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Indian Manufacturing – Strategic and Operational Decisions and Business Performance[1]

Ananth Iyer
Susan Bulkeley Butler Chair in Operations Management,
Karnnert School of Management,
Purdue University,West Lafayette, IN 47907
aiyer@mgmt.purdue.edu

Peter Koudal
Director of Global Manufacturing,
Deloittee Research,
New York, NY, USA
pkoudal@deloitte.com

Haritha Saranga
Associated Professor,
Production and Operations Management,
Indian Institute of Management Bangalore
Bannerghatta Road, Bangalore – 5600 76
harithas@iimb.ernet.in

&

Sridhar Seshadri
Professor, IROM Department,
McCombs School of Business
University of Texas, Austin, TX 78727
Sridhar.Seshadri@mccombs.utexas.edu

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Ananth Iyer*, Peter Koudal, Haritha Saranga*** and Sridhar Seshadri******

*Susan Bulkeley Butler Chair in Operations Management, Krannert School of Management, Purdue University, West Lafayette, IN 47907,
aiyer@mgmt.purdue.edu

** Director of Global Manufacturing, Deloitte Research, New York, NY, USA, pkoudal@deloitte.com

*** Production and Operations Management, Indian Institute of Management Bangalore, Bannerghatta Road, Bangalore 560076, India,
harithas@IIMB.ERNET.IN

**** Toyota Motor Term Professor of the IOMS Department Stern School of Business New York University, 44 W 4th St., New York, NY 10012,
sseshadr@stern.nyu.edu

Abstract

India is attracting significant attention as an attractive location for manufacturing industries in recent times. There have been many studies that demonstrate the rapid productivity and technological growth of Indian manufacturing industries post- industrial liberalization. We focus on the firm level strategic operational decisions with regard to (i) Scale and Operating Focus, (ii) Product and Process Technologies and (iii) Planning, Control, and Execution Systems. We find little evidence that firms have taken advantage of scale economies in India during the post-liberalized era. However, we find evidence that firms in industries such as chemicals and pharmaceuticals imported sophisticated process technologies and developed in-house R&D capabilities to adapt them to the local environment even prior to liberalization. These capabilities seem to have enabled them to undertake more technology-intensive activities and take further advantage of liberalization to improve product technologies.

Keywords: Manufacturing Strategy, Developing Countries, Capacity, Technology and Quality

[1] We are grateful for feedback provided for this paper by Mr Kumar Kandaswami

1. Introduction

The balance of global manufacturing value added is gradually shifting to developing economies. Over the last decade or so, developing countries have increased their share of global manufacturing value-added from a mere 15.73 percent in 1990 to 23.58 percent in 2002 (UNIDO Industrial Development Report, 2005) and their share in world export from 24.3 percent in 1990 to 32.1 percent in 2003. (UNCTAD, Trade and Development Report 2005). The average annual flow of foreign direct investment (FDI) into developing countries more than quadrupled from US$16.9 billion in the 1989-1991 period to US$70.0 billion in the 2001-2003 period; growing more than twice as fast as FDI flows into developed countries (UNCTAD, World Investment Report 2005).

India has begun to attract significant attention as a manufacturing destination, following the ascent of China's manufacturing industry. The next wave of off shoring is going to take place in the skill intensive industries and India has an advantage in this segment (NMCC, 2005). The changing demographics of the developed and developing world is another important factor. Various demographic related studies have revealed that, while the ageing population in the developed world is driving the manufacturing jobs to the developing countries, amongst the low cost manufacturing destinations including countries like China, Brazil and Russia, India is expected to have the largest percentage of young working age population leading up to 2050 (Wilson and Purshothaman, 2003). Productivity-related studies on the impact of Indian economic reforms of 1991 reveal that there has been significant growth in productivity in many of the Indian manufacturing sectors. Empirical studies have shown that, there has been an approximately 15 percent increase in aggregate productivity growth in FDI-liberalized industries and 20 percent increase in tariff-liberalized industries during the period 1987-1995 (Sivadasan 2003). Research at the industry-level has shown a significant increase in the average productivity of the Indian auto component industry (about 40 percent) and Indian pharmaceutical industry (about 15 percent) during the decade after the liberalization took place (Iyer *et al* 2006, Saranga and Banker 2006). The share of Indian exports, although not significant in comparison to other large developing economies such as China, has increased from 0.5 percent in 1990 to 0.8 percent in 2003 (UNCTAD, Trade and Development Report 2005).

The dramatic change in the importance of manufacturing in emerging markets has made it critically important to understand how the manufacturing sector and in particular individual manufacturing firms are moving into the global economy. Therefore, it has become imperative to take note of various operational choices available to manufacturing firms in these countries for decision making, the constraints imposed by the external environment, as well as the outcomes in terms of firm performance, profitability, growth, and competitiveness.

Specifically, we survey the literature on Indian manufacturing with the goal of delineating the factors that have shaped various manufacturing industries to their present form. We also survey the theory necessary to understand the operational choices made by firms in a policy environment that strongly regulated monopolies, controlled capacity expansion decisions as well as technology imports and favored the small scale sector, investments in public sector enterprises and substitution of critical imported materials. We also use the analysis to predict the future evolution of these industries.

A variety of methods were used to study the factors that have influenced the progress of Indian manufacturing sectors over the last 50 years. In the sections that follow, we first try to predict the short- and long-term reaction of firms to various favorable and unfavorable policy regulations. We then review the available empirical and anecdotal evidence to test the predictions from the theory. Not only do we aim to provide a perspective on the state of current research on Indian manufacturing industries in a global perspective, we also aim to identify issues for further research and analysis. More generally we hope that the study provides a perspective on the current knowledge of Indian manufacturing industries and future issues, problems and opportunities for the Indian manufacturing sector.

Based on an initial survey of papers on the Indian manufacturing industry, we find that most researchers have focused upon the choices made by firms regarding: (1) Scale and Operating Focus (2) Product and Process Technologies and (3) Planning, Control and Execution Systems. The survey is organized accordingly. This grouping is broader than the major types of choices listed by Hayes and Wheelwright (1985), but, we believe that its broader scope better suits the nature of this survey, i.e., impact of policy restrictions on choices made by firms.

2 Policy Restrictions and Firm Decisions

In this section, we first list the important restrictions placed on the sector. This is followed by a review and discussion of the literature related to Scale and Focus Product and Process Technologies and Planning, Control and Execution Systems.

Restrictions on manufacturing choices

Athreye and Kapur (2003) report that most industries in the Indian manufacturing sector were subject to licensing requirements and capacity controls during the 1960s and ‘70s. In particular, the restrictions that seem to have had significant impact on the above mentioned operational choices are:

1. In eighteen industries, significant market share was reserved for the public sector, including manufacturing industries like iron and steel, heavy plant and machinery, telecom equipment and petrochemicals. But there were exceptions in each industry e.g., Tata Steel in the steel sector.

2. Some industries were reserved for the small-scale sector, e.g., mechanical engineering, chemical products and auto ancillaries. Production of certain items was also restricted to small-scale sector, e.g., garments, shoes and toys.

3. Most sectors were subject to capacity restrictions and industrial licensing.

4. Monopolies and Restrictive Trade Practices (MRTP) Act, 1969 monitored investments by large industrial houses by inviting objections and holding public hearings before granting a license for production.

5. Foreign Exchange Regulation Act (FERA) 1973 amongst other restrictions mandated foreign equity share to be less than 40%, unless the company was engaged in 'core' activities or was using sophisticated technologies or met certain export commitments.

6. High import tariffs on capital goods and technology were levied to encourage firms to develop in-house R&D and complementary technologies and discourage import of capital goods.

7. Process Patenting Laws.

8. Labor Laws.

9. Restrictions on foreign direct investment (FDI).

2.1. Choice of Scale and Operating Focus

In this section we study the impact of policy restrictions on scale, efficiency and focus of operations and how these have affected the focus of firms.

Scale

As listed above, several restrictions were placed on capacity expansion as well as on entry of firms. When restrictions on expansion are placed on firms, it is logical to assume that demand will exceed supply for many goods. Therefore we expect to see higher prices than those that would prevail in more competitive or efficient markets. Also, limited capacities may not allow for scale efficiency and firms may not be able to adjust capacities fast enough to take advantage of growing market demand.

In the short run, firms' decision-making may be characterized by capacity restricted price competition (termed Cournot competition by economists) under capacity restrictions. In their empirical study of UK manufacturing firms during 1980-89, Haskel and Martin (1994) find that within an industry producing homogenous goods, firms that are more capacity-constrained act in a more Cournot-like way and have higher profits than they would have had under the Bertrand alternative.[2] Haskel and Martin also show that this effect gets magnified in more concentrated industries[3]. The hypothesis that capacity constrained firms are more profitable in the short run in comparison to firms that are able to undercut rivals with excess capacity by Bertrand pricing should hold true even in the case when capacity constraints are imposed due to external regulations.[4]

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[2] Cournot competition assumes more than one firm in the market and assumes that firms compete on quantities and choose quantities simultaneously, whereas Bertrand competition assumes at least two firms and firms compete on prices and choose prices simultaneously.

[3] Note that the capacity constraints studied by Haskel and Martin (1994) are due to industries moving into an upswing, rather than externally imposed government restrictions on quantity.

[4] Theoretical and empirical evidence discussed by Rodrik (1992) and Tybout (2000) also suggests that firms in protected regimes enjoy higher price-cost markups than their counterparts in liberalized regimes.

Restrictions also affect the size distribution of firms. The industrial evolution models developed by Jovanovic (1982) and Ericson and Pakes (1995) assume that, at any point in time, firms of different sizes, ages and productivity levels coexist. Lucas' (1978) model of size distribution with heterogeneous workers and entrepreneurs shows that when large firms face higher input costs due to regulatory restrictions on larger firms, the most talented entrepreneurs operate big firms to exploit their productivity advantage. The resulting scale economies they achieve pay for the higher input costs, while the less talented entrepreneurs will stay in small and more informal firms. Lucas's model shows a "missing middle," because it never pays to be just large enough to attract regulatory scrutiny and enforcement.

Consistent with this prediction, in the case of Indian manufacturing industries, policy restrictions around capacity combined with government favoritism towards smaller firms discouraged the majority of smaller firms from growing, as they would have had to cope with a much more difficult licensing policy, higher labor costs and substantially higher excise duties once they exceeded a certain size limit (Little *et al* 1987). In his 1995 study, Gang observes that firms manufacturing products such as chemical products and auto components, that were reserved for the small-scale sector, were operating at capacities below the minimum efficiency scale because they risked losing their preferential status if they expanded output. In his earlier study Gang (1992) also found that smaller firms performed better in industries where vertical integration was discouraged by policy makers and in which there were few or no economies of scale in management.[5] As a result, the small and medium enterprises[6] (SMEs) in 2002 roughly constitute about 73 percent of Indian manufacturing enterprises, according to a World Bank survey.[7] Tybout's (2000) study of manufacturing firms in other developing countries reports similar findings, with the emphasis on small scale production being negatively correlated with per capita income levels across countries and also within countries through time.

The decision to stay small could additionally have been influenced by several market factors. The inward orientation of Indian government, unlike the other emerging economies (e.g., East Asian countries) might have influenced firms to focus only on meeting the local demand. Infrastructural problems such as poor transportation networks and warehousing facilities could have also influenced firms to stay small, spread out and produce locally to meet the small diffused pockets of demand. The higher volatility in developing markets might have discouraged the use of advanced mass-production techniques and encouraged firms to remain small and rely more heavily on labor, to stay flexible (Tybout, 2000).

Smaller firms, being more labor-intensive and less automated, are more flexible towards volatility in demand and may not have allocative inefficiencies, unlike the larger firms that try to adapt capital-intensive imported technologies originally developed for industrialized countries. In order to stay in the small scale category, many companies had their businesses split up into multiple entities but ran them as a single value chain. They thus achieved efficiencies and at the

[5] In other words, Gang (1992) finds that if an industry sales structure, regulatory environment or technology is such that there are significant economies of scale in management, then small firm presence is reduced, where the economies of scale in management is measured in terms of worker to employee (managerial staff) ratio. Thus economies of scale in management are present, if the worker-to-employee ratio in large firms is greater than that of small firms.

[6] A firm is defined as an SME if it has fewer than 150 employees.

[7] http://lnweb18.worldbank.org/sar/sa.nsf/Attachments/wbcii/$File/FACSReport.pdf

same time enjoyed the benefits available for the small scale units. In many cases they operated as clusters and achieved efficiencies.

In addition, the capacity allocations at the level of individual firms and plants more or less determined the market share of each firm prior to liberalization. The MRTP Act of 1969 imposed additional capacity restrictions on large business houses. Licenses were extremely restrictive with respect to what products could be manufactured. For example, production as a share of the total manufacturing sector in the textile industry, which employs more workers than any other manufacturing sector, fell from 79 percent in 1951 to under 30 percent in the early 1990s, primarily as a result of curbs on capacity expansion and new equipment, as well as differential excise duties.[8] The fertilizer industry not only faced these restrictions but also a subsidy was given based on cost and transportation costs were borne by the government.

As laws pertaining to market share changed, firms tended to adjust within the limits imposed by policies like MRTP, FERA, capacity constraints and industrial licensing. Lacking the ability to grow organically, firms chose to grow through acquisitions in unrelated areas. For example, the large family businesses such as Birla, Tata and Reliance have entered diverse areas of business, ranging from agriculture, automobiles, oil, and steel to aviation, entertainment, hospitality, information technology, retailing and telecommunication. We next assess the evidence to understand whether this led to lower efficiency in general.

Efficiency

Although there have been many studies in the fields of economics, policy, trade and development (Tybout 2000; Rodrik, 1992; Brunetti 1997) surveying the distinctive features of developing countries that have influenced the growth of manufacturing sectors, we have not come across any papers that studies them either from a strategic or an operations management perspective. Through an extensive survey of empirical studies on developing countries, including India, Tybout (2000) tries to identify the distinct features of developing country manufacturers that can be traced to structural characteristics of their economies as opposed to those induced by industrial, trade or labor policies. In particular, using firm and plant-level data sets, Tybout addresses questions such as (i) whether the regulatory regimes have prevented small firms from growing and hence created losses due to unexploited scale economies, (ii) whether manufacturing firms in less developed countries are less innovative, technically efficient and price competitive (i.e., together might indicate a lack of focus) and (iii) whether trade protection exacerbated technical inefficiencies (i.e., innovation). After reviewing numerous theoretical and empirical studies, Tybout concludes that the evidence does not support the notion that manufacturing firms in less developed countries are relatively stagnant or inefficient.

In a survey, drawing upon a rich theoretical literature that predicts the effects of trade liberalization in developing countries, Rodrik (1992) analyzes the impact of various trade-related policy reforms. He discusses the effects of trade reform on welfare through four channels: (i) volume of trade effect, (ii) excess profits effect, (iii) scale efficiency effect and (iv) technical efficiency effect. He concludes that, under the imperfect competition prevalent in most developing countries, trade liberalization is expected to result in expansion of import competing

[8] http://reference.allrefer.com/country-guide-study/india/india108.html

firms, increase in domestic sales and scale efficiencies, and reduction in unit costs. However, he finds the empirical evidence on technical efficiency improvements inconclusive, although theoretical arguments would suggest a big welfare gain on this account. Thus, empirical parts of both Tybout and Rodrik's studies are inconclusive regarding the effect of liberalization on scale and technical efficiency.

If indeed scale inefficiencies were present due to these restrictions, one would expect to see firms operating in the increasing-returns-to-scale region prior to liberalization, and be in a position to exploit the scale economies after the partial reforms of the early 1980s and the new industrial policy of 1991. However, we have to keep in mind that the findings may depend on the nature of the industry and the market growth as well. A study by Fikkert and Hasan (1998) on the returns to scale for a panel of 232 firms belonging to 6 manufacturing industries, namely automobiles, electrical machinery, non-electrical machinery, basic chemicals, pharmaceuticals and paper from 1976 to 1985 finds that large firms in these industries on average were operating close to constant returns to scale. Studies that focus on the period after liberalization show that the firms in these industries are growing to take advantage of scale economies. The study by Guhathakurta, (1994) shows that, in industries such as television manufacturing, small-scale manufacturers took advantage of the benefits offered by the government and grew rapidly, resulting in an efficient and rapid growth of the Indian television industry during the period 1973-1987. Krishna and Mitra's (1998) study for the period 1986-1993 also finds evidence that firms might have exploited returns to scale in electronics, transport equipment and non-electrical industries after 1991.

In fact examples from such low growth industries such as fertilizer shows that more efficient firms took advantage of liberalization and grew to capture market share. Other examples from diverse industries are Bombay Dyeing (textiles and garments), Corramandal Cement, L&T (heavy engineering and construction), NTPC (thermal plant construction and operation), ONGC (oil and natural gas), Orpat, Reliance (various, including textiles, petrochemical and telecommunications), Saint Gobain (float glass), Samay and Thermax.

Systematic studies in industries such as automobiles, machine tools, dyes and paper, that have been liberalized to a greater extent, allowed for a much greater play of market forces that led to increase in efficiency. Pattnayak and Thangavelu (2004) have found that firms in key manufacturing industries, such as chemical and chemical products, machinery and equipment, leather and leather products, metal products and parts, electrical and related parts have experienced technological progress and exploited scale economies subsequent to the lifting of restrictions in 1991. As another example, the empirical study by Kumar and Pradhan (2003), finds that firms in high- and medium-high technology segments of manufacturing benefited from access to foreign raw material and inputs during the period 1990-2001. They also find that the abolishment of import restrictions on technology had a significant positive impact on export performance of these firms. These can be interpreted as resulting from increased efficiency both due to scale efficiency and technological progress.

We also note that reforms that took place at different times in different industries might have influenced the rate of expansion of each industry. For example, the reservation by government policy placed on manufacture of around 800 items for the small scale sector was not relaxed until

2001. Similar quantity restrictions on import of the consumer goods remained in force until 2001, most of this segment was earlier reserved for the small scale sector. Many of these items, like garments, shoes and toys had high export potential, but investment in plant and machinery for any individual unit producing these items could not exceed US$250,000, thus precluding firms from taking advantage of scale and potential export opportunities (Ahluwalia, 2002). However, the situation has changed recently, with 64 items removed from the reserved list during the period 2000-2002. Many more are expected to be removed in the coming years. The investment ceiling for certain items was increased to US$1 million and quantitative restrictions on the import of consumer goods, which were reserved for small scale sector, were also removed in 2001, giving rise to increasing competition in the domestic market. Since these changes came into effect only recently, one has to wait and see how firms will react in the long run. As an example, expansion in industries like cotton textiles and brewing is still difficult as these industries are still subject to capacity regulations, price controls, and these goods are reserved for small scale industries.

Another factor that might have influenced firm choices and efficiency is their ownership. The empirical study by Ramaswamy (1996) of 108 state-owned enterprises (SOEs) during the 1988-1992 period finds evidence that escalating competition in product markets propel SOEs to realize greater levels of technical efficiency. His later study (Ramaswamy 2001) also finds that SOEs do not perform as well as their private sector counterparts, and that the magnitude of the private versus SOE performance differential increases with increasing competitive intensity in industrial and commercial machinery, chemicals, food and metals industries. These findings can be attributed to the fact that, even after many regulations have been lifted by the 1991 reforms, SOEs still need government approvals for capital investments required for capacity expansions and technical upgrades, which in turn are required to improve scale and technical efficiencies.

In conclusion, firms in medium and high technology sectors, those in which there was rapid growth or scope for rapid growth in demand due to more competitive scenarios or those liberalized early (these factors might not be independent) seem to have benefited the most due to improvement in scale and technical efficiency. A systematic study both at the firm level and across industries tracing the scale and technical efficiency change to the extent and rate of liberalization is necessary to substantiate these findings.

Differentiated Versus Cost Focus

We suggested above that due to capacity restrictions and inability to vertically integrate, some firms chose to pursue unrelated expansion. In the long run, however, firms could choose to offer higher value through product differentiation and/or quality in order to remain profitable. We have been unable to find research articles that predict how the focus of firms would change once restrictions are lifted. We can only speculate on the firm-level decisions over the long term. Prior to liberalization, *faced with constraints to growth, firms might befaced with the choice of focusing on cost or differentiating through product or service*. The former choice might have been more attractive for firms serving markets that are regulated or for which technology cannot be imported. Firms in this category might focus on cost reduction. Thus, when the import restrictions are lifted, firms that were cost efficient might pursue their existing trajectories even more and try to capture market share through a low price strategy.

In contrast, firms that could differentiate themselves earlier, upon liberalization might try to upgrade to more sophisticated technologies and strengthen their position within their niche. This implies that the firms with differentiated products are more likely to import technology and capital goods, provided there is enough demand to recoup their investments. If trade liberalization is implemented simultaneously, domestic prices are expected to fall with the influx of cheap imports, pushing firms to either become more efficient or exit. In this case, it would be hard to separate out the effect due to the operating focus of firms.

Not much research is available to conclude how Indian manufacturing firms will respond to the liberalization in the long run. What we know from the anecdotal evidence is how they have responded in a few sectors, in the short run. The relaxation of capacity restrictions coupled with trade liberalization seem to have negatively affected the profitability of firms due to cheaper imports and increased competition. This is consistent with the predictions by Kumar and Pradhan (2003) that relaxation of restrictions on imported technologies will lead to cost reduction, provided there is scope for expansion, increase in market size and associated pay-off from marginal cost reductions.

Firms manufacturing less differentiated products, such as chemical products, electrical machinery and transport equipment were found by Kalirajan and Bhide (2005) to have increased their capacities and grown by increasing their factor inputs rather than improving technical efficiency during the reform period. Anecdotal evidence cited above of firms such as Orpat, Samay and Aurobindo Pharmaceuticals Ltd. that took advantage of liberalization to leverage their efficient operations to grow and capture market share supports the prediction regarding firms that had low cost as their focus.

The evidence related to firms pursuing a strategy of differentiation is limited. We expect to see increase in technical efficiency for such firms. Consider the auto component industry in India. For decades the industry had stagnated with obsolete models and technologies. Following the trade liberalization in early 1990s, entry of global auto majors into the Indian market, and the high demand forecasts by McKinsey had encouraged some of the auto component makers to increase their scale during late 1990s. The global slump in demand during 1997-98 had a negative impact on the scale-ups and the automotive firms became more cautious in their capital investments (Saranga, 2006b). Apparently, the investments were still not commensurate with market growth rates. A benchmark study by Deloitte Research (2005) finds that depreciation rates are below growth rates for the majority of Indian manufacturers studied (dominated by automotive companies), and suggests that the industry is still suffering from capacity constraints and a lack of capital investment. The research indicates that Indian manufacturers are behind in adopting technology and investing in research and development (R&D) relative to the global manufacturing industries overall. The lack of investment, it is suggested, may in part be due to high cost of capital and lack of internationalization of finance among other factors. It might also be due to pursuit of a differentiation strategy in a relatively small market.

A detailed investigation by Iyer *et al* (2006) provides evidence for this. The study shows that the productivity growth post liberalization is mostly due to the technical changes and not due to increase in relative efficiency. Iyer et al find that even though few innovative firms have pushed

the technology frontier, the rest of the industry did not lag behind. Other examples include Bajaj Auto Ltd. Bharat Forge, Hindustan Lever Ltd. (HLL), Rashtriya Ispat Nigam Ltd. (RINL) and Tube Investments of India Ltd.

Reliance Industries Ltd.(RIL) provides a good example of a corporation that followed both cost efficiency and differentiated strategies based on the industry it was operating in. Being one of the few Indian companies that was successful in vertically integrating most of its operations, RIL, followed a differentiated strategy in the fabric business by offering an entire range of high quality products manufactured with world class technology, while opting for a cost efficiency strategy through scale economies in the manufacturing of raw materials like Polyester Filament Yarn (PFY), Polyester Staple Fiber (PSF) and fiber intermediates like PTA and MEG. Post liberalization, RIL not only expanded its capacities in the existing businesses, but further backward integrated by entering into manufacturing of the raw materials and intermediates for own use and selling purposes. Other recent ventures of RIL include oil and gas exploration, telecommunications, retailing, logistics and supply chain management.

These results are somewhat in line with Rodrik's (1992) findings that there is no conclusive evidence on the impact of trade liberalization on technical efficiency growth in developing countries. Our hypothesis about "differentiation versus efficiency" as an influencing factor about firm behavior provides a plausible explanation in this regard. Thus, the empirical evidence gathered so far suggests that the behavior of manufacturing firms, pre liberalization is, in general, consistent with theoretical predictions and our hypotheses, but with exceptions due to government policy towards small-scale enterprises and state-owned enterprises. The findings with respect to the prevalence of small scale firms during the pre liberalization era in India are similar to that of Tybout's (2000) in other developing countries. The evidence on Indian manufacturing industries is *not* similar to the case of emerging economies in general -- there does seem to be major potential gains from better exploitation of scale economies (in sectors like electronics, fertilizer, telecommunication, textile, transport equipment and non-electrical industries). There is evidence that firms facing growth in demand or being able to grow demand through price in more competitive industries and also those in high or medium technology industries have improved their efficiency. Only relaxations of all restrictions will allow us to make this statement with confidence. This is somewhat different from Tybout and Rodrick's survey findings. Finally, we argued that firms might continue pursuit of their operating focus after liberalization.

Firm-level studies are needed to elicit and confirm several conjectures made regarding past decisions and future trajectories. Even though we did not find any studies on firm decisions on vertical integration post liberalization there seems to be several firms attempting to vertically integrate to consolidate their positions. Examples include, Aurobindo Pharmaceuticals Ltd, Dr. Reddy's Laboratories, Ranbaxy Laboratories Ltd, Reliance Industries Ltd., Tata Steel and Visaka Industries etc.

2.2. Choice of Product and Process Technologies

In this section we study the impact of policy restrictions on development of technological capabilities, adaptability of technology and process and product development.

Technological Capabilities

High tariffs and restrictions on the import of technology and capital goods are intended to induce firms in developing countries to develop in-house technological capabilities, in addition to generating government tax revenue, and improving the balance of trade. Many classifications of technological capabilities and their modes of transfer exist in the literature, both in the context of developed and developing countries. Katz (1985), Ozawa (1985) and Westphal *et al* (1985) identify factors described below that influence the ability of developing countries to improve their technological capabilities through technology transfers. It is expected that firms that invest in a certain amount of in-house R&D in order to complement imported technologies are better able to assimilate and adapt the new technologies to the local environment. The imperative for import substitution of raw material and intermediate goods, as well as the local capability to repair imported machinery and make minor modifications in product and process technologies, requires firms to invest in local R&D and employ a certain number of R&D personnel in-house. These activities fall under basic capabilities, as characterized by Lall (1987). This in turn enables firms to carry out minor modifications and make incremental innovations, which are adaptive and duplicative in nature and fall under intermediary capabilities. In the long run, these basic and intermediary technological capabilities are expected to give rise to research-based advanced capabilities that are innovative and risky (like new molecular development in the pharmaceutical sector), but can result in breakthrough products and technologies.

With an intention to gradually develop these technological capabilities and achieve technological self-reliance, India followed an Import and Adapt Technology (IAT) strategy after its independence in 1947. According to this strategy, partial restrictions were placed on import of technologies, to encourage firms to develop complementary technologies in-house to adapt the imported technologies. Bhagwati and Srinivasan (1975) find that the overwhelming emphasis on import substitution in all branches of the industry has fostered considerable technological effort, primarily directed towards adapting processes to the use of local materials. Thus, it seems, the Indian government was at least successful in creating basic technological capabilities (as characterized by Lall) through an amalgamation of IAT and other import substitution strategies.

Katrak, (1985, 1990, and 1997) carried out empirical studies to determine if the IAT strategy has stimulated local R&D significantly and whether the technological self reliance has been achieved through the resulting indigenous capabilities, using data (i) from all Indian manufacturing industries pertaining to the time period 1964-1979 (Katrak, 1985), (ii) from electrical, electronic and industrial machinery industries during 1980-1984 (Katrak, 1990) and (iii) from electrical, and electronic industries pertaining to year 1990 (Katrak, 1997). The results from the first study suggest that, although imprts of technology appear to have stimulated in-house R&D, the magnitude of this effect was limited and weaker for more complex technologies. Although R&D expenditures increase with enterprise size, larger firms seem to undertake proportionately lesser R&D. However, he notes that the use of industry-level data might have affected the results. In his second study, Katrak (1990) finds that the technological effort is higher in firms whose technology imports include those intended to strengthen their in-house technological capabilities, but lower in the enterprises that have negotiated an exclusive right of sale in the home market. The third study (Katrak, 1997) finds that probability of importing technology is only weakly

affected by the initial in-house capabilities, though the probability of impact was greater amongst larger and older enterprises.

Adaptability of Technology

These mixed results suggest that the technological activities of Indian firms were considerably influenced by the technological complexity of the industry and size of the firm during the pre-liberalized era. These findings are in line with Alam's (1985) arguments that the nature of the market and industrial structure had a significant impact on the development of technical capabilities of Indian firms.

The effect of IAT strategy appears to be moderated by the adaptability of technologies to the local market. Complex technologies developed elsewhere might not stimulate in-house R&D, because either they were not easily adaptable, or did not have sufficient market or could not be improved to preserve advantage. The restrictions on import of ready-made technologies which are essential to master the complex technologies would have further contributed to this. For example, the empirical study by Basant and Fikkert (1996) for the period 1975-1982, which uses firm level panel data, shows that the returns from technology purchase were high and significant, both for the scientific firms[9] (166%) and nonscientific firms (95%), while the returns from inhouse R&D were high and significant for the nonscientific firms (64%), they fall to a mere 1% for the scientific firms. Katrak (1985) also observes that there is considerable under-usage of local technology compared to imported technology. This could be because firms prefer to import reputable foreign technology in lieu of experimenting with relatively less established local technology, which was most often developed in government laboratories isolated from production, in the case of India (Desai, 1980).

In their empirical study covering the period 1960-1970, Deolalikar and Evenson (1989) determine that industrial structure, firm size, public and private ownership and the pool of purchasable foreign technology have influenced the mix of firms' own R&D and technology purchase in the Indian manufacturing industries. They also find that purchased foreign technology and in-house inventive activity complemented each other in the Indian manufacturing industries from1960 to 1970. Thus while the industrial structure, pool of purchasable foreign technology, and complementary nature of in-house R&D point towards the importance of *adaptability* of technology, firm size and public and private ownership seem to play an important role in developing and sustaining the technological advantage. For example, large private industrial conglomerates like Reliance Industries Ltd. (RLL), the Birla Group and the Tata Group have invested heavily in technology imports as well as in-house R&D in industries like auto components, steel and textile, and contributed significantly to the technological growth of these industries in India.

Through his study of Indian technology exports and technological development, and in support of our hypothesis, Lall (1987 and 2001) argues that, while India's highly protectionist strategy has created various inefficiencies, it has also led to the creation of substantial technological capability which enabled India to become the leading exporter of industrial technology in the

[9] The "scientific" subgroup of firms consists of firms in chemicals, drugs and electronic industries, while the "nonscientific" firms are in all other industrial categories (Basant and Fikkert, 1996)

Third World, in terms of the range, diversity and complexity of technologies it exports. He attributes this technological development to the firm-level technological efforts such as tailoring (*adaptation*) of capital goods to local customer needs, transmission of technology to subcontractors, product diversification and new product development in response to internal competition and cost reducing process improvements. The public sector units like Bharat Heavy Electricals Ltd. (BHEL), IRCON, Hindusthan Machine Tools (HMT) and RITES are examples of firms with significant exports of technology and turnkey projects.

The empirical study of Kumar and Saqib (1996) qualifies Lall's finding and contests that Indian firms exhibited greater R&D and technological capabilities in sectors like electrical equipment, non-electrical machinery and machine tools. This was necessary to exploit the greater opportunities for product adaptations present in these sectors. These findings indicate that at least some Indian manufacturing firms would have developed basic and intermediary technological capabilities, which were not just driven by IAT strategy, but by the sector specific incentives to innovate and adapt the previously designed products and processes to local environment. The reaction of firms to the relaxation of import restrictions after 1991 is not well-documented except for a few studies. Athreye and Kapur (2003), for example, observe that relaxation in patent laws as well as with regard to restrictions on royalty payments led to a marked increase in technology expenditures by firms. According to them, import liberalization resulted in lower tariff levels and the costs of capital goods and embodied technology imports were lowered. They give the example of high technology industries like passenger-car and auto-ancillary parts, where technology intensity increased sector-wide after liberalization and firms adopted the latest technology including modern assembly lines. Anecdotal evidence from firms such as Coromandel Fertilizer (CFL), Lakshmi Mittal, SCL, Saint Gobain, Tata Steel indicates that Indian firms have attempted to perform major modifications on process technologies to adapt to local inputs, reduce capital and operating costs post-liberalization. These examples seem to indicate that the current thinking about adaptability being easier for less complex technologies might need to be revised. There is growing evidence that sector specific incentives might play a larger role in the actual adaptation.

Process and Product Development

A specific form of incentive is the firm's ability to exploit the product or process innovation for an extended period of time. In the case of the pharmaceutical industry, the adoption of process patenting in the early 1970s appears to have realized the effects of IAT strategy. Process patenting was intended to develop an indigenous chemical and pharmaceutical industry to meet the domestic demand for drugs and pharmaceuticals at affordable prices. Since pharmaceutical R&D is capital-intensive, and as none of the domestic firms possessed the required capital and technical capabilities, firms were allowed to reverse-engineer products that were invented elsewhere, as long as they could invent a new process for production.

It is expected that the *imitative capabilities* will in the long run lead to pioneering R&D capabilities, as in the case of Japan, which initially began in the 1960s with imitative R&D and within few decades progressed to become a leading country in new drug development (Grabowski, 1989). Chaudhuri (1999) argues that Indian patent regulations had a positive impact on in-house technological capabilities of local firms. Consistent with this argument, the empirical

evidence by Kumar and Saqib (1996) suggests that innovative activity in the chemical and drug industry has been stimulated by the process-patent policy which encouraged firms to work out alternative processes for manufacture of known chemical compounds and bulk drugs. The success of the Indian pharmaceutical industry can be attributed to the presence of a *large captive market and sustainability of process technologies* (once developed) due to process patenting.

Licenses allocated in the 1960s and 1970s were extremely specific with regard to what could be manufactured. In many ways, the effect of licensing was similar to that of capacity restrictions. Firms that were trying to differentiate products were affected most by licensing requirements, as all the technology upgrades and entry into new product ranges required licenses from government. The early deregulation of the 1980s introduced 'broad-banding' of production licenses. This change allowed firms to use their existing licensed capacity (previously tied to a narrow product specification) to manufacture a broader range of related products. Though licensing requirements were formally retained, they were granted more easily. There is no empirical evidence regarding whether firms took advantage of broad-banding by introducing more products. However, case studies of select firms suggest that firms like Reliance in the Textile industry took advantage of broad banding to increase scale and backward integrate most of the raw material and intermediates for manufacturing of Polyester Fiber Yarn.

Pradhan's (2003) empirical study finds that the competitive pressure generated by liberalization has pushed Indian pharmaceutical firms into more R&D activity to develop new products. Saranga (2006a) provides evidence that the strong processing capabilities developed during the process-patent regime have opened up new avenues of growth and opportunities for domestic firms to become part of global supply chain through contract research and manufacturing operations for global drug majors. Nagabhushana and Shah (1999) determine that, post-liberalization, improving the performance of the products has become one of the prime objectives of Indian manufacturing firms. They also find that product and process design issues are gaining more importance as firms are trying to reduce lead times in introducing new products into the market. However, new product development strategies such as concurrent engineering are not yet attracting enough adherents, as they require major investments and structural changes.

To conclude, the evidence from empirical and case studies pre-liberalization suggests that the external policy environment has had a significant effect on manufacturing firm decisions regarding strategic and operational choices of process and product technologies. While firms in certain sectors, such as chemicals and drugs, took advantage of patent regulations and improved their process capabilities, firms in sectors like electrical equipment, non-electrical machinery and machine tools developed their technical capabilities to exploit the product adaptation opportunities following the IAT strategy. The adaptation, sector specific incentives and sustainability of technological advantage seem to have influenced the technological efforts of firms in adopting the IAT strategy. The drawback of the IAT strategy has been the forced reduction of imported readymade technologies, which affected high technology industries where local enterprises could not master the requisite technology or having mastered it, could not keep pace with its development.

Restrictions on import of technologies as well as licensing requirements might have restricted firms in certain industries -- that were already suffering from capacity restrictions -- from differentiating themselves through product and process improvements.

The evidence from post-liberalization suggests that, despite operating within a restricted regime for a long time, firms reacted positively to the economic reforms and adapted quickly by upgrading to advanced manufacturing technologies and focusing on new product development. There is scope for further research to determine how the innovative capabilities developed during the period of process patenting helped firms in developing new products and processes in a competitive global environment and a strong patent regime that favors innovators to imitators. There is also a need to analyze how firms reacted to factors like increased competition and internal demand for products post liberalization. A more important issue is to carry out firm level analysis to ascertain why R&D expenditures are still very low compared to research outlays in advanced countries.

2.3. Choice of Planning, Control and Execution Systems

In this section, we discuss the literature on planning, control and execution systems adopted by manufacturing firms. The literature in this area is quite sparse. Therefore, we use the manufacturing effectiveness of a firm as a proxy. Hayes and Wheelwright (1985) have classified manufacturing firms into four stages, based on the degree of emphasis a firm places on its manufacturing division to achieve the strategic objectives at the corporate level. In the Hayes and Wheelwright (H-W) framework, the degree of manufacturing effectiveness in each firm is evaluated in a continuum from stages 1 to 4, with:

(i) Stage 1 firms described as "internally neutral" with their main focus on minimizing manufacturing negative potential,

(ii) Stage 2 firms seeking to maintain parity with rest of the industry, and hence being "externally neutral"

(iii) Stage 3 firms being "internally supportive" of the corporate strategy and

(iv) Stage 4 firms being "externally supportive" of the organization in its competitive endeavor.

Hayes and Wheelwright describe various sector-specific factors and organizational characteristics as a basis for this classification. Although there has been wide acceptance of the H-W framework in the literature and it has been applied to a few developed country scenarios (Hum and Leow, 1996; Rowbotham and Barnes, 2004), it has not been applied to manufacturing firms in less developed countries. The stage of the firm might be reflected by the sophistication of the planning and control systems adapted by the firms. Therefore, we believe that the H-W framework can be used as a proxy for the degree of sophistication of planning and control systems. We classify the Indian manufacturing firms in terms of the H-W framework, based on the progress they have made with the choices available to them due to policy environment and other external constraints.

Rosenzweig and Roth's (2004) competitive progression theory (CPT) holds that sustainable, competitive capabilities are built cumulatively, from conformance quality to delivery reliability

to volume flexibility to low cost, because moving up each step in the model requires more learning than in the earlier steps. We also trace the developments in Indian manufacturing industries to the predicted sequence.

Stage 1 Firms

In the absence of competition and sluggish economic growth, we would expect to see limited progress made by firms in India. Firms in sectors reserved for public sector units did not face competition, and hence had limited incentives to modernize, while firms in many private sectors did not have the flexibility to modernize their equipment and process technologies due to the restrictions on import of technology. The protected regime also meant captive consumers, further reducing incentives to initiate quality programs or adapt information systems and advanced manufacturing systems (Seth and Tripathi, 2005). Correspondingly, the manufacturing functions of many public and private sector firms were in stage 1 of the H-W framework, as they did not upgrade their laborintensive, low-technology processes, when products involving a new generation of technologies appeared in the world market.

A survey by Saxena and Sahay (2000) identifies quality, delivery, inventory reduction and capacity utilization as the important objectives, while manufacturing lead time reduction and linking manufacturing to corporate strategy were considered slightly less important by the participant firms, based on a representative sample of Indian manufacturing firms. They also warn that there is a need to align IT initiatives towards agile manufacturing rather than simply automating conventional operations, as they find that currently most of the firms have fragmented information management systems which may not enable them to deliver superior value to their customers and lead them to world class status. *This evidence corroborates the earlier findings that majority of the firms (except for firms in pharmaceutical and auto component industries), are still in stage 1 of the H-W framework.*

Stage 2 Firms

The automobile industry obtained an impetus for development in 1982, when the Government of India established a joint venture (Maruti-Suzuki) with Suzuki of Japan, with an intention to bring affordable cars to the masses. During the 1980s, the government carefully protected and supported Maruti by preventing other foreign firms from entering the Indian market, and other domestic firms from entering the small-car segment, through licensing and policy measures. The entry of Suzuki, a quality-conscious Japanese OEM, gave rise to a strong, customer-oriented auto component industry in India. Maruti-Suzuki also recruited each year a considerable number of apprentices from the Industrial Training Institutes[10] (ITI) – a two-year vocational school for high-school graduates – which accounts for approximately 15 percent of its workforce. Maruti then trained these ITI apprentices at the actual production sites and recruited many of them at the end of their training.

[10] According to Okada (1998), along with a number of universities and 6 Indian Institutes of Technologies (IIT) for higher education, the Government of India also established a number of Industrial Training Institutes (ITI), two-year vocational schools for high school graduates all over the country. For instance, Delhi alone has 13 ITIs for 8500 trainees in 50-60 different trades.

Thus, unlike countries such as Mexico, where foreign-owned auto plants and auto component suppliers often rely heavily on poorly-paid hourly workers with less educational background, Indian auto workers often are well educated and well trained in their respective fields (Okada, 1998). The liberalization of 1991, which allowed the entry of multinational enterprises, further encouraged the auto component firms to upgrade their quality programs by adapting just-intimae (JIT), total-quality management (TQM), total productivity management (TPM), Six Sigma etc. The number of ISO, QS and automotive industry-specific TS 16949 certifications, and quality awards like Deming and the Japanese quality medal etc. substantiate the achievements of auto component firms relative to quality standards (Balakrishnan *et al*, 2006).

According to Iyer *et al* (2006), during the period 1993-1998, the auto component firms have also moved a step ahead and achieved cost efficiency along with technical efficiency gains, which further resulted in productivity growth. *Thus, conformance quality and technical upgrades directly gave rise to cost efficiency*. However, anecdotal evidence suggests that some of the component suppliers were unable to fill the larger standard orders of multinational companies even in the late 1990s. One supplier had to reject half of the 20 requests for price quotations it had received from multinational OEMs, because the order sizes seemed colossal (Luthra *et al*, 2005). The recent market stability and renewed interest by multinational OEMs such as General Motors, Ford, and BMW, etc., in India as a market and manufacturing base are encouraging the auto component firms to pursue *volume flexibility, which falls at level three in the cumulative capability model*, CPT of Rosenzweig and Roth (2004).

On the whole, a *majority of Indian auto component firms seem to be in stage 2 of the H-W framework by following industry standards in manufacturing practices, while a few firms, such as Sundaram Fasteners, have progressed to stage 3 by upgrading their processes and quality levels and achieving volume flexibilities* to supply 100 percent of GM's radiator caps. It is likely that most of the auto component firms merely embraced the control systems, but have not yet built the supply-chain systems that require more sophistication.

Stage 3 and 4 Firms

The process-based industries, such as chemicals and pharmaceuticals, have placed much more importance on manufacturing since the early 1970s. Firms in these industries invested heavily in the research and development of process technologies as the emphasis was on low cost production of bulk drugs and formulations to compete with other domestic low cost producers (Chaudhuri 1999, Saranga 2006a). The strong manufacturing capability thus developed during the process-patenting regime enabled many Indian pharmaceutical firms to enter export markets before and after the policy restrictions were lifted (Kumar and Pradhan, 2003). The need to obtain approvals of Good Manufacturing Practices (GMP) from international regulatory authorities such as the Food and Drug Administration (FDA) in the United States, the Medicines Control Agency (MCA) in the United Kingdom, and the Therapeutic Goods Administration (TGA) in Australia, which were mandatory for export contracts, encouraged these firms to further improve their facilities, equipment and internal processes. Since firms in these sectors derive their competitive advantage from manufacturing capability, the manufacturing functions of *some of the leading pharmaceutical firms, such as Aurobindo Pharmaceuticals Ltd., Dr.*

Reddy's Laboratories, Ranbaxy Laboratories Ltd., Cipla Ltd., Wockhardt Ltd. and Nicholas Piramal Ltd., seem to have reached stages 3 and 4 of the H-W framework, by internally and/or externally supporting the strategic objectives of the enterprises at the corporate level.

Correspondingly the empirical studies (Pradhan (2003), Saranga (2006a), Saranga and Banker (2006)) provide evidence that the quality initiatives, technical upgrades and R&D investments pre and post liberalization have resulted in significant quality improvements in the Indian pharmaceutical industry. Self- sufficiency in the domestic market, as well as increasing export markets for bulk drugs and formulations, offer proof of Indian drug industry's delivery reliability and volume flexibility, achieved through collaboration between small bulk drug manufacturers and established formulation producers. Finally, cost efficiency can be inferred from the broadly affordable drug prices, which are a fraction of prices prevailing internationally, *confirming the cumulative nature of these competitive capabilities as suggested in Roth's CPT*.

The empirical and anecdotal evidence suggests that process and quality management practices post liberalization have contributed to the better performance of manufacturing functions at the corporate level in just a few sectors (Kumar and Pradhan 2003, Chaudhuri 1999, Saranga 2006a, Iyer *et al* 2006), pushing them to stages 3 and 4 of the H- W framework. Although a few studies suggest that infrastructural elements like vendor management, human resource management and information systems are receiving increased attention in recent times (Nagabhushana and Shah 1999), we did not find any papers that systematically study the developments in these areas. We have posited a linkage between stages of the firm development and the systems adapted. Thus, there is a need and scope for future studies to verify this linkage. There is also scope for using a framework for determining the stage of a firm and the reasons for their choices.

3. Conclusions and Suggestions for Future Work

Productivity studies of Indian manufacturing industries reveal that there has been significant growth in productivity in various manufacturing sectors after policy restrictions were relaxed through economic liberalization in 1991. In this paper, we reviewed various empirical, anecdotal, case study and survey-based evidence to determine the choices made by firms during the pre and post liberalized years, and to explain the factors that have contributed to the progress of various manufacturing sectors. In particular, we focused on three major groups of manufacturing strategic and operational choices: (i) Scale, efficiency and focus, (ii) Product and Process Technologies and (iii) Planning, Control, and Execution Systems.

Our analysis reveals that there is a strong presence of small-scale firms in Indian manufacturing, which generate almost 85 percent of the manufacturing employment in the country,[11] due to a variety of external factors like the government policy, dispersed local demand, poor infrastructure and transport facilities. In sectors where small firms were discouraged from growing, one would expect to find slack due to unutilized economies of scale, such as mechanical engineering, chemical products, and auto ancillaries. We found some empirical studies that report that firms in medium and high technology sectors, those in which there was rapid growth or scope for rapid growth in demand due to more competitive scenarios or those liberalized early (these factors might not be independent) have benefited the most with regard to

[11] http://www.unido.org/userfiles/RussoF/Small.pdf

scale and technical efficiency. However, since the capacity restrictions in the small scale sector were relaxed only recently, one has to wait and see how firms in this sector will react in the long run. If the reduced import tariffs result in lower domestic output, then local firms would not get the opportunity to exploit the unutilized scale economies to become more efficient. On the other hand, if the structural characteristics of India – e.g., the size, underdeveloped transportation networks, and presence of a vast rural population dispersed across small regions – have caused the existence of smaller firms to meet the local demands in the first place, then industrial liberalization alone may not induce firms to take advantage of scale economies.

We find mixed evidence with regard to how firms reacted to these external restrictions, pre-and post-liberalization. Based on the empirical studies, we hypothesized that, faced with capacity and other external constraints, firms would follow either a cost-efficiency strategy or a differentiation strategy. The evidence seems to suggest that productivity growth in sectors like auto components, which were reserved for small scale sector, is driven by the firms that followed a differentiation strategy and upgraded by importing product and process technologies to face the increased foreign competition. In sectors like pharmaceuticals, where firms had adapted a cost-efficiency strategy and developed strong processing capabilities since the early 1970s, firms benefited by upgrading their facilities and investing in research and new product development to avail themselves of the globalization opportunities.

There is a strong need for infrastructural improvements, support from state and central governments and export opportunities to compensate the domestic demand volatility. A recent study by the World Bank and the Confederation of Indian Industry (CII) finds that more investor-friendly states are attracting higher investments, both domestic and foreign, as investors perceived a 30 percent cost advantage in some states over others on account of the availability of infrastructure and quality of governance. Thus, it is possible that firms would have achieved scale economies more rapidly if the pace of the liberalization was faster, and accompanied by infrastructural, labor and corporate governance reforms.

We hypothesized that the *adaptability* of technologies seems to have influenced firms in different sectors in developing technological capabilities through the IAT strategy. Higher incentives for *adaptation* coupled with a favorable patent system and market size have encouraged firms in the pharmaceutical sector to achieve strong processing capabilities. These capabilities seem to have enabled them to enter into more technologically intensive activities and take further advantage of liberalization to improve product technologies. However, we believe that restrictions on the importation of technologies, as well as licensing requirements, have constrained firms in certain industries -- that were already suffering from capacity restrictions – from differentiating *themselves through product and process improvements*. .

We hypothesized that there is a positive correlation between the degree of importance a firm places on its manufacturing function and the sophistication of it's planning and control systems. Although the protectionist trade regime and restrictions on importing technologies had discouraged many public and private sector firms to invest in advanced product and process technologies, we find evidence that in some sectors firms have successfully established quality management systems and strong processing capabilities over the years. The economic reforms of 1991 have given these firms further impetus to improve their planning and control systems to

compete with global companies and win supply contracts in order to become part of the global supply chains.

Future Research

After carrying out an extensive survey of existing research on Indian manufacturing, and supplementing it with our own research, we find that there is a strong need to address additional research questions to understand how different firms' different strategic and operational choices lead to different performance outcomes. Most of the existing empirical studies were based on industry-level data and were focused on more macro-level issues. We believe that the implications and learning that can be derived by studying the following firm-level issues can contribute significantly to understanding and guiding the future growth and success of Indian manufacturers in global competition.

- How did firms react to the relaxation of restrictions on **vertical integration**? Did the larger firms manage to become more efficient by backward and/or forward integration of operations? How did the firm strategies of cost efficiency and differentiation prior to liberalization affect the opportunities to vertically integrate post-liberalization? How did the vertical integration decisions by larger firms affect smaller firms, which were the suppliers of raw materials and intermediate goods before the restrictions were removed?

- How did firms react to competition after the **trade liberalization**? Did the hangover from pre-liberalization inhibit growth? What kind of operational and manufacturing strategies did they use to counter competition and protect their market shares? Were they able to raise enough capital in order to scale-up the facilities and import state-of-the-art technologies? Did the smaller firms manage to survive competition from low cost and high volume producers like China, particularly in industries such as consumer goods, garments, leather, toys etc.? What kind of support and opportunities did the liberalized economy offer the small-scale firms that could not upgrade?

- How did changes in patent protection and **intellectual property rights** affect firms in industries like food, chemicals and pharmaceuticals? Did the stronger patents encourage firms to venture into basic research and new product development? If so, how did the imitative capabilities developed during the period of process patenting help domestic firms in new product development? Did the patent protection encourage multinational enterprises (MNEs) to establish R&D facilities in India? If so, are there any spillovers between MNEs and domestic firms and amongst domestic firms due to higher research and development activities? What kind of outsourcing opportunities are the domestic firms availing due to stronger patent laws?

- How did firms react to the **reductions in tariffs** on the import of technology and goods? Did it increase or decrease the firm's in-house R&D? Did the relaxation of restrictions on technology encourage firms to enter high technology industries such as semiconductors, aerospace and defense technologies? Did the adaptation of technologies and imitative capabilities developed during the IAT regime help them in new product development

post-liberalization? Did the three factors discussed earlier -- adaptability, market size and sustainability -- continue to affect firm behavior after the import restrictions were lifted?

- What type of **planning and control systems** are firms adopting post liberalization? Are these systems helping firms to progress into the next stages of the Hayes and Wheelwright framework? Are quality initiatives and advanced manufacturing techniques enabling firms to integrate their manufacturing functions into global supply chains? What kind of impact do the certification programs and quality awards have on the performance and productivity of the firm?

References:

1. Ahluwalia, M.S. (2002) Economic Reforms in India Since 1991: Has Gradualism Worked? Journal of Economic Perspectives, Vol. 16, No.3, pp.67-88.

2. Alam, G. (1985). India's technology policy and its influence on technology imports and technology development. Economic and Political Weekly, Vol. 20, Nos. 45, 46 and 47, November.

3. Athreye, S and Kapur, S. (2003). Industrial Concentration in a Liberalizing Economy: A study of Indian Manufacturing. Working Paper

4. Balakrishnan, K, Iyer, A., Seshadri, S and Sheopuri, A. (2004), Indian Auto Supply Chain at the Crossroads, (under review in Interfaces)

5. Banker, R., and Saranga, H. (2006). Productivity and Technical Changes in the Indian Pharmaceutical Industry, Working Paper.

6. Bhagwati, J.N and Srinivasan, T.N. (1975). Foreign Technology Trade Regimes and Economic Development: India. National Bureau of Economic Research, New York.

7. Chaudhuri S (1999). *Growth and Structural Changes in the Pharmaceutical Industry in India* in Sen Anindya, Gokarn Subir and Vaidya Rajendra (eds), *The Structure of Indian Industry*, Oxford University Press, New Delhi.

8. Deolalikar, A.B and Evenson, R.E (1989) Technology Production and Technology Purchase in Indian Industry: An Econometric Analysis. The Review of Economics and Statistics, pp. 687-692.

9. Fikkert, B and Hasan, R. (1998). Returns to scale in a highly regulated economy, evidence from Indian firms. Journal of Development Economics. Vol. 56 (1), pp. 51-79.

10. Gang, I.N, 1992. Small Firm "Presence" in Indian Manufacturing., World Development, Vol. 20, No.9, pp.1377-1389.

11. Grabowski, H.G., and Vernon, J.M. (1987). Pioneers, Imitators and Generics – A Simulation Model of Schumpeterian Competition. The Quarterly Journal of Economics, Vol. 102, No.3, pp. 491-526.

12. Guhathakurta, S (1994). Electronic Policy and the Television Manufacturing Industry: Lessons from India's Liberalization Efforts. Economic Development and Cultural Change, pp. 845-868.

13. Haskel, J. and Martin, C., (1994). Capacity and Competition: Empirical Evidence on UK Panel Data. The Journal of Industrial Economics, Vol. XLII, No. 1, pp. 23-44.

14. Hayes, R.H., and Wheelwright, S.C. (1985) Competing through manufacturing. Harvard Business Review, January - February, pp. 99-109.

15. Iyer, A., Saranga, H., Seshadri, S and (2006) Productivity and Technical Change in the Indian Auto Component Industry, Paper presented at the *North American Productivity Workshop,* 27 – 30 June, 2006.

16. Katz, J.M., (1985). Domestic Technological Innovations and Dynamic Competitive Advantages: Further Reflections on a Comparative Case-Study Program, in International Technology Transfer: Concepts, Measures and Comparisons, edited by Rosenberg, N and Firschtak, C., Praeger: New York.

17. Kalirajan, K and Bhide, S. (2005). The Post-reform Performance of the Manufacturing Sector in India. Asian Economic Papers, Vol.3, No.2. pp.126-157.

18. Katrak, H. (1985). Imported Technology, Enterprise size and R&D in a newly industrializing country: The Indian Experience. Oxford Bulletin of Economics and Statistics, 47, 3, pp. 213-229.

19. Katrak, H. (1990). Imports of Technology and the Technological Effort of Indian Enterprises. World Development, Vol. 18, No.3, pp. 371-381.

20. Katrak, H. (1997). Developing countries' imports of technology, in-house technological capabilities and efforts: an analysis of Indian experience. Journal of Development Economics, Vol. 53, pp. 67-83.

21. Krishna. P and Mitra, D. (1998) Trade liberalization, market discipline and productivity growth: new evidence from India. Journal of Development Economics. Vol. 56, pp. 447-462.

22. Kumar, N. and Saquib, M (1995) Firm size, opportunities for adaptation and in-house R&D activity in developing countries: The case of Indian Manufacturing. Research Policy 25, pp.713-722.

23. Kumar, N and Pradhan, J.P. (2003). Export Competitiveness in knowledge based Industries: A Firm-Level Analysis of Indian Manufacturing RIS-DP # 43/2003.

24. Lall, S. (1987) Learning to Industrialize – The Acquisition of Technological Capability by India. Macmillan Press, Hong Kong.

25. Lall, S. (2001) Competitiveness, Technology and Skills. Edward Elgar Publishing Ltd. UK.

26. Lucas, R.E., (1978). On the Size Distribution of Business Firms, Bell Journal of Economics, Vol. 9, pp. 508-523.

27. Luthra, S, Mangaleswaran, R., and Padhi, A. When to make India a manufacturing base, Fulfilling India's Promise, Mackinsey Special Edition 2005.

28. Mandal, P., Love, P.E.D., Sohal, A.S. and Bhadury, B. (2000) The propagation of quality management concepts in the Indian manufacturing industry: some empirical observations. The TQM Magazine. Vol.12, No.3, pp.205-213.

29. Nagabhushana, T.S and Shah, J (1999). Manufacturing priorities and Action Programs in the Changing Environment – An Empirical Study of Indian Industries. International Journal of Production & Operations management, Vol. 19, No. 4, pp.389-398.

30. NMCC (2005) National Strategy for Manufacturing, National Manufacturing Competitiveness Council – NMCC, Udyog Bhavan, New Delhi.Okada, A (1998). Does Globalization Improve Employment and the Quality of Jobs in India?: A Case from the Automobile Industry.

31. Ozawa, T (1985) Macroeconomic Factors Affecting Japan's Technology Inflows and Outflows: The Postwar Experience, in International Technology Transfer: Concepts, Measures and Comparisons, edited by Rosenberg, N and Firschtak, C., Praeger: New York.

32. Pradhan, J.P. (2003). Liberalization, Firm Size and R&D Performance: A Firm Level Study of Indian Pharmaceutical Industry. Research and Information System for the Non-Aligned and Other Developing Countries, RIS-DP # 40/2003.

33. Ramaswamy, K. (1996). Competitive Intensity and Technical Efficiency in Public Sector Firms: Evidence from India. International journal of Public sector management, Vol. 9, No.3, 4-17.

34. Ramaswamy, K. (2001) Organizational ownership, competitive intensity and firm performance: An empirical study of the Indian manufacturing sector. Strategic Management Journal, Vol.22, pp 989-998.

35. Rosenzwig, E. D. and A. V. Roth, 2004. Towards a theory of Competitive Progression: Evidence from High-Tech Manufacturing. *Production and Operations Management Journal*. Winter, p. 354-368.

36. Saranga, H. (2006a). Multi Objective DEA as applied to Indian Pharmaceutical Industry. Forthcoming in Journal of Operational Research Society.

37. Saranga, H. (2006b). Application of Super Efficiency, RTS and Congestion DEA to Indian Auto Component Industry, (under review at European Journal of Operational Research)

38. Saxena, K.B.C. and Sahay, B.S. Managing IT for world-class manufacturing: the Indian scenario. International Journal of information Management, Vol.20, pp.29-57.

39. Seth, D and Tripathi, D. (2005) Relationship between TQM and TPM implementation factors and business performance of manufacturing industry in Indian context, The international journal of Quality & Reliability Management. Vol. 22, No. 2/3, pp. 256-277.

40. Sivadasan J (2003) Barriers to Entry and Productivity: Micro-Evidence from Indian Manufacturing Sector Reforms∗ Graduate School of Business, University of Chicago, http://bpp.wharton.upenn.edu/Acrobat/Sivadasan_AEW_paper_1_16_04. pdf#search=-Barriers%20to%20Entry%20and%20Productivity:%20MicroEvidence-, last sited on 24th March 2005.

41. Tybout, J. (2000) Manufacturing Firms in Developing Countries: How well do they do, and why? Journal of Economic Literature; XXXVIII, 11-44.

42. Westphal, L.E., Kim, L., and Dahlman, C.J, (1985). Reflections in the Republic of Korea's Acquisition of Technological Capability, in International Technology Transfer: Concepts, Measures and Comparisons, edited by Rosenberg, N and Firschtak, C., Praeger: New York.

43. Wilson, D and Purshothaman, R (2003). Dreaming with BRICS: The Path to 2050 Global Economics Paper 99, Goldman Sachs