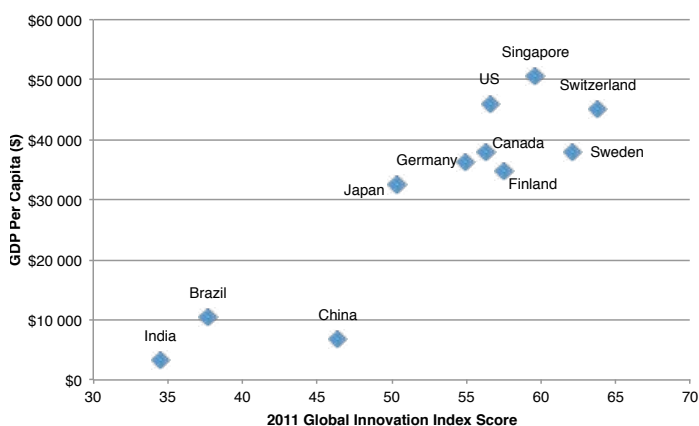
Innovation is becoming increasingly important as the challenges that confront mankind in the 21st century (e.g. increased competition for earth's resources, energy and carbon challenges, rising population and social needs) continue to grow. Innovation is a central driver of economic prosperity, development, and job growth. It is the key that enables firms to successfully compete in the global marketplace, and the process by which solutions are found to social and economic challenges ranging from climate change to disease.¹⁵⁷

An examination of INSEAD's Global Innovation Index shows that there is a strong relationship between innovation and GDP per capita (Figure 50). Switzerland tops the 2011 Global Innovation Index and has a GDP per capita that trails only the United States and Singapore, while Brazil ranked 47th in the 2011 Global Innovation Index and has a GDP per capita greater than India and China but significantly lower than developed economies.

Switzerland has a long history of being an excellent place for innovation. It is no surprise that innovative industries contribute more than one-third of Swiss GDP and, over the past 10 years, grew at better than twice the rate of other industries in the country. The culture of innovation is marked by aggressive patenting, excellent universities and research institutes, a productive workforce with a deep-rooted proclivity for lifelong development, and a high standard of living, including conveniences such as an advanced transportation sector.¹⁵⁹

In comparison, Brazil lags other countries in a number of categories, including, high tech imports and quality of tertiary science and engineering education programmes. However, recognizing its importance to prosperity, Brazil is taking a number of steps to foster innovation, with new training programmes meant to develop science, technology, and innovation policy professionals. Brazil recently passed a new Patent Act and acceded to the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS).¹⁶⁰

Figure 50: Innovation Index Score and GDP Per Capita (US\$) by Country



INSEAD computes the Global Innovation Index scores based on a broad spectrum of indicators encompassing both direct investment levels (e.g. R&D spend per capita) and indirect (or intangible or innovation-enabling) factors (e.g. political stability and education).

Source: Dutta, S. ed. (2011) The Global Innovation Index 2011: Accelerating Growth and Development. Available at: http://www.globalinnovationindex.org/gii/GII%20COMPLETE_PRINTWEB.pdf. Pg. 18-19, 41-44.

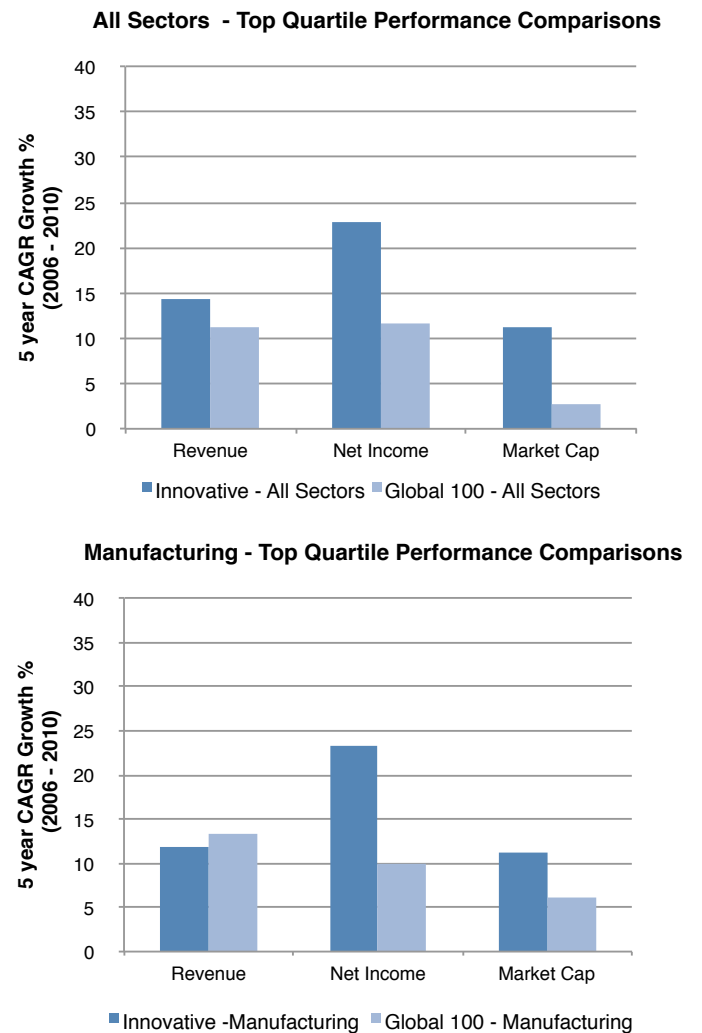
Innovative companies consistently outperform their peers

Comparison of the 2011 Forbes Most Innovative Companies versus their Global 100 sector peer groups across a set of key financial performance indicators, including growth rates for revenue, net income and market cap, demonstrates that innovative companies are on average more successful than their peers. Looking specifically at the manufacturing sector, innovative manufacturers lag in revenue growth but far outpace peers in net income growth, suggesting a higher quality of revenue for innovative companies, and they outpace their peers on market capitalization, suggesting investors recognize and reward their innovative ways (Figure 51).

Country and company quest for innovation is accelerating

Company and country focus on innovation is intensifying as CEOs and policy-makers move innovation to the top of corporate and country agendas. In a 2011 survey, 29% of CEOs indicated that innovation would be the top growth driver for their organizations, up from 14% in 2007.¹⁶¹ Country-level focus on innovation is evident in the growing number of national innovation strategies. In 2010 the OECD launched its own innovation strategy and urged countries to continue investments in innovation to drive recovery and address global challenges.

Figure 51: Top Quartile Performance Comparisons (Manufacturing vs. All Sectors)



Source: Deloitte analysis of data extracted from CAP IQ in October 2011.

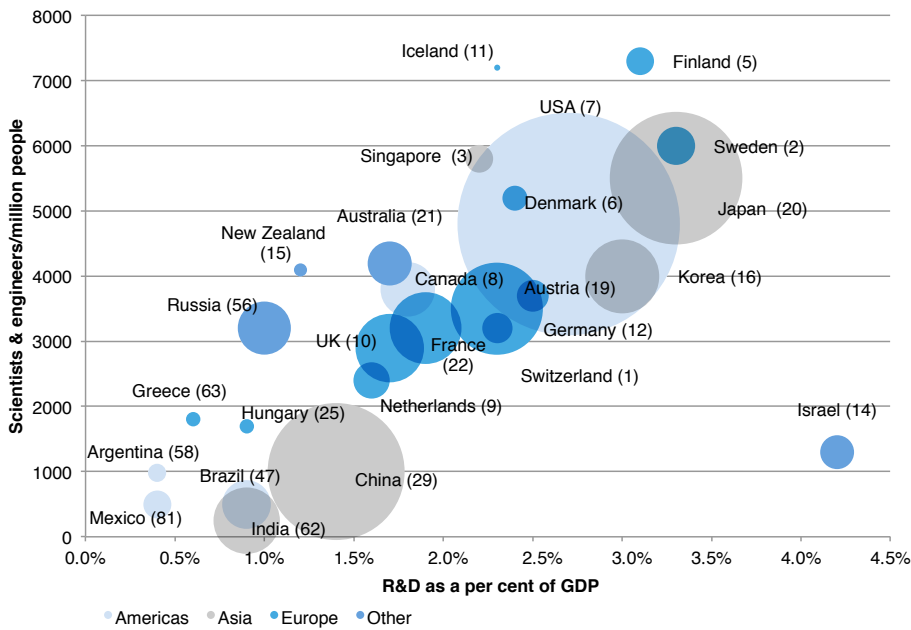
Forbes. (2012) The World's Most Innovative Companies. Available at: <http://www.forbes.com/special-features/innovative-companies-list.html>

R&D spend is important, but does not guarantee innovation

As countries and companies have pursued innovation, it has become clear that R&D spend is an important element, but not the sole driver, of innovation. Other factors such as quality of educational system, infrastructure and policy environment are critical factors to national innovation effectiveness. At the country level, neither absolute R&D spend nor R&D as a percentage of GDP are effective predictors of innovation effectiveness. Despite relatively low absolute R&D spends, Switzerland and Sweden are considered among the most innovative countries. Meanwhile, China has the second-largest absolute R&D spend, but placed 29th on the Global Innovation Index (Figure 52).

Figure 52: R&D Spend by Country

The diameter of each circle represents the relative annual R&D spend by country. The number in the parentheses represents the innovation ranking on The Global Innovation Index, INSEAD 2011.

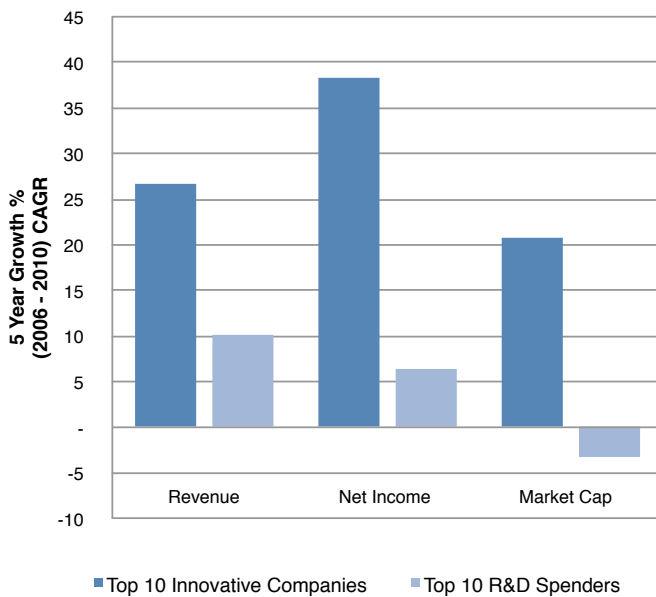


Sources: Dutta, S. ed. (2011) The Global Innovation Index 2011: Accelerating Growth and Development. Available at: http://www.globalinnovationindex.org/gii/GII%20COMPLETE_PRINTWEB.pdf. Pg. 18-19
 R&D Magazine. (2010) 2011 Global R&D Funding Forecast. Available at: <http://www.rdmag.com/Feature-Articles/2010/12/Policy-And-Industry-Government-Funding-2011-Global-RD-Funding-Forecast/>

Historically, global innovation has been dominated by developed nations, but the landscape will likely shift, given emerging nations' increased focus and investment levels. China's R&D investment growth is outpacing that of other nations and is expected to accelerate. China and India are pursuing collaborative research programmes that include government, academia, and industrial companies. Meanwhile US, European and Japanese spending is expected to decline.

From a corporate perspective, implementing organizational structures and processes designed to foster innovation and a willingness to collaborate with outside partners (suppliers, customers, research labs, etc.) combined with R&D spend, drive innovation. An analysis comparing top innovators to R&D spenders shows that the top 10 innovators in manufacturing significantly outperformed the top R&D spenders (as a percentage of revenue) on all key financial performance measures (Figure 53).

Figure 53: Manufacturing: Top 10 Innovators vs. Top 10 R&D Spenders



Sources: Deloitte analysis of data extracted from CAP IQ in October 2011.
Forbes. (2012) The World's Most Innovative Companies.
Available at: <http://www.forbes.com/special-features/innovative-companies-list.html>

The concept of disruptive innovation provides some insight as to why R&D does not translate directly into innovation success. Disruptive innovation is often characterized by the application of an existing technology to solve a problem, rather than an advanced technological breakthrough. It is finding simple solutions to what appeared to be complex problems. For instance, in recent years, Indian agriculture has been transformed by existing mobile phone technology; firms have developed a broad range of applications that address longstanding needs from enabling remote start water pumps that save water, electricity and time to a text message and photo platform that allows farmers to save diseased crops through communication with experts.¹⁶² This type of innovation often has business model implications (i.e. a change in service delivery or focusing on an “undesirable” customer segment) and therefore, tends to have a longer lifespan and be more difficult to replicate.

Common components to successful national innovation efforts are emerging

Innovation entails investment in a range of complementary assets beyond R&D such as software, human capital and new organizational structures. Successful innovators are pursuing multifaceted strategies balancing between direct and indirect investments. They include the following.

- **Attracting and retaining high-quality researchers:** To this end, tiny Singapore adopted a pro-immigration stance that expedited work visa processes for foreign professionals. The country has implemented programmes to attract the best scientists (domestic and foreign) to national labs.
- **Developing science and engineering talent:** In India, a five-year plan launching in 2012 aims to address current skills gaps in innovation. The plan also encourages industry-university collaborations to develop curricula for grooming graduate engineers and supervisory managers for various facets of manufacturing.¹⁶³
- **Funding R&D initiatives that align with the nation's strategic priorities:** In China, investments of 10 trillion rmb are being made in strategic sectors such as energy efficiency and environmental protection, next-generation information technology, pharmaceuticals and biotech, high-end manufacturing, new energy, new materials, and new energy automobiles. Using substantial tax incentives and subsidies, the country expects to attract supplemental investment from private and foreign entities.¹⁶⁴
- **Implementing policies that encourage R&D:** This includes tax code, patent processing and intellectual property protection. Analysis of the effect of R&D tax incentives on private sector research shows a yield in excess of one dollar for every dollar of incentive. What's more, countries offering R&D tax incentives are regarded as a more suitable location for those R&D operations that can be relocated.¹⁶⁵
- **Facilitating collaboration between countries:** French and German researchers are finding common ground through Solarbond, a project to develop reusable substrates to replace expensive materials in solar cells and reduce the cost of production by up to 20%.¹⁶⁶
- **Supporting national research labs:** Excellent examples are Germany's Fraunhofer Institute, a private-public partnership with a mandate of transforming scientific discovery into useful applications, and Taiwan's Industrial Technology Research Institute. In 2011, ITRI again won a Wall Street Journal Innovation award, making it the first organization in Asia to be so honoured three years in a row. The winners – unique technologies ready for commercialization – are chosen from around 1,000 entries each year, based on such criteria as breakthrough importance and revolutionary or evolutionary concepts.¹⁶⁷

Companies are aggressively pursuing innovation through collaboration, structure and polycentric R&D

Partnerships between corporate and academic interests can shorten the path between discovery and commercialization. In 2000, DuPont and MIT joined forces on a US\$ 60 million project to study biotechnology, biomaterials, and catalysis. The alliance has proven successful enough that it has expanded beyond bioscience to other areas.¹⁶⁸

Companies are altering their organizational culture and structure to promote innovation capabilities. Leading companies exhibit a more advanced approach to the ideation phase of the innovation process compared to their less innovative peers, employing advanced customer analytics, deep market insights, and an overall acceptance of open innovation. These companies also exhibit a substantial degree of internal consistency between processes, metrics, reward mechanisms, messaging, and top management behaviour. The most effective pro-innovation organization models destroy the structural silos that usually separate people, ideas, and resources. Instead, they create a high level of cross-boundary connection, conversation, and collaboration.¹⁶⁹

Pursuit of polycentric R&D, a model in which capabilities are distributed globally and integrated into a network, is a widespread practice as 91% of Fortune 1,000 companies report an R&D footprint outside of their headquarter country.¹⁷⁰ Although representation in emerging markets currently lags, 28% of respondents to Ernst & Young’s 2010 globalization survey estimate that that they will spend more than one-quarter of their overall R&D investment in emerging markets five years from now.¹⁷¹

At the same time, emerging market multinationals are eyeing similar investments in the West. “In the future, we will set up innovation centres in the United States and Europe,” says Kris Gopalakrishnan, President and CEO of Infosys “Technology allows you equal access and distance is not a problem.”¹⁷² Cisco is among the companies that have successfully pursued polycentric innovation, launching a business unit in Bangalore to integrate US technology and Indian R&D expertise, while John Deere has developed a low-cost, high-value product line, the 5003 tractor series, entirely based on the needs of the Indian market.¹⁷³

Innovation capabilities will continue to increase in importance, as nations and companies drive toward ever more advanced manufacturing product sets, as well as higher levels of national prosperity and company profitability. More importantly, being able to drive innovation will be necessary just to keep up with peers and competitors. In the 21st century manufacturing environment, being able to develop creative ideas, addressing new and complex problems and delivering innovative products and services to global markets will be the capabilities most coveted by both countries and companies. And what will be essential for innovation to flourish will be access to a workforce capable of driving it.

Competition for Top Talent Intensifies

Talented human capital will be the most critical resource differentiating the prosperity of countries and companies

An estimated 10 million jobs globally with manufacturing organizations cannot be filled today due to a growing skills gap. Despite the high unemployment rate in many developed economies, companies are struggling to fill manufacturing jobs with the right talent. Emerging nations cannot fuel their growth without more talent. Access to talent will become more important and more competitive. The skills gap that exists today will not close in the near future, which means companies and countries that can attract, develop and retain the highest skilled talent – from scientists, researchers and engineers to technicians and skilled production workers – will come out on top. In the race to future prosperity, nothing will matter more than talent.

Talent is a nation’s most critical natural resource

CEOs view talent as key to the success of both companies and countries. In the 2010 Global Manufacturing Competitiveness Index, top executives identified talent-driven innovation as more important than any other single driver of manufacturing competitiveness (Figure 54). Talent-driven innovation is characterized as both the quality and availability of a country’s workers, scientists, researchers, engineers and teachers – who “collectively have the capacity to continuously innovate and, simultaneously, improve production efficiency.”¹⁷⁴

The 2010 index, which is based on survey of over 400 CEOs around the world and dozens of additional in-person interviews, supports the idea that a nation’s skilled workers, scientists and engineers are a greater driver of manufacturing competitiveness than access to low-cost labour.

Figure 54: Drivers of Global Manufacturing Competitiveness

Rank	Drivers of Global Manufacturing Competitiveness	Driver Index Score 10=High 1=Low
1	Talent-driven innovation	9.22
2	Cost of labour and materials	7.67
3	Energy cost and policies	7.31
4	Economic trade, financial and tax systems	7.26
5	Quality of physical infrastructure	7.15
6	Government investments in manufacturing and innovation	6.62
7	Legal and regulatory system	6.48
8	Supplier network	5.91
9	Local business dynamics	4.01
10	Quality and availability of healthcare	1.81

Source: Deloitte and the U.S. Council on Competitiveness. (2010) 2010 Global Manufacturing Competitiveness Index. Available at: http://www.deloitte.com/view/en_GX/global/industries/manufacturing/a1a52c646d069210VgnVCM200000bb42f00aRCRD.htm

Manufacturing companies continue to face a global talent crisis

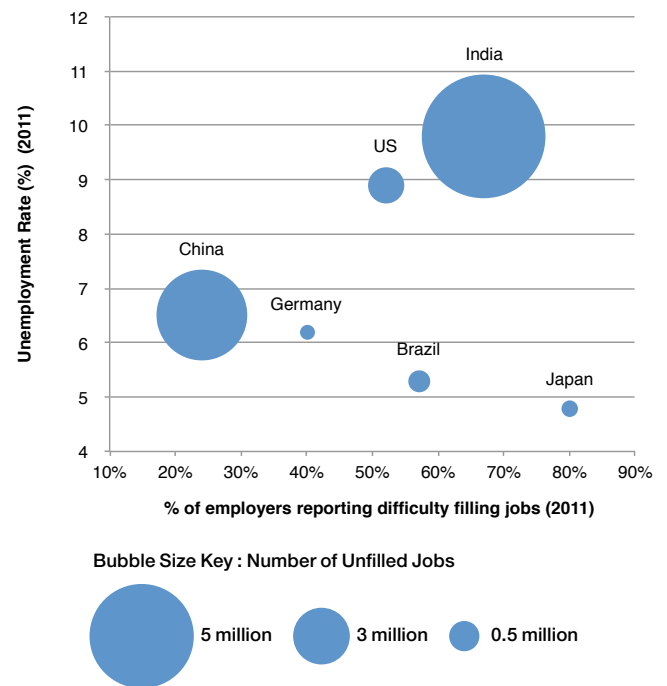
The talent shortage persists as 10 million manufacturing jobs remained unfilled globally, despite significant unemployment rates in many countries (Figure 55). According to Manpower's 2011 survey, 34% of global employers report difficulty filling jobs due to lack of talent, up from 31% in 2010. Employers in Japan (80%), India (67%), Brazil (57%), and the United States (52%) were most likely to report problems finding talent.¹⁷⁵ As a result, employers are delaying or abandoning growth plans, or opting to proceed at higher costs due to the need to hire overqualified candidates or imported labour.

Although many of the unfilled jobs are skilled positions, there is a multiplier effect on adjacent, less-skilled jobs. If a third shift is not running, for example, there is no need to hire unskilled personnel to support the shift.

Stories of shortages abound, including 600 openings for skilled tradespeople at AAR, a Chicago-based aviation parts maker.¹⁷⁶ Indian firms have imported tens of thousands of Chinese workers to build and operate power plants, steel mills and telecommunications towers.¹⁷⁷ Due in part to labour shortages, Brazilian wages and inflation are rising as the country struggles to sustain its rapid growth.¹⁷⁸ *The China Daily* reports that the city of Dongguan, where most of the world's toys are made, is a million workers short, while other Chinese cities have been offering health benefits and housing subsidies to attract workers.¹⁷⁹

Economists warn that the impact of the talent shortage can stall economic progress. In Germany, industry watchers are warning about the need to address staff shortages in mathematics, informatics, natural sciences and engineering before these shortages impede economic recovery.¹⁸⁰ Similarly, there are concerns that insufficient supply of qualified labour in Brazil and India will hamper growth.

Figure 55: Unfilled Manufacturing Jobs by Country



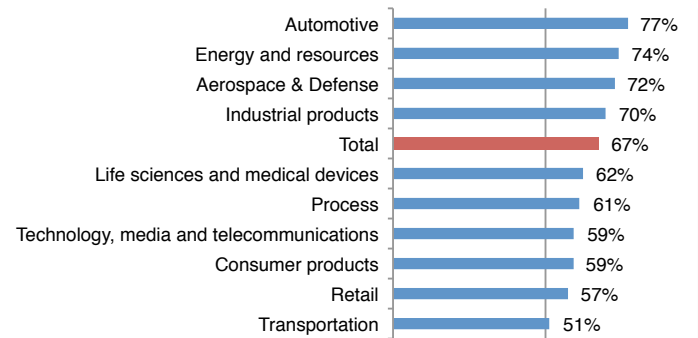
Sources: Deloitte analysis of data extracted from 2011 The Economist Intelligence Unit
 Organisatin for Economic Co-operation and Development. (2012) STAT Extracts: Registered Unemployed and Job Vacancies. Available at: <http://stats.oecd.org/index.aspx?queryid=250>
 BusinessWeek. (2006) How Rising Wages Are Changing The Game In China. March 27. Available at: http://www.businessweek.com/magazine/content/06_13/b3977049.htm
 Latin American Herald Tribune. (2011) Brazil Had 1.6 Million Jobs Go Unfilled in '09. Available at: <http://www.laht.com/article.asp?ArticleId=352367&CategoryId=14090>
 National Skill Development Corporation. (2011) NSDC Skill Gap Analysis Reports. Available at: <http://www.nsdcindia.org/knowledge-bank/index.aspx>
 Deloitte and The Manufacturing Institute. (2011) Boiling point? The skills gap in U.S. manufacturing. Available at: <http://www.themanufacturinginstitute.org/Research/Skills-Gap-in-Manufacturing/2011-Skills-Gap-Report/2011-Skills-Gap-Report.aspx>
 Manpower Group. (2010) Supply/Demand: 2010 Global Talent Shortage Survey. Available at: http://www.manpower.com.tw/pdf/2010%20Global%20Shortage%20Survey%20%20Results_050410_en.pdf. Pg. 11-12
 Manpower Group. (2011) Talent Shortage Survey Results. Available at: <http://us.manpower.com/us/en/multimedia/2011-Talent-Shortage-Survey.pdf>.

Across all sectors, US manufacturers are facing talent shortages in areas most critical to driving innovation

The talent crisis is evident in the United States. According to a 2011 Survey of 1,123 manufacturing executives conducted by Deloitte and the Manufacturing Institute, 67% of US-based manufacturers are reporting a moderate to severe shortage of available, qualified workers and 56% anticipating the shortage to grow worse in the next three to five years.¹⁸¹ The volume of available candidates due to the high unemployment rate has not improved the talent shortage as 5% (or 600,000) of manufacturing jobs remain unfilled simply because employers cannot find people with the right skills.¹⁸²

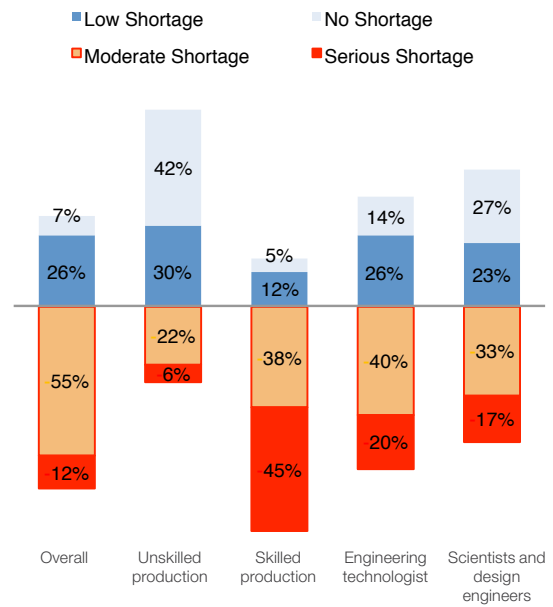
All sectors are impacted by the skills gap but automotive, energy, aerospace and defence, and industrials are showing greater than average difficulty filling jobs (Figure 56). The greatest shortages are evident among skilled production workers, technologists, scientists and design engineers (Figure 57). This is concerning, but not surprising, as these are the job types that are traditionally among the hardest to find existing talent to fill as they are the most critical to driving innovation, have the biggest impact on performance and require the most training. The chief executive of Caterpillar recently said that the company’s difficulty finding qualified hourly production staff, technicians, and engineering personnel is “hurting our manufacturing base in the US.”¹⁸³

Figure 56: US Companies Facing Shortages by Sector



Source: Deloitte Analysis of 2011 Skills Gap Survey, Deloitte Development LLC and The Manufacturing Institute

Figure 57: US Manufacturing Shortage of Workers by Job Type



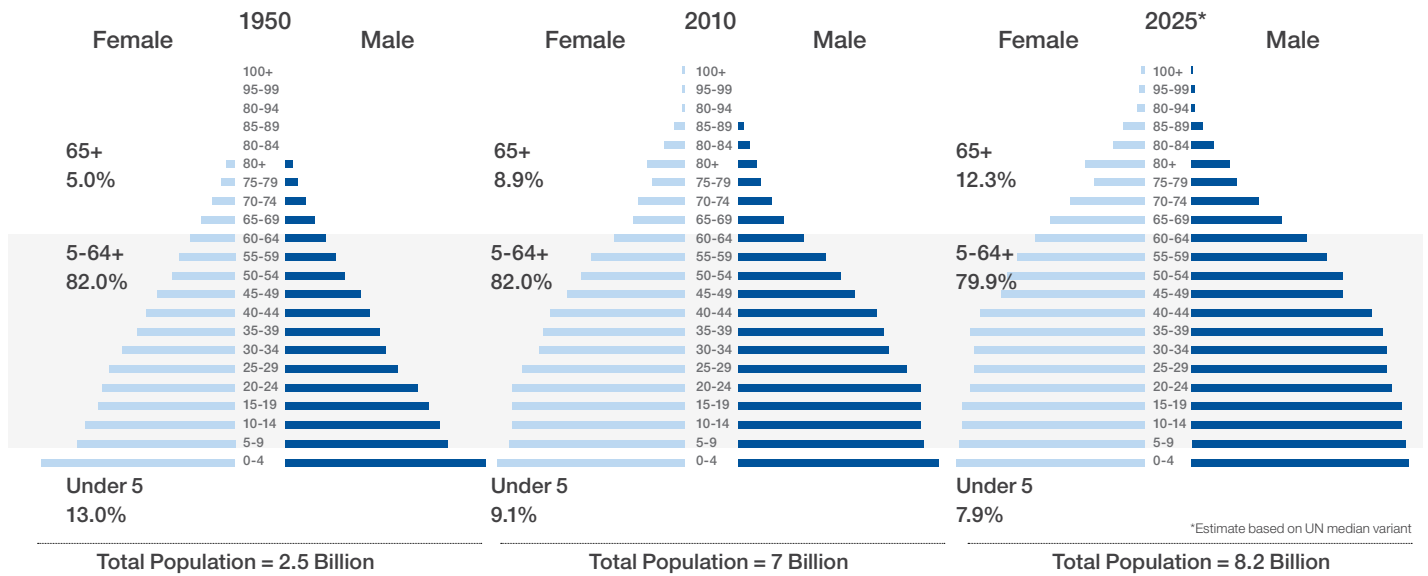
Source: Deloitte Analysis of 2011 Skills Gap Survey, Deloitte Development LLC and The Manufacturing Institute

The ageing global population will exacerbate the talent shortage

The talent shortage is the result of both the skills mismatch, and shifting global populations that result in 65,000 people a day reaching retirement age.¹⁸⁴ The retirement trend is worldwide and is expected to sustain for the next 10 years.¹⁸⁵ The ageing global population will change workforce demographics, tighten labour supply, and increase the tax burden on the working population, whose relative size is declining. Some countries, including France, Germany, Greece, Italy, Russia, and the Ukraine, already have seen an absolute decline in the size of their workforce.¹⁸⁶

The most rapid increases in the 65-and-older population are occurring in emerging countries, which will see a jump of 140% by 2030 (Figure 58).¹⁸⁷ In China, the United Nations predicts 28% of the population will pass 65 by 2040, translating into roughly 400 million senior citizens, more than the combined populations of France, Germany, Italy, Japan and the United Kingdom. In all cases, an ageing population limits the growth of the science and engineering labour force.¹⁸⁸ Only India will continue to possess a large, youthful workforce. By 2030, only 12% of its swelling workforce of scientific, technical and professionals will be over 60 years old.¹⁸⁹

Figure 58: Global Age Distribution



Source: United Nations. (2010) United Nations World Population Prospects: The 2010 revision. Available at: <http://esa.un.org/wpp/Documentation/publications.htm>

Universities in emerging markets are producing plenty of graduates, but the quality of these graduates has been questioned

Although many believe that the increased volume of graduates from universities in emerging markets will remedy the talent shortage, quality concerns render this unlikely, at least in the short term. It is true that the number of graduates is rapidly increasing; however, the relative quality of the universities is not keeping pace. Concerns regarding the employability of engineering graduates from institutions in emerging markets linger due to questions around instructor qualifications, soaring student-teacher ratios, and variability of curricula. In addition, the word “engineer” can mean different things in China than it does in the rest of the world and may include auto mechanics and shipbuilding labourers.¹⁹⁰ In general, multinationals consider graduates from emerging nations as less employable than their developed world counterparts.¹⁹¹

Examination of the QS World University Rankings provides a fact base for the quality concern. In 2011, 215 US-based science, technology, engineering and math (STEM) programmes are ranked globally, while only 29 Chinese programmes can claim the honour.¹⁹² However, Chinese universities graduated many more students in the STEM disciplines (over 500,000 compared with 150,000 in the United States).¹⁹³ However, it should be noted that government initiatives in emerging markets have helped many universities improve their rankings and, therefore, the future educational picture may be quite different.

Nations and corporations are fighting to overcome the talent scarcity on multiple fronts. Emerging nations are pursuing multiple tactics to overcome the talent shortage, including competing fiercely to attract and retain skilled workers, and working to develop advanced capabilities to transform the labour pool

China and other emerging nations are implementing strategies to retain or recall skilled workers from overseas. A study by the Academy of Social Sciences in Beijing reported that approximately two-thirds of Chinese who have studied abroad since the 1980s have chosen not to return home. In an effort to reduce the brain drain, China has implemented a series of incentives such as granting special privileges to those who graduate from foreign universities (e.g. the right to work either in urban or rural areas without adhering to their native provincial registration); offering special promotions to high-salaried positions; facilitating visa documents for domestic and international travel; and, for current international students, providing research support budgets.¹⁹⁴

India is among the nations implementing strategies to develop local talent to drive economic progress. With aspirations of increasing manufacturing output to 25% of GDP and creating 100 million jobs by 2025, India needs to train 500 million skilled labourers by 2022 and improve on the 5% of the labour force with formal training (compared with 70% in China and 95% in South Korea). The government has engaged private industry and mobilized a new organization, the National Skill Development Corporation (NSDC), to identify and fund vocational education businesses. To date, NSDC has approved US\$ 150 million in funding for 29 ventures that will train 40 million youth in diverse trades over the next 10 years.¹⁹⁵

Corporations and private organizations are collaborating with educators to reduce the impact of the talent shortage

Collaboration among corporations, academia and private organizations is critical to reducing the skills gap and talent-focused alliances are evident throughout the world. In India, Satyam, a large IT outsourcing company, began training talent in-house following concerns over the skills of domestic graduates. The resulting programme, Satyam Entry-level Engineering Development (SEED), trains 600 to 800 engineers per year with curricula for aerospace and mechanical design generated in collaboration with the Indian Institute of Science, Bangalore; the Indian Institute of Technology, Chennai; and the Central Institute of Tool Design. Its graduates help the company avoid the high costs associated with recruiting experienced professionals from other firms.¹⁹⁶

Non-government organizations are playing a key role in labour pool transformation. In an effort to boost employability of recent university graduates, Education for Employment, an international not-for-profit organization, offers short courses to equip graduates in the Middle East with the practical skills they need to find employment.¹⁹⁷ Similarly, in the United States, The Manufacturing Institute launched the Manufacturing Skills Certificate System, endorsed by the National Association of Manufacturers (NAM), which is working with high schools and community colleges to provide competency-based, customized education and training for a work-ready manufacturing workforce.¹⁹⁸

Efforts like these in developed nations, such as the United States, will be critical to keep pace with the emerging nations talent strategies. Emerging nations cannot afford to be complacent as manufacturing evolves and demands new and more skilled talent for the advanced manufacturing necessary to drive their economies.

Government Policy Shapes the Future of Manufacturing

The strategic use of public policy to enable economic development will intensify resulting in a competition between nations for policy effectiveness and placing a premium on collaboration between policy-makers and business leaders to create win-win outcomes.

With competition increasing for so many resources and capabilities, and with the prosperity of nations hanging in the balance, policy-makers will be actively looking for the right combination of trade, tax, labour, energy, education, science, technology and industrial policy levers to generate the best possible future for their citizens. Despite many instances of failed industrial policies in history, policy-makers are increasingly turning to intervention in an attempt to influence positive outcomes and accelerate development.

This means that policy-makers will need to carefully pull the right levers, at the right time in a balanced approach while being mindful of unintended consequences. Companies will need to be more sophisticated and engaged in their interactions with policy-makers to help strike the balanced approach necessary to enable success for all.

Manufacturing policy is changing as countries use more sophisticated and assertive policies as a competitive tool

While it remains controversial in many circles, countries are using industrial policy to stimulate specific activities and promote structural change. Broader macroeconomic policies are being used to promote certain domestic industries through tax and subsidy measures. Some of these protectionist measures are meant to be temporary, enforced only until the target industry matures enough to compete on a global scale, while others are being used as competitive tools to intervene with market forces, propping up and entrenching potentially less efficient domestic firms in order to meet short-term job and economic goals or disadvantage foreign rivals.

Industrial policy becomes fashionable again

Supporting the renewed use of industrial policy are the following excerpts from an August 2010 article in *The Economist* entitled, "Picking Winners, Saving Losers":¹⁹⁹

- Japan's Prime Minister, Naoto Kan, said in April (2010) that the government wanted to create a new "Japan Inc.", deepening the links between business and the state. In June the Ministry of Economy, Trade and Industry (METI) announced a strategy to combat the "increasingly aggressive" industrial policies of America, Britain, China, France, Germany and South Korea.
- Like America, European countries have lavished money on banks and carmakers. The European Commission will unveil a new, active industrial strategy later this year, which will pay more attention to manufacturing and less to services and "knowledge" industries.
- "Industrial policy is no longer taboo," says Mario Monti, a former competition commissioner. "There's a revival of demand for it." France's government, having retreated from directing industry in recent years, launched a heavily interventionist policy in March, vowing to lift manufacturing output by one-quarter over five years.
- Inspired by the French, Britain's Labour government last year set up a Strategic Investment Fund to steer £750m (US\$ 1.2 billion) of state money to particular industries and companies. The Conservative-led coalition has since rejected what it calls a "new interventionism," around the world. It has cancelled some loans, such as one to Sheffield Forgemasters, a northern steel firm. But much of Labour's plan remains.
- The World Bank, after decades of consensus that industrial policy does not work for emerging nations, is now recommending its use. A recent paper by Justin Lin, the bank's chief economist, and a colleague, Célestin Monga, examines how governments can identify possibly successful policies and likely failures.

Definitions

Industrial policy “denotes a nation’s declared, official, total strategic effort to influence industry sector development and, thus, national industry portfolio.”²⁰⁰ These interventionist measures comprise “policies that stimulate specific activities and promote structural change.”²⁰¹ Industrial policies are typically sector specific.

Many types of industrial policies contain common elements with other types of interventionist practices such as trade policy and fiscal policy. An example of a typical industrial policy is import-substitution-industrialization (ISI), where trade barriers are temporarily imposed on some key sectors, such as manufacturing.²⁰² By selectively protecting certain industries, these industries are given time to learn (learning by doing) and upgrade. Once competitive enough, these restrictions are lifted to expose the selected industries to the international market.²⁰³

Macroeconomic policies are broader than industrial policies, impacting numerous or non-specific industry sectors. Examples of horizontal, economy-wide policies are tightening credit or taxing capital gain, while examples of vertical, sector-specific policies comprise protecting textiles from foreign imports or subsidizing export industries. Free market advocates consider industrial policies as interventionist measures typical of mixed economy countries.

Manufacturing strategy or manufacturing policy for a country can be considered the collective elements of industrial policy and macroeconomic policy that contributes to a growing, competitive manufacturing industry.

Policy-makers are getting more involved for four reasons:

1. To stimulate growth. With unemployment stubbornly high in many markets, well-fashioned policy may be a way to save or create jobs, and help domestic firms fight competition.
2. To diversify away from stagnant industries both within manufacturing and in other parts of the economy, including services, and rebalance the economy with next generation industries with the potential for strong growth and high-value jobs, such as in clean energy technology.
3. To not fall behind global competitors and to follow what are often considered successful examples such as China and South Korea, which have used policy to shape industry with positive results in fuelling economic prosperity and global competitiveness.
4. To respond to political pressure from important constituents in business and labour demanding policy-makers address competitiveness issues and confront the practices of other nations.

Whatever the reason, the practice is winning converts. As noted above, the World Bank, after years of suggesting that industrial policy was anathema for emerging countries, is now recommending its use.²⁰⁴

The best policies learn from past missteps

The worst policy problems occur when politicians intervene in an attempt to save jobs, businesses or industry sectors that are no longer competitive. Policy is least prone to failure when it follows, rather than tries to lead, the market, targeting industries that already demonstrate a comparative advantage. Policy also tends to be successful when a government is dealing with areas where it is of strategic importance, natural competence, or vital to the nation’s defence, such as military technology or energy supply.

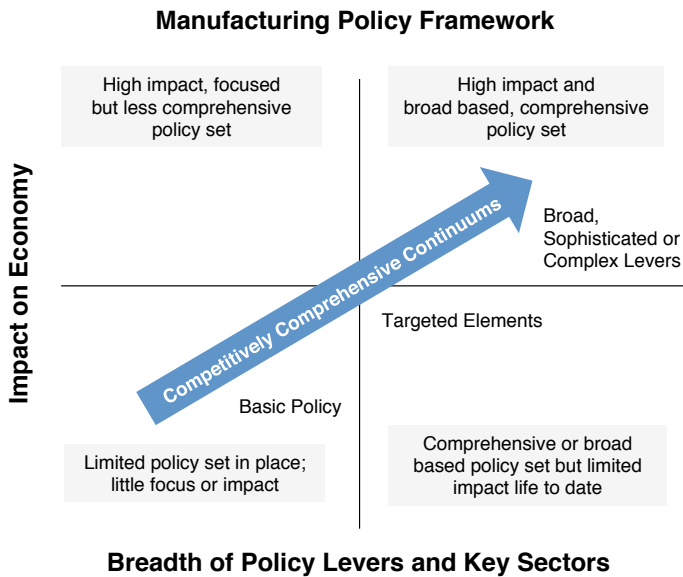
Cited Examples of Missteps

- **China:** China’s experiments with the high-tech industry have not fared well. The Chinese government tried to promote a home-grown 3G technology, TD-SCDMA, or TD-S, which was not successful. In 2008, the government insisted the country’s largest mobile operator, China Mobile, adopt the technology, but even this huge firm has struggled to sell it to its customers.²⁰⁵
- **Denmark:** In 1992, the Danish Business Development Fund was established to provide high-risk loans to start-ups and established enterprises in emerging industries. With generous provisions for renegotiation, more than 60% of total funding was lost on the 900 projects the fund supported in its initial years.²⁰⁶
- **France:** In 1980s, the French government spent about US\$ 6 billion on acquiring a number of lumbering electronics giants like CII Honeywell Bull and Thomson. In addition, a number of promising smaller firms were either acquired directly by the government or pressured into merging with the giants. The result was a disaster, with annual subsidies for annual losses growing from US\$ 226 million in 1980 to US\$ 4.6 billion in 1982.²⁰⁷

Cited Examples of Success

- **China:** China’s public assistance to new industries helped it to register phenomenal growth in manufacturing. State-owned enterprises served as incubators for the right talent and skill-sets. Further, the export incentives helped Chinese companies to break into global markets.²⁰⁸
- **India:** Economic liberalization played a significant role in starting the country’s growth trajectory. The economy has fared quite well in all dimensions, including GDP growth, FDI inflows, FOREX reserves and trade.²⁰⁹
- **United States:** The US Department of Defense acted as the growth catalyst in the developing phase of the Silicon Valley. The Internet is a product of a Defense Department project initiated in 1969.²¹⁰

Figure 59: Manufacturing Policy Framework – Governments Employ a Breadth of Policy Levers Across a Variety of Sectors to Make an Impact on Their Economies



Source: Deloitte analysis

Policy-makers can make an impact by employing a wide breadth and depth of policy levers across a variety of sectors

Globalization, and the rapid development of emerging economies into the manufacturing landscape, has changed the way countries use policy. Historically, large developed nations have taken a similar approach in targeting and implementing foundational policies such as tax policies. However, new global entrants in emerging nations tend to focus first on core basics such as infrastructure and energy, followed by areas like science, technology, and innovation to provide a competitive advantage (Figure 60).

These emerging nations may end up leap-frogging developed nations in certain areas and therefore change how countries compete from a policy perspective. The globalization of markets has increased competition in many industries, which in turn has placed a premium on a government's ability to provide quickness and flexibility in responding to shifts in market demand.

Industry sectors targeted and the specific policy levers employed have a strong impact on the overall effect of manufacturing policy on an economy

Some sectors (such as clean tech) will benefit more than others (such as the garment industry), and nations will place their bets according to where they want to end up – with hopefully a strong acknowledgment of current capabilities and future required capabilities. The typical policy levers used – tax, trade, talent, infrastructure, education, energy, science, technology and innovation – will evolve over time and be used at different strategic points.

Having a robust set of policies in place over just one dimension may not be as beneficial as using multiple levers. Too much focus in any one area at the expense of the others could also result in only a minimal impact on the overall prosperity of a nation. However, more policy is not necessarily better policy. Policy should not attempt to defy natural market forces, but rather stimulate natural market forces that will lead to a favourable outcome.

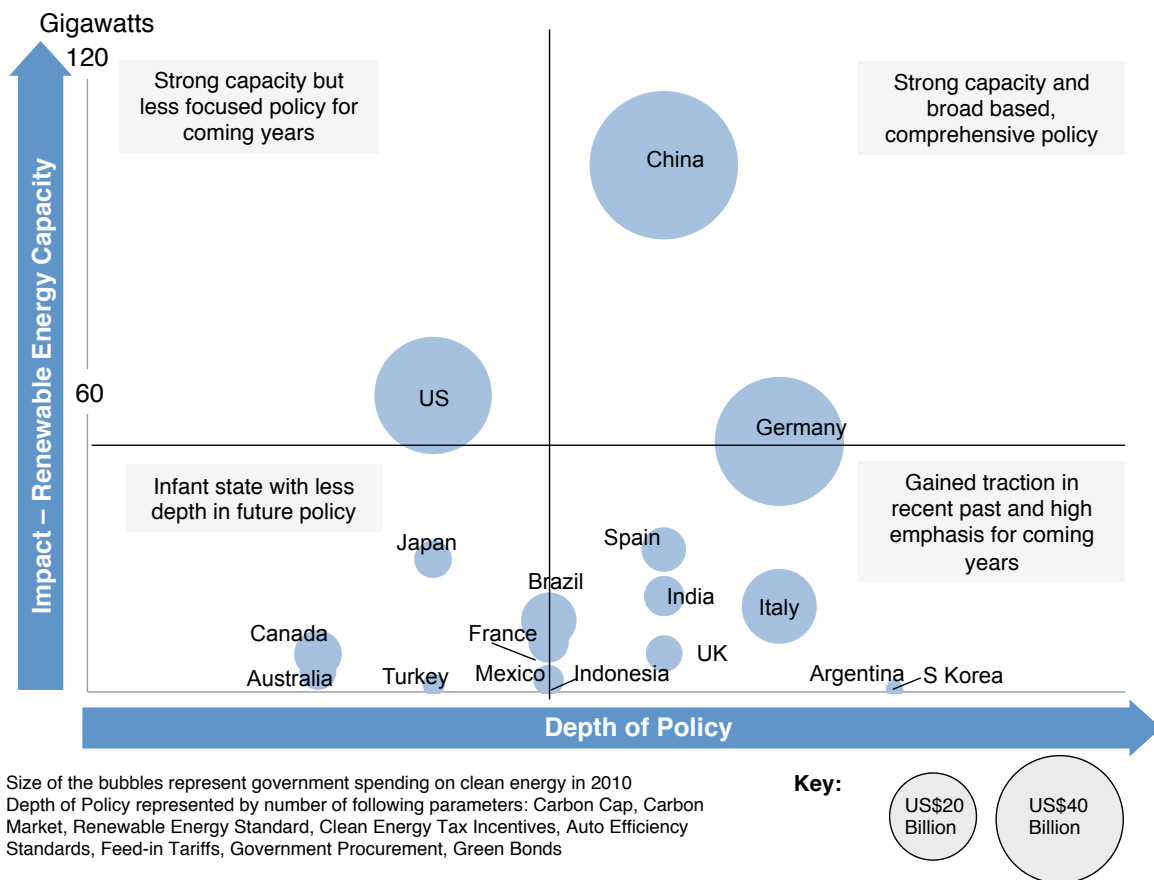
Case Study #1: Comparing Policy Frameworks for Clean Energy

Clean energy is a sector of particular focus in the global marketplace. Like policy in other sectors, clean energy policy must strive to be comprehensive, cohesive, and investor-friendly to be effective. Figure 61 maps the clean energy policies of various countries based on an assessment of the depth of the policy levers used, the amount of money being spent by the nation, and the impact, measured as gigawatts of renewable energy capacity that a nation is generating.

Depth of policy represents the number of parameters covered by a nation's clean energy policy (e.g. carbon cap, carbon market, renewable energy standard, clean energy tax incentives, auto efficiency standards, feed-in tariffs, government procurement and green bonds) to indicate the relative comprehensiveness of a country's policy within this sector. Government spending on clean energy in 2010, depicted by the size of the bubble shows the size of a country's investment in this sector, that is, how big of a bet it is placing in this sector, how much it is trying to influence/invest in the sector. The analysis seems to strongly suggest that one approach does not work for all and reinforces that notion that policy is as much an art as it is a science.

Some countries have broader and deeper policies, and have spent more money, but with a limited impact. Others seem to be using a much narrower set of levers but have much more to show for it, assuming the goal is to develop gigawatt hours of renewable energy capacity. Based on this analysis, China has a strong overall position, with high capacity, strong government support, and a relatively comprehensive policy. At the same time, Germany appears to be employing a wider breadth of policy levers and making sizeable investments with capacity still lagging that of China's. With continued focus and fine-tuning, the right set of policies and incentives, Germany's capacity is likely to increase in the future.

Figure 60: Case Study: Manufacturing Policy Framework for Alternative Energy – How do Countries Compare?



Size of the bubbles represent government spending on clean energy in 2010

Depth of Policy represented by number of following parameters: Carbon Cap, Carbon Market, Renewable Energy Standard, Clean Energy Tax Incentives, Auto Efficiency Standards, Feed-in Tariffs, Government Procurement, Green Bonds

Source: The Pew Charitable Trusts. (2010) Who's Winning The Clean Energy Race? Available at: <http://www.pewenvironment.org/uploadedFiles/PEG/Publications/Report/G-20Report-LOWRes-FINAL.pdf>, 2010 Edition

Case Study #2: India's Industrial Policy Journey²¹¹

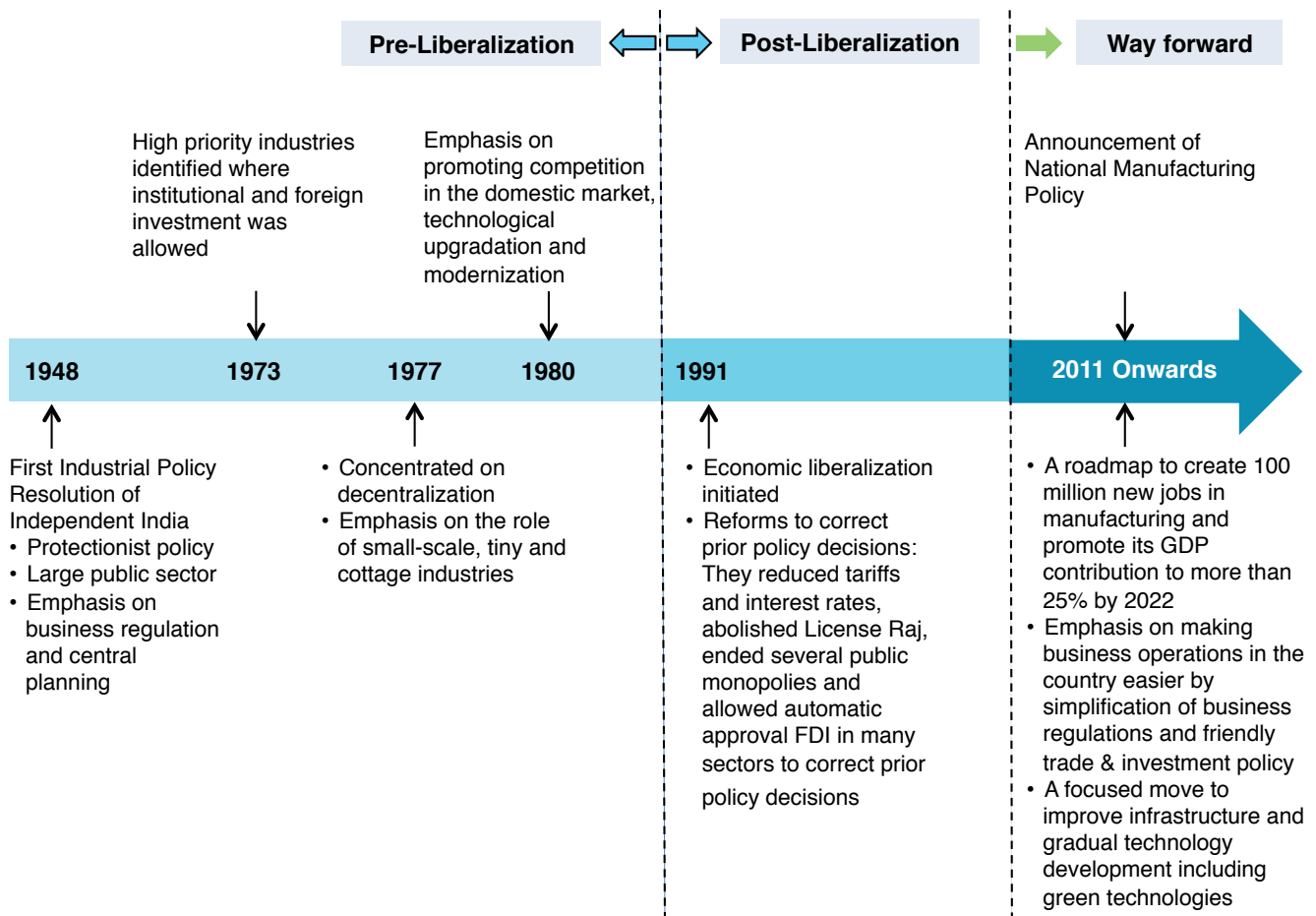
By looking at India's recent history, most notably since the post-economic liberalization of 1991, there is compelling evidence that policy reforms have had a positive impact on the industry and economy as a whole. Figure 62 depicts India's recent journey of policy reformation, where beginning in 1948, the first Industrial Policy Resolution of a newly independent India used policy to develop business regulations and initiate central planning efforts, though it incorporated protectionist measures as a way to develop its infant industrial base. Later, the Industrial Policy statement of 1973 identified high priority industries where institutional and foreign investment was allowed.

A few years later, in 1977, policy emphasized decentralization and the role of small-scale industries. In 1980, further attention was focused on the need for encouraging competition in the domestic market, as well as modernizing and upgrading on the technological front. Through the development and use of these policies, India cultivated a climate for rapid industrial growth.

These early policies encouraged the development of an industrial base, however, India recognized that to achieve further growth and objectives of the industrial sector for the 1990s and beyond it was necessary to make a number of changes in the system. Through the post-liberalization of India beginning in 1991, major policy initiatives and reforms were put in place to actively encourage Indian entrepreneurship to be internationally competitive. Tariff and interest rates were reduced, the industrial licensing system was abolished, several public monopolies were ended, and automatic approval of FDI in many sectors was allowed.

As a result, the Indian economy benefited greatly as these policy measures enabled industrial progress through becoming more competitive, efficient and modern, as exhibited by significant increases in FDI, imports, foreign exchange reserves, manufacturing GDP, and overall GDP (Figure 63).

Figure 61: Case Study: India: Timeline of Policy Reforms



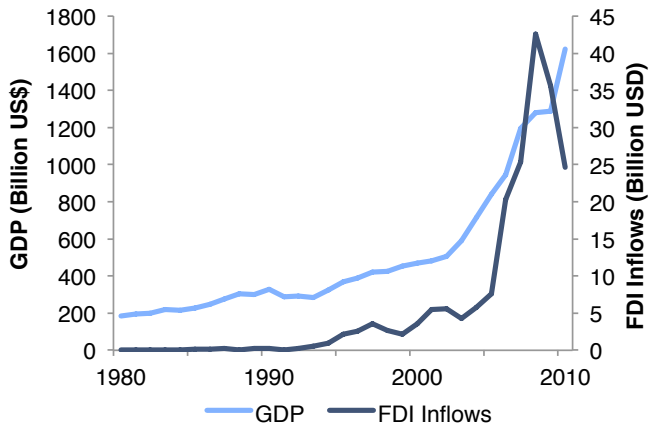
Sources:

Indian Ministry of Industry. (1991) Statement on Industrial Policy. Press Release, July 24. Available at: <http://india.gov.in/outerwin.php?id=http://siadipp.nic.in/publicat/nip0791.htm>

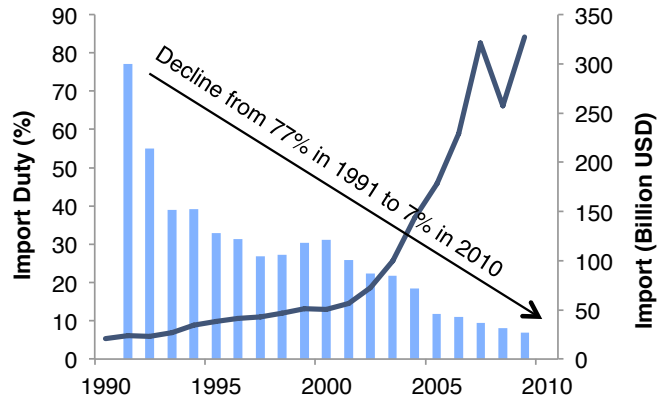
Indian Department of Industrial Policy & Promotion. (2011) National Manufacturing Policy. Available at: http://dipp.nic.in/English/Policies/National_Manufacturing_Policy_25Octm10ber2011.pdf

Figure 62: India Case Study: Policy reforms have had a positive impact on industry and economy as a whole, as India witnessed an all-round growth post-economic liberalization in 1991

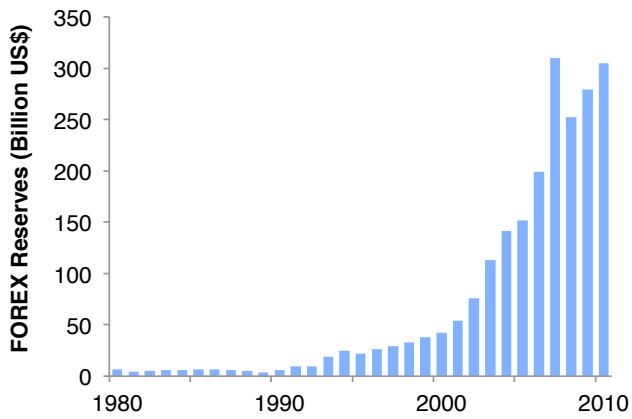
GDP and FDI Inflows



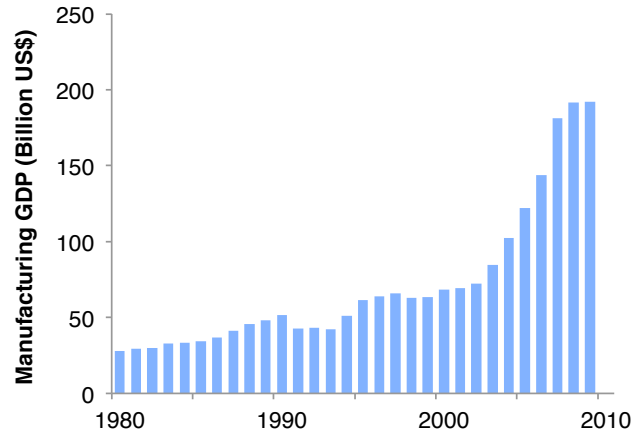
Imports & Weighted Average Import Duty Rates (All Commodities)



Foreign Exchange Reserves



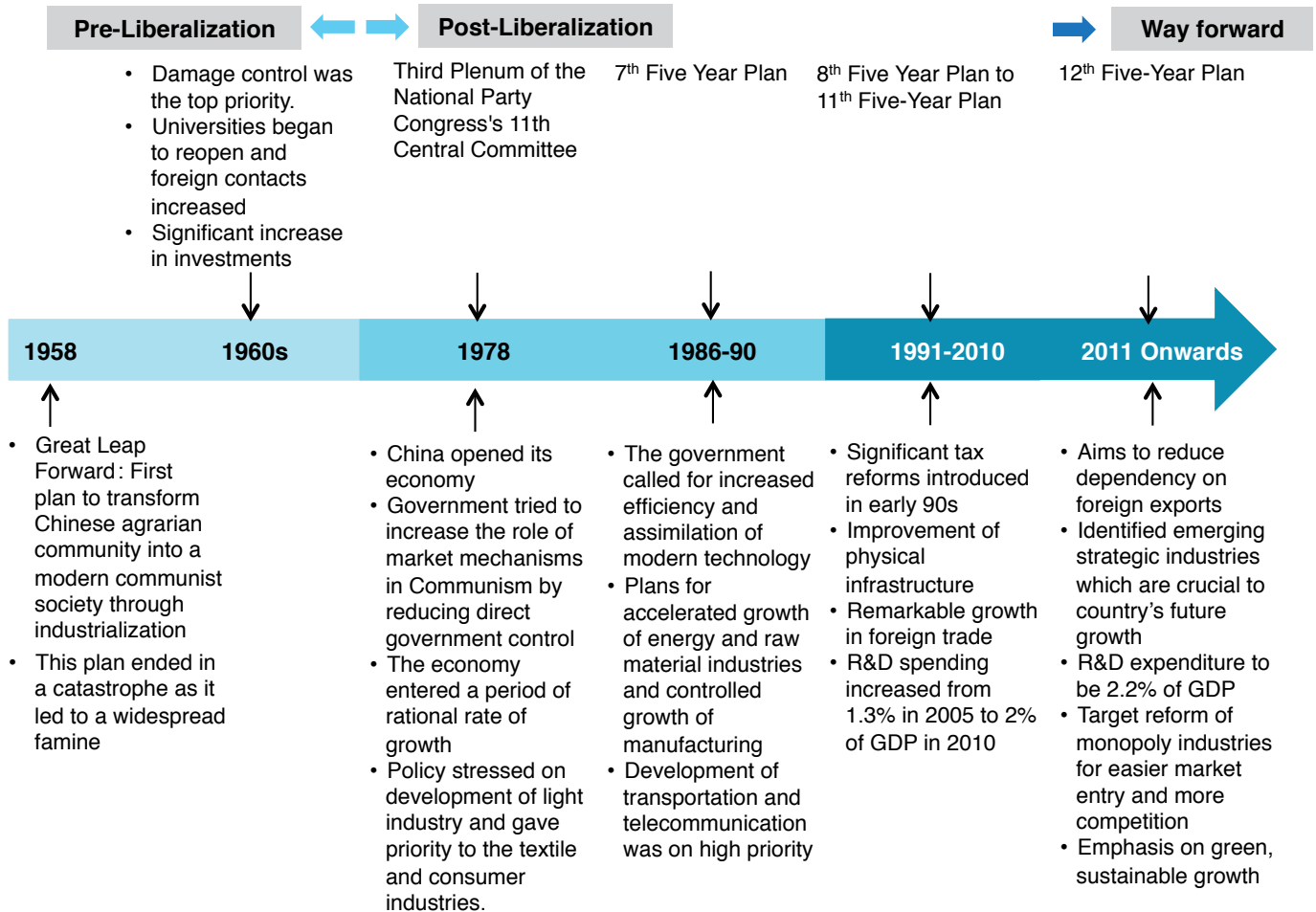
Manufacturing GDP



Source: WTO; UNCTAD; Reserve Bank of India; Planning Commission of India

Case Study #3: China's Industrial Policy Journey

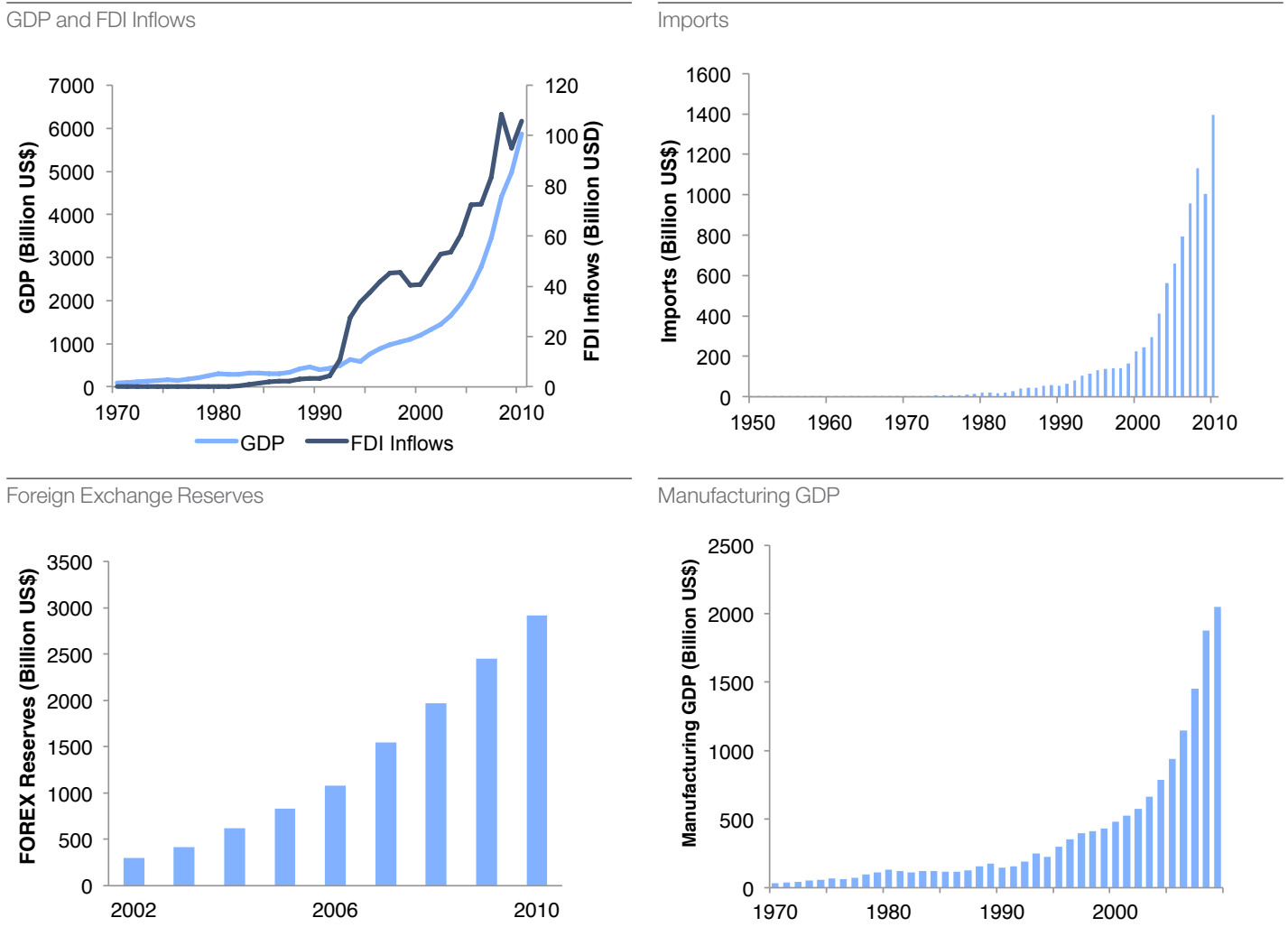
Figure 63: China Case Study: Timeline of Policy Reforms



Sources:

AllRefer.com (2011) China: Trends in industrial production. Available at: <http://reference.allrefer.com/country-guide-study/china/china197.html>
 Chinese Government. (2012) The 8th Five-Year Plan (1991-1995). Available at: http://www.gov.cn/english/2006-04/05/content_245691.htm
 Chinese Government. (2012) The 9th Five-Year Plan (1996-2000). Available at: http://www.gov.cn/english/2006-04/05/content_245690.htm
 Chinese Government. (2012) The 10th Five-Year Plan (2001-2005). Available at: http://www.gov.cn/english/2006-04/05/content_245690.htm
 Chinese Government. (2012) Facts and figures: China's main targets for 2006-2010.. Available at: http://www.gov.cn/english/2006-03/06/content_219504.htm
 Chinese Government. (2012) Key targets of China's 12th five-year plan. Available at: http://www.gov.cn/english/2011-03/05/content_1816822.htm

Figure 64: China Case Study: Policy Reforms – A Positive Impact on Industry and Economy as a Whole



Sources:

United Nations Conference on Trade and Development. (2012) UNCTADSTAT: GDP and FDI Inflows. Available at: http://unctadstat.unctad.org/ReportFolders/reportFolders.aspx?sCS_referer=&sCS_ChosenLang=en

United Nations Conference on Trade and Development. (2012) UNCTADSTAT: Imports. Available at: http://unctadstat.unctad.org/ReportFolders/reportFolders.aspx?sCS_referer=&sCS_ChosenLang=en

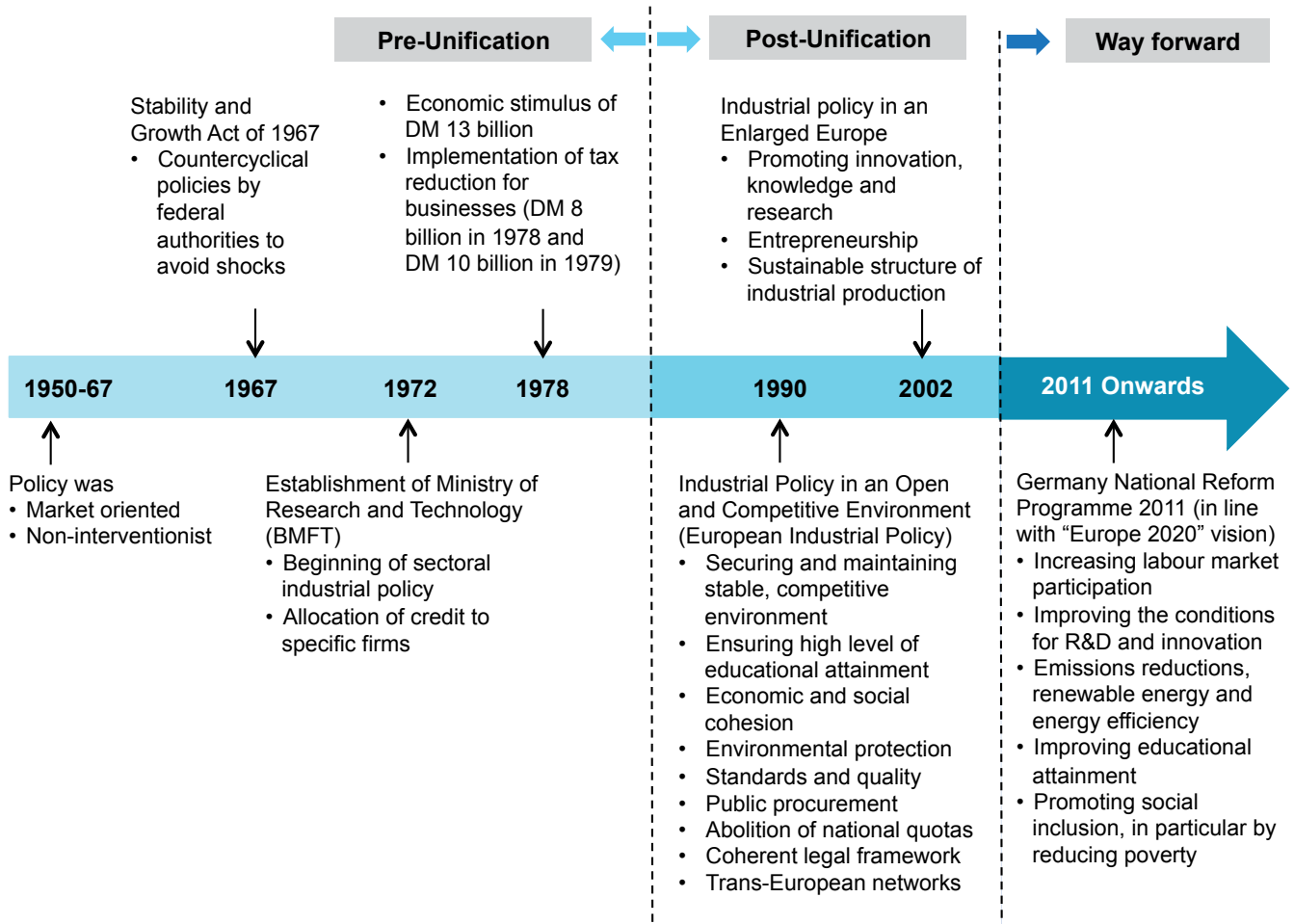
World Bank. (2011) Total Foreign Exchange Reserves. Available at: http://search.worldbank.org/quickview?name=Total+reserves+%28includes+gold%2C+current+US%24%29&id=FI.RES.TOTL.CD&type=Indicators&cube_no=2&qterm=%22foreign+exchange%22

United Nations Conference on Trade and Development. (2012) UNCTADSTAT: Manufacturing GDP. Available at: http://unctadstat.unctad.org/ReportFolders/reportFolders.aspx?sCS_referer=&sCS_ChosenLang=en

Note: Billion USD at current prices and current exchange rates

Case Study #4: Germany's Industrial Policy Journey

Figure 65: Germany Case Study: Timeline of Policy Reforms



Sources:

Hart, J.A. (1986) West German Industrial Policy. Available at: <http://www.indiana.edu/~globalm/pdf/gerinduspol.pdf>

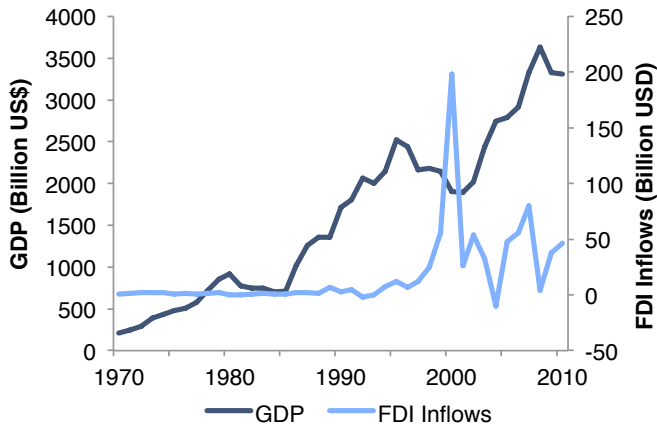
German Government. (2011) Germany National Reform Programme 2011. Available at: <http://www.bmwi.de/English/Redaktion/Pdf/dokumentation-596-nationales-reformprogramm,property=pdf,bereich=bmwi,sprache=en,rwb=true.pdf>

European Industrial Policy (1990) - http://aei.pitt.edu/5690/1/003082_1.pdf

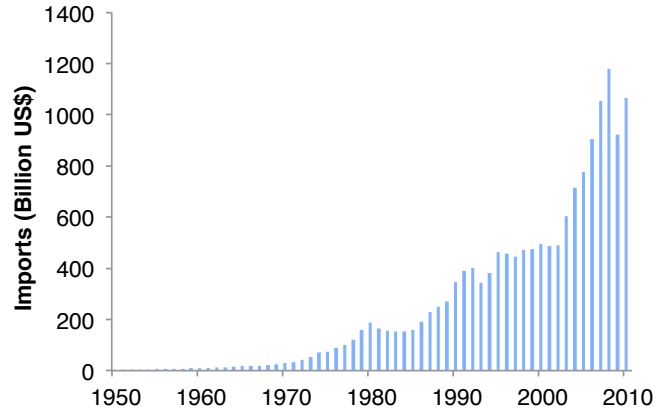
Commission of the European Communities. (2002) Industrial Policy in an Enlarged Europe. Available at: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2002:0714:FIN:en:PDF>

Figure 66: Germany Case Study: Policy Reforms – A Positive Impact on Industry and Economy as a Whole

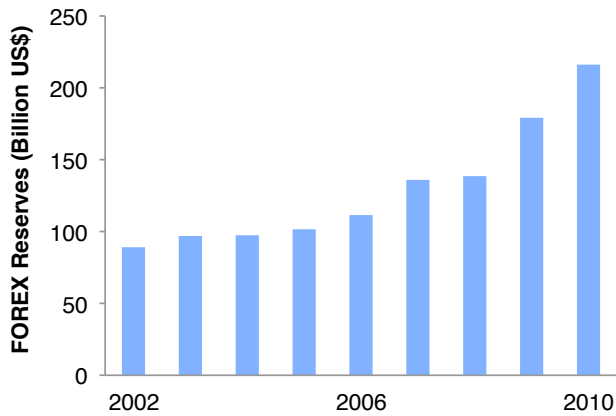
GDP and FDI Inflows



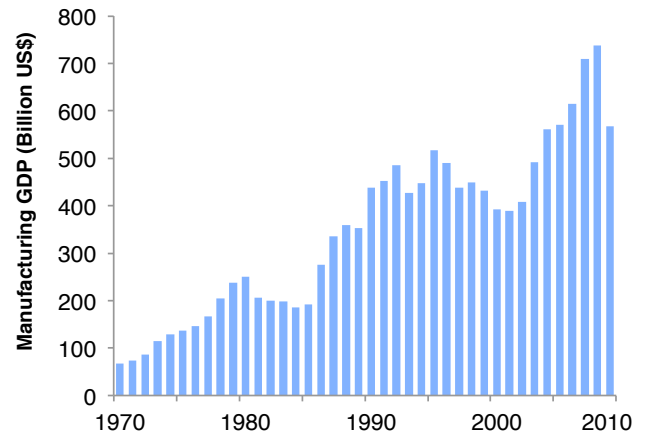
Imports



Foreign Exchange Reserves



Manufacturing GDP



Sources:

- United Nations Conference on Trade and Development. (2012) UNCTADSTAT: GDP and FDI Inflows. Available at: http://unctadstat.unctad.org/ReportFolders/reportFolders.aspx?sCS_referer=&sCS_ChosenLang=en
- United Nations Conference on Trade and Development. (2012) UNCTADSTAT: Imports. Available at: http://unctadstat.unctad.org/ReportFolders/reportFolders.aspx?sCS_referer=&sCS_ChosenLang=en
- World Bank. (2011) Total Foreign Exchange Reserves. Available at: http://search.worldbank.org/quickview?name=Total+reserves+%28includes+gold%2C+current+US%24%29&id=FI.RES.TOTL.CD&type=Indicators&cube_no=2&qterm=%22foreign+exchange%22
- United Nations Conference on Trade and Development. (2012) UNCTADSTAT: Manufacturing GDP. Available at: http://unctadstat.unctad.org/ReportFolders/reportFolders.aspx?sCS_referer=&sCS_ChosenLang=en

Note: Billion USD at current prices and current exchange rates

Discovering balance is the key

The use of manufacturing policy, including all forms of industrial policy, is an art form with opportunities for both success and sometimes failure, with unintended consequences and negative effects for years to come. A clear, comprehensive and stable policy will provide the transparency and certainty needed for corporations and investors to make longer-term strategic decisions and investments, thereby improving the welfare of their economy and society.

Policy will be increasingly important, active, and strategic in the future, and in many cases serve as a game changer, as manufacturing competition increases and so many other sources of manufacturing competitive advantage challenged. Effective public policy can be the critical competitive differentiator for both nations and businesses.

A government's role is to facilitate business activities and foster effective competition, without creating bureaucracy or significantly disrupting markets. The key challenge for policy-makers, and their business leader collaborators, will be to artfully develop and execute policies of thoughtful strategic intervention, with positive outcomes, without enacting policy that disrupts, excessively distorts, or interferes with the market, resulting in negative outcomes or unintended consequences for themselves or their key trading partners.



The right model for industrial policy is not that of an autonomous government applying Pigovian taxes or subsidies (i.e. lump sum taxes or subsidies), but of strategic collaboration between the private sector and the government with the aim of uncovering where the most significant obstacles to restructuring lie and what type of interventions are most likely to remove them.



Dani Rodrik, Harvard University
Industrial Policy in the Twenty First Century

Acknowledgements

This publication is a synthesis of manufacturing insights of many individuals across industry, policy, and academia. The Future of Manufacturing project team would like to thank everyone involved for contributing their time, perspective and passion.

The project team would also like to offer its special gratitude to the members of the project Task Force and to most of the Global Agenda Council on Advanced Manufacturing members for their contributions through virtual calls, workshops, and document reviews. Their dedication was critical to the shaping of this report.

The members of the Task Force and Global Agenda Council on Advanced Manufacturing are listed at the beginning of the report. Subject Matter Advisors to the research included (in alphabetical order):

- John Seely Brown, Independent Co-Chairman, Deloitte LLP Center for the Edge
- Atanu Chandhuri, PhD, Indian Institute of Management, Lucknow
- Ken Dewoskin, Senior Advisor to Deloitte China Research and Insight Center
- Rod Eggert, PhD, Professor and Division Director, Division of Economics and Business at Colorado School of Mines
- Doug Gish, Principal, Deloitte United States (Deloitte Consulting LLP)
- John Hagel III, Co-Chairman, Deloitte LLP Center for the Edge
- Ricardo Hausmann, PhD, Director, Center for International Development, Professor of the Practice of Economic Development, Kennedy School of Government, Harvard University
- César Hidalgo, PhD, ABC Career Development Professor, The Media Laboratory, MIT, and Faculty Associate, Center for International Development, Harvard University
- Elaine Hutson, PhD, UCD Michael Smurfit Graduate Business School, Dublin
- Bob Kimmitt, Independent Chairman, Deloitte Center for Cross-Border Investment
- Mike Reopel, Principal, Deloitte United States (Deloitte Consulting LLP)
- Aleda V. Roth, PhD, Burlington Industries Distinguished Professor in Supply Chain Management at Clemson University
- Matthew Slaughter, Associate Dean of the MBA Program and the Signal Companies' Professor of Management at the Tuck School of Business at Dartmouth; Senior Advisor to the Deloitte Center on Cross-Border Investment
- Branko Terzic, Executive Director, Deloitte Center for Energy Solutions
- James H. Quigley, Senior Partner, Deloitte LLP
- Jeff Watts, Principal, Deloitte Consulting LLP

In addition, the project team would like to thank all Special Guests, Discussion Leaders, Panellists, and Moderators at the global workshops/events. These individuals are (in alphabetical order):

- N.S. Bala, Global Head and Senior Vice-President, Manufacturing and Hi-Tech, Wipro Technologies
- Ron Bloom, Senior Counselor to the President for Manufacturing Policy (2009-2011), Department of the Treasury, USA
- Fabrice Brégier, Chief Operating Officer, Airbus SAS
- James Bujold, President, Honeywell International, India
- Gary Coleman, Managing Director, Global Industries, Deloitte Touche Tohmatsu, Ltd
- Rob Davies, Minister of Trade and Industry, South Africa
- Cui Dianguo, President, China CNR Corporation Limited (CNR)
- Robert Greenhill, Managing Director and Chief Business Officer, World Economic Forum
- Baba N. Kalyani, Chairman and Managing Director, Bharat Forge, India
- Robert Z. Lawrence, Albert L. Williams Professor of Trade and Investment, Harvard Kennedy School, Harvard University
- Andrew N. Liveris, Chairman and Chief Executive Officer, The Dow Chemical Company
- Heloisa Menezes, Secretary, Production Development, Ministry of Development, Industry and Foreign Trade, Brazil
- Takahisa Miyauchi, Executive Vice-President and Group Chief Executive Officer, Chemicals, Mitsubishi Corporation
- Romulo Roux, Chairman of the Board of Directors, Minister for Canal Affairs, Panama Canal Authority, Panama
- Siegfried Russwurm, Member of Managing Board and Chief Executive Officer, Industry, Siemens, Germany
- Kshatrapati Shivaji, Principal Secretary of Industry, Government of Maharashtra; Chief Executive Officer, Maharashtra Industrial Development Corporation, India
- Alessandro Texeira, Deputy Minister of Development Industry and Foreign Trade, Brazil
- Kevin Thieneman, President, Caterpillar Asia Pte. Ltd
- Roger Wood, President and Chief Executive Officer, Dana Holding Corporation
- Alberto Alemán Zubieta, Chief Executive Officer, Panama Canal Authority

Finally, the project team would like to thank all workshop, call and interview participants for contributing their insights and time. These individuals are (in alphabetical order):

- Vineet Agarwal, Executive Director, Transport Corporation of India Ltd
- Manish Agrawal, Director, MSP Steel & Power Ltd
- Ashwini K. Aggarwal, Head, Government Affairs, Applied Materials India Pvt. Ltd
- Othman Aljeda, Chief Executive Officer, Asia, Aramex
- Allen Antao, Executive Vice-President and Business Head, Godrej & Boyce Mfg Co. Ltd
- Percy Avari, Country Manager, Aramex, India
- Pascale Balance, Director, European Strategy, UPS Europe, Belgium

- Ban Choon Jang, President, Hanwha Latin America
- Pritam Banerjee, Head, Corporate Public Policy, South Asia, DHL Express (India) Pvt. Ltd
- Vijay Kumar Bhatnagar, Executive Vice-President, ArcelorMittal and Chief Executive Officer, India and China, Arcelormittal India Limited
- Ken Bloom, Chief Executive Officer, INTTRA Inc.
- Kevin Brannon, Senior Manager, SAP Package Technologies, Deloitte Consulting
- Daniel J. Brutto, President, UPS International
- Stephen Bull, Director, Strategy, Agility, United Kingdom
- Brian Budeslich, Senior Manager, Supply Chain & Manufacturing Operations, Deloitte Consulting
- James Bujold, President, Honeywell International India Pvt. Ltd
- Michael Buscher, Chief Executive Officer, OC Oerlikon Management, Switzerland
- Nirvana Chaudhary, Executive Director, Chaudhary Group, Nepal
- Pei Cheng, Global Public and Government Affairs, Alcoa
- Anindya Chowdhury, Country Lead - Gas/LNG New Business Development, Shell India Markets Pvt. Ltd
- Gary Chu, President, Greater China, General Mills China
- R. Marcelo Claire, Chairman of the Board, Chief Executive Officer and President, Brightstar
- Sean de Cleene, Vice-President, Global Business Initiatives, Yara International ASA
- Jared Cohon, President, Carnegie Mellon University
- Thomas M. Connelly, Executive Vice-President and Chief Innovation Officer, DuPont
- Antonio Roberto Cortes, President and Chief Executive Officer of Latin America, MAN Latin America Ltda
- Artur Coutinho, Executive Vice-President and Chief Operating Officer, Embraer S.A.
- Daniel Cruise, Vice-President and Officer, Public and Government Affairs, Alcoa
- Weili Dai, Co-Founder, Vice-President and General Manager, Communications and Computing Business, Marvell Technology Group
- Jason, Dedrick, PhD, Associate Professor, School of Information Studies, Syracuse University
- Daniel Deng, Country Manager and Head, Corporate Affairs, ArcelorMittal
- Kleber Douvletis, Chief Financial Officer, Healthcare Sector, Latin America, Siemens Ltda
- Newton Duarte, Chief Executive Officer, Energy Sector, Siemens Ltda
- Dan Elbert, Consultant, Strategy & Operations, Deloitte Consulting
- Amir Elstein, Chairman, ICorp., Israel
- Bill Flite, Lead, Advanced Manufacturing Portfolio, Lockheed Martin Corporation
- Patricia Florissi, Vice-President, Americas Chief Technology Officer, Distinguished Engineer, EMC Corporation
- Cristiane Elisa Foja, Director, Government Affairs, Latin America, The Dow Chemical Company
- Pedro Luis Discacciati Fortes, Director-General, Eastman do Brasil Ltda
- Justo Pastor Fuentes Fuentes, Group Managing Director, Bata LatAm, Bata Shoe Organization
- James Gagne, Chief Executive Officer, Greater China, Agility
- Enrique Genzone, Chief Executive Officer, Siemens SA
- Rob Gorham, Senior Manager – MXD, Advanced Development Programs, Lockheed Martin Aeronautics
- Jaime Gornsztejn, Representative, Brazilian Development Bank (BNDES), Brazil
- Guo Ping, Deputy Chairman of the Board, Huawei Technologies, People's Republic of China
- Tom Hannon, Director, Advanced Practices and Tools, Corporate Engineering & Technology, Lockheed Martin
- Tom Hayes, Vice-President, Corporate Marketing, Marvell Technology Group Ltd
- Hans Oust Heiberg, Head, International Section, Shipping, Offshore and Logistics Division, DNB ASA
- Donald Hepburn, Economist, Chatham House, United Kingdom
- Leandro Hernandez, General Manager, Latin America, TIBCO Software Inc.
- Gopichand P. Hinduja, Chairman, Hinduja Automotive, United Kingdom
- Sam Hsu, Senior Vice-President and General Manager, Ecolab Inc.
- Rudolf W. Hug, Chairman of the Board of Directors, Panalpina World Transport Holding, Switzerland
- Wu Jian, Vice-President, Government Affairs, China, DuPont China Holding Co. Ltd People's Republic of China
- Naveen Jindal, Chairman and Managing Director, Jindal Steel and Power Limited
- Liu Kaiming, Executive Director, The Institute of Contemporary Observation (ICO)
- Paulo Sergio Kakinoff, President, Audi do Brasil e CIA
- Raju Kalyani, Executive Director, Manufacturing Operations, Bharat Forge Ltd
- Michael Kamel, Director, Strategy & Business Development, Bombardier Aerospace, Canada
- Onkar S. Kanwar, Chairman, Apollo Tyres Ltd
- Ravi Kastia, Global Head, International Trading, Aditya Birla Management Corporation Pvt. Ltd
- Dinesh A. Keskar, President, Boeing India and Vice-President, Boeing International Corporation India Pvt. Ltd
- Kim Chul-Hoon, President and Chief Executive Officer, Hanwha Asset Management
- Bob King, President, United Auto Workers (UAW), USA
- Sanjay C. Kirloskar, Vice-Chairman and Director, Kirloskar Oil Engines Ltd
- Kenneth L. Kraemer, PhD, Research Professor, Paul Merage School of Business, Co-Director of the Personal Computing Industry Center (PCIC) and Associate Director of the Center for Research on Information Technology and Organizations (CRITO), UC Irvine
- Dulesha Kulasoorya, Manager, Customer & Market Strategy, Deloitte Consulting

Acknowledgements

- Siddharta Lal, Managing Director and Chief Executive Officer, Eicher Motors Limited
- Robert Larsson, Local Division Manager, ABB (China) Ltd
- Wolfgang Lehmacher, Partner and Managing Director, Greater China and India, Corporate Value Associates (CVA)
- James Z. Li, Chairman and Chief Executive Officer, E. J. McKay & Co Inc.
- Lou Librandi, Senior Manager, Supply Chain & Manufacturing Operations, Deloitte Consulting
- Greg Linden, PhD, Research Associate, Institute for Business Innovation, Berkeley Haas School of Business
- Marcello Lomelino, Managing Director, Public & Governmental Affairs, Alcoa
- Michael Lopez, Manager, Public Affairs, Alcoa
- Michael Macht, Member of the Board of Management, Group Production, Volkswagen, Germany
- Chetan Maini, Founder and Chief of Technology and Strategy, Mahindra Reva
- Tarkan Maner, President and Chief Executive Officer, Wyse Technology Inc.
- Juan Gilberto Marin Quintero, President and Chief Executive Officer, Grupo P.I. Mabe SA de CV
- Paul McCaffrey, Project Leader, Future of Manufacturing Project, Foresight, UK Government Office for Science, United Kingdom
- Navas Meeran, Managing Director, Eastern Condiments Pvt. Ltd
- Jock Mendoza-Wilson, SVP Strategy and Productivity, Braskem
- Liao Min, Director-General, China Banking Regulatory Commission People's Republic of China
- Vineet Mittal, Co-Founder and Managing Director, Welspun Energy
- Krishan Kumar Modi, Chairman, Modi Enterprises
- Hubertus M. Mühlhäuser, Senior Vice-President and General Manager, AGCO Corporation, Switzerland
- Ramakrishnan Mukundan, Managing Director, Tata Chemicals Ltd
- Daniel F. Muzyka, Dean, Sauder School of Business, University of British Columbia
- Ganesh Natarajan, Vice-Chairman and Chief Executive Officer, Zensar Technologies Ltd
- Christopher Ng, Regional Secretary, Asia and Pacific, UNI Global Union - Asia and Pacific Regional Office
- Idan Ofer, Chairman of the Board, Better Place, Israel
- Shoji Okuyoshi, Senior Manager, Group Management, Planning Office, Strategy Planning Division, Hitachi
- Dan Sten Olsson, Chief Executive Officer, Stena, Sweden
- David Palmer, Principal, Arup Americas, Arup
- Ravi Pandit, Chairman and Group Chief Executive Officer, KPIT Cummins Infosystems Ltd
- Sunil R. Parekh, Strategic Adviser, Zydus Cadila Group
- Park Han-Woo, Managing Director, Hyundai Motor India Ltd (HMIL)
- Kishor Patil, Chief Executive Officer and Managing Director, KPIT Cummins Infosystems Ltd
- Olof Persson, President and Chief Executive Officer, Volvo, Sweden
- Jorge Luis Ramos Santos, Deputy President, Heineken Americas
- Don Ratliff, Executive Director, Supply Chain & Logistics Institute, Georgia Tech
- Andreas Renschler, Member of the Board of Management, Daimler and Chief Executive Officer, Daimler Trucks and Daimler Buses, Daimler AG, Germany
- Sancha Salgueiro, Senior Manager, Head of Business Development for Textiles, Novozymes A/S
- Arvind Saxena, Director, Hyundai Motor India Ltd (HMIL)
- Joel Schwartz, Senior Vice-President and General Manager, Common Storage Platforms, EMC Corporation
- Toshiyuki Shiga, Chief Operating Officer, Nissan Motor Co., Japan
- Jaidev R. Shroff, Chief Executive Officer, United Phosphorus Ltd (UPL)
- Nikhil Soares, Global Director, Supply Chain Innovation, Nike
- Dan Stone, Vice-President, Strategy and Corporate Development, Lenovo
- Tony Su, President, DuPont Greater China, DuPont China Holding Co. Ltd
- Pedro E. Suarez, President, Latin America, The Dow Chemical Company
- Jan-Eric Sundgren, Executive Vice-President, Public and Environmental Affairs, Public and Environmental Affairs, Volvo, Sweden
- Sehat Sutardja, Chairman, President and Chief Executive Officer, Marvell Technology Group
- Peter Sykes, President, Greater China, The Dow Chemical Company
- João Pedro Taborda, Director, External Relations, Europe, Africa, and Middle East, Embraer Aviation Europe
- Victoria Vakhrusheva, International and Investor Relations, System Capital Management
- Venkatesh Valluri, Chairman and President, Ingersoll Rand, India
- Luis Cesar Verdi, Managing Director, SAP do Brasil Ltda
- Vivek Wadhwa, Professor, Pratt School of Engineering, Duke University
- Andreas Weishaar, Vice-President and Managing Director, China and India, AGCO Corporation
- Rich Wells, Former VP, Global Government Affairs and Public Policy, The Dow Chemical Company
- Brandon Widmer, Director, Business Development, Pratt & Miller Engineering
- Siegfried Wolf, Chairman of the Board of Directors, Russian Machines, Russian Federation
- Gavin Liu Xingang, Division Manager, Power Systems, ABB (China) Ltd
- Jilian Yang, Interpreter to Cui Dianguo, China CNR Corporation Limited (CNR)
- Kenneth Zhang Yixiao, Chief Executive Officer, Guangdong Haohe Construction, Haohe Engineering and Construction
- Anne Zhao, Director, Public Policy, The Dow Chemical Company People's Republic of China

Core Project Team

From the World Economic Forum (in alphabetical order)

- Stefano Ammirati, Associate Director, Head of Automotive Industry, World Economic Forum
- Ronald Philip, Community Manager, Logistics & Transportation, Mobility Industries, World Economic Forum USA, Project Manager, Future of Manufacturing
- Frances Robles, Team Coordinator, Mobility Industries
- Amish Thakker, Deloitte Seconded, Project Manager, Future of Manufacturing

From Deloitte LLP (in alphabetical order)

- Jodi Benkarski, Deloitte United States (Deloitte Services LP)
- Pulkit Bohra, Deloitte United States (Deloitte Support Services India Pvt Ltd)
- Jeffrey Callahan, Deloitte United States (Deloitte Consulting LLP)
- Michelle Drew, Deloitte United States (Deloitte Services LP)
- Bharath Gangula, Deloitte United States (Deloitte Support Services India Pvt Ltd)
- Megan Harvey, Deloitte United States (Deloitte Consulting LLP)
- Pandarinath Illinda, Deloitte United States (Deloitte Support Services India Pvt Ltd)
- Dorothy Powers, Deloitte United States (Deloitte Consulting LLP)
- Satish Raghavendran, Deloitte United States (Deloitte Support Services India Pvt Ltd)
- Achyoot Sinha, Deloitte United States (Deloitte Support Services India Pvt Ltd)

Contributors

From the World Economic Forum

Production

- Creative Design: Kamal Kimaoui, Director
- Design: Yoren Geromin, Graphic Designer (Kissing Kourami)
- Video: Marta Chierago, Senior Manager, Content Production

From Deloitte LLP (in alphabetical order)

- Dawn Desantis, Deloitte United States (Deloitte Services LP)
- Mimi Lee, Deloitte Touche Tohmatsu Ltd

Production

- Editor and Creative Design: Steve Schmith, Deloitte United States (Deloitte Services LP)

Endnotes

- Hausmann, R., Hidalgo, C.A. et al. (2011) The Atlas of Economic Complexity: Mapping Paths to Prosperity. Available at: <http://www.cid.harvard.edu/documents/complexityatlas.pdf>
- Hepburn, D. (2011) Mapping the World's Changing Industrial Landscape. Chatham House, Briefing Paper. Available at: http://www.chathamhouse.org/sites/default/files/0711bp_hepburn.pdf
- United Nations. (2010) United Nations World Population Prospects: The 2010 revision. Available at: <http://esa.un.org/wpp/Documentation/publications.htm>
- Hepburn, D. (2011) Mapping the World's Changing Industrial Landscape. Chatham House, Briefing Paper. Available at: http://www.chathamhouse.org/sites/default/files/0711bp_hepburn.pdf
- Ibid.
- Ibid.
- Hepburn, D. (2011) Mapping the World's Changing Industrial Landscape. Chatham House, Briefing Paper. Available at: http://www.chathamhouse.org/sites/default/files/0711bp_hepburn.pdf Pg. 4
- World Bank. (2011) Emerging Market Growth Poles are Redefining Global Economic Structure, Says World Bank Report. Press Release, May 17. Available at: <http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:22915632~pagePK:64257043~piPK:437376~theSitePK:4607,00.html>
- United States Energy Information Administration. (2011) Annual Energy Outlook 2011. Available at: <http://www.eia.gov/forecasts/archive/aeo11/>
- Kharas, H. (2010) The Emerging Middle Class in Developing Countries. OECD Development Centre, Working Paper. Available at: <http://www.oecd.org/dataoecd/12/52/44457738.pdf>
- Ibid.
- Kharas, H. (2010) The Emerging Middle Class in Developing Countries. OECD Development Centre, Working Paper. Available at: <http://www.oecd.org/dataoecd/12/52/44457738.pdf> Pg. 28
- World Bank. (2011) Emerging Market Growth Poles are Redefining Global Economic Structure, Says World Bank Report. Press Release, May 17. Available at: <http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:22915632~pagePK:64257043~piPK:437376~theSitePK:4607,00.html>
- Zhong, N. (2011) Digging Deeper for Growth. China Daily, November 11. Available at: http://usa.chinadaily.com.cn/weekly/201111/11/content_14076509.htm
- Yee, L. C. & Jim, C. (2011) Foxconn to rely more on robots; could use 1 million in 3 years. Reuters, August 21. Available at: <http://www.reuters.com/article/2011/08/01/us-foxconn-robots-idUSTRE77016B20110801>
- Kharas, H. (2010) The Emerging Middle Class in Developing Countries. OECD Development Centre, Working Paper. Available at: <http://www.oecd.org/dataoecd/12/52/44457738.pdf> Pg. 28-9
- World Trade Organization. (2012) The multi-lateral trading system – past, present and future. Available at: http://www.wto.org/english/thewto_e/whatis_e/inbrief_e/inbr01_e.htm
- U.S. and Singaporean Governments. (2004) The U.S.–Singapore Free Trade Agreement. Available at: <http://export.gov/FTA/singapore/index.asp>
- China Daily. (2009) China moves forward with FTA strategy. October 24. Available at: http://www.chinadaily.com.cn/bizchina/2009-10/24/content_8843876.htm
- Snell, A. & Willard, C.G. (2010) Modeling and Simulation among U.S. Manufacturers: The Case for Digital Manufacturing. Intersect360. Available at: <http://www.intersect360.com/industry/reports.php?id=35> Pg. 2
- CADAZZ. (2004) CAD Software – History of CAD CAM. Available at: <http://www.cadazz.com/cad-software-history.htm> Bozdoc, Marian. (2003) The History of CAD. Available at: <http://mbinfo.mbdesign.net/CAD-History.htm>
- Ibid.
- Bozdoc, Marian. (2003) The History of CAD. Available at: <http://mbinfo.mbdesign.net/CAD-History.htm>
- Business Wire. (2011) Jon Peddie Research Releases the Worldwide CAD Market Report 2012. December 1. Available at: <http://www.marketwatch.com/story/jon-peddie-research-releases-the-worldwide-cad-market-report-2012-2011-12-01>
- Deloitte analysis based on total revenues of eight of the top 10 digital modeling companies; total revenue data pulled from annual reports of Dassault Systemes, Autodesk, Synopsys, PTC, Cadence, Mentor Graphics, National Instruments, Ansys
- Deloitte analysis based on WTO import / export data for Machinery & Transport Equipment category between 1990-2000 and 2000-2010 for Japan, China, Brazil, India, Germany and the US
- McDonald, C. J. (1998) The Evolution of Intel's Copy EXACTLY! Technology Transfer Method. Intel Technology Journal, Q4. Available at: <ftp://download.intel.com/technology/itj/q41998/pdf/copyexactly.pdf> Pg. 3
- Kelly, K. (2009) Rapid Manufacturing @ Intel. Time Compression, November 4. Available at: <http://www.timecompression.com/articles/rapid-manufacturing-intel>
- Gertner, J. (2011) Does America Need Manufacturing? The New York Times, August 24. Available at: <http://www.nytimes.com/2011/08/28/magazine/does-america-need-manufacturing.html?pagewanted=all>
- Denning, S. (2011) Bringing Back 'Lost' Industries: The Case Of Batteries (Part 10). Forbes, September 21, <http://www.forbes.com/sites/stevedenning/2011/09/21/bringing-back-lost-industries-the-case-of-batteries-part-10/>
- Wilcox, J. & Hannon, T. (2011) Author Interview with Jeff Wilcox, Vice-President, Engineering, Corporate Engineering and Technology at Lockheed Martin, and Tom Hannon, Director, Advanced Practices and Tools, Corporate Engineering & Technology at Lockheed Martin. October 11.
- Ibid.
- Campbell, T., Williams, C., Ivanova, O. & Garrett, B. (2011) Could 3D printing change the world? Atlantic Council, Strategic Foresight Report. Available at: http://www.acus.org/files/publication_pdfs/403/101711_ACUS_3DPrinting.PDF
- Wohlers Associates. (2011) New Industry Report on Additive Manufacturing and 3D Printing Unveiled. Press Release, May 16. Available at: <http://www.wohlersassociates.com/press54.htm>
- Emerson, G. (2010) How 3-D Printing Changes Everything. The Street, October 14. Available at: <http://www.thestreet.com/story/11277789/1/how-3-d-printing-changes-everything.html>
- Hagel III, J., Brown, J.S. & Davison, L. (2009) The Big Shift, Measuring the Forces of Change. Harvard Business Review, July-August. Available at: <http://hbr.org/hbr-main/resources/pdfs/comm/fmglobal/the-big-shift-measuring-forces-of-change.pdf>
- The Council on Competitiveness. (2011) Make: An American Manufacturing Movement. Available at: http://www.compete.org/images/uploads/File/PDF%20Files/USMCI_Make.pdf Pg. 20
- Ibid.
- Airframer.com. (2011) Boeing 787 Dreamliner Program Suppliers Report. Available at: http://www.airframer.com/aircraft_detail.html?model=B787
- Dedrick, J., Kraemer, K.L. & Linden, G. (2008) Who Profits from Innovation in Global Value Chains? A Study of the iPod and notebook PCs. Industry Studies Association, Working Paper 2008-15. Available at: <http://isapapers.pitt.edu/97/>
- World Trade Organization. (2011) Information Technology Agreement – introduction. Available at: http://www.wto.org/english/tratop_e/inftec_e/itaintro_e.htm
- Ibid.
- Evenett, S.J. ed. (2011) Resolve Falters as Global Prospects Worsen: the 9th GTA Report. London: Centre for Economic Policy Research. Available at: <http://www.globaltradealert.org/sites/default/files/GTA9.pdf> Pg. 1
- Ibid
- Baldwin, R. & Evenett, S. eds. (2008) What world leaders must do to halt the spread of protectionism. London: Centre for Economic Policy Research, VoxEU.org. Available at: <http://www.voxeu.org/reports/protectionism.pdf> Pg. 1
- "Beggart-hy-neighbor" is an expression in economics describing policies that seek benefits for one country at the expense of others. World Trade Organization. (2011) World Trade Report 2011. Available at: http://www.wto.org/english/res_e/booksp_e/anrep_e/world_trade_report11_e.pdf Pg. 87
- Evenett, S.J. ed. (2011) Trade Tensions Mount: the 10th GTA Report. London: Centre for Economic Policy Research. Available at: <http://www.globaltradealert.org/gta-analysis/trade-tensions-mount-10th-gta-report> Pg. 20
- Ibid.
- Evenett, S.J. ed. (2011) Trade Tensions Mount: the 10th GTA Report. London: Centre for Economic Policy Research. Available at: <http://www.globaltradealert.org/gta-analysis/trade-tensions-mount-10th-gta-report> Pg. 22, 30
- Evenett, S.J. ed. (2011) Trade Tensions Mount: the 10th GTA Report. London: Centre for Economic Policy Research. Available at: <http://www.globaltradealert.org/gta-analysis/trade-tensions-mount-10th-gta-report> Pg. 4, 22
- Evenett, S.J. ed. (2011) Trade Tensions Mount: the 10th GTA Report. London: Centre for Economic Policy Research. Available at: <http://www.globaltradealert.org/gta-analysis/trade-tensions-mount-10th-gta-report> Pg. 33
- Evenett, S.J. ed. (2011) Trade Tensions Mount: the 10th GTA Report. London: Centre for Economic Policy Research. Available at: <http://www.globaltradealert.org/gta-analysis/trade-tensions-mount-10th-gta-report> Pg. 23
- Evenett, S.J. ed. (2011) Trade Tensions Mount: the 10th GTA Report. London: Centre for Economic Policy Research. Available at: <http://www.globaltradealert.org/gta-analysis/trade-tensions-mount-10th-gta-report> Pg. 7
- Evenett, S.J. ed. (2011) Resolve Falters as Global Prospects Worsen: the 9th GTA Report. London: Centre for Economic Policy Research. Available at: <http://www.globaltradealert.org/sites/default/files/GTA9.pdf> Pg. 7
- Evenett, S.J. ed. (2011) Resolve Falters as Global Prospects Worsen: the 9th GTA Report. London: Centre for Economic Policy Research. Available at: <http://www.globaltradealert.org/sites/default/files/GTA9.pdf> Pg. 3
- Ibid.
- World Trade Organization. (2011) World Trade Report 2011. Available at: http://www.wto.org/english/res_e/booksp_e/anrep_e/world_trade_report11_e.pdf Pg. 3
- World Trade Organization. (2011) World Trade Report 2011. Available at: http://www.wto.org/english/res_e/booksp_e/anrep_e/world_trade_report11_e.pdf Pg. 62
- World Trade Organization. (2011) World Trade Report 2011. Available at: http://www.wto.org/english/res_e/booksp_e/anrep_e/world_trade_report11_e.pdf Pg. 3
- World Trade Organization. (2011) World Trade Report 2011. Available at: http://www.wto.org/english/res_e/booksp_e/anrep_e/world_trade_report11_e.pdf Pg. 198
- World Trade Organization. (2011) World Trade Report 2011. Available at: http://www.wto.org/english/res_e/booksp_e/anrep_e/world_trade_report11_e.pdf Pg. 14, 182
- Hutson, E. (2011) Why risk management matters more than ever: Foreign exchange exposure in an open economy in the Eurozone. Executive Edge UCD Smurfit School. Available at: <http://www.smurfit.ie/t4cms/ExecEdSlides/ElaineHutson.pdf>
- Hutson, E. & Stevenson, S. (2010) Openness, hedging incentives and foreign exchange exposure: A firm-level multi-country study. Journal of International Business Studies, 41: 105-22
- Hutson, E. (2011) Conversation with Dr. Elaine Hutson, Professor of Banking and Finance at UCD Michael Smurfit Graduate Business School in Blackrock, Co. Dublin. December 9, 2011

61. Ibid.
62. Ibid.
63. Ibid.
64. Husain, A. M., Mody, A. & Rogoff, K.S. (2004) Exchange Rate Regime Durability and Performance in Developing Versus Advanced Economies. Available at: http://www.carnegie-rochester.rochester.edu/April04-pdfs/regimes_cr.pdf . Pg. 1
65. Taylor, J.B. (2011) An Empirical Analysis of the Revival of Fiscal Activism in the 2000s. *Journal of Economic Literature*, 49(3): 686–702
66. Benita, G. & Lauterbach, B. (2007) Policy Factors and Exchange Rate Volatility. *International Research Journal of Finance and Economics*, 7: 8
67. World Economic Forum. (2012) The Global Competitiveness Report 2011-2012. Available at: <http://reports.weforum.org/global-competitiveness-2011-2012>. Pg. 6
68. Wei, L. & Davis, B. (2011) Yuan's Rise is Out of Steam. *The Wall Street Journal*, December 9. Available at: <http://online.wsj.com/article/SB10001424052970204319004577085744162675830.html>
69. Lyons, J. (2011) Brazil Industry Slows Sharply. *The Wall Street Journal*, November 2. Available at: <http://online.wsj.com/article/SB10001424052970204528204577012180026401966.html>
70. Ibid.
71. Ibid.
72. Dalton, M. & Kinch, D. (2011) Debate on Yuan Manipulation moves to WTO. *The Wall Street Journal*, November 16. Available at: <http://online.wsj.com/article/SB10001424052970203503204577040133923921786.html>
73. Ibid.
74. Smith, P. (2011) Exchange Rate Kills Australian Steel Exports. *Financial Times*, August 22. Available at: <http://www.ft.com/cms/s/0/7da0dbfe-cc9e-11e0-b923-0014feabdc0.html#axzz1oatpflI>
75. Mijuk, G. (2011) Strong Franc Hurts Swiss Business. *The Wall Street Journal*, October 20. Available at: <http://online.wsj.com/article/SB10001424052970204485304576641012389872374.html>
76. Lubin, G. Nintendo Blames Strong Yen For First Expected Annual Loss In 30 Years. *Business Insider*, October 27. Available at: http://articles.businessinsider.com/2011-10-27/markets/30326838_1_nintendo-3ds-satoru-iwata-yen#ixzz1ceeHyZ7k
77. Yasu, M. & Fujimura, N. (2011) Sony Forecasts Full-Year Loss on Yen Sales. *Bloomberg*, November 2. Available at: <http://www.bloomberg.com/news/2011-11-02/sony-forecasts-full-year-loss-on-yen-waning-sales-of-tvs-cameras-in-u-s-.html>
78. Ramsey, M. & Takahashi, Y. (2011) Car Wreck: Honda and Toyota. *The Wall Street Journal*, November 1. Available at: online.wsj.com/documents/print/WSJ_B001-20111101.pdf
79. Dawson, C. & Takahashi, Y. (2011) Yen and Floods Sap Toyota. *The Wall Street Journal*, November 9. Available at: <http://online.wsj.com/article/SB10001424052970204554204577025090836213690.html>
80. Takahashi, Y. (2011) Nissan Adapts to Strong Yen. *The Wall Street Journal*, October 25. Available at: <http://online.wsj.com/article/SB1000142405297020477904576650810113082114.html>
81. Deloitte Analysis based on overall labor rate data and projections to 2015 for selected countries, published by the Economist Intelligence Unit, extracted November 15, 2011, <http://www.eiu.com>
82. Rabinovitch, S. (2011) China labour costs soar as wages rise 22%. *Financial Times*, October 25. Available at: <http://www.ft.com/cms/s/0/25f1c500-ff14-11e0-9b2f-0014feabdc0.html#axzz1gzSnMe3p>
83. India Knowledge@Wharton. (2011) Salaries on the Rise: Globalization Brings New Pressures to India. *Knowledge@Wharton* blog, April 7. Available at: <http://knowledge.wharton.upenn.edu/india/article.cfm?articleid=4585>
84. Deloitte Analysis based on overall labor rate data and projections to 2015 for selected countries, published by the Economist Intelligence Unit, extracted November 15, 2011, <http://www.eiu.com>
85. India Knowledge@Wharton. (2011) Salaries on the Rise: Globalization Brings New Pressures to India. *Knowledge@Wharton* blog, April 7. Available at: <http://knowledge.wharton.upenn.edu/india/article.cfm?articleid=4585>
86. Bradsher, K. (2011) As China's Workers Get a Raise, Companies Fret. *The New York Times*, May 31. Available at: <http://www.nytimes.com/2011/06/01/business/global/01wages.html>
87. Sirkin, H.L., Zinsner, M. & Hohner, D. (2011) Made in America, Again. Why Manufacturing Will Return to the U.S. *The Boston Consulting Group*. Available at: <http://www.bcg.com/documents/file84471.pdf>
88. Hille, K. (2011) Foxconn Looks to a Robotic Future. *Financial Times*, August 1. Available at: <http://www.ft.com/intl/cms/s/2/e5d9866e-bc25-11e0-80e0-0014feabdc0.html>
89. Aepffel, T. (2011) Otis Shifts Work Closer to Home. *The Wall Street Journal*, October 7. Available at: <http://online.wsj.com/article/SB1000142405297020429450457661497328673108.html>
90. Deloitte and the U.S. Council on Competitiveness. (2010) 2010 Global Manufacturing Competitiveness Index. Available at: http://www.deloitte.com/view/en_GX/global/industries/manufacturing/ata52c646d069210VgnVCM200000bb42f00aRCRD.htm
91. World Economic Forum. (2012) The Global Competitiveness Report 2011-2012. Available at: <http://reports.weforum.org/global-competitiveness-2011-2012>. Pg. 5
92. World Economic Forum. (2012) The Global Competitiveness Report 2011-2012. Available at: <http://reports.weforum.org/global-competitiveness-2011-2012>. Pg.
93. Rahul, S., Rahul, M. & Sahay, A. (2009) An assessment of competitiveness of BRICS nations with special focus on India. *Abhigyan*. 27(1): Table VII
94. World Bank. (2012) World Bank Data: Infrastructure. Available at: <http://data.worldbank.org/topic/infrastructure>
95. Ibid.
96. Jing, J. (2006) Huge rail investment announced. *China Daily*, November 23. Available at: http://www.chinadaily.com.cn/china/2006-11/23/content_740517.htm
97. Associated Press. (2011) China Just Cut Railway Construction Plans Again As Debt Continues To Pile Up. December 23. Available at: http://articles.businessinsider.com/2011-12-23/markets/30547877_1_railway-construction-new-rail-projects-rail-network#ixzz1hhMmQjS1
98. Moore, M. & Foster, P. (2011) China to create largest mega city in the world with 42 million people. *The Telegraph*, January 24. Available at: <http://www.telegraph.co.uk/news/worldnews/asia/china/8278315/China-to-create-largest-mega-city-in-the-world-with-42-million-people.html>
99. Calderón, C. & Servén, L. (2004) The Effects of Infrastructure Development on Growth and Income. *World Bank Policy Research Paper*. Available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=625277. Pg. 9, 42-3
100. Isaksson, A. (2009) Public Capital, Infrastructure and Industrial Development. UNIDO Research and Statistics Branch Working Paper. Available at: http://www.unido.org/fileadmin/user_media/Publications/RSF_DPR/WP152009_Ebook.pdf
101. Fan, S. & Chan-Kang, C. (2004) Returns to Investment in Less-Favored Areas in Developing Countries: A Synthesis of Evidence and Implications for Africa. *Food Policy*, 29(4): 431–44. In: *World Bank. (2007) The Nexus Between Infrastructure and Environment From the Evaluation Cooperation Group of the International Financial Institutions*. Available at: http://siteresources.worldbank.org/INTOED/Resources/infrastructure_environment.pdf. Pg. 3
102. Bugge, A. (2011) Fitch cuts Portugal rating on high debts, worse outlook. *Reuters*, November 24. Available at: <http://www.reuters.com/article/2011/11/24/us-portugal-fitch-idUSTRE7AN00120111124>
103. Corporate Financier. (2011) Who will pay? Available at: <http://www.icaew.com/en/technical/corporate-finance/initial-public-offerings/who-will-pay>
104. Laxmidas, S. & Lima, F. (2011) Portugal must ditch PPP investments, focus on exports-minister. *Reuters*, August 2. Available at: <http://www.reuters.com/article/2011/08/02/portugal-economy-idUSLDE7710HE20110802>
105. Abadie, R. & Brown, P. (2011) Infrastructure investment in the wake of crisis. *PWC Talking Points*. Available at: http://download.pwc.com/ie/pubs/2011_infrastructure_investment_in_the_wake_of_crisis.pdf. Pg. 1, 7
106. Abadie, R. & Brown, P. (2011) Infrastructure investment in the wake of crisis. *PWC Talking Points*. Available at: http://download.pwc.com/ie/pubs/2011_infrastructure_investment_in_the_wake_of_crisis.pdf. Pg. 3, 4
107. Abadie, R. & Brown, P. (2011) Infrastructure investment in the wake of crisis. *PWC Talking Points*. Available at: http://download.pwc.com/ie/pubs/2011_infrastructure_investment_in_the_wake_of_crisis.pdf. Pg. 4
108. Thomason, A. & MacDonald, A. (2011) U.K. Seeks to Revive Growth. *The Wall Street Journal*, November 28. Available at: <http://online.wsj.com/article/SB10001424052970203935604577064080775527226.html>
109. Slaughter, M. & Marchick, D. (2008) The Council on Foreign Relations Special Report Global FDI Policy: Correcting a Protectionist Drift. *Council on Foreign Relations* Special Report. Available at: <http://www.cfr.org/international-finance/global-fdi-policy/p16503>. Pg. 1
110. Ibid.
111. Caplen, B., ed. (2011) Manufacturing Makes a Comeback: FDI Global Outlook Report 2011. *FDI Intelligence*, *Financial Times*. Available at: http://www.ofii.org/docs/Global_Outlook_Report.pdf
112. Ibid.
113. United Nations. (2001-9) World Investment Reports, FDI Statistics. *United Nations Conference on Trade and Development*. Available at: <http://www.unctad.org/Templates/Page.asp?intlItemID=1465>
114. Ibid.
115. Caplen, B., ed. (2011) Manufacturing Makes a Comeback: FDI Global Outlook Report 2011. *FDI Intelligence*, *Financial Times*. Available at: http://www.ofii.org/docs/Global_Outlook_Report.pdf
116. Ibid.
117. Moran, T.H. (2011) Foreign Direct Investment and Development: Launching a Second Generation of Policy Research: Avoiding the Mistakes of the First. *Reevaluating Policies for Developed and Developing Countries*. Washington, DC: Peterson Institute for International Economics. Pg. 34
118. Hepburn, D. (2011) Mapping the World's Changing Industrial Landscape. *Chatham House*, Briefing Paper. Available at: http://www.chathamhouse.org/sites/default/files/0711bp_hepburn.pdf. Pg. 2
119. Shinde, R. (2011) India's top 500 companies like Coal India Limited, RIL, ONGC, NTPC, SAIL, NMDC, Infosys, Oil India, Tata Motors, Tata Steel and others sit on cash pile of Rs 4.7 lakh crore instead of investing. *The Economic Times*, October 17. Available at: http://articles.economictimes.indiatimes.com/2011-10-17/news/30289988_1_cash-pile-investments-tata-steel

120. Industryweek. (2011) IW 1000: The World's Biggest Manufacturers. Available at: <http://www.industryweek.com/section.aspx?sectionid=40>
121. Ibid.
122. World Bank. (2010) Investing Across Borders 2010: Indicators of foreign direct investment regulation in 87 economies. Available at: <http://iab.worldbank.org/~media/FPDKM/IAB/Documents/IAB-report.pdf>. Pg. 9
123. Invest Korea. (2012) About Us. Available at: www.investkorea.org
124. Slaughter, M. & Marchick, D. (2008) The Council on Foreign Relations Special Report Global FDI Policy: Correcting a Protectionist Drift. Council on Foreign Relations Special Report. Available at: <http://www.cfr.org/international-finance/global-fdi-policy/p16503>. Pg. 2
125. Ibid.
126. Slaughter, M. & Marchick, D. (2008) The Council on Foreign Relations Special Report Global FDI Policy: Correcting a Protectionist Drift. Council on Foreign Relations Special Report. Available at: <http://www.cfr.org/international-finance/global-fdi-policy/p16503>
- United States Government Accountability Office. (2008) Foreign Investment – Laws and Policies Regulating Foreign Investment in 10 Countries. Available at: <http://www.gao.gov/new.items/d08320.pdf>
- Gati, T. (2008) Russia's New Law on Foreign Investment in Strategic Sectors and the Role of State Corporations in the Russian Economy. Akin Gump: Strauss Hauer & Feld LLP. Available at: https://www.usrbc.org/pics/File/Member%20Contributions/legal/Foreign_InvestmentInStrategicSectors.pdf
127. Ibid.
128. Ibid.
129. Ibid.
130. REEs are the 15 elements in the Periodic Table with atomic numbers from 57 to 71, i.e. from lanthanum to lutetium (called "lanthanides"), plus scandium (21) and yttrium (39), which are chemically similar to the lanthanide elements and thus typically included with the rare earth elements. The platinum group elements (PGEs) include ruthenium, rhodium, palladium, osmium, iridium, and platinum. Energy critical elements include gallium, germanium, selenium, indium, and tellurium, all semiconductors with applications in photovoltaics. Cobalt, helium, lithium, rhenium, and silver round out the list.
131. Eggert, R.G. (2010) Critical Minerals and Emerging Technologies. Issues in Science and Technology Online. Available at: <http://www.issues.org/26.4/eggert.html>
132. U.S. Department of Energy. (2010) Critical Materials Strategy. Available at: <http://cr.aiag.org/files/criticalmaterialsstrategy.pdf>. Pg. 22-3
133. Eggert, R.G. (2010) Critical Minerals and Emerging Technologies. Issues in Science and Technology Online. Available at: <http://www.issues.org/26.4/eggert.html>
134. Li, M. et al. (2011) China Rare Earth Industry: An Industry at a Turning Point. Yuanta Research. Available at: http://ipreo.yuanta.com/NSightWeb_v2.00/Downloads/Files/17675.pdf. Pg. 6
135. Li, M. et al. (2011) China Rare Earth Industry: An Industry at a Turning Point. Yuanta Research. Available at: http://ipreo.yuanta.com/NSightWeb_v2.00/Downloads/Files/17675.pdf. Pg. 5-12
136. Deloitte analysis based on: Long, K.R., Van Gosen, B.S., Foley, N.F. & Cordier, D. (2010) The Principal Rare Earth Element Deposits of the United States – A Summary of Domestic Deposits and a Global Perspective. U.S. Department of the Interior, U.S. Geological Survey. Available at: <http://pubs.usgs.gov/sir/2010/5220/>. Pg. 15
137. Chen, Z. (2011) Global rare earth resources and scenarios of future rare earth industry. *Journal of Rare Earths*, 29(1):1
138. Long, K.R., Van Gosen, B.S., Foley, N.F. & Cordier, D. (2010) The Principal Rare Earth Element Deposits of the United States – A Summary of Domestic Deposits and a Global Perspective. U.S. Department of the Interior, U.S. Geological Survey. Available at: <http://pubs.usgs.gov/sir/2010/5220/>. Pg. 15
139. Ohnsman, A. (2011) Toyota Ready Motors That Don't Use Rare Earths. Bloomberg, January 14. Available at: <http://www.bloomberg.com/news/2011-01-14/toyota-readying-electric-motors-that-don-t-use-rare-earth.html>
140. Shamsky, T. (2011) Testing Their Metals: Companies are searching for ways to reduce their need for increasingly scarce minerals. *The Wall Street Journal*, September. Available at: http://online.wsj.com/article/SB1000142405311903639404576516012428805034.html?mod=ITP_thejournalreport_0
141. U.S. Energy Information Administration. (2011) International Energy Outlook 2011. Available at: <http://www.eia.gov/forecasts/archive/aio11/>. Pg. 1
142. U.S. Energy Information Administration. (2011) International Energy Outlook 2011. Available at: <http://www.eia.gov/forecasts/archive/aio11/>. Pg. 107
143. Deloitte Analysis based on data from the U.S. Energy Information Administration (EIA)'s International Energy Outlook 2011. 'World total primary energy consumption by region, Reference case' Available at: http://www.eia.gov/oiat/aio/tablebrowser/#release=IEO2011&subject=0-IEO2011&table=1-IEO2011®ion=0-0&cases=Reference-0504a_1630
144. U.S. Energy Information Administration. (2011) International Energy Outlook 2011. Available at: <http://www.eia.gov/forecasts/archive/aio11/>. Pg. 109
145. Deutsche Bank Climate Change Advisors. (2011) Investment Research: Global Climate Change Policy Tracker – Winners and Losers. Available at: http://www.dbcca.com/dbcca/EN/investment-research/investment_research_2375.jsp
146. Deutsche Bank Climate Change Advisors. (2010) Investment Research: Global Climate Change Policy Tracker – The Green Economy: The Race is On. Available at: http://www.dbcca.com/dbcca/EN/investment-research/investment_research_2296.jsp
147. International Energy Agency. (2011) World Energy Outlook 2011 Fact Sheet. Available at: <http://www.iea.org/weo/docs/weo2011/factsheets.pdf>
148. Deutsche Bank Climate Change Advisors. (2011) Investment Research: Global Climate Change Policy Tracker – Winners and Losers. Available at: http://www.dbcca.com/dbcca/EN/investment-research/investment_research_2375.jsp. Pg. 5
149. International Energy Agency. (2011) World Energy Outlook 2011 Fact Sheet. Available at: <http://www.iea.org/weo/docs/weo2011/factsheets.pdf>. Pg. 1
150. Frankfurt School United Nations Environment Programme and Bloomberg New Energy Finance. (2011) Global Trends in Renewable Energy Investment 2011. Available at: <http://www.fs-unep-centre.org/publications/global-trends-renewable-energy-investment-2011>
151. Deloitte analysis based on: United States Environmental Protection Agency. (2007) Energy Trends in Selected Manufacturing Sectors: Opportunities and Challenges for Environmentally Preferable Energy Outcomes. Available at: <http://www.epa.gov/sectors/pdf/energyreport.pdf>
152. National Energy Education Project. (2012) About Us. Available at: <http://www.need.org/About-NEED>
- Natural Resources Canada. (2009) Canadian Cement Industry Energy Benchmarking Summary Report. Available at: <http://oe.nrcan.gc.ca/sites/oe.nrcan.gc.ca/files/pdf/Publications/Industrial/cement-eng.pdf>
153. Unilever. (2011) Our Manufacturing Performance. Available at: <http://www.unilever.com/sustainability/environment/climate/performance/index.aspx>
154. Business Wire. (2011) Hershey Announces Warehouse and Distribution Alliance. October 5. Available at: <http://www.thehersheycompany.com/newsroom/news-release-1613887.aspx>
155. The Prince of Wales's EU Corporate Leaders Group on Climate Change. (2011) The Low Carbon Compendium. Available at: <http://www.cpsl.cam.ac.uk/Resources/Publications-and-Downloads/Featured-Publications.aspx>
156. P&G. (2011) P&G Sustainability Consumer Education: Helping Consumers Conserve. Available at: http://www.pg.com/en_US/sustainability/environmental_sustainability/products_packaging/consumer_education.shtml
157. Gurry, F. (2011) Foreword: Why Innovation Is Important. In: Dutta, S. ed. (2011) Global Innovation Index 2011: Accelerating Growth and Development. Available at: http://www.globalinnovationindex.org/gii/GII%20COMPLETE_PRINTWEB.pdf. Pg. XI
158. Dutta, S. ed. (2011) Global Innovation Index 2011: Accelerating Growth and Development. Available at: http://www.globalinnovationindex.org/gii/GII%20COMPLETE_PRINTWEB.pdf
159. Swiss-American Chamber of Commerce and The Boston Consulting Group. (2008) Creative Switzerland? Fostering an Innovation Powerhouse. Available at: http://www.amcham.ch/publications/downloads/2009/studylll_creative_switzerland.pdf. Pg. 14
160. Mendes, R.C. (2010) Innovation Promotion in Brazil. *WIPO Magazine*. Available at: http://www.wipo.int/wipo_magazine/en/2010/05/article_0005.html
161. PWC. (2011) Demystifying innovation: Take barriers to new down the growth. Available at: <http://www.pwc.com/gx/en/corporate-strategy-services/assets/ceosurvey-innovation.pdf>
162. Chokshi, N. (2010) How Mobile Phones Are Transforming Indian Agriculture. *The Atlantic*. Available at: <http://www.theatlantic.com/technology/archive/2010/08/how-mobile-phones-are-transforming-indian-agriculture/61394/>
163. Indian Department of Industrial Policy & Promotion. (2011) National Manufacturing Policy. Available at: http://dipp.nic.in/English/Policies/National_Manufacturing_Policy_25October2011.pdf
164. APCO Worldwide. (2010) China's 12th 5 Year Plan: How it actually works and what's in store for the next five years. Available at: http://www.apcoworldwide.com/content/pdfs/chinas_12th_five_year_plan.pdf
165. AIA. (2009) A Special Report: Research and Development Tax Credit. Available at: <http://www.aia-aerospace.org/assets/RandPaper.pdf>
166. Fraunhofer-Gesellschaft. Press Release, Fraunhofer researchers receive the Franco-German Business Award 2011, 06 December 2011. Available at: <http://www.fraunhofer.de/en/press/research-news/2011/december/Franco-GermanBusinessAward2011.html>
167. Taiwan Government Information Office. (2011) ITRI wins WSJ Technology Innovation Awards, again. Press Release, November 26. Available at: <http://www.taiwanembassy.org/ct.asp?xite m=234547&ctNode=2237&mp=1>
168. Slywotzky, A. (2009) Where have you gone Bell Labs? *Business Week*. Available at: http://www.businessweek.com/magazine/content/09_36/b4145036681619.htm
169. Jaruzelski, B. & Dehoff, K. (2010) The Global Innovation 1000: How the Top Innovators Keep Winning. Booz Allen Hamilton. Available at: http://www.booz.com/media/file/sb61_10408-R.pdf
- Gibson, R. (2011) Making innovation a systemic capability. *Innovation Tools*. Available at: <http://www.innovationtools.com/Articles/EnterpriseDetails.asp?a=5261>
170. Radjou, N. (2009) Polycentric Innovation: A New Mandate for Multinationals. *Wall Street Journal*, November 9. Available at: <http://online.wsj.com/article/SB125774328035737917.html>
171. Ibid
172. Ernst & Young. (2011) Winning in a Polycentric World. Available at: <http://www.ey.com/GL/en/Issues/Business-environment/Winning-in-a-polycentric-world-globalization-and-the-changing-world-of-business---Winning-in-a-world-with-many-centers>
173. Radjou, N. (2009) Polycentric Innovation: A New Mandate for Multinationals. *Wall Street Journal*, November 9. Available at: <http://online.wsj.com/article/SB125774328035737917.html>
174. Deloitte and the U.S. Council on Competitiveness. (2010) 2010 Global Manufacturing Competitiveness Index. Available at: http://www.deloitte.com/view/en_GX/global/industries/manufacturing/ata52c646d069210VgnVCM200000bb42f00aRCRD.htm
175. Manpower Group. (2011) Talent Shortage Survey Results. Available at: <http://us.manpower.com/us/en/multimedia/2011-Talent-Shortage-Survey.pdf>. Pg. 6
176. Casselman, B. (2011) Help Wanted: In Unexpected Twist, Some Skilled Jobs Go Begging. *The Wall Street Journal*, November 26. Available at: <http://online.wsj.com/article/SB10001424052970203707504577010080035955166.html>

177. Overdorf, J. (2011) Blame Gandhi: Did the great pacifist kill India, Inc.? GlobalPost, June 17. Available at: <http://www.globalpost.com/dispatch/news/regions/asia-pacific/india/110616/shiva-rules-india-economy-labor-shortage-vocational-training-corporate>
178. Weitzman, Robinson and Pearson Kazmin, "Talent shortage adds to growth strains," Financial Times, May 2011
179. Demick, B. & Pierson, D. (2010) People, people everywhere in China, and not enough to work. Los Angeles Times, March 28. Available at: <http://articles.latimes.com/2010/mar/28/world/la-fg-china-labor28-2010mar28>
180. Gardner, M. (2011) Industry complains of skills shortage. University World News, March 27. Available at: <http://www.universityworldnews.com/article.php?story=20110325204522328>
181. The Manufacturing Institute. (2011) 2011 Skills Gap Report. Available at: <http://www.themanufacturinginstitute.org/Research/Skills-Gap-in-Manufacturing/2011-Skills-Gap-Report/2011-Skills-Gap-Report.aspx>
182. Deloitte and The Manufacturing Institute. (2011) Boiling point? The skills gap in U.S. manufacturing. Available at: <http://www.themanufacturinginstitute.org/Research/Skills-Gap-in-Manufacturing/2011-Skills-Gap-Report/2011-Skills-Gap-Report.aspx>
183. Jones, J. (2011) Caterpillar says has worker shortage despite job woes. Reuters, September 9. Available at: http://www.realclearmarkets.com/news/reuters/finance_business/2011/Sep/09/caterpillar_says_has_worker_shortage_despite_job_woes.html
184. Schertz, A. (2011) Employment: Job market on the mend. BizTimes.com, January 21. Available at: <http://www.biztimes.com/news/2011/1/21/employment-job-market-on-the-mend>
185. Ibid
186. National Institute of Aging. (2007) Why Population Aging Matters: A Global Perspective. Available at: <http://www.nia.nih.gov/research/publication/why-population-aging-matters-global-perspective>
187. United Nations. (2010) United Nations World Population Prospects: The 2010 revision. Available at: <http://esa.un.org/wpp/Documentation/publications.htm>
188. National Science Board. 2012. Science and Engineering Indicators 2012. Arlington VA: National Science Foundation (NSB 12-01). 3-6, 3-62.
189. International Center for Peace and Development. (2011) Employment Trends in the 21st Century. Available at: <http://www.icpd.org/employment/Empltrends21century.htm>
190. Wadhwa, V. (2005) About That Engineering Gap... Business Week, December 13. Available at: http://www.businessweek.com/smallbiz/content/dec2005/sb20051212_623922.htm
191. QS Top Universities. (2010) 2010 QS Asian University Rankings: a case of quantity over quality for mainland China's universities?. Available at: <http://www.topuniversities.com/asia-university-rankings/2010-qs-asian-university-rankings-case-quantity-over-quality-mainland-chin>
192. QS Top Universities. (2011) 2011 QS Asian University Rankings: a case of quantity over quality for mainland China's universities?. Available at: <http://www.topuniversities.com/university-rankings/world-university-rankings/2011>
193. Colvin, G. (2010) Desperately seeking math and science majors. CNNMoney, July 29. Available at: http://money.cnn.com/2010/07/29/news/international/china_engineering_grads.fortune/index.htm
194. Nawab, S. & Shafi, K. (2011) Retaining the brains, policies adopted by P.R. China to attract and retain research talent. Australian Journal of Business and Management Research, 1(4):72-7
195. Overdorf, J. (2011) Blame Gandhi: Did the great pacifist kill India, Inc.? GlobalPost, June 17. Available at: <http://www.globalpost.com/dispatch/news/regions/asia-pacific/india/110616/shiva-rules-india-economy-labor-shortage-vocational-training-corporate>
196. Deloitte. (2009) Necessity Breeds Opportunity: Constraints, Innovation and Competitive Advantage. Available at: http://www.deloitte.com/assets/Dcom-Global/Local%20Assets/Documents/dtt_dr_necessitybreedsopportunity_151108.pdf
197. The Economist. (2011) Bottom of the pyramid. September 10. Available at: <http://www.economist.com/node/21528435>
198. The Manufacturing Institute. (2011) NAM-Endorsed Manufacturing Skills Certification System. Available at: <http://www.themanufacturinginstitute.org/Education-Workforce/Skills-Certification-System/Skills-Certification-System.aspx>
199. The Economist. (2010) The global revival of industrial policy: Picking winners, saving losers. August 5. Available at: <http://www.economist.com/node/16741043>
200. Graham, O. (1994) Losing Time: The Industrial Policy Debate. Harvard: Harvard University Press. Pg. 3, 27
201. Rodrik, D. (2004) Industrial Policy for the 21st Century. United Nations. Available at: http://www.un.org/esa/sustdev/publications/industrial_development/full_report.pdf
202. Krugman, P. (1987) The narrow moving band, the Dutch disease, and the competitive consequences of Mrs. Thatcher. Journal of Development Economics, 27(1-2):41-55
203. Gereffi, G & Wyman, D.L. (1990) Manufacturing miracles: paths of industrialization in Latin America and East Asia. Princeton, NJ: Princeton University Press
204. The Economist. (2010) The global revival of industrial policy: Picking winners, saving losers. August 5. Available at: <http://www.economist.com/node/16741043>
205. Ibid
206. The Economist. (2010) Industrial policy: This house believes that industrial policy always fails. Economist Debates. Available at: <http://www.economist.com/debate/days/view/541>
207. Ibid
208. Rodrick, D. (2010) The Return of Industrial Policy. Project Syndicate Blog, April 12. Available at: <http://www.project-syndicate.org/commentary/rodrik42/English>
209. Panagariya, A. (2001) India's Economic Reforms, What Has Been Accomplished? What Remains to Be Done? Asian Development Bank, ERD Policy Brief Series. Available at: http://www.adb.org/Documents/EDRC/Policy_Briefs/PB002.pdf
210. Rodrick, D. (2010) The Return of Industrial Policy. Project Syndicate Blog, April 12. Available at: <http://www.project-syndicate.org/commentary/rodrik42/English>
211. Indian Ministry of Industry. (1991) Statement on Industrial Policy. Press Release, July 24. Available at: http://dipp.nic.in/English/Policies/Industrial_policy_statement.pdf



COMMITTED TO
IMPROVING THE STATE
OF THE WORLD

The World Economic Forum is an independent international organization committed to improving the state of the world by engaging business, political, academic and other leaders of society to shape global, regional and industry agendas.

Incorporated as a not-for-profit foundation in 1971 and headquartered in Geneva, Switzerland, the Forum is tied to no political, partisan or national interests

World Economic Forum
91-93 route de la Capite
CH-1223 Cologny/Geneva
Switzerland

Tel +41 (0) 22 869 1212
Fax +41 (0) 22 786 2744

contact@weforum.org
www.weforum.org