

Deloitte.



NEW YORK UNIVERSITY
NYU
STERN
LEONARD N. STERN
SCHOOL OF BUSINESS


KRANNERT
SCHOOL OF MANAGEMENT
PURDUE UNIVERSITY

A scenic view of the Gateway of India in Mumbai, India, with several boats docked in the water in the foreground. The Gateway of India is a large, ornate stone archway. To its left is the Taj Mahal Palace Hotel, a grand building with a large red dome. To its right is a tall, modern skyscraper. The sky is clear and blue.

Globalizing Indian Manufacturing

Competing in Global Manufacturing and Service Networks

A Report on the Summit on Indian Manufacturing Competitiveness by Deloitte Research, the Indian School of Business, New York University, and Purdue University with support from the National Science Foundation

Table of Contents

Executive Summary: Globalizing Indian Manufacturing	1
Competing in Global Manufacturing and Service Networks	5
The path to becoming competitive	5
Cracking the code for success in emerging markets.....	5
Overcoming the size barrier.....	6
Growth strategies for Indian manufacturing	7
Indian Manufacturing and Global Competitiveness	8
Scale and innovation	8
Reverse currents: Going overseas for growth	9
Going global with pharmaceuticals.....	9
The opportunity in the food chain	10
Becoming suppliers of choice.....	10
Simplifying India for global retailers	11
Multinational Companies Entering Indian Markets	12
From India to the world.....	12
Beyond borders.....	12
Operational Excellence in Indian Manufacturing	14
The importance of going lean	14
In pursuit of quality.....	15
Global Policy Issues and Indian Manufacturing	16
Learning from China's growth.....	16
China vs. India—separating reality from hype	16
Indian infrastructure supply chains.....	17
Collaborating Across the Supply Chain: Customer and Supplier Management	18
Innovative supply chains and innovative auctions	18
Negotiating better outsourcing deals	18
Standardization of vendor selection	19
Reverse supply chains	19
Customer segmentation and supply chains	19
Supply chain maturity	20
Risk Management and Global Supply Chains	21
Risk models for global manufacturing and service networks.....	21
External risk and the global supply chain.....	21
Competitiveness of Indian Manufacturing Industries	22
Productivity and technical change in the auto components industry.....	22
TQM in the hinterland.....	22
Currents of change in textile manufacturing.....	23
Theoretical and Empirical Issues in Global Industries	24
Theory building in operations management	24
The challenge of multi-firm collaboration in product development	24
Container operations in India.....	25
Integrated marketing communications in emerging markets	26
Demand management in retailing.....	26
Using prices to kindle demand.....	27
RFID: Beyond the early promise	27
International Research Collaboration around Manufacturing in Emerging Markets	28
Preserving research pipelines in a flat world	28
Collaborative research—a solution?.....	28
Appendix: Speaker Roster from the Second Summit on Indian Manufacturing Competitiveness	30
Endnotes	31

Executive Summary: Globalizing Indian Manufacturing¹

The pace of change has been blistering. Both the perceptions and the reality of manufacturing in India have shifted radically, even in the last several months.

Less than two years ago, most international observers were still on the fence when discussing the potential of Indian manufacturing. Did India really have what it takes to become a powerhouse in global manufacturing? Opinion on Indian manufacturing is dramatically different today. Recently, the chairman of Toyota Motor Corporation said "...Indian companies are fast catching up. My fear is that Japan will soon be overcome."²

The Summit on Indian Manufacturing Competitiveness set out to map the challenges and opportunities of manufacturing in India and other emerging markets.³ The summit was co-hosted by the Center for Global Logistics and Manufacturing Strategies of the Indian School of Business, Deloitte Research, the Global Business Institute of the Stern School of Business at New York University, the National Science Foundation, and the Krannert School of Management at Purdue University. The Summit provides a forum for industry experts, business executives and academic researchers from around the world to share experiences, ideas and research focused on the manufacturing sector. A dominant theme at the Summit was India's ability to continue to develop its manufacturing sector to the point where it might revolutionize global industry.

This is no small question. Without a doubt, manufacturing is the backbone of the economy in most countries, especially so in fast-growing emerging markets. It is clear that for the Indian economy to successfully distribute wealth across its population, manufacturing has to grow from its current 17 percent share of GDP to a number closer to 30 percent (which is the standard for most developed economies). This growth will require several significant changes:

- significant increase in productivity and quality at the plant levels
- pursuit of worldwide competitive manufacturing strategies and operations
- successful integration into the global supply chains

While there are significant challenges for Indian manufacturing entering the global arena—whether through the expansion of domestic enterprises or investments by global manufacturers

from abroad—the opportunities are arguably more than worth the effort. Global competitiveness in manufacturing fosters growth, productivity and employment, and strengthens the agriculture and service sectors. Rapid advances in worldwide distribution systems and information technology, combined with a lowering of trade barriers, have led to the growth of global manufacturing and service networks that take advantage of low-cost wages and reach local markets. By scaling business through innovative investments and practices, Indian manufacturing is slated to become a hallmark of manufacturing prowess in the future.

Peering into the future

India's prospects for revolutionizing global industry hinge on the answers to many crucial questions. Among these:

- Can the industry sustain its current growth rate for some years into the future?
- Can it develop the jobs, investments and demand needed to propel the Indian economy?
- Does India need to follow the same development path as Japan, South Korea and China? Or is there another way? One that is more innovative, more efficient, less polluting, more productive and more sustainable? One that is tailored to the unique characteristics of Indian culture and polity?

A second set of questions looks from the outside in and addresses the role that Indian manufacturing will play in global industries and the global economy:

- How will Indian manufacturers fit into global value chains?
- How will Indian manufacturers affect the relative advantage and disadvantage of different countries as locations for industrial activity?
- From a sourcing, production, distribution and sales perspective, how will foreign multinationals engage with Indian manufacturers?
- What are the critical areas where innovation in Indian manufacturing industries (for example, operations management, process innovation, design or distribution) is starting to lead rather than lag behind innovation by global manufacturers?
- In which areas will innovation in Indian manufacturing change the structure and performance of manufacturing industries around the world?

Research that can answer these and other questions and come up with new insights that impact companies, industries and government policy is urgently needed. The study of the competitiveness of global manufacturing and service networks requires expertise in diverse fields such as manufacturing operations, innovation and product development, sourcing strategies, supply chain network design and optimization, systems development and implementation, service network management, international trade, finance and economics, international logistics, and transportation. Such research requires collaboration across academia, think tanks and industry.

The Summit on Indian Manufacturing Competitiveness is an excellent example of such collaboration. It brought together nearly 200 industry executives, government officials and researchers from leading academic institutions and think tanks around the world. It allowed a comprehensive assessment of the challenges and opportunities of manufacturing in Indian and other emerging markets. It provided a forum for sharing case studies, best practices and leading innovations in different industries, and helped lay the foundation for new research and new collaborative approaches. Through collaboration the aim was not only to improve the quality and quantity of research, but also to ensure that leading-edge research, company experience and other insights are shared and put to practical use.

The peril and promise of supply chain management in India

Improvement of supply chain operations emerged as a major theme at the Summit. Key questions included:

- How is the competitiveness of supply chains in select sectors dependent on improving the capabilities to design, produce and deliver products and services? And are these capabilities (or the ability to develop them) specific to the countries or regions of operations?
- How did companies build upon initial successes in supply chain management, not only within individual firms but also across firm boundaries and regions? And can this success be duplicated by undertaking similar activities in other areas and regions?

Multinationals based in industrialized markets often pursue emerging market manufacturing solely to use low-cost resources. However, as discussions at the Summit indicated, cost reduction by itself will not support development of stronger capabilities over time. This puts cost-led manufacturing investments in peril. Without a stronger focus on long-term capability development, many investments (in factories, distribution systems, sourcing and so on) run the risk of rapid obsolescence as competing firms break the mold for more innovative product development, manufacturing, distribution and sales models.

From policy makers to academics to industry experts, the consensus is that efficiency of operations must be dramatically improved. At the broadest level, one of the most worrying factors in Indian manufacturing is the lack of visibility into strategic information, which is a significant obstacle in increasing capacity investments across the value chain. Limited visibility increases the risks associated with new investments. Thus, despite high growth rates, companies may be holding back on investments because they cannot ensure the certainty of the returns to those investments.

Protecting investments in better capabilities is an additional challenge. But, while it might be difficult to prevent process and product capabilities from migrating to the competition, cooperation and competition have been shown to co-exist in modern competitive analysis frameworks. Such developments presage new forms of competition for firms based in mature markets. Understanding capability development in supply chains in emerging economies is therefore vital for any government and manufacturer concerned with future competitiveness in global industries.

All of this will have to happen even as the performance of other global companies continues to improve. The role of large multinationals in realizing this aspiration is crucial. A key issue is execution and thus a significant role is also played by the management of manufacturing and operations.

Scaling for long-term growth

Even though the ingredients seem to be in place, the conditions for long-term rapid growth of the manufacturing sector seem to lack a catalyst. There are no large manufacturing investments on the scale of the public sector investments that took place immediately after the country's independence. Indian firms appear to have trouble scaling organically to world standards, carrying out R&D, innovating, creating brands, investing in long-term capacity, and building human resources (training, research and so on and infrastructure).

The cost of the overall supply chains needs to be lowered, which can be achieved by improving efficiency in processes, rationalization of duty structures, and other means— not the least of which are improved infrastructure and the legal strengthening of intellectual property rights. This will in turn help increase the inflow of foreign direct investment.

Indeed, the short- and long-term challenges for manufacturers in India and other emerging markets are legion. But the opportunities are arguably much larger. Because growth rates of manufacturing output in many emerging market industries far exceed those in more mature markets, investing in those markets presents an opportunity for re-inventing the business model. In many manufacturing industries in India, for example, growth rates reach (and sometimes surpass) 15-20 percent per year. If (and this is a big question) investment rates follow the growth rates, companies could in just 5 or 10 years completely reinvent themselves at a much larger scale.

Seizing this once-in-a-lifetime opportunity, however, is a challenge for both domestic manufacturers and multinationals. It requires rethinking the business model in emerging markets—of product development, production, distribution, marketing and sales. Some companies excel in some of these areas, but few have mastered all of them and the complexity of synchronizing them.

As this report shows, there are invaluable lessons to be learned from manufacturing innovators in emerging markets. This report collects the perspectives presented at the second Summit on Indian Manufacturing Competitiveness. While the subject is inherently vast and often defies neat categorization, we have arranged it according to the broader themes emerging at the Summit.

Competing in global manufacturing and service networks. Despite its modest 17 percent share of domestic GDP, Indian manufacturing has the potential to become a world power. To fully exploit its potential, the Indian government has created the National Manufacturing Competitiveness Council (NMCC). The NMCC has begun to develop a national strategy with regard to technology and academic leadership. Similarly, companies have so far been unable to tap the full potential of emerging markets such as India, with only 29 percent of executives in a global survey indicating their companies have actually achieved higher margins in these markets. Talent management has emerged as a crucial factor, as has the ability to move beyond successful developed-economy strategies that may not be optimal in the context of a multinational strategy.

For Indian manufacturing, growth strategies can be viewed through the lens of the Four Forces framework of enablers, which encompasses modularity of products and supply chains, connecting technologies, economic integration, and resource management. National competitiveness—a prerequisite for corporate and industry competitiveness—tends to emerge from savvy decisions by governments and the private sector in these four areas.

Indian manufacturing and global competitiveness. Call it the downside of explosive growth, but India's manufacturers face a daunting array of opportunities in the transition from being solely a low-cost manufacturing center to competing on the basis of innovation. This transition is being fueled by rapid growth in what for India are nascent industries—an opportune time for change.

The challenge in catching up in R&D competitiveness is to do it right. Acquisition of a recognized brand or established company is one of the ways to compete with multinationals on their home turf. In some cases, such as pharmaceuticals, India has among the best manufacturing infrastructures in the world, and the stage is already set for a foray into research.

Finally, global competitiveness involves reliability. Unfortunately reliable sourcing from India is not always easy, as retailers have learned.

Multinational companies entering Indian markets. It is well enough for the board to say that setting up shop in India seems like a sensible idea, but a good hunch and a good plan are two different animals. Global companies coming to India are well-advised to have a clear vision that guides their decisions. Is the end goal simply to cut wage costs? Or are there strategic advantages that accrue from investing in the countries in which a company does business?

3M, for example, has located its R&D and manufacturing near its final markets and has enhanced its capability to tailor its products and services and respond faster to customer demands.

Moreover, India presents the sorts of challenges that demand foresight. The infrastructure is frequently and rightly criticized. And, in a country where land acquisition can be extremely difficult, it is best to anticipate future expansion early if not during the initial move to India.

Operational excellence in Indian manufacturing. Most activity in the manufacturing cycle constitutes waste: inefficiencies abound. Lean manufacturing is key to pushing prices lower while maintaining profits and quality and, happily, India is uniquely positioned to pursue excellence in this area.

From customized machines that can perform operations more efficiently to low-cost automation, which would take advantage of the skills of legions of talented design engineering people in India, process improvement is both feasible and essential.

Operational excellence in Indian manufacturing often involves considerations foreign to planners in developed countries. Backward integration, for example, can be a wise move in India, where irregularities in power delivery can wreak havoc on a tightly run production facility. Reliance, for example, has a captive power plant, which it runs on an economical scale.

Global policy issues and Indian manufacturing. It's hard not to talk about China when speculating about India's growth potential, because both countries have enjoyed the spotlight in manufacturing over the last decade. But in fact there are major differences, and while services are presumed to be the key to India's continued growth, China has surpassed India in service exports.

On the other hand, India may be poised to occupy the manufacturing space vacated by China due to its wage advantage. Much of the future of Indian manufacturing may hinge on the plight of Indian infrastructure—currently the biggest obstacle on the road to growth. Most infrastructure remains in the public sector, even as the Indian government has begun to reduce its borrowings and therefore may be tightening funding.

The software and IT industry has been very good to India, and in many ways it has been more glamorous than the types of investments required for an infrastructure conducive to manufacturing.

Collaborating across the supply chain: customer and supplier management. Supply chains appear to be an almost bottomless well for improvement, even with outsourcing having already moved from new idea to accepted practice. More recently, dynamic supply chains have emerged to offer a new dimension of supply chain efficiency and, simultaneously, complexity.

Dynamic supply chains are agile, ad hoc networks that work together as the situation dictates. They make supply chain optimization—never a paper-and-pencil exercise to start with—even more of a complex science. Additional wrinkles, such as reverse supply chains, which retrieve a used product from a customer and repair or dispose of it, point to a world where supply chain management may be the forefront of competition.

Another consideration is how the rise of outsourcing has placed an increased importance on negotiation, and how companies can best approach that arena alone and collectively.

Risk management and global supply chains. The need for managing risk is not new, but the increased complexity of global supply chains, especially as they become more dynamic, demands new models of risk, supported by analysis from the field of reliability theory.

External risks in a post-9/11 world go beyond industry- and firm-specific risks. From political events, legal liabilities, social trends and natural disasters, the benefits of emergent global supply chains can be negated if companies lack a studied understanding of the risks and do not put plans in place to manage them.

Competitiveness of Indian manufacturing industries.

How competitive are India's manufacturing industries? Growth fueled by relatively low wages may be something of a smokescreen, as much improvement for the longer term remains to be done. The answer varies by industry, but there are common themes.

Liberalization of the Indian economy in the early 1990s led to major changes in the auto component industry, most notably the start of widespread collaboration with global automakers and their suppliers. This spawned competition for Deming Awards and a widespread move to adopt Total Quality Management practices. As a result, auto component makers are doing fairly well.

But in general there are areas from equipment selection, tooling, quality and safety in which India must improve. Plant locations left over from the planned economy are a thorn in the textiles industry. The process of reimbursing suppliers, to cite one example, hardly instills confidence in business partners. Finally, deeper exploration of the need to protect intellectual property and the often overlooked significance of customer input is required.

Theoretical and empirical issues in global industries.

Globalization brings with it many new questions. These range from vast topics such as how to go about developing new products to the ostensibly simple task of moving products from one point to another. The answers to these and other questions can be as complex as they are necessary.

For example, with regard to multi-firm collaboration in product development, two collaboration mechanisms rise to the fore: investment sharing and innovation sharing. Which is better? The answer varies for different businesses. In pharmaceuticals, time to market is what keeps executives awake at night. Innovation sharing can lead to uncertainty on this key metric, whereas investment sharing is optimal in this case because it doesn't depend on the vagaries introduced by knowledge sharing.

Similarly, the opening up of container movement by rail in India has ended a state monopoly, but offers a more complex set of options. Suddenly, transport is an aspect of business that has many variables, as does the seemingly more esoteric task of integrated marketing communications in emerging markets. How should products be made and advertised in other countries while maintaining a consistent brand image?

International research collaboration around manufacturing in emerging markets.

In another era, nearly all research and production took place in a handful of countries. But in a world where manufacturing and services continue to migrate to less developed countries like India, how will this affect investment in the research pipeline?

This is a new question for businesses. In the past, much innovation was funded by the U.S. government or companies in developed countries—entities that can't be counted on indefinitely to fund ideas realized wholly outside their borders. Moreover, shortening timeframes in which to reap exclusive benefits make long-term investments in R&D less attractive.

At the same time the world is running low on researchers, the scope and complexity of opportunities for manufacturing research have surged, and more engineering problems of relevance are moving to India. Joint academic research programs offer a partial solution, but the future of research and innovation is not something to be left to chance.



Competing in Global Manufacturing and Service Networks

The path to becoming competitive⁴

Notwithstanding the Indian manufacturing industry's current growth rate of 7 percent and its paltry 17 percent share of the GDP, India has the unquestionable potential to be a world manufacturing power. For that to happen, however, the industry needs to wean itself from its labor cost advantage and focus instead on markedly improving the efficiency of its operations. To this end, the Indian government has constituted the National Manufacturing Competitiveness Council (NMCC), which includes industry leaders, academics and select government executives.

The NMCC's aims include:

- improving the manufacturing industry's efficiency of operations and increasing its competitiveness
- enabling the industry to provide better quality goods and services at affordable prices
- increasing India's share of global trade
- increasing employment opportunities for the bulk of the population

The NMCC works with the sector to help it become competitive; it also works with government ministries to help map out long-term strategies and find practical solutions to current problems. The NMCC is beginning to work with the states, too, as much of what needs to be done lies in the domain of state governments.

The NMCC's document on a national strategy for manufacturing advocates a growth rate of 12–14 percent for the sector for the next 10 years and lists action points toward this goal. These include:

- Increase use of information and communication technology to improve the manufacturing sector's global competitiveness.
- Develop leadership programs for the industry in partnership with premier institutions such as the Indian Institutes of Management; channel the capabilities of premier technical institutes like the Indian Institutes of Technology to benefit small and medium enterprises.
- Upgrade training institutions, increase their numbers, and encourage public-private partnerships to manage them.

- Set up technology parks around institutes of higher learning, similar to the Stanford Research Park near Stanford University in the United States.
- Create "Centers of Excellence in Manufacturing Technologies" where academics can apply their skills to serve both the short-term and long-term innovation requirements of manufacturing companies.

The most important challenge in attaining competitiveness is, however, changing the collective mindset. To this end, the Indian prime minister has agreed to preside over a committee formed to implement the NMCC's strategy, which strengthens the initiative immeasurably.

The Indian School of Business, in particular the Centre for Global Manufacturing and Logistics (GLAMS), is already implementing some of the recommendations of the NMCC strategy. The scope and quality of their research projects in logistics and manufacturing is commendable; it is rare to find management institutes that are as research-driven.

Cracking the code for success in emerging markets⁵

For multinationals, emerging markets have been the promised land of future growth for a while now. Yet, results from a global survey by Deloitte Touche Tohmatsu (Deloitte) suggest that companies have not been able to fully tap into the potential of emerging markets. Of the more than 400 senior executives surveyed, 56 percent expect company revenues in emerging markets over the next three years to grow substantially. However, only 29 percent said their companies have actually achieved higher margins in emerging markets.

So, what does it take to achieve sustainable profitable growth in emerging markets? A look at the companies surveyed by Deloitte with higher margins affords some crucial insights.

Companies are acquiring new skills and providing local autonomy while using the strengths of the headquarters, and offering unique products aligned to the needs and buying behavior of markets with much lower per capita GDP.

While global manufacturers can certainly sell developed-market products to high-income consumers in emerging markets, this approach may cause manufacturers to miss out on the far larger opportunity to serve the mass of emerging market customers. In fact, 63 percent of the companies surveyed offered very different or somewhat different products from what they offered in their home market. For example, South Korea's Samsung Electronics builds washing machines for sale in India that include a memory backup to compensate for frequent power outages and a special rinse cycle for saris to prevent them from getting knotted.

For new product launches, 49 percent of the successful companies conducted R&D in the local emerging market. Executives cited the need to understand the local market, reduce product development costs, and achieve faster time to market as their top three reasons for local R&D investment.

Global manufacturers also identified the need for a strong local employee presence in emerging markets to be successful. Local employees know how local governments work, what policies those governments are considering that could impact business, and what those policy trends may be down the road.

Talent is a crucial factor in implementing any strategy targeted at emerging markets. Talent management is becoming increasingly critical to manufacturers, especially because the strong demand for qualified labor is outpacing the supply. In India, for instance, manufacturers have to compete with the big IT firms for white-collar employees. While attracting, developing and retaining talent is difficult the world over, the needs and aspirations of employees in emerging markets are different from those of employees in developed markets. Considering these differences and developing a strategy to cater to them is crucial.

It is difficult to put successful developed-economy innovation strategies aside. It is even harder to design, build, market and distribute products that meet the unique needs of buyers in emerging markets. It is also difficult to leverage the commercial experiences found in developed economies because many of these experiences are not relevant.

Furthermore, the quest for sustainable profitable growth in emerging markets has made organizations very complex. As various constituencies seek to influence the organization, executing good ideas becomes difficult.

Shying away from these challenges, however, means giving up on what emerging markets offer: lower global costs, fast growth, new customer markets and an advantageous perspective when it comes to obtaining intelligence on the changing global competitive landscape.

Overcoming the size barrier⁶

The idea of global competitiveness for the Indian manufacturing industry has gained currency only in the last 5-6 years. The opening up of the economy in 1991 and the lowering of import duties forced the domestic industry move toward competing globally.

For example, when Jindal Steels started building a 1.6-million-tonne steel plant in Karnataka in 1995, the total capacity in all of India was just 12 million tonnes. The steel industry was completely protected and, except for Tata Steel, was dominated by public sector companies.

Jindal Steels went in for a new technology that had not been tried anywhere in the world. On the first day of plant operation, the rains chilled the furnace and the raw material became cold. This meant that the plant had to be rebuilt and at a time when the steel industry was going through a downturn. Despite the false start, the plant was rebuilt in just four months and it achieved 120 percent capacity utilization. This was in contrast to the 90 percent capacity utilization of a similar plant owned by POSCO in South Korea. The Vijayanagar steel plant in Karnataka is now a 4-million-tonne plant.

Then, of course, there is the example of L.N. Mittal, an Indian businessman, who has built Mittal Steel into a 120-million-tonne conglomerate.

For any industry to become globally competitive, a strong home market is essential. On this front, things look set to get even better for India. As GDP grows and crosses the thousand-dollars-per-capita inflection point, it will spark huge growth in manufacturing, in the consumption of various items, and in housing construction. This in turn will cause a sudden boom in consumerism. India is currently close to 750 dollars-per-capita and, with the projected growth rate of 8-9 percent, it should be at the inflection point in about 3-4 years.

Once again, however, infrastructure is of critical concern. Power supply is a crucial factor in sustaining this pace of growth. Any industry that is growing very rapidly or has got mega plans is setting up its own captive power, an investment not permitted even five years ago. This huge step forward notwithstanding, companies in the private sector are still unable to expand their power business because the majority of power distribution is controlled by the state electricity boards. Transmission is also in the domain of the national government. If this area is opened up, it could become the engine of growth for the manufacturing industry.

Growth strategies for Indian manufacturing⁷

One can look at competitiveness at various levels—at the level of individual corporate firms, at the industry level and at the national level. Of course, these three are not independent but are highly correlated. An individual firm's competitiveness is dependent on the competitiveness of the environment in which the vertical industry and the national economy operate. Excellent logistics and IT infrastructure are becoming prerequisites for global competitiveness among manufacturing and service companies. The need of the hour for India is to meet local and global markets under open and fair economic conditions.

It is possible for India to achieve very dynamic growth based upon labor-intensive manufacturing, which combines the vast supply of Indian labor, including skilled managerial and engineering services, with foreign capital, technology and markets. But to succeed, India must follow a balanced approach of developing its manufacturing capabilities, service infrastructure and operational capabilities, follow the right economic and trade policies, and finally develop the right kind of resource management skills. The Four Forces framework provides a basis for creating a competitive global manufacturing network in this context.

The Four Forces Model. Manufacturing in the supply chain era is primarily influenced by four forces. The first is the product/process; the second is connecting technology, including logistics and information technology; the third is economic integration that includes tariffs and economic policy; and the fourth is resource management.

Globalization of manufacturing and service industries is the result of advances in technologies as well as the desire of countries to integrate their industries with world markets. Driven by a need to cut costs while preserving quality, change is underway: production is moving to low-cost locations with good service infrastructure and services are moving to locations with low-cost, skilled manpower. These changes affect how countries as well as companies must plan their strategic operations, and provide guidance as to how India can become a globally competitive manufacturing hub and a preferred destination for MNCs seeking new factory locations.

Modular product and modular supply chains. Prior to the 1980s, manufacturing was dominated by large, vertically integrated firms (for example, GM, GE, IBM, DEC, Fujitsu and Hitachi) that produced most parts and components within their country and firm boundaries using proprietary architecture. Today industries have increasingly become vertically segmented, with each segment managed by a different company, perhaps in a different country. Each stage in the value chain involves significant competition and the value and market power lie in the standards that create intellectual property-based monopolies (Intel chips and Windows

operating systems, for example). This has led to a growing proportion of international trade occurring in components and other intermediate goods, resulting in the growing integration of world markets, with an increased service component (for example, logistics and customs clearance) in the production of the final product. The new strategic weapon for assemblers (Dell, GM and Nokia) is supply chain management.

Connecting technologies. Technology enables and facilitates globalization. It is a fundamental force shaping the pattern of transformation of economies. Transportation and communication technologies—from commercial jets to container shipping, satellites and, of course, the Internet—have shrunk the world dramatically. Recent innovations such as wireless and RFID will create further efficiencies in supply chain co-ordination.

Economic integration. Nations collaborate in several ways to achieve specific economic and welfare goals. There is a tendency for states to develop political-economic relationships at the regional scale. These regional blocs have considerable influence on the world trade as evidenced by European Union, NAFTA and AFTA. Given the geography, it would be an interesting study to investigate the regions with which India should seek economic integration. The government of India is promoting special economic zones (SEZs), with the objective of freeing available goods and services of taxes and duties. This objective is supported by integrated infrastructure for export production, quick approval mechanisms, and a package of incentives to attract foreign and domestic investments for promoting exports.

Resource management. India has vast natural resources: coastlines, fertile agricultural land, waterways, a large population of young talent, and a world-class education system in place to train engineers, R&D specialists and managers. Seemingly absent, however, is the vision to leverage its geography and resources to gain sustainable advantage as a supply chain hub. Located midway between Australia, the Middle East and Europe, India can play the role of a trans-shipment hub, knowledge services hub and, potentially, a food hub for the oil-rich Middle Eastern neighbors. Several South-East Asian countries have created wealth with world-class resource management skills with minimal or no resources. In the case of India, the country's abundant natural resources are wasted for lack of management skills and political will.

Our analysis shows that national competitiveness is the product of the above four elements. To gain competitiveness, nations need to choose the products and location of supply chain partners, prioritize the development of logistics infrastructure, make trade policies, and develop human, financial and managerial resources as appropriate to the vertical industry.

Indian Manufacturing and Global Competitiveness

Scale and innovation⁸

For Indian companies, it is a problem of plenty as far as opportunities go. Typically, companies react to opportunities by going low-cost, expanding geographically or through mergers and acquisitions, or innovating continuously.

The low-cost story is becoming less applicable in Indian manufacturing because of rising wages and firming interest rates. As for geographic expansion, most manufacturing companies do not necessarily have the managerial capability to run profit centers in other parts of the world. Also, few Indian companies are cash-rich. Most would therefore end up acquiring very small companies that might not add value. Mergers and acquisitions, again, are often difficult to accomplish for Indian manufacturing companies.

That leaves innovation, which has not yet been fully exploited. An ongoing Deloitte benchmark study of more than 35 Indian manufacturing companies against 140 multinational companies that have manufacturing operations in India has shed light on what Indian manufacturing companies are doing right and what they need to change.

Companies across the spectrum agree that innovation is probably the manufacturing industry's most underexploited strategy. If the Indian manufacturing industry is to remain competitive over the next 15 years, it will need to focus on its innovation capabilities. The opportunity for dramatic improvement and transformation of business models in Indian manufacturing is significant. With average annual growth rates of nearly 20 percent among the companies benchmarked based in India, companies are presented with an unprecedented chance for re-inventing themselves. Growing at that rate, just five or ten years down the road, the vast majority of investments in the business will be new investments.

As opposed to the multinational companies that have stopped depending on the well-being of the economy or just the market in which they operate, Indian companies seem to consider those two as the main drivers for business in the foreseeable future. *Indeed, Indian companies lag behind their global competitors in research and development.* This is, however, something that will start to change in the coming months and years as these companies look to launch products and services on a continual basis. The challenge is doing it right.

The best-performing companies in the global benchmark research, called “complexity masters,” are far better at synchronizing innovation across the enterprise. They invest in better processes and technologies for optimizing the entire life cycle of products and services. The result is far better performance with profit levels up to 73 percent higher than the competition. Many domestic Indian manufacturers as well as multinationals operating in India have a hard time keeping up and building the capabilities needed to succeed.

In Indian manufacturing, the most worrying evidence is that of the lack of visibility into strategic information. In fact, and somewhat alarmingly, the more strategic the information, the less the visibility! This makes it difficult to take the right decisions in strategy, planning and execution.

The other major challenge is that of flexibility. Indian companies will face increased complexity and constraints on flexibility as they continue their domestic and global expansion. In fact, the average Indian company is not lean at all. Even companies that operate with just five or six customers have frozen timeframes for production of two weeks or more. Were they to aim for less time, they believe they would lose money reconfiguring their manufacturing schedules. They have difficulty connecting their sales forecast to material plans or even their production plans.

Indian manufacturers lack the technology support for looking at the life cycle data of the products. Without this data, innovating on the product portfolio is difficult, if not impossible. Indian manufacturers are far behind multinationals in India when it comes to adopting leading technologies—despite the (perceived or real) low cost of technology in India compared to the more developed countries. This low rate of technology adoption poses a real risk to Indian manufacturers' futures, limiting their participation in global value chains where these technologies are required.

In the absence of lean processes or visibility, a lot of management time goes into day-to-day issues and firefighting with very little time left over for future planning and innovation. Despite a lackluster record when it comes to R&D, Indian manufacturing has recorded high growth, creating a unique opportunity for innovation. In fact, India is the top destination in the world for R&D investment. The cost of innovation in India is typically one-third that in developed

markets; it is among the lowest globally. Manufacturers need to seize this opportunity to innovate with respect to products, processes, technologies and business models.

Reverse currents: going overseas for growth⁹

Crompton Greaves is an excellent example of the new breed of Indian companies that have cut their teeth competing with multinationals on the home turf after the liberalization of the Indian economy. Success on the home front has prompted a foray overseas.

The 68-year-old company is the largest private electricals company in India. It is also the first Indian electricals multinational.

The realization that it was a leader in all the fields in which it had a presence in India prompted the company to consider entering the world market. India comprised only 2.5 percent of the world market. The search for a bigger slice of the pie led Crompton Greaves to acquire Belgium-based Pauwels Transformers.

The decision to enter developed markets via an acquisition came about after the company determined that a recognizable brand was crucial. Product approvals, experience and image are the main barriers for Indian companies entering developed markets. Customer relationships and quick service are also essential for success in developed markets. Building such a brand from scratch would take time and be very expensive, and serving developed markets from an Indian base would prove costly. In addition, acquiring a company in the developed market would provide access to the latest technology.

After the acquisition, Crompton Greaves opted not to run Pauwels as a stand-alone company but to convert it to a solutions company for customers and integrate it into the business. The integration was achieved by forming several cross-functional teams in fields including design, manufacturing, technology and marketing. The design and technology were moved to the back end in India. The front end, consisting of sales and marketing, continued as before. The objective of the integration was to create a multinational organization that was not focused on the location of the corporate headquarters, but centered on performance. The guiding principles were performance excellence, customer orientation and engineering knowledge.

The chief advantage that Crompton Greaves brought to the integration was its operational excellence, as well as its access to the abundant engineering talent available in India—a young workforce eager to learn and motivated to work hard. Then, of course, there was the advantage of low-cost manpower in India.

Today, out of Crompton Greaves' consolidated sales of Rs. 43.57 billion, Rs. 15.30 billion, or more than 33 percent, comes from developed countries.

The company's acquisition strategy is focused on companies that are not doing well financially but have good brands that were leaders in their segment not long ago. The brands would still have customer relationships and customer access.

Going global with pharmaceuticals¹⁰

At US\$4.5 billion, the Indian pharmaceutical industry makes up just 1 percent of the global industry. Yet, there is also the almost US\$4 billion of rapidly growing exports that include exports to Europe and the United States. The two together add up to a vibrant industry that is coming into its own in a globally resurgent sector.

The Indian pharmaceutical industry was born in the 1970s after the government instituted patent laws that encouraged reverse engineering. When government policies became export-oriented in the 1990s, the industry began exporting to developing countries and then later to developed countries. Drug companies went in for backward integration, sourcing building blocks from proliferating small-scale industries. The country's established petrochemical industry pitched in with building blocks of hydrocarbons. A system of science education modeled on the western system, combined with the prevalence of the English language, had already built up an invaluable talent pool. The presence of multinationals in the country since the 1950s had helped meet international standards in work cultures and fostered a familiarity with regulatory requirements.

Over the last seven years, about US\$1.5 billion have been spent in the country on building up one of the best pharmaceutical manufacturing infrastructures in the world. India has more than 85 plants that are approved by the U.S. FDA—the highest number outside the United States. World-class research institutes are beginning to thrive. The industry has moved from manufacturing bulk drugs to formulations and from generics to the branded sector. Key international players are setting up shop in India either for manufacturing or R&D. The industry is now ready for the next step of getting into the basic research around discovery.

Globally, health care cost containment is a priority for the developed world, resulting in legislations promoting generics. In 2006 alone, close to US\$50 billion worth of patents will expire in the United States. In this scenario, India's huge cost advantage will continue to attract business. Although the cost of manpower is increasing faster than in Europe and the United States, India is still a low cost base for skilled manpower. Every year 10,000 chemists and pharmacists and about 1,500 PhDs in chemistry and pharmacy graduate from good schools in the country.

There remain, however, several challenges. For one, India is perceived as inconsistent from a supply chain point of view. Though Indian companies have filed many drug master files, they are yet to deliver sizable quantities of those drugs. Another area of concern is the retention of talent in the current scenario, where different sectors are competing fiercely for the available talent pool. Also, big pharmaceutical companies are more comfortable dealing with European countries than with Asian companies because the perception is that intellectual property may not be so safe with the latter.

To continue moving up the value chain, the Indian pharmaceutical industry needs to start thinking like a knowledge base provider rather than just a material base provider. It must invest in people, and buy and build technologies. It also needs to work with the government to push for changes that benefit the industry. The industry should support intellectual property initiatives, push innovation and leverage information technology in pharmaceuticals. It needs to work with academia to align curricula with changing industry needs, and to be open to global talent and practices.

The opportunity in the food chain¹¹

For insight into the food and agriculture sector, companies rarely turn to a bank. Rabobank, however, is different. Its reputation as a knowledge bank for the food industry is rooted in its history. It is a farmers' cooperative bank that has, since its inception more than 100 years ago, focused on the food and agriculture business. The bank acts as a consultant, advisor and knowledge partner for the food industry and is today one of the top 25 banks in the world, with 50 percent of its revenue coming from the food and agriculture business.

India has become a major focus for the bank. The country presents a huge opportunity for the food sector, in no small part because income levels in India are rising. For example, the number of households with annual incomes between US\$5,000 and US\$25,000 will rise from 76 million currently to 127 million in 2014-2015. Also, India will soon have the largest population of young people in the world. These changes will be reflected in increased demand for processed food.

Logistics will prove key to realizing the opportunity in this sector. For example, in the fruits and vegetables value chain, intermediaries take away around 65 percent of the maximum retail price while the farmers receive only 15 percent. There are other fallouts in an unorganized food sector, such as non-transparent pricing, primitive grading, opportunistic profiteering, wastage, quality and hygiene problems, high prices, limited choices, and high costs. There is an opportunity to shorten the chain to extract value that can be distributed to the farmers and consumers. Logistics can act as a chain organizer.

Worldwide, logistics players offer an end-to-end solution. That is something India still lacks. A total solutions provider will find great opportunity for profit through providing more value-added services like packaging and private labeling, and also by holding inventories at times. Some of the key success factors include cost, efficiency, turnaround time and food safety. It will be the responsibility of the logistics player to ensure feasibility and food safety. In places such as the United States, logistics players are also ensuring protection from fire, bioterrorism and other risks. As the central link, logistics will play an increasingly important role.

A big opportunity for logistics players is growing food retail and food services. The proposed relaxation of restrictions on foreign investment in retail makes for an attractive investment climate. Global retailers need to position now or lose out in a fast-saturating market. In particular, the opportunity for cold chain logistics could be quite lucrative. There is no major integrated cold chain logistics company in India.

Becoming suppliers of choice¹²

With customer prices expected to remain flat for the next 10 years, global auto original equipment manufacturers and component manufacturers will continue to source from low-cost countries. Additional pressure to keep costs low comes from new features mandated by higher environmental and safety standards and the increasing costs of production.

India is well-placed to benefit from global sourcing. Cost arbitrage, local talent, access to local markets, investment incentives and even advantageous time zone differences are just some of the advantages that the country offers. The country is maturing as a global export hub with exports growing from 3.5 percent to 7.4 percent of total sales. Domestic growth, as well as growth in exports, has fuelled the auto components sector, making India a global sourcing hub for several original equipment manufacturers (OEMs) and Tier 1 suppliers.

Amid all the exuberance, however, the realities of global sourcing are more complicated. Increasing complexity in supply chains and products coupled with increasing customer expectations have led to increased variability. There is a growing need to control the complexity of upstream fulfillment operations, better synchronize planning flows, improve accuracy of forecasts, adhere more widely to service level agreements, and constantly review planning parameters and policies.

In global sourcing, focusing solely on cost risks while ignoring several process-centric issues can result in sub-optimal supply chains. For example, a piecemeal approach can result in lower operating efficiency at the supplier's end, expensive premium on freight, inventory left over due to changes at the OEM that are not reflected soon enough in operations at the supplier's end, and costs resulting from poor-quality products and overtime payments on subassembly/machining lines.

A further complicating factor is that priorities for the OEM and the supplier pull in opposite directions. Where the OEM looks for flexibility, the supplier seeks stability; low costs are a driver for the OEM whereas the suppliers needs to obtain the best possible margins; the OEM would prefer to have to provide minimum tutoring while it is in the interest of the supplier to learn as much as possible about the product. A high visibility into the supply chain is the only shared priority between the two.

In order to secure business, Indian suppliers must learn to visualize themselves as a part of the extended supply chain. They must deploy strategies aligned with those of their OEM/ Tier 1 sourcing companies.

Transforming supply chain capability calls for the creation of total cost models, investment in innovation, aligned human resources and performance management between OEM and supplier, and improving employee capability in technical and managerial areas, as well as plant operation. Technology plays an essential role, allowing increased information visibility, establishment of knowledge management and business intelligence, and enhanced engineering and design capabilities.



Simplifying India for global retailers¹³

Indian merchandise exports grew from US\$22.2 billion in 1993-94 to US\$101 billion in 2005-06. They are expected to reach US\$150 billion in 2008-09. This impressive growth can be attributed to the liberalization of the investment policy, export subsidies and the devaluation of the rupee. Also, global retailers' increased interest in India's unique product mix, available at low costs, fuelled this growth.

Sourcing from India is not easy, though. Retailers encounter small factories with limited capacities, and must deal with multiple vendors for different products. Manufacturers' lack of awareness of quality norms and design and trend requirements are other hindrances. Unhealthy working conditions for employees and the language and communication barriers in parts of the country make dealing with Indian manufacturers very difficult.

Small Indian manufacturers have their own problems, beginning with a lack of awareness of what is happening around the world. There is little R&D infrastructure in the country to support them. The absence of any centralized information centre and the lack of information on best manufacturing practices are further handicaps. Small manufacturers are also short on marketing expertise and capital.

These roadblocks assume greater significance in view of China's growing strength in areas previously considered India's domain. For example, glass ornaments from Ferozabad are being replaced by plastic ornaments from China. Metal decorative items from Moradabad are being replaced by resin items from China. China has some obvious advantages over India, not the least of which are a head start in manufacturing, high capacity and shorter lead times to markets in the United States and Europe.

Given these challenges, the emergence of buying houses has been a bonus. Set up mostly by professionals who have worked for the Indian offices of western trading companies, these buying houses are emerging as a link between Indian manufacturers and global retailers. For retailers, these buying houses are business partners who speak the same language, work on transparent terms of payment, and can guarantee that the factories they work with follow environmental and safety norms, and that the goods produced are of acceptable quality.

For the manufacturers, buying houses offer guidance on product and process knowledge and can be their advocates with the retailers. Buying houses help vendors develop capacities, research products and pass on the resulting solutions to the manufacturers. They also have more negotiation power with service providers, including logistics players, as they combine volumes from different manufacturers and retailers.

Multinational Companies Entering Indian Markets

From India to the world¹⁴

Global companies that come to India need to have a very clear vision of what they want to achieve. For example, after Saint-Gobain Glass decided to seek a long-term business opportunity in India, it discovered that its India operations could be leveraged for its global operations. Had this been the plan right from the start, the company probably would have evolved differently.

Multinationals setting up operations in a new country usually pass through three stages. The first stage is that of building the base—crucial, as the first three to four years determine what happens down the road. The second phase is scaling up; the third, innovation.

In the first stage, using global relationships to establish a presence in the local market in India is a good strategy for MNCs. Also, everything in India, even the availability of power and water, is variable. Companies have to take this variability into account as they build up their business.

India's high-quality, low-cost engineering talent can be a huge advantage if used properly. Saint-Gobain introduced a large number of engineering methods on the line to make process improvements, and trained the engineers to adapt themselves very quickly to these. Investing in people should be a priority, starting from recruitment. Choosing the right people will ensure that a team works well together because getting a team to function well is often more difficult in India than it is in some other cultures. Also, with rising attrition, it is essential that a second and third layer be in place in the event the first tier of employees leaves.

Overinvesting in physical space and logistics can be a wise move. Getting land in India is very difficult, and it is common for the value of the land to exceed that of the company. It is therefore advisable to acquire more land than may seem necessary in the beginning. Other infrastructure needs such as water and power should also be anticipated by investing in rainwater harvesting and alternative technologies.

The second phase of scaling up calls for rapid product development and prototyping. This in turn calls for a significant investment in tools and people skills, as well as in laying the ground for innovation. For Saint-Gobain, creating an expert pool on tool design and simulation was made easier because these are areas of strength for India. The company is now looking at sourcing machine-building capabilities, also from India. Employees in the Indian operations have already made over 100 small improvements on machines bought from European vendors.

As a next step, the company is looking at working with world-class research institutions in India like the IITs and the Indian Institute of Science. In the third phase of innovation, the company hopes to leverage such a collaborative network for incubating and encouraging innovation.

Beyond borders¹⁵

As national borders have blurred, the rules of doing business have changed rapidly. For 3M, this new reality is reflected in the fact that 61 percent of its top-line sales come from outside of the United States—growing from about 35-40 percent just ten years ago.

A well-thought-out strategy has the company investing in the countries it does business in: it has 69 subsidiaries and 33 laboratories in different countries. Also, 99 percent of the company's international employees are local employees of the country where the business is based. Such a strategy helps speed up service in addition to saving on costs. By locating R&D and manufacturing near final markets, 3M is able to better tailor its products and services to local markets and respond faster to customer demands.

The low cost of labor, however, is not a key issue in the decision to source from a particular geography. The low cost of labor may be useful in a basic converting operation. Moving up the technology chain, however, the cost of labor is not as important as the skill level. In the absence of skills, the cost of mistakes tends to become very high.

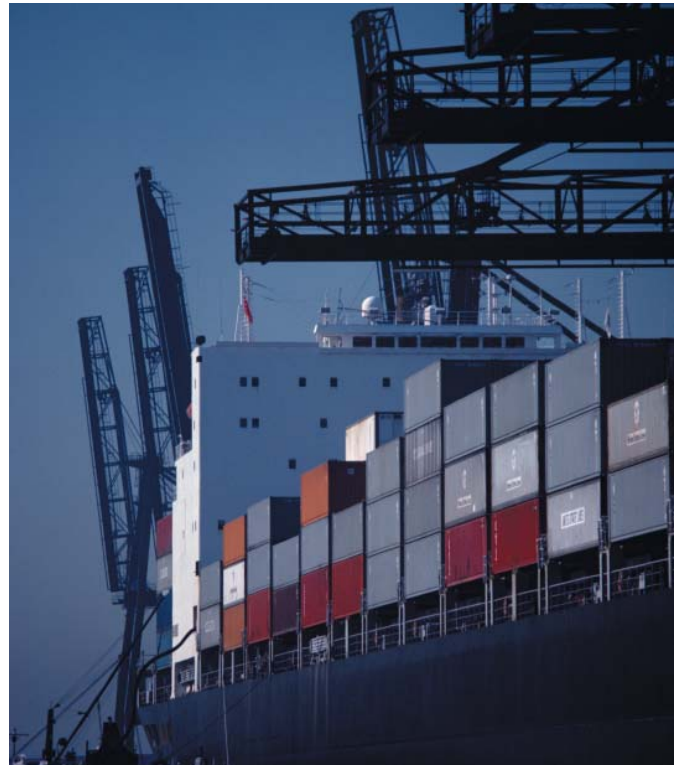
From 3M's perspective, India's excellent academic structure is a major strength in considering it as a sourcing destination. The country has first-rate universities and a great network. Its other strengths are domestic entrepreneurialism and the base of local manufacturing.

A growing middle class is one of the keys to having successful manufacturing, particularly on a global basis. If you have a growing middle class, those are really the consumers that drive manufacturing. Without that middle class, it is very hard to get manufacturing to grow. The challenge for India is how to leverage and grow the foundation that it possesses, spread it across the country, and get more entrepreneurs to invest in manufacturing growth.

A major handicap is the limited infrastructure that has not been able to keep up with industrial growth. For example, the longer and the more complicated the transportation network is, the more difficult it is to have an efficient supply chain. Whereas the preoccupation in other geographies is with speeding up the supply chain and limiting inventory, in India the major concern is buffering inventory.

Capital spending by companies to deal with the lack of infrastructure is not really an option and it is difficult, for example, to explain to headquarters why you have to put up your own power plant. Bureaucracy surfaces as another handicap: investors become very discouraged when it takes a couple of weeks to get a paper through a government authority in order to release goods from the customs department.

Also, the different regulations in different states slow down the supply chain considerably. To move goods from the south to the north, you have to stop at every state border to be inspected, and appallingly enough it can take a week to go from north to south. The different tax structures in different states make things very complicated, and thus create significant inefficiencies for businesses. On top of a convoluted system, there is corruption to the point where it can have a significant financial impact.



Operational Excellence in Indian Manufacturing

The importance of going lean¹⁶

One of the difficult things about customers is that they prefer prices to keep going down. Yet, it need not be that hard to keep satisfying this desire.

To keep pushing prices lower without affecting profits or quality, a company needs to take a hard look at the waste generated in the production system. On an average, 95 percent of what any manufacturing company does falls under the headings of non-value-adding activity, non-value-adding time or non-value-adding cost. Removing this waste and passing on the savings to customers in the form of lower prices can be sustained for several years.

This is what lean manufacturing aims to do. The acknowledged benchmarks are Toyota and Canon, and even they have reduced waste only to 50 percent. Clearly, there is plenty of potential for the average company to extract value from waste. Southwest Airlines, Apple's iPod, and the dabbawalas of Mumbai are some examples of success achieved through going lean.

The opportunities for going lean exist everywhere in a production system. For example, expensive equipment used for only 10 percent of its potential constitutes waste. In lieu of buying readymade machines from a catalog, a company can minimize waste by buying a machine customized to its needs. Low-cost automation is another option. India has a strong corps of talented design engineering people, a strength that can be used to implement low-cost automation to bring down equipment cost by over 70 percent. Buy standard parts and once a project is completed, dismantle the machine and reuse the parts.

The same principle applies to people. Stretch productivity through accountability and incentives. Ensure that employees are not constantly in firefighting mode and hence unable to think up ideas. This will unleash their full potential.

Inventory is often an opportunity to cut waste. Inventory requires space, equipment and people to handle it, all of which translates into needless cost. The solution is to go lean and scrap inventory through a sophisticated tracking system and single-piece flow. Waste is also inherent in not reaching out to the customer base—for example, by focusing on the urban market and ignoring the rural market which constitutes 90 percent of the Indian market. Reducing developmental time, the time to market, and using innovation to provide customers with what they want are other ways to save on time and avoid wasting opportunity.

Lean manufacturing is a broad-based system that requires considering the totality of the business and not just manufacturing. The entire process, from order to delivery to collecting cash, has to be mapped and made lean.

The first important step is to include all employees in the strategy. The next is improvement in management and housekeeping. Then comes a sound quality system that ensures stable quality. An ownership culture in which cost, quality and delivery are owned by the person who produces the product is crucial. And then a total production maintenance that assures zero breakdown.

For Sundaram-Clayton Limited, going lean has meant being able to offer prices that are 2.5 to 5 percent lower, at a time when commodity prices and wage costs have been going up. At the company, going lean has taken several forms—going from 12 operators to 3 operators, from an output of 40 per hour to 60, and employee productivity that has gone up over 500 percent. Not surprisingly, Jim Womack, the founder of “lean enterprise” in the United States, visited Sundaram-Clayton two years ago and called it “one of the leanest operations I have ever seen outside of Toyota.”

In pursuit of quality¹⁷

For Reliance, combining quality with profits began with lowering costs through backward integration. This translated into a lower cost of raw material.

The company has a captive power plant and utility generation on an economical scale. In-house development of catalysts, a supply-customer interface that lowers the cost of packing material, and common service to multi-plants also combine to achieve a low cost of production. Compared with competitors, the company has the lowest cost of raw material, the lowest cost of power, and world-scale plants with low-cost utility, all of which translate to low fixed costs. Optimizing cost has become a particular strength for the company.

Another important element in achieving quality is delivery. The company's plants in Mumbai and Surat supply to far-flung countries like Egypt, Turkey, China and several in Europe. Delivering the product to the right place, on time, and in a cost-effective manner is a crucial part of quality. So is safety—safety of the material, safety at the workplace, as well as safety of the product. A breakdown in safety such as an accident would mean additional cost and a delayed schedule. Attempts to make up the delay could result in work that is of poor quality.

The company's pursuit of quality is reflected in its values of customer focus, involving its people in decision making, the process approach and the system approach to management. The company focuses on building mutually beneficial relationships with suppliers and concentrates on continual improvement.

Reliance's strong customer focus is realized through identifying customer needs and converting those needs into product specifications through its quality function deployment. The company's emphasis on state-of-art technology for its plants as well as its reliance on Six Sigma, benchmarking, quality control circles and customer satisfaction index further reflect its culture of quality.



Global Policy Issues and Indian Manufacturing

Learning from China's growth¹⁸

For several reasons, the India story is almost always clubbed with the China story. Yet China has a head start on India in growth through integrating its economy with the world economy. The lessons learnt along China's path to growth via manufacturing can serve India well as it seeks to strengthen its manufacturing sector.

China's spectacular growth has inevitably led to questions about the sustainability of such growth. A close examination reveals several similarities between China's growth today and that of Japan between 1960 and 1990. Both countries started with underemployed labor and a high savings rate. In terms of importing foreign technology, management skills and capital, China has done better than Japan, welcoming foreign direct investment.

The parallel with Japan can be a cautionary tale for China in view of Japan's decline post-1990. The pitfalls that crippled Japan—poor capital markets, resources misallocation, limited risk taking, lack of creative destruction—can hobble China too. China is also facing the problem of an aging population thanks to its one-child policy. In addition, China has other serious problems like pollution and income inequality. Nearly 50 percent of the urban population and 80 percent of the rural population in China lack medical insurance. The health of its citizenry is endangered by pollution. Up to a million children are born with birth defects each year, and this can be attributed in part to environmental hazards. China's economy suffered US\$63.8 billion in costs related to sulfur dioxide emissions in 2005 alone.

The fundamental solution to these problems facing the country is the establishment of a government that can protect property rights. An able and just administration would promote income equality, curb pollution, lower infant mortality and increase spending on higher education. Stronger enforcement of the law will also promote the growth of the capital market and attract more foreign investment.

The core issue is that of developing public institutions starting with a government that develops and enforces laws to define and protect rights. A modern economy needs information asymmetry and payoffs for opportunistic behavior to be curbed. Strong institutions will raise transactional trust and thereby promote growth.

Governments are like corporate executives. They need incentives and constraints to do their best. This ideal state can be developed even in the Chinese one-party government.

This can be done by developing the rule of law within the party and by allowing different opinions within the party to compete based on transparent platforms and fair rules.

In the long run, China's growth will depend on institutional reforms at the government level, better flow of social information, and market-based competition among its provinces.

China vs. India— separating reality from hype¹⁹

Companies that club India and China together risk working off a flawed strategy that does not allow for the very major differences between the two countries. Equating China with manufacturing and India with services is also simplistic and does not take into account several ground realities such as the fact that China has already surpassed India in service exports.

There is no doubt that these two countries will dominate global trade in the next few decades. In this context, a nuanced understanding of the two nations and the directions they are headed in is crucial.

For long, China's faster rate of growth has been attributed to better infrastructure, an authoritarian government and India's aversion to foreign capital. A more accurate explanation will, however, point to its higher savings, the higher investment as share of GDP, a more open economy, and less cumbersome regulations. Yet there is also the fact that much of Chinese investment is wasted. Its authoritarian government's commandeering of capital leads to inevitable inefficiencies.

Another common assumption is that services will continue to propel India's growth. The fact is that IT services account for only 4.1 percent of India's GDP and 0.25 percent of employment. Also, China may already have overtaken India in IT-related service exports, mostly to non-English speaking countries.

In a similar pattern, China's strength as a manufacturing powerhouse may change gradually in tandem with a fading socialist legacy of emphasis on heavy industry. As state-owned enterprises are privatized and wages rise, China will move toward services. India, on the other hand, may well occupy the manufacturing space vacated by China, mainly on the strength of its cheap labor. Monthly wages in manufacturing stand at US\$23.80 in India as compared with US\$110.80 in China. Also, India's legacy of punitive regulation—a traditional handicap for the manufacturing sector—is fading in the current era of economic reforms. An inevitable revaluation of the Chinese currency will further boost India's manufacturing sector.

India has some other little-known advantages compared with China. China's financial system is dominated by state-owned banks. Capital is cheaper but is also poorly allocated, while India's banks and equity markets work more efficiently, even with 30 percent of bank assets in government bonds. Credit is expanding faster in India, reflecting a deepening of its financial sector. Also, China's non-performing loans greatly exceed India's.

India has more financially successful private firms and Indian entrepreneurs have greater access to capital. In China, 57 percent of private investment is generated through internal funds. In India, the figure is 27 percent.

Looking ahead, both countries will grow rapidly. Trade between China and India will expand. Both countries will create world-class companies, and both will be important markets for selling goods and services.

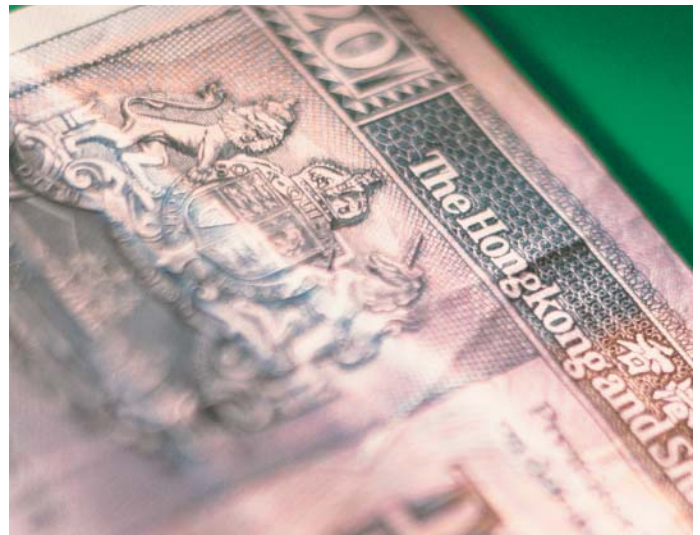
Indian infrastructure supply chains²⁰

The Indian growth story that began in the early 1990s after the current liberalization initiative was launched is now very obviously straining at the seams. The ambitious reform program, involving a shift from a controlled to an open market economy, is showing signs of overheating.

The biggest obstacle in the country's path to growth is the limited basic infrastructure, both physical and non-physical. Even today, the bulk of infrastructure remains in the public sector, traditionally subsidized by the Indian government. This may not remain an option, however, because the government has recently begun attempting to reduce its borrowings.

In the Indian context, infrastructure has been consistently outshone by the glitz of the Indian software industry in particular, and the information and communication technologies industry in general. The long gestation periods for infrastructure projects do not help, and as a result infrastructure needs have been neglected. The implication, not surprisingly, is an alarming gap between the supply and potential demand for infrastructure for high growth. This has emerged as a challenge for the Indian public and private sectors as well as a concern among foreign investors.

Identifying financing for the infrastructure demand-supply shortfall will not be enough. India must analyze and address the need for an appropriate framework for infrastructure supply chains. This is will be a critical part of realizing the country's reform objectives.



Collaborating Across the Supply Chain: Customer and Supplier Management

Innovative supply chains and innovative auctions²¹

Supply chains seem to possess limitless potential for improvement. Just when corporate giants appeared to have mastered the procurement network, along came the phenomenon of outsourcing, forcing a rethinking of the supply chain.

The latest are dynamic supply chains consisting of electronic freelancers. These are formed to deliver a specific product or service and are dissolved at the end of the project. A dynamic supply chain is expected to be an agile, ad hoc network of appropriate entities. It involves a complex web of tasks to be executed by different agents across the supply chain.

This complexity raises some critical issues of supply chain formation. How should an optimal mix of supply chain entities and the protocols of their interaction be determined? The speed, scale and complexity of dynamic supply chain formation render this problem unsolvable through manual means. Instead, it demands mathematical modeling and computer-based solutions.

This is where game theory modeling comes in. Buyers and sellers, and more generally all the agents involved in this problem, are rational and intelligent and hence selfish. The belief here is that sound game theoretic analysis will provide a scientific footing for formulating and solving supply chain formation problems. Things like incentives and penalties have always been a part of supply chain transactions. The emergence of software agent technologies has ensured that these can be deployed more efficiently in practice.

A technology that has become popular in this context is the auction technology, because the bids received in an auction tend to be true values. An auction ensures that it is the best response for all the players to reveal their true costs. In game theory terms, this is the dominant strategy incentive compatibility.

Of course, the auctions involved in supply chain formations are not going to be for single indivisible items. They could be for multi-unit single items or multi-unit multi items or even involve items with multiple attributes. Designing mechanisms that are incentive-compatible and induce truth revelation by all the players will therefore be progressively more difficult.

Supply chain formation is emerging as an extremely important issue, encompassing the traditional optimization problems, as well as being a game theory problem. Game theory and mechanism design will come in very handy here and auctions can be the technology to put these into practice.

Negotiating better outsourcing deals²²

It is hard to talk about India these days without outsourcing entering the conversation. Over the years researchers have offered many rationales for outsourcing, ranging from issues of lowering production cost and improving economies of scale, to focusing on the core competence of companies. Understanding the forces that drive outsourcing is crucial for contractors if they want to increase their negotiation power.

Traditionally, negotiation took place between two parties. In the context of a supply chain, however, negotiation involves several parties including suppliers, manufacturers, labor and assemblers.

Consider a scenario where the assembler negotiates with one supplier at a time and suppliers can compete for their position in the negotiation sequence and can also form alliances among themselves if they wish. In this scenario the assembler and each of the suppliers have some negotiation power. How, then, are profits allocated between the assembler and the suppliers? What is the effect of negotiation power? Does the position in the negotiation sequence have an effect on the outcome?

Research indicates that the profit of the assembler is independent of the negotiation sequence. The suppliers' profits, however, depend on their position in the sequence. The earlier a supplier negotiates, the higher their profit.

Take a related scenario wherein the suppliers are able to negotiate for their position in the negotiation sequence in return for offering the assembler a discount. Assuming all suppliers have the same negotiation power, all suppliers will get the same profit. If several suppliers supply the same component, their profits approach zero.

Now suppose the suppliers are able to form alliances for negotiations. Contrary to accepted wisdom, such alliances may not work to the benefit of all suppliers. Research indicates that only suppliers who already have considerable clout in the negotiation benefit by forming alliances. Weaker suppliers do better by going it alone.

Standardization of vendor selection²³

On the other side of the coin is the strength and quality of suppliers. How do buyers rate vendors to choose the ones best suited to their needs? Supplier selection is one of the key issues in supply chain management because the cost of raw materials and components constitute a major portion of the cost of a product.

The Vendor Performance Index is one tool used in the automobile industry to rate suppliers. The index currently in use does not have strong statistical validation in terms of weightings for selection criteria.

The supplier selection process includes both qualitative and quantitative factors. Two issues that come up for discussion are 1) which criteria should be considered and 2) what methods should be used. In 1966, G.W. Dickson identified 23 criteria in the supplier selection process. These formed a framework for the process, and have been expanded further into sub-criteria. For example, the net price can be subdivided into discounts, the fixed cost, design cost, supplier cost, inventory holding cost, fixed ordering cost, freight charges and so on.

Based on a survey carried out among purchase managers in the automobile sector of the Chennai hub, an attempt was made to understand the relative importance of supplier selection attributes. The relative weighting of attributes in vendor selection were then determined and the Vendor Rating Index has been standardized using analytical hierarchical process. Based on this, a software application package has been developed for purchase managers to rank and select vendors.

Reverse supply chains²⁴

A reverse supply chain consists of the series of activities required to retrieve a used product from a customer and dispose of it properly or reuse it. Reverse supply chains can be necessitated by environmental legislation, economic benefits of remanufacturing, or corporate social responsibility.

A study of a reverse supply chain at a manufacturer of lead-acid automotive batteries was propelled by the legislation on battery disposal and the fact that previous studies on reverse supply chains dealt with closed-loop supply chains but did not deal with the location of remanufacturing facilities. The study sought to explore the synergy in the integration of the forward and the reverse supply chains.

The model derived from the study establishes that a variation in demand affects the required capacities for all the facilities that are a part of the reverse supply chain, making it important to estimate demand accurately. Similarly, the rate at which the used batteries are returned affects the capacities of the facilities. The demand and the return rate therefore influence the franchisee location to some extent.

In terms of sensitivity to warehouse capacity and warehouse cost, if the cost of the selected facility exceeds a certain limit, the model chooses the alternative. The model also selects an alternative location if the selected facility does not possess the required capacity.

The model is developed independent of existing facilities, and thus calls for some modification in the existing network. A second model can also be developed with the reverse flow routed through warehouses before it reaches smelters, and this model compared with the first. A queuing network can be applied to study this network design. System dynamics can be used to study the dynamic nature of flows in both directions and its impact on network design.

Customer segmentation and supply chains²⁵

Whether to optimize efficiency or profits, companies in several industries have successfully sold common products to different customers at prices reflecting their value to the customer. The classic example of service differentiation may well be the airline industry where a common inventory of seats is sold under multiple fare classes. Hotels and car rental companies, too, have multiple customer classes based on their price and service preferences.

There's nothing devious about this—quite the contrary, it makes financial sense to provide superior service to customers who are willing to pay for it while providing no-frills service to the remaining customers at a lower price. The key to implementing this concept lies in differentiating demand classes as well as supply resources.

The issues on the demand side include the question of how many service segments a firm should offer and, on the supply side, how should it define their attributes. In addition, the process for setting prices and service level targets for different segments must be defined. On the supply side, the issues include defining the attributes of segmented resources. Managing capacity for differentiated service classes requires choosing between pooled and segmented resources, as well as setting policy for inventory allocation for each part in terms of demand from differentiated customer classes. This policy would subsume proper inventory stocking and replenishment policies.

Performance evaluation would depend on fill rates for segments, the costs for different resources and, of course, profits.

The inventory rationing policy is a crucial part of delivering differentiated service to customers in a cost-effective way. Research findings presented at the manufacturing summit were based on an analysis of a nested threshold rationing policy. The study provides a more complete definition of rationing policy by considering the clearing of back orders. It develops precise expressions for key performance measures, such as average backlog and fill rate, for each customer class, formulates a cost-minimization objective function, and defines convexity properties of key performance measures.

The study prescribed switching to a threshold rationing policy—a move for which the potential savings are very high. A threshold rationing policy is an effective way of providing differentiated service in a cost-effective fashion. The policy is most attractive when there are wide differences in service requirements for customer classes and critical demand is a small fraction of total demand.

Supply chain maturity²⁶

In manufacturing today, competition is not about manufacturing site versus manufacturing site. Rather, it is about supply chain versus supply chain. Improvement in the supply chain is critical to a company's bottom line in the current era of global sourcing and global competition. Going a step further, the maturity of the supply chain governs a company's performance, affecting the top line as well as the bottom line.

The maturity of a supply chain depends on the depth of the practices, the capabilities and the internal knowledge that reside in the supply chain organization. Supply chain maturity can be gauged in terms of four stages.

Stage one is about functional orientation. In this stage, discrete supply chain processes and data flows are documented and understood. Resources are managed at the department level and performance is measured at the functional level. In stage two, there is cross-functional integration with company-wide process and data continuously measured at the diagnostic level. Resources are managed at both functional and cross-functional levels.

The third stage involves integration with external partners. Strategic partners throughout the global supply chain collaborate to identify joint business objectives and action plans, enforce common processes and data sharing, and define, monitor and react to performance. The final stage is the cross-enterprise stage, in which IT and solutions enable a collaborative supply chain strategy that aligns participating companies' business objectives and associated processes. This results in real-time planning, decision making and supply chain responses to customer requirements.

Many of the companies that have attained the highest stages of supply chain maturity embody a number of the tools and techniques in the Supply Chain Operations Reference (SCOR) model. The SCOR model enables companies to look at the supply chain as an end-to-end process and manage its critical interfaces. It has multiple levels of metrics that give a sense to the company of how well its supply chains are performing. SCOR is based on five core processes—the planning process, sourcing process, making process, delivery process, and in some instances, the process of returning products for repair or maintenance. It addresses the things that enable those processes, be they rules and policies around inventory management or systems and tools, and organization design.

Within SCOR there are four levels. At the very top is determining the basis of competition: cost, service, delivery, or rapidly delivering innovative new products to the market. A company cannot compete on all four of these because the tools and methods needed to compete on one basis are often ill-suited for another method of competition.

At the next level, a company's supply chain can be configured from about 17 core process categories. At the third level, companies fine-tune their operations strategy and define all the processes in detail. The fourth level is that of implementation and is up to each individual company to customize.

Risk Management and Global Supply Chains

Risk models for global manufacturing and service networks²⁷

All global manufacturing and service networks are constantly subjected to random fluctuation in supply, capacity and demand. Typical models for global manufacturing and service networks account for baseline variations in these factors, and can then be used to find ways to manage these variations.

To be effective, however, these models need to incorporate financial risks along with supply, capacity and demand variations. In addition to baseline variations, event-driven variations such as major supply disruptions, capacity changes, demand spikes and credit defaults must be taken into account. Implementing appropriate models to hedge against such risks will result in flexible manufacturing and services networks for global operations.

Using fault and event tree analysis, borrowed from the reliability theory, a network was generated that represented propagation of financial distress. Supply chain is a sub-network of the financial network thus generated.

Risk models for manufacturing and service networks are developed to study the time taken up by a major disruption in the network. For example, it could be the number of times a customer demand is not met within a pre-specified time limit, when the backlogged demand for goods/services exceeds a pre-specified threshold, or when the time to recover from a major disruption exceeds a preset limit.

For the purpose of modeling, the network is considered a reliability/performance system composed of components. These components can be a supply node, a manufacturing/service node or a demand node. The variability and stability of the nodes are then modeled by an uncertainty process. For example, a manufacturing node will be represented by the fluctuation in its capacity over time, including possible total disruptions that may result in a complete loss of capacity.

External risk and the global supply chain²⁸

The increasingly ubiquitous global supply chains have created a dimension that has not received its due share of attention. External risk does not yet have properly developed corporate strategies devoted to it. This is in stark contrast to internal risk, the assessment of which is an integral part of business

operations. However, we have seen the global supply chain emerge as an essential business function in all industries, and a comprehensive assessment of environmental risks—market and non-market forces at play in the external business environment—must become an important part of corporate strategy.

Consider the global chemicals industry. Before the terrorist attacks of September 11, 2001, the assessment of risks in this industry was limited to industry- and firm-specific risks. The terrorist attacks set off a gradual shift in risk assessment to include internal as well as external risks. Business continuity planning, adjusted supply chain resource management, and avoiding supply chain breakdown became priorities.

External risk management includes adopting a strategic approach, identifying external risks that the supply chain is exposed to, determining specific vulnerabilities, and effecting policy options to tackle these risks. External risks can take the form of political events and upheavals, infrastructural breakdowns, legal liabilities, social factors and trends, and natural disasters. These risks can be operational and competitive risks, or the risk of asset impairment, and even franchise risks.

Risk vulnerabilities arise from handling dangerous products, a common hazard for the chemicals industry. Also, dependence on intermediaries, the location of production facilities, issues of capacity, information technology breakdowns, and government regulations can contribute to increasing vulnerability to external risks.

There are several options for managing external risks and mitigating the costs involved in risk management. Supply chain partners, insurers and governments can be crucial allies in such initiatives. For instance, sharing capital costs as well as insurance with supply chain partners can be an effective policy for protecting investments in plants. Governments can work as risk management partners through government security measures and initiatives as well as laws, and through government-sponsored reinsurance. In situations of political risk, governments can act as referees.

An effective risk management strategy comprises continual monitoring, effective metrics and integration of external and internal risk management.

Competitiveness of Indian Manufacturing Industries

Productivity and technical change in the auto components industry²⁹

As in other sectors, the liberalization of the Indian economy in the early 1990s brought about major changes in the auto components industry. Many firms entered into technical collaboration and equity partnership agreements with global OEMs and Tier 1 suppliers.

Some Indian auto components firms also began to focus on improving quality. Their efforts included quality initiatives like ISO 9000 certification (QS-9000 and TS 16949 certifications in early 2000) and deployment of TQM. Many firms also aimed for quality awards like the Deming, and several companies—such as Sundaram-Clayton and Mahindra & Mahindra—succeeded during the last decade.

What is the link, if any, between such certificates and awards and the productivity of the firms in question? Do externally validated changes in quality have an impact on productivity?

Using a Data Envelopment Analysis approach to estimate productivity change for each year from 1993 to 2003 for a sample of 50 firms in the Indian automobile component industry provided some interesting findings.

Productivity improvement was divided into gains due to technical change and improvement in relative efficiency. The study showed that the average productivity of the industry increased by nearly 40 percent over this 11-year period, which is essentially due to technical gains of 40.5 percent and a negative contribution from relative efficiency change of -0.5 percent.

There was nearly equal growth in productivity and technical changes during the periods 1993-1998 (25.4 percent and 22.75 percent) and 1998-2003 (22.5 percent and 25.69 percent). However, there was an increase in relative efficiency of 2.6 percent during 1993-1998, offset by a decrease of 3.1 percent during 1998-2003, which ultimately resulted in the negative growth in relative efficiency of 0.5 percent for the entire period.

Next, both parametric and non-parametric methods were used to study the impact of certification and quality awards on estimated productivity, technical and relative efficiency

gains, controlling for factors such as age, export orientation, and firm size. The study found that award-winning firms, whose initial characteristics were no different from the rest of the industry, do not show significantly higher productivity gains during either period. Firms that were certified after 1998 are associated with significantly higher technical and relative efficiency gains. In addition, larger firms exhibited higher technical gains, and newer firms exhibited both technical and relative efficiency gains.

There is a positive correlation between quality initiatives and productivity improvement in the Indian auto component industry, but the results suggest the need for further analysis to understand the financial benefits of quality improvement in the industry.

TQM in the hinterland³⁰

Total Quality Management as an organizational philosophy has gained widespread favor among Indian companies as it has in the rest of the world. The economic reforms in the early 1990s and the resultant competitive scenario have prompted Indian organizations to increasingly adopt TQM as a change management program to become globally competitive.

TQM initiatives have been spreading even in Assam, an industrially backward state, spearheaded by the public sector units in the oil and paper industries. ISO 9000-based certification initiatives for quality management have also begun to gain momentum. A study of 121 organizations in Assam from 10 different industry sectors reveals an interesting range of experiences for managers attempting to implement TQM. The state's low level of industrialization and a low awareness of TQM make implementation a challenge. The study identified the critical components of TQM and evaluated and compared the TQM status of different industries in Assam.

Through factor analysis and by using multiple and forward stepwise regression, the critical factors for performance quality were identified. These included factors such as process management, customer satisfaction orientation and employee relations. These critical success factors were used to rate the management practices in both the manufacturing and service industries in Assam.

The paper industry emerged at the top of the rankings, followed by the petroleum and the non-durables manufacturing industries. The tea processing industry ended up at the bottom. Surprisingly, public sector companies did much better than those in the private sector.

The major barriers to positive change included a lack of commitment from top management, the lack of a vision, the lack of a system to gather customer feedback, insufficient training in quality, and organizational politics, especially territorialism. Other barriers included the lack of a system for recognition and rewards, a high turnover among top executives, underdeveloped measures of quality, a lack of confidence and commitment to quality on the part of employees, and a lack of leadership.

With regard to the adoption of ISO 9000 certification, Assam's industries are far behind those in the other states in India. Initiatives to obtain certification began in 1994 with public sector companies in the oil and paper sectors. Certification initiatives have gradually spread to various sectors. About 70–80 organizations have been certified so far and 30–40 are in the pipeline.

Currents of change in textile manufacturing³¹

Textiles have always been one of India's most successful exports. The maturing of the domestic market is, however, a more recent phenomenon. Greater consumer choice has led to an increased demand for quality. This can be partly attributed to the entry of multinationals, which have brought in better practices, new technologies and superior products.

In this competitive setting, there are several handicaps hobbling Indian textile manufacturers. For one, the cost of working capital has gone up despite schemes like the Technology Upgradation Fund for the textiles sector that provides a subsidy of 5 percent on the interest rate for capital purchases.

A legacy of India's planned economy, the ill-chosen locations of several manufacturing facilities continue to haunt companies striving for efficiency. Earlier government policies provided incentives for locating factories in underdeveloped regions of the country. Many firms that own more than one plant are finding it difficult to contain the cost of distribution from these plants.

Use of non-standard tools and methods of production have locked a large number of firms into low-quality production. For instance, the "addas" or locally made machine tools of Rajkot and Batala are still used by a large number of small and medium enterprises (SMEs) despite their poor precision and short life.

Frequent changes in the tax regime have introduced uncertainty in operational planning. Octroi, excise, customs, central sales tax, among others, have yet to be rationalized and their collection is not automated.

There have been upsides too. The new retail environment, diminishing labor militancy, and the skill and professionalism of younger workers have been a boost to the sector.

Big-format retailing in the consumer goods segment is posing new requirements for operations management. Robust supply chain management has become key. Rather than focusing on disadvantages like the tax regime, Indian firms must focus on maximizing their competitive advantages. They must aspire to global standards in work practices, equipment, tooling, quality and safety. They should learn about best practices from global suppliers, consultants, customers and even competitors.

Indian firms also need to invest in generating intellectual property. They must attract technical expertise, provide technical training in advanced disciplines, focus on process R&D on the shop floor (as this is harder for a competitor to copy), and include the number of patents filed as a performance measure for the plants.

One killer practice in most firms in India is the long delay in reimbursing suppliers, a weak practice that often negates any goodwill earned by the manufacturer. Also, Indian firms' supply chains are fragmented, complex and often lacking in discipline. Firms still source from a large number of vendors and supply to a large number of distributors. Lastly, customers' inputs are seldom sought when designing new products and services. Obviously, with the increased information and options available to customers, this must change.



Theoretical and Empirical Issues in Global Industries

Theory building in operations management³²

A recent review of 230 empirical articles in leading operations management (OM) journals since 1990 revealed that the OM discipline falls short on theory compared with other management disciplines. This is despite the significant growth of empirical research.

The development and testing of theory is central to empirical science in any discipline.

But it is not enough for the OM discipline to have theories; it must have “good” theories. How is good theory formed? To illustrate this, consider how Roth’s Competitive Progression Theory (CPT) was developed.

The first step in developing the theory was a summarization of ten years of empirical observations on combinative competitive capabilities of quality, delivery, flexibility and costs. Competitive capabilities are measured on the firm’s realized competitive strength due to operations relative to primary competitors in the same target market. These observations of combinative capabilities were inconsistent with prevailing conventional wisdom that said these operations criteria should be traded off—for example, that cost should be traded off for quality, or flexibility for cost.

The second step in theory building is to explain observed phenomena in terms of defined constructs and the causal relationships among them. The aim is to resolve the apparent contradictions to conventional wisdom. CPT offered the first theoretical rationale for the observations. It explained the ubiquity of combinative capabilities in practice with the “laws of operations physics.” These four capabilities share common work processes and, in turn, process variation. Process variance corresponding to each capability can be partitioned into two parts: unique and common. Common variance represents that portion which is shared among capabilities and accounts for the observed correlations, whereas unique variance is attributed solely to one particular capability.

The third step in the theory development journey involves (1) developing precise definitions of the capability constructs and the items tapping into them, and (2) modeling the hypothesized relationships among the constructs.

Finally a new dataset was put together to test the model. An empirical test, using a sample of 119 high tech manufacturers, supported CPT. The empirical results also indicated that some refinement was necessary. CPT suggests that the competitive progression holds in environments where there are slack resources (for example, inside the production frontier or over an innovation cycle) and breaks down at the frontier. In production environments like a job shop, where bottlenecks limit resources, the competitive progression acts as if it were on a production frontier.

CPT is an important contribution to OM theory and practice because it explains why low-cost capabilities may not be achieved. It explains why productivity plateaus exist and what types of resource investments should be made to progress. It highlights the criticality of accelerated learning in manufacturing.

The challenge of multi-firm collaboration in product development³³

The increasing technical complexity of innovation in recent times has prompted firms to collaborate by forming suitable alliances. Collaboration of this sort can take the form of resource or cost-sharing arrangements.

The product innovation embarked upon jointly by a supplier and its industrial customer, however, brings up new issues. The alignment of decisions and incentives has to be managed, in addition to managing performance and the timing of new product development. The questions that arise are: What are the main issues in collaborative innovation? What are the different approaches to managing these issues? Which approaches are optimal and under what circumstances? How do you structure and execute such joint development projects? What are the implications for different industries?

The two collaboration mechanisms found in industrial practice involve sharing the development cost and sharing the development work or, in other words, investment sharing and innovation sharing.

- Investment sharing: This involves co-financing and cost sharing. An example is the alliance between Eli Lilly and Amylin Pharmaceuticals for a diabetes drug: in the alliance, Eli Lilly had the prerogative to decide how much money to invest.
- Innovation sharing: This involves sharing of the innovative effort. An example of such an alliance is that between Dell and Sony. Dell decides what innovation activities to partake in.

A study of multi-firm product development resulted in a model of the collaborative multi-firm development process. It was based on a joint consideration of technology uncertainty and market parameters, as well as structure and sensitivity analysis of both investment and innovation sharing. The study identified appropriate areas for investment and innovation sharing.

For example, in the pharmaceutical industry, the time to market is very important. Innovation sharing could, however, amplify timing uncertainty. Investment sharing is therefore optimal for this industry. For example, the alliance between Amylin and Eli Lilly involved an upfront investment of US\$80 million but no transfer of knowledge or joint development by Lilly.

The emerging operations landscape is marked by increasing complexity and variety, and worldwide competition that mandates a global presence. It has made collaboration a necessity, not a choice. A lack of collaboration in the current business environment, however, translates into smaller investments in quality improvements. As the level of complementarities or technology feasibility increases, the penalty for lack of collaboration increases.

Container operations in India³⁴

The opening up of container movement by rail in India to private operators has ended Container Corporation of India's (CONCOR) monopoly in the sector. Rail movement, though, will still be open only to Indian Railways. (CONCOR, a high performing public sector enterprise, has a network of terminals and owns rolling stock. It has a strategic alliance with Indian Railways.) Many players have entered the sector in various route categories, with 13 companies so far having signed up to provide rail-based services. But no models have yet emerged in terms of infrastructure for private operators.

Container movement by rail requires terminals with rail siding, fleet management, network operation and fleet sizing, cargo monitoring, customer interface and railway interface, and coordination of trucking and handling activities. Freight movement by rail offers the advantage of economy of scale but it is cost-effective only for distances beyond 700 kilometers. A profitable enterprise will estimate aggregate demand and plan services accordingly while considering the reliance on Indian Railways.

Three possible scenarios for the use of terminals include:

1. Leasing assets from CONCOR or other big players. This would presuppose only occasional use of the terminals.
2. Medium and long-term contracts. These will permit ramp-up of services and ensure a certain level of service to customers in terms of asset availability.
3. Dedicated assets acquired by larger players with large enough demand.

Then comes the question of ownership of rolling stock assets. Containers are leased under an international scheme. Rail wagons/flats are not manufactured in large enough numbers in India so that importing them, especially wheel sets, is an option that needs to be considered. Locomotives will have to be leased from Indian Railways.

Private players will also need to consider certain operational and pricing issues. They will need to come up with a network, and plan service levels after considering the frequency of service that they can provide, and whether they will provide services on demand or work by contract. They will have to figure out short-term pricing, reserve some capacity for last-minute customers, lock in long-term commitments, and consider tie-ups with shipping lines.

In signing medium-term contracts, private players will have to consider asset availability versus uncertain demand. How does an asset provider allot capacity to multiple players based on specified service requirements? How does scale economy translate into detailed service requirements for individual chunks of demand?

Suggestions from private players include a penalty for delays in running trains and in supply of locomotives. They have also suggested an annual increase in haulage charges based on input costs, and that locomotives must be made available at two hours' notice.

In terms of strategy and industry structure, there are many possibilities for integration. For example, shipping lines and rail companies can form alliances, as can trucking companies and manufacturers. Also, it is essential to make the right level of investment in the network or at a given location. Growth possibilities exist but not for all players to invest in dedicated infrastructure. Some other issues that will emerge include the possible participation of players in railway infrastructure.

Integrated marketing communications in emerging markets³⁵

For Indian companies looking to compete against established giants in any market, the example of how Samsung Electronics used an integrated marketing campaign in the Southeast Asian market could provide useful insights.

The Southeast Asian home appliance market is very attractive, with a high potential for growth. Existing European and Japanese companies were, however, building high entry barriers and competition between global companies was getting fierce. Samsung Electronics, a late entrant, needed a strategy to establish a premium brand image.

The Southeast Asian market has a wide income disparity, as it is composed of both developed and less developed countries. The consuming population with strong purchasing power is growing rapidly in this region. The percentage of premium products in the home appliances market, which stood at 7 percent in 2004, is expected to jump to 60 percent by 2006.

Samsung first conducted a wide-ranging market survey that indicated that consumers desired products that promised good health. The company spotted an opportunity in consumers' "lifestyle and higher needs." It was, however, difficult for Samsung to launch a premium product in the market because of the widespread perception that it manufactures low- to mid-end products. It needed to develop a new communication strategy.

Samsung applied silver nano technology to its products and implemented an integrated marketing communication strategy to communicate the technology's benefits to consumers.

The company identified the economic differences among Southeast Asian nations and localized marketing communication strategies for each country. It took care, however, to retain the same branding for all Southeast Asian countries to build a consistent brand image. National differences were reflected in the implementation of the marketing communication strategies.

With regard to product positioning and concept development, Samsung is the only brand that has the same technology across all products. Its advertising and public relations campaigns built on this unique aspect by using a consistent image to communicate the products' technical features and distinctive benefits.

It is a strategy that apparently has paid off, as reflected in Samsung's increased share of the home appliances market. The Silver Nano Health System communication strategy won a 2005 Asia Pacific PR award for excellence in product and promotion.

The value of the integrated, consistent approach to brand building was endorsed by the results of a consumer survey. The survey found that the campaign fared well in terms of brand awareness. The communication of the health benefits of Silver Nano was less effective, however. Consumers had a low understanding of and trust in the Silver Nano technology. Clearly, the awareness of the brand was not prompted by the health benefits of the new technology but because of the unified, easily recognizable promotion of all of Samsung's appliances.

Demand management in retailing³⁶

Most companies have processes for forecasting aggregate sales. For example, World Co has a very structured method that relies on expert judgment. The Gap employs a company planner in every division, while L. L. Bean uses top-down and bottom-up forecasting processes.

Firms can and often do use inventory and prices to stimulate demand in order to meet forecasts. Inventory affects gross margin decision, gross margin affects inventory decision, and sales forecasts influence and are influenced by both decisions. Firms therefore use joint time series and causal models for forecasting aggregate sales.

Examples illustrating the effect of inventory on sales include that of Joseph A. Bank, where ending inventory grew by 54 percent and sales grew by 24 percent in 2003. Home Depot lowered inventories to boost cash flows, resulting in a drop in their same store sales and stock price in 2001-02. The company then reversed course and started increasing inventory. Same store sales increased and so did the stock price.

The question, then, is how to forecast firm-level sales using past sales data when this data was managed using inventory and gross margin. A study designed to predict this was based on the hypothesis that inventory affects sales in two ways. It affects the service level and it stimulates demand. Sales affect inventory by determining stock-up-to levels and through forecast updating during the year.

In the relationship between inventory and gross margin, high inventory increases the probability of markdowns. Higher margins increase the propensity to carry more inventory. With respect to gross margin and sales, higher margins lead to lower sales and higher sales lead to higher optimal margins.

The resulting simultaneous equations model provides evidence of the effect of inventory and margins on sales and on each other, and also evidence of the effects of exogenous variables like capital investment. For sales forecasting, it provides better or comparable results than pure time-series models or joint time-series and causal models.

Using prices to kindle demand³⁷

Globalization is the phenomenon that has had the greatest impact on manufacturing in recent times. Its most visible effect has been the shift from a manufacturer-driven market to a customer-dictated market. The customer now is spoiled for choice.

In such a scenario, supply-chain analysts from the industry as well as academia have begun to focus on retail chain management. Retail chains form the lower echelons of the supply chain network and comprise the direct interface with customers.

The analysis of retail chains is often interesting and challenging. For one, there is the large variety of products. The scale, scope and mix of products are ever growing. Second, retail chains produce quick realization of revenue, thereby remarkably shortening the cause-effect cycle. Third, the impact of changes in retail chains on customers is clearly visible and therefore more easily measured. The intensity of competition among products is very visible at this stage. Retail chains constitute a valuable space and tool for promoting products. This opportunity is, however, regulated by the fact that shelf space is limited and must be used judiciously.

Retail chains have scope for differential as well as dynamic pricing. Pricing has emerged as an effective tool to boost demand in the context of retail chains. Retail stores have been using various pricing mechanisms like discount sales and rebates to maximize their profit. Manufacturers have also joined in, most notably using rebates as a price control mechanism to attract more demand. Supermarkets and shopping centers give away rebate coupons that customers redeem for assorted goods and services. These coupons are often given away by both the manufacturers and by the retailers. For manufacturers, these coupons are a tool to boost demand, adjust prices and control inventory.

RFID: Beyond the early promise³⁸

A key tool for tracking and reducing inventories and thereby implementing price control mechanisms is RFID, or Radio Frequency Identification Devices. In the United States, Wal-Mart spent about US\$100 million in 2004-5 on RFID. This is projected to touch US\$1 billion in 2007-8. Yet will the implementation of RFID technology in supply chains deliver on its early promise?

The benefits of RFID are obvious. It saves labor, provides visibility, enables inventory reduction, helps reduce stock-outs, and limits phantom stock. Benefits are likely to increase over time, with the possible accrual of intertwined benefits depending upon scaling and the network. There are, however, issues with uncertainty around the implementation.

The costs include the purchase of readers, tags and middleware. Costs decrease over time, of course, and are also dependent upon scale and the network. Retailer mandates will also add to cost.

A technology adoption model was created, considering the retailer and manufacturer's costs and benefits, to explain the possible slowdown in RFID implementation. The model explains differential adoption rates for suppliers and customers: while customers' adoption rate increased progressively over the years, the rate was zero for the initial periods and increased significantly thereafter.

The model can guide individual decisions for RFID adoption and help explain the dynamics of the customer and supplier adoption curves. The model can also be used to study the effect of industry connectedness and country characteristics on the adoption curves.



International Research Collaboration around Manufacturing in Emerging Markets

Preserving research pipelines in a flat world³⁹

The migration of manufacturing and services from the developed world to less developed countries like India has created a serious challenge for research.

Current innovations like the Apple iPod are the result of technologies developed through basic science and engineering research. Such research was primarily funded by governments, foremost among them the U.S. government. Individual companies do not have the mandate or the resources to fund research that can only be used 30 or 40 years after the money has been invested.

Now that the market is shifting, what are the implications for research? For example, it is becoming increasingly harder to justify U.S. government funding for research in manufacturing because manufacturing activity is on the decline in that country. How will this affect the intellectual property that is going to be created? How will new innovation and new ideas be fueled?

Another issue is the shortening timelines for obtaining exclusive benefits from new technologies. Almost as soon as a new technology is invented, everybody has access to it. Juxtapose this against the investment requirements that keep growing; obviously the payoffs for investing in research are disappearing. For example the National Science Foundation funds most of the basic science research in the United States, spending about US\$6 billion annually. This generates about a US\$1 billion worth of returns. As soon as these technologies mature or as soon as they are invented, the jobs go somewhere else. If the United States is to share the benefits of such research with other countries, it will seek to distribute the risks, too.

There is a point at which every ounce of efficiency is squeezed out of a product or process, and one must move to the next paradigm. This, however, requires new development, which means fundamentally new discoveries. There is a

long gestation period for such activity. For example, some technologies in use now are the result of investment that took place in the 1940s, and the basic research underlying many of the successful innovations is often conducted several years prior, in diverse fields, without specific applications in mind. Flattening of the world has led to severe economic pressures in developed economies, resulting in reduced investment in basic research, both by governments and industries, and limited access to the talent pool in developing countries. These trends clearly point to a potential shortfall in the raw materials needed to sustain innovation and competitiveness in the future. The issue now is how to keep feeding this pipeline so that the knowledge base that creates innovation is not exhausted.

This pipeline gets fed with two things: people and investment. In terms of people, the numbers do not paint an encouraging picture. The United States is producing fewer people with PhDs, China is not very prolific, and even Germany, which used to generate a lot of PhDs, is seeing a slowdown.

This slowdown in the production of researchers just when the world actually needs a lot more of them is a fundamental problem. It is an issue that all countries, developed or developing, need to tackle together.

Collaborative research—a solution?⁴⁰

Worldwide research collaboration is the inevitable cost-sharing solution and a way to keep the knowledge pipeline from drying up. An obvious benefit is the globalization of research, which can enable more relevant research in the increasingly integrated marketplace.

India, as an emerging economic giant, can provide international researchers the right environment to develop and test new management theories. Endeavors in this direction include the joint program between the University of Southern California's Marshall School of Business and the Indian Institute of Technology, Chennai in supply chain management. Part of the resources realized through this program will be earmarked for use in joint research in the United States and India.

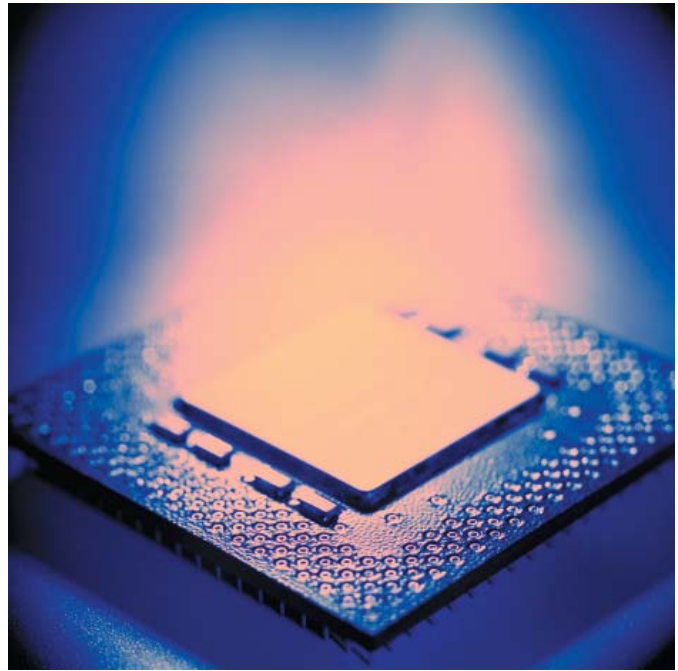
A major challenge in starting and maintaining research programs in India is manpower. Persuading students to take up research is not easy. This shortage of talent is exacerbated by the fact that many big U.S. firms and multinationals are setting up headquarters in India. Efforts are on to mitigate the shortage of PhDs through collaborations between companies and educational institutions, and through non-traditional doctoral programs at Indian research institutions such as the IITs and the Indian Institute of Science.

As more engineering problems of relevance move to India, the need for advanced research will continue to increase there. Indian enterprises may then be forced to seek research help in the United States. For example, Tata Consultancy Services is engaged in setting up a large research facility in Indianapolis, primarily to tap research talent available at Purdue University and University of Illinois. Other exchange mechanisms that could foster interaction and possibly collaboration are student internships. Short courses in India on advanced topics can also enable U.S. faculty to assist U.S. companies with R&D labs in India. Co-hosting conferences is a natural way to bring industry and academia together, as are professional societies and chapters.

Joint work on case studies and eventually data collection from supply chain participants can be quite valuable. Face-to-face meetings allow extended conversations to take place. Once the connection is made, collaborating electronically is very viable. Collaboration tools such as SharePoint make document management much easier in such virtual collaboration.

Additionally, creation and maintenance of a database of willing research partners, both in academia and in industry, would be useful. Funds for research, internships, a supply of good problems, and “soft rules” for collaboration are additional aids for collaboration. Complementarity and diversity of ideas and communication, research standards, defining intellectual property rights, and rules of engagement are vital for any collaborative effort.

Good projects will attract international researchers, and the importance of bringing these experts of international repute to join projects cannot be overstated.



Appendix: Speaker Roster from the Second Summit on Indian Manufacturing Competitiveness

S. Aravindanath, Reliance Industries	Rajiv Malik, Matrix Laboratories Ltd.
Ram Bala, Indian School of Business	V. Krishna Murthy, National Manufacturing Competitiveness Council
Mukulesh Barua, Assam Institute of Management	Y. Narahari, Professor, Indian Institute of Science
Yehuda Bassok, Marshall School of Business, University of Southern California	C. Narasimhan, Sundaram-Clayton Limited
P. Chandiran, Vellammal College of Management and Computer Studies	Rohit Pandey, J&J Buying Services
Dileep C. Choksi, Deloitte Haskins & Sells, India	M. Rammohan Rao, Indian School of Business
Gary Coleman, Deloitte Touche Tohmatsu	Narayan Rangaraj, Indian Institute of Technology, Bombay
Abhijit Deshmukh, National Science Foundation	B. Santhanam, Saint-Gobain Glass India Ltd.
Vinayak Deshpande, Krannert School of Management, Purdue University	Haritha Saranga, Indian School of Business
N. Ganesh, Satyabhama University	B. A. Saravanan, Anna University
Vishal Gaur, Stern School of Business, New York University	S. S. Prasad Satyavolu, Tata Consultancy Services
Steve Hussey, PRTM India	Sridhar Seshadri, Stern School of Business, New York University
Ananth Iyer, Krannert School of Business, Purdue University	J. George Shanthikumar, University of California, Berkeley
Apurva Jain, University of Washington Business School	Milind Sohoni, Indian School of Business
Sajjan Jindal, Jindal Steel	Rajesh Srivastava, Rabobank
Ira Kalish, Director of Consumer Business, Deloitte Research	S. M. Trehan, Crompton Greaves Ltd.
Kumar Kandaswami, Deloitte India Private Ltd.	Jay van Wyk, Pittsburg State University
Youngchan Kim, School of Business, Yonsei University	Linn K. Veltema, 3M India Ltd.
Peter Koudal, Director, Deloitte Research	N. Viswanadham, Centre for Global Logistics and Manufacturing Strategies, Indian School of Business
Satyendra Kumar, Manugistics Software Services India Pvt. Ltd.	Bernard Yeung, The Stern School of Business, New York University
Arvinder Loomba, San Jose State University	

Endnotes

- ¹ Based on speeches and contributions by M Rammohan Rao, Professor and Dean, Indian School of Business; Dileep C. Choksi, Joint Managing Partner, Deloitte Haskins & Sells, India; N. Viswanadham, Professor, Center for Global Logistics and Manufacturing Strategies, Indian School of Business; Milind Sohoni, Professor, Indian School of Business; Sridhar Seshadri, Professor, Stern School of Business, New York University; Ananth Iyer, Professor, Krannert School of Business, Purdue University; Kumar Kandaswami, Country Manufacturing Leader, Deloitte India Private Ltd.; Peter Koudal, Director, Deloitte Research; Abhijit Deshmukh, Director, Manufacturing Enterprise Systems, National Science Foundation; and Ram Bala, Professor, Indian School of Business.
- ² From Santanu Choudhury, "Toyota Touts Indian, Thai Rivals," the *Wall Street Journal*, November 29, 2005.
- ³ The Second Summit on Indian Manufacturing Competitiveness was held in Hyderabad, India, in August 2006, and organized by Deloitte Research, the Indian School of Business, New York University, and Purdue University with support from the National Science Foundation.
- ⁴ Based on a keynote presentation by V. Krishna Murthy, Chairman, National Manufacturing Competitiveness Council.
- ⁵ Based on a presentation by Gary Coleman, Global Managing Director of Manufacturing, Deloitte Touche Tohmatsu.
- ⁶ From a presentation by Sajjan Jindal, Vice Chairman and Managing Director, Jindal Steel.
- ⁷ Based on a presentation by N. Viswanadham, Professor and Executive Director, Center for Global Logistics and Manufacturing Strategies, Indian School of Business.
- ⁸ Based on a presentation by Kumar Kandaswami, Manufacturing Industry Leader at Deloitte Touche Tohmatsu, and Peter Koudal, Director of Manufacturing at Deloitte Research.
- ⁹ Based on a presentation by S. M. Trehan, Managing Director, Crompton Greaves Ltd.
- ¹⁰ Based on a presentation by Rajiv Malik, Chief Executive Officer, Matrix Laboratories Ltd.
- ¹¹ Based on a presentation by Rajesh Srivastava, Managing Director, Rabobank.
- ¹² Based on a presentation by S. S. Prasad Satyavolu, Practice Director-Business Consulting, Tata Consultancy Services.
- ¹³ Based on a presentation by Rohit Pandey, J&J Buying Services.
- ¹⁴ Based on a presentation by B. Santhanam, Managing Director, Saint-Gobain Glass India Ltd.
- ¹⁵ Based on a presentation by Linn K. Veltema, Director, Total Supply Chain, 3M India Ltd.
- ¹⁶ Based on a presentation by C. Narasimhan, President - Automotive Products Division, Sundaram-Clayton Limited.
- ¹⁷ Based on a presentation by S. Aravindanath, Vice President, Reliance Industries.
- ¹⁸ Based on a presentation by Bernard Yeung, Professor, the Stern School of Business, New York University.
- ¹⁹ Based on a presentation by Ira Kalish, Director of Consumer Business, Deloitte Research.
- ²⁰ Based on a presentation by Arvinder Loomba, Professor of Operations and Supply Chain Management, San Jose State University.
- ²¹ Based on a presentation by Y. Narahari, Professor, Indian Institute of Science.
- ²² Based on a presentation by Yehuda Bassok, Marshall School of Business, University of Southern California.
- ²³ Based on a presentation by B. A. Saravanan, Department of Manufacturing Engineering, Anna University.
- ²⁴ Based on a presentation by P. Chandiran, Assistant Professor, Velammal College of Management and Computer Studies.
- ²⁵ Based on a presentation by Vinayak Deshpande, Krannert School of Management, Purdue University.
- ²⁶ Based on a presentation by Steve Hussey, Managing Director, PRTM India.
- ²⁷ Based on a presentation by J. George Shanthikumar, University of California, Berkeley.
- ²⁸ Based on a presentation by Jay van Wyk, Professor, Pittsburg State University.
- ²⁹ Based on a presentation by Ananth Iyer, Professor, Krannert School of Management, Purdue University; Haritha Saranga, Professor, Indian School of Business; and Sridhar Seshadri, Professor, New York University.
- ³⁰ Based on a presentation by Mukulesh Barua, Professor, Assam Institute of Management.
- ³¹ Based on a presentation by N. Ganesh, Director and Researcher, EDC Cell, Satyabhama University.
- ³² Based on a presentation by Aleda V. Roth, Professor, College of Business and Behavioral Science, Clemson University.
- ³³ Based on a presentation by Vish V. Krishnan, Professor, Rady School of Management, University of California, San Diego.
- ³⁴ Based on a presentation by Narayan Rangaraj, IEOR Group, IIT Bombay.
- ³⁵ Based on a presentation by Youngchan Kim, Professor, School of Business, Yonsei University.
- ³⁶ Based on a presentation by Vishal Gaur, Professor, Stern School of Business, New York University.
- ³⁷ Based on a presentation by Satyendra Kumar, Manugistics Software Services India Pvt. Ltd.
- ³⁸ Based on a presentation by Apurva Jain, University of Washington Business School.
- ³⁹ Based on a presentation by Abhijit Deshmukh, the National Science Foundation.
- ⁴⁰ Based on a panel discussion on collaborative research. Participants included Yehuda Bassok of USC's Marshall School of Business; Narayan Rangaraj of IIT Bombay; Aleda Roth of Clemson University; Shankar Dey of ISB; and Ganesh Subbarayan and Jackie Rees of Purdue University.

Authors

Ananth Iyer

Krannert School of Business, Purdue University

Kumar Kandaswami

Deloitte Touche Tohmatsu India Private Limited

Peter Koudal

Deloitte Research, Deloitte Services LP

Sridhar Seshadri

Stern School of Business, New York University

Milind Sohoni

Operations and Information Technology Department,
Indian School of Business

N. Viswanadham

Centre for Global Logistics and Manufacturing Strategies,
Indian School of Business

Editors

Jon Warshawsky

Deloitte Research, Deloitte Services LP

Reshma Trenchil

Deloitte Research, Deloitte Services LP

For further information, please contact:

Abhijit Deshmukh

Director, Manufacturing Enterprise Systems
National Science Foundation
Tel: +1 703 292 7061
Email: adeshmuk@nsf.gov

Ananth Iyer

Professor of Management
Krannert School of Management
Purdue University
Tel: +1 765 494 4514
Email: aiyer@krannert.purdue.edu

Kumar Kandaswami

Manufacturing Industry Leader
Deloitte Touche Tohmatsu India Private Limited
II Floor, Temple Tower, 672 Anna Salai, Nandanam
Chennai 600 035, India
Tel: +91 44 2435 6685
Email: kkumar@deloitte.com

Peter Koudal

Director of Global Manufacturing
Deloitte Research
Deloitte Services LP
Tel: +1 212 436 2647
Email: pkoudal@deloitte.com

Sridhar Seshadri

Toyota Professor of Operations Management
Leonard Stern School of Business
New York University
Tel: +1 212 998 0294
sseshadr@stern.nyu.edu

Milind Sohoni

Assistant Professor of Management Science
Operations and Information Technology Department
Indian School of Business
Tel: +91 40 23187140
Email: milind_sohoni@isb.edu

N. Viswanadham

Professor and Executive Director
Centre for Global Logistics and Manufacturing Strategies
Indian School of Business
Tel: +65 94 35 6206
Email: mpenv@nus.edu.sg

Deloitte Research

Deloitte Research, a part of Deloitte Services LP, identifies, analyzes, and explains the major issues driving today's business dynamics and shaping tomorrow's global marketplace. From provocative points of view about strategy and organizational change to straight talk about economics, regulation and technology, Deloitte Research delivers innovative, practical insights companies can use to improve their bottom-line performance. Operating through a network of dedicated research professionals, senior consulting practitioners of the various member firms of Deloitte Touche Tohmatsu, academics and technology specialists, Deloitte Research exhibits deep industry knowledge, functional understanding, and commitment to thought leadership. In boardrooms and business journals, Deloitte Research is known for bringing new perspective to real-world concerns. Please visit www.deloitte.com/research for the latest Deloitte Research thought leadership or contact Deloitte Research at delresearch@deloitte.com.

Indian School of Business

The Indian School of Business symbolizes the vision of the School's founders. The School evolved from a need for a globally top-ranked and distinctive business school in the Asian region dedicated to providing the best management education. The School is the dream of some of the best minds from the corporate and academic world. Their aspiration in creating the ISB is to establish an internationally top-ranked, research-driven, independent management institution that grooms future leaders for India and the world. The School's Governing Board comprises business leaders, entrepreneurs, and academicians from some of the world's leading business and management education institutions. Our partnership with the Kellogg School of Management, The Wharton School, and London Business School makes the ISB one of its kind in Asia. Our vision is to become an internationally top-ranked, research-driven, independent management institution that grooms future leaders for India and the world. The ISB's aspiration to groom tomorrow's leaders is grounded in the belief that leadership skills can be learned and that successful leaders must take charge of their own development and growth to achieve their true potential. However, it is our strong belief that whatever your model of leadership, it should be grounded in a strong foundation of core values.

National Science Foundation

The National Science Foundation (NSF) is an independent federal agency created by Congress in 1950 "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense..." With an annual budget of about \$5.5 billion, we are the funding source for approximately 20 percent of all federally supported basic research conducted by America's colleges and universities. In many fields such as mathematics, computer science and the social sciences, NSF is the major source of federal backing.

Global Business Institute, Leonard N. Stern School of Business, New York University

The Stern Global Business Institute (GBI) was established in 2003 to consolidate an array of long-standing academic activities and create a coherent platform for their future development. Stern was one of the first institutions to emphasize the international dimensions of business over three decades earlier, spanning first-rate applied research, an extensive list of undergraduate and MBA course offerings, and a doctoral specialization in the international dimensions of academic disciplines to develop the next generation of professorial faculty. The School launched an academic International Business initiative long before international and global business aspects were formally built into the curricula of any of the other major business schools. This 30-year "first mover" history is now capitalized in the franchise value of the School. Each of the international activities has been firmly rooted in the academic key disciplines, so that both faculty and students combine discipline-based rigor with ample opportunities to focus on the international dimensions. Throughout this period, the Stern School was consistently rated among the top-five institutions focusing on international business worldwide. This remains so today. The Stern Global Business Institute is charged with taking this evolution to the next level, leveraging the School's growing research strength in core disciplines into the global arena and providing consistent academic oversight and support for the School's extensive activities in global business education.

Global Supply Chain Management Initiative, Krannert School of Business, Purdue University

Many of today's most successful firms attribute their success to a strategically managed global supply chain. The complexities of coordinating and collaborating within a global network of designers, manufacturers, distributors and retailers grow as businesses seek to attain a competitive advantage through carefully formulated strategies for managing flows in physical, informational and financial channels. The Global Supply Chain Management Initiative gives current and future managers the opportunity to be on the forefront of emerging ideas and technologies that promise to provide a differentiating advantage to businesses in the future. This initiative offers a broad-based, global approach to taking your business skills global through a variety of programs, including conferences and events for executives, students and faculty.

ISBN 1-934025-01-1

Centre for Global Logistics and Manufacturing Strategies (GLAMS). The Centre for Global Logistics and Manufacturing Strategies (GLAMS) at ISB is created with the vision of being a knowledge partner of choice to both Government and Industry in the areas of manufacturing, logistics and supply chain management. Its focus is to engage in innovative research, conduct training programs and work with the government and industry to become the driving force for the growth of global logistics and manufacturing in India. Two top industry houses TAFE and Hero Group support some of the Centre's activities. GLAMS intends to develop partnerships and collaborations with leading industrial institutions and work closely with the industry in disseminating information. The research activities at GLAMS include: Developing frameworks and techniques for analysis and design of global supply chain networks, Lean Supply Chain design for various industry sectors, Retail in emerging markets and developing strategies for Rural Business Transformation. www.isb.edu/glams.

About Deloitte

Deloitte refers to one or more of Deloitte Touche Tohmatsu, a Swiss Verein, its member firms and their respective subsidiaries and affiliates. Deloitte Touche Tohmatsu is an organization of member firms around the world devoted to excellence in providing professional services and advice, focused on client service through a global strategy executed locally in nearly 150 countries. With access to the deep intellectual capital of approximately 135,000 people worldwide, Deloitte delivers services in four professional areas, audit, tax, consulting and financial advisory services, and serves more than one-half of the world's largest companies, as well as large national enterprises, public institutions, locally important clients, and successful, fast-growing global growth companies. Services are not provided by the Deloitte Touche Tohmatsu Verein and, for regulatory and other reasons, certain member firms do not provide services in all four professional areas.

As a Swiss Verein (association), neither Deloitte Touche Tohmatsu nor any of its member firms has any liability for each other's acts or omissions. Each of the member firms is a separate and independent legal entity operating under the names "Deloitte", "Deloitte & Touche", "Deloitte Touche Tohmatsu" or other related names.

In the United States, Deloitte & Touche USA LLP is the U.S. member firm of Deloitte Touche Tohmatsu and services are provided by the subsidiaries of Deloitte & Touche USA LLP (Deloitte & Touche LLP, Deloitte Consulting LLP, Deloitte Financial Advisory Services LLP, Deloitte Tax LLP, and their subsidiaries), and not by Deloitte & Touche USA LLP. The subsidiaries of the U.S. member firm are among the nation's leading professional services firms, providing audit, tax, consulting, and financial advisory services through nearly 40,000 people in more than 90 cities. Known as employers of choice for innovative human resources programs, they are dedicated to helping their clients and their people excel. For more information, please visit the U.S. member firm's Web site at www.deloitte.com

Copyright © 2007 Deloitte Development LLC. All rights reserved.

Member of
Deloitte Touche Tohmatsu