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Productivity and capital investments: An empirical study of three manufacturing industries in India

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Abstract Investments in the Indian manufacturing sector do not seem to match the rate of growth of sales. This study empirically determines factors explaining within-firm variation in investment growth in three industries—auto components, chemicals and electronics—using panel data from 2002 to 2006. The results show that common firm-specific factors and some industry-specific factors, explain variation in investments within firms. Capital productivity is a significant factor in auto components and chemicals while capital intensity is significant for chemicals and electronics. Labour productivity is significant only for the electronics industry. The results suggest that there is a need to manage productivity improvements from the growth point of view and not only for efficiency improvements.

Introduction

Even though manufacturing has long been recognised as a main engine of growth and wealth creation in India, the share of manufacturing in the GDP has stagnated at 17% for almost two decades (NMCC, 2006). The average growth of manufacturing fixed assets in India also compares poorly with those of China and Brazil World Bank (2004). On the positive side, in recent years we have seen a resurgence in some industries within the sector, such as auto components and pharmaceuticals. In the 2009 Global Competitiveness report published by the World Economic Forum, India ranked 49th overall with high scores in capacity for innovation and sophistication of firm operations. Thus, though the manufacturing sector has both the potential as well as the policy imperative for growth, the share of manufacturing in the GDP has remained stagnant. Furthermore, investments in this sector do not seem to match the rate of growth of sales. Table 1 provides a summary of growth statistics for the three industries that we study. We see that investment growth has lagged far behind sales growth in the electronics and chemicals industries, though it has almost matched sales growth in the auto components industry. The ratio of average year-on-year (2002–2006) investment growth to sales growth is

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Table 1 Average annual investment and sales growth in the auto components, chemicals and electronics industries in India (2002—2006)

		Auto Components	Chemicals	Electronics
	No of firms	66	86	66
Sales in 2005—2006 (in million Rs)	Average	3418.5	3167.8	3906.1
	Standard Dev	4267.0	3213.9	9337.0
	Median	1628.9	1768.4	720.4
Investment in 2005—2006 (in million Rs)	Average	1892.07	2083.70	2704.35
	Standard Dev	3541.19	2671.87	9393.29
	Median	901.15	515.30	378.35
Average annual investment growth % (2002—2006)	Average	22.08	8.54	10.47
	Standard Dev	36.88	29.62	28.76
Average annual sales growth % (2002—2006)	Average	23.73	19.99	30.39
	Standard Dev	25.55	54.33	138.88

Source: Prowess Database, Centre for Monitoring Indian Economy, New Delhi, India.

0.93 for auto components, 0.43 for chemicals and 0.34 for electronics. The data also reveals that there is substantial variation in investment growth within each industry. The coefficient of variation (defined as the ratio of standard deviation to the mean) of year-on-year investment growth is 1.67 for auto components, 3.47 for chemicals and 2.75 for electronics.

Thus, as is probably well understood, imperative and opportunity do not translate into action. Many factors might need to co-exist before growth takes place. We focus on the role of productivity in explaining within-firm variation in investment growth. Researchers in strategy have long held that productivity impacts the overall competitiveness of industries and nations (Porter, 1990). There is also a need to align productivity improvement strategy and business strategy. When productivity priorities are not aligned with the requirements of business strategy, efficiencies may not relate to or may become detrimental to the business (Judson, 1984). With a strategic approach to productivity, any strategy for improving productivity becomes an aspect of business strategy (Wheelwright, 1981). Crandall and Wooton (1978) also suggest a shift from traditional efficiency oriented productivity improvement to productivity strategies focused on growth and development of organisations.

Chandra (2009), based on a survey of 683 manufacturing companies in India, noted that while manufacturing performance has improved, continuous productivity improvement is not a norm and firms will be served well if they specifically measure and improve the productivity of their assets, particularly labour. The author also notes that scale continues to be a problem; the extent of investment on upgrading equipment has generally been low except by large firms. This restricts firms from entering the high value add markets or product segments and thus halts growth.

Despite the important role played by productivity on a firm's competitiveness, there has been very limited work isolating the effect of productivity on firm growth. There are several reasons that might have contributed to the absence of such research, starting with the lack of data for comparing like with like. The rapid growth of the Indian economy helps provide a common background to examine firm level investment decisions within the same time frame, thus obviating one of the hurdles to making comparisons amongst firms. Thus, despite the firm-level heterogeneity, there is one overriding reason to expect common factors to impact growth within and across the industries: the rate of growth in the economy is so high that it seems to put all firms on an equal footing with regard to opportunity for expansion. Also, investments that were made even a few years ago will become inconsequential if the sales growth continues at this pace. Thus, decisions made in the past need not influence future actions. However, the rapid growth also creates some problems for analysis. The phenomena of liberalisation and rapid growth in Indian manufacturing industries are recent and the data available is too sparse to conduct a longitudinal study. The sales growth has been really high only in the last five years. This situation is ideal for using panel data analysis techniques. A study using panel data allows us to control between-firm variation and focus attention on the variables that affect within-firm variation in investment growth. However, there are substantial differences in the market conditions of each industry that we study. Therefore, we conduct separate panel estimates for each industry. Even within each industry, firms operate in diverse locations, under different local conditions, and face very different local problems. We control for such variation by including factors related to investment climate, risk, distribution costs etc.

Our analysis reveals that there are indeed common factors across industries but also some industry-specific factors that explain within-firm variation in investments. The impact of productivity is positive and significant in all three industries. Capital productivity is significant for auto components and chemicals while capital intensity is significant for chemicals and electronics. Labour productivity is significant only for the electronics industry. Firm size and interest on long-term loans significantly affect investment growth in all three industries. The lack of significance in our analysis of several other factors, such as investment climate and operating and financial performance metrics, in explaining variations in investment is somewhat surprising. We discuss the implications of these findings for firms and also suggest areas that warrant further data collection and analysis.

The rest of the paper is organised as follows: We review the relevant literature in Section 2, followed by the description of the model in Section 3. We provide the details of the data used in Section 4. The methodology and results along with analysis of outliers are laid down in Section 5. We conclude with a discussion of the results and the limitations of the study in Section 6.

Literature review and hypotheses

The World Bank (2004) study on the investment climate and the manufacturing industry in India identifies those states that attracted almost all the Foreign Direct Investment (FDI) in India as having a better investment climate. It concludes that investment climate affects industrial growth and development because it influences firm performance and growth. Certainly, improvement in the investment climate will create a better operating environment. However, the above study could not explain why some firms are able to invest more aggressively than others despite being located in states with similar investment climate. Ahluwalia (1985 and 1991) and Goldar (1986) focus on output growth in Indian manufacturing. They report that capital contributed more to the growth of output than did labour and technology. More recently, Pradhan and Barik (2004) conclude that output growth in the Indian industrial sector is driven by capital and raw material inputs. They consider the aggregate manufacturing sector and eight industries in India during the period 1963—1964 to 1994—1995. The contribution of raw material in output growth is higher in four out of eight industries, while capital has a higher contribution in the other four. The authors argue that the predominantly input-driven growth of Indian manufacturing is evidence of the non-sustainability thesis proposed by Krugman (1994). These studies are somewhat dated and their conclusions need not apply to firm-level decisions made in recent years. Thus, there is a need to identify the firm level factors and their relative importance to explain the within-firm variation in investment growth.

Capacity decisions

Capacity decisions affect most operating decisions such as unit production costs, production plans, inventory levels, scheduling, distribution etc and thus have a significant impact on the profitability of the firm (Hendricks, Singhal, & Wiedman, 1995). Using an event study methodology, Hendricks et al (1995) showed that financial markets view capacity expansion announcements by firms favourably. Their study also pointed out the negative relationship of share price changes with capacity utilisation. Thus, the market treats the 'wait and see' approach of capacity expansion less favourably compared to the expansionist strategy. The concept of performance frontier further helps us in understanding the role of capital investments in manufacturing performance. The performance frontier is derived from the production frontier, which according to economic theory, is defined as the maximum output that can be produced from any given set of inputs, given technical considerations (Samuelson, 1947). The performance frontier expands the scope of this definition to include cost, product range and quality by including all choices affecting the design and operation of a manufacturing unit and the sources and nature of inputs. Such performance frontiers will be formed based on an asset frontier and operating frontier (Schmenner & Swink, 1998). A manufacturing plant is immediately subjected to its operating frontier and ultimately to its asset frontier. As a company improves its operating policies, it will lead to a change in the shape and position of its operating frontier. However, the company will be able to simultaneously improve product flexibility, delivery, and quality at a lower manufacturing cost and create an operating frontier superior to its competitors if all the companies are further away from the asset frontier. As all the companies reach closer to the asset frontier, the ability to improve all operating parameters simultaneously gets limited. In recent years, as more and more firms in India have moved closer to the asset frontier, they needed to invest in technology and upgrade assets to create a new asset frontier (Iyer, Saranga, & Seshadri, 2006). Failing to do so would limit their chances of further growth. In this paper we try to identify the factors that explain the difference in investment growth among firms. We expect labour and capital productivity, firm size, cost of capital, marketing and logistics costs to play a significant role in explaining the above difference.

Hypothesis generation

We surveyed the operations strategy literature regarding the various factors that contribute to the growth of firms such as productivity improvements, firm size and cost of capital. The operations strategy literature does not seem to have linked productivity to growth. In fact, Skinner (1986) comments on how focus on increasing direct labour productivity creates a short term, operational mindset among managers. Thus, by emphasising productivity from the labour cost reduction point of view, companies fail to provide or support a coherent manufacturing strategy. To make productivity improvements an integral part of business strategy, Judson (1984) recommends that all aspects of work being done everywhere in the organisation, and how it is being accomplished (both substance and process) should be considered in an effort to improve productivity. Personal conversation with managers at Toyota corroborates Judson's argument. Toyota recognises that simply exhorting employees to be more productive does not lead to results but only frustration. To ask managers to reduce costs or improve productivity is too general. The Toyota method emphasises that targets be as specific as possible. Toyota sets a measure of hours of labour per car. A target would be: can you make labour per car 5% better? Internal competition is used to set standards and make it possible to determine whether improvements are achievable. The target is made more specific by classifying labour into different categories such as labour that actually makes the product, labour team comprising leaders and supervisory staff, maintenance, accountants and purchasing, etc. Different targets are set for different categories. With regard to productivity, Toyota has set long-term goals. To our knowledge, there is no study which empirically establishes the relationship between productivity improvement and growth.

To understand why productivity is often not viewed from a growth perspective, it is important to analyse how firms plan for investments and examine whether the capital budgeting process accounts for operational measures like productivity and capability building. Baldwin and Clark (1992) comment that investments are necessary to achieve superior performance in terms of speed, quality, flexibility and innovation. But, companies fail to invest in capability building as they do not have the objective tools to value the embedded capabilities. The authors conclude that managers must look beyond the present competitive environment to the capabilities that will deliver future advantage and target their investment programmes to create those organisational assets. The size of the firm, in terms of its stock of assets, also plays an important role in the future growth of the firm.

Competitive advantage depends on the stock of resources and capabilities of the firm (Grant, 1991). The ability to maximise productivity of tangible assets and the transfer of existing assets into more productive employment can provide substantial returns (Grant, 1991). To explain the cost of implementing strategies, Barney (1986) concludes that an analysis of the external environment may not provide above normal returns to firms, as all firms have access to publicly available information, the methodology and frameworks for conducting such an analysis either with their own skills or using rented services. On the other hand, the internal analysis of the firm's existing assets and capabilities could provide the above normal returns as that internal information would be proprietary to the firm and thus would enable the firm to have better expectation of returns. Thus, a firm's internal capabilities in the productive use of assets may not be easily replicated and other firms may not have access to the capital to acquire such'enabling' assets. Schroeder, Bates, and Junttila (2002) studied the impact of internal and external learning and proprietary processes and technologies on developing competitive advantage and the performance of manufacturing plants. The authors empirically validated that internal and external learning lead to proprietary processes which are difficult to imitate and thus improve manufacturing performance.

The above discussion suggests that productivity improvement is important but not easily achieved because the techniques are innate to firms. Also, focusing excessively on cost reduction is counterproductive. We also know that productivity certainly impacts growth in the long term (Funk & Strauss, 2000) Therefore, there should exist a method by which successful firms are able to translate their productivity achievements into short and medium term growth when opportunity exists to grow in emerging markets. Thus, we hypothesise the following:

Hypothesis 1a: Firms with higher capital productivity are associated with higher investment growth.

Hypothesis 1b: Firms with higher labour productivity are associated with higher investment growth.

As mentioned above, the size of the firm reflects the resources gathered to conduct operations. Thus, one reason that larger firms might be at an advantage is that they have the ability to use additional inputs. Dierickx and Cool (1989) showed that firms which possess the initial stock of resources required for competitive advantage may be able to sustain their advantages over time. The authors proposed the asset stock accumulation framework and stated that the need for incremental addition to asset stock arises as firms have to continuously identify'resource gaps' and upgrade their competitive position. The upgradation of competitive advantage forms a central theme in Michael Porter's analysis of the competitive advantage of nations (Porter, 1990). Competitive advantage also depends on the stock of resources (Grant, 1991). Hence we hypothesise that firms with larger asset size will have higher investment growth. Finally, larger firms might have an advantage in the capital markets to raise funds (Dhawan, 2001; Love, 2001)

Hypothesis 2: Firms with more assets are associated with higher investment growth.

As capital markets are imperfect, firms incur differential costs in raising investment funds in capital markets. Higher cost of capital is expected to negatively affect investment growth. Hence we frame the following hypothesis.

Hypothesis 3: Firms with higher cost of capital are associated with lower investment growth.

Porter (1985) discussed linkages among value adding activities in two dimensions—a vertical linkage among value chain activities including those of suppliers and customers and horizontal linkages within a firm. The horizontal linkages are developed between direct value chain activities like production with supporting activities like new product development, sales and marketing, logistics and distribution etc. Porter also suggested that stronger linkages and higher degrees of integration across functional and organisational boundaries lead to better performance. A lesser degree of integration among functions will result in lack of visibility of the market, increase costs of co-ordination and thus result in higher inventory carrying costs, higher logistics, marketing and research and development cost. We hypothesise how the above costs are expected to influence investment decisions.

Berry, Hill, and Klompmaker (1999) built the case for aligning marketing and manufacturing strategy decisions and developed a framework which linked marketing's view of the market in terms of customer requirements, assessed manufacturing's performance against those requirements and identified investments and developments necessary to bridge the gap between manufacturing and customer requirements. They applied their framework to link manufacturing and marketing strategies in an apparel manufacturer and demonstrated how the process of developing manufacturing strategy can be enriched by the inputs from the market and vice versa. This highlights the need for incorporating marketing costs in manufacturing investment decisions. Failure to integrate marketing inputs in developing manufacturing strategy will result in manufacturing products, which are not synchronised with the market needs. This will result in potential failure of the products in the market, higher marketing costs and reduced future investments. Smiley (1987) also suggested that when it comes to new products, firms try to limit entry through patent preemption and creation of product loyalty by spending heavily on advertising. For mature existing products, filling all available product lines, masking product-specific data on profitability and creating product loyalty by investing in advertising are the commonly used strategies to deter entry. For both new and existing products, maintenance of excess production capacity is the least frequently chosen strategy to keep competition out. Thus firms with higher marketing cost as percentage of sales might invest less as they focus more on advertising and brand building at the expense of investments. Based on the above discussion, we frame our hypothesis for investment growth in firms.

Hypothesis 4a: Firms with higher marketing costs are associated with lower investment growth.

Stock, Greis, and Kasarda (1998) showed how the use of logistics integration both within the firm and across firms can play an important role in defining competitive priorities, competitive dimensions and geographic scope of the firm's operations. Enterprise logistics can help in linking logistics activities to other functional areas of the firm and to the logistics activities of other firms, that is, suppliers and customers. Gimenez and Ventura (2005) showed that integration of logistics and production results in improvement in performance in terms of reduced costs, lead time and stock-outs. Logistics costs also have been considered by many researchers for investment decisions like supply chain network design and facility planning (Arntzen, Brown, Harrison, & Trafton, 1995). Higher logistics cost will negatively impact profitability and free cash flow and is thus expected to result in lower investment growth. Hence we hypothesise as below:

Hypothesis 4b. Firms with higher logistics costs are associated with lower investment growth.

Distortion of demand information among different members of the supply chain like suppliers, manufacturers, distributors and retailers creates a phenomenon called the'bullwhip effect', where the orders to the suppliers tend to have larger variance than the sales to the buyers (Lee, Padmanabhan, & Whang, 1997). As a consequence of the bullwhip effect, suppliers and manufacturers end up with higher finished goods inventory. Such firms might have reduced visibility of their market and consequently invest less.

Hypothesis 4c: Firms with higher finished goods inventory are associated with lower investment growth.

Model

Given the rapid growth in sales, it is conceivable that firms might pursue a preemptive capacity expansion strategy to capture a bigger share of the market. If that is true, we are less likely to find statistical evidence from the panel data because investments might be random and lumpy. But, as empirical evidence indicates, firms typically do not invest in capacity as a preemptive strategy; rather they tend to use it for non-strategic purposes. Studies by Lieberman (1987), Lieberman and Montgomery (1987) and Dixit (1980) also indicate that firms rarely undertake capacity additions as a strategic preemptive action. Therefore, we do not expect investment growth rates to be higher than firm growth rates even in a rapidly growing economy. If the investment growth is not strategic, then firm and environmental variables may capture more of the variation in investment growth.

We develop a model based on a standard production function of a firm to test the hypotheses. We also add several control variables to account for heterogeneity amongst firms as well as to include exogenous variables that might explain variations in investment growth. The panel data regression model containing all the variables is used for determining the source of within-firm variation in investments in individual sectors. The dependent variable in our model is the year-to-year percentage change in capital employed (INVG).'Capital employed' is defined as 'share capital plus reserves and long-term company debt'. The two other options we considered for the dependent variable were investments in plant and machinery and gross fixed assets. Since we did not want to restrict ourselves to investment in physical assets alone, but wished to study the total capital invested in the business, we chose the broader definition of capital employed as our dependent variable.

To understand the model behind the research, consider a Cobb—Douglas model of output for a firm in a given industry:

$$\ln(VA_{it}) = a_{0i} + a_1\ln(K_{it}) + a_2\ln(L_{it}) + e_{it}$$

where ln stands for the natural logarithm, VA_{it} is the value added by firm i in period t, K_{it} and L_{it} are the capital and labour employed and e_{it} is statistical noise. The constant a_{0i} captures firm i's productivity. This model treats capital employed as an independent variable and thus value added is the consequence of an increase in capital and labour. Instead, if we treat value added as the'planned' growth, change in capital employed can be predicted using:

$$\Delta K_{it}/K_{it} = b_1\Delta VA_{it}/VA_{it} + b_2\Delta L_{it}/L_{it} + u_{it}$$

where $\Delta K_{it} = K_{it+1} - K_{it}$, $\Delta L_{it} = L_{it+1} - L_{it}$, and $\Delta VA_{it} = VA_{it+1} - VA_{it}$. The term u_{it} might now include not just statistical noise but other environment and firm-specific variables that impact capital investment. We include variables to test our hypotheses and also to control for other firm-specific effects[1]. We elaborate on these below.

Firm size is also expected to explain variation in investment growth of firms. (Dierickx & Cool, 1989; Grant, 1991) We expect larger firms to have better access to capital markets and therefore invest more. We could have used either logarithm of net fixed assets (LNNFA) or sales as a proxy for the size of the firm. We found high correlation (0.84, 0.39 and 0.74 for auto components, electronics and chemicals respectively) between LNNFA, and the logarithm of sales for all the three industries. Therefore, the results would have been almost identical with sales as the proxy. We use the logarithm of net fixed assets because the graph of the data reveals that the logarithm more closely approximates a normal distribution.

The variables considered in the productivity category are labour productivity as measured by the ratio of net value added to salaries and wages (NVALAB); capital productivity as measured by the ratio of net value added to

[1] We thank one of the reviewers for pointing out that value added growth can be endogeneous to capital employed. We have not come across similar procedure being followed in the extant literature. For the model where we suspect endogeneity, we have included value added growth as an endogeneous variable while applying the Hausman—Taylor Instrumental Variable Regression. See the Methodology and Results section.

depreciation (VADEP); and capital intensity as measured by the ratio of depreciation to salaries and wages (DEPSAL). Labour productivity assumes significance for India due to the shortage of skilled labour in the manufacturing sector. There is a serious mismatch between the needs of the industry and the availability of skilled engineers and technicians for the manufacturing industry (NMCC, 2006). Due to the rapid growth of the service sector industries, such as information technology (IT) and business process outsourcing industries, the manufacturing sector faces severe competition for labour. Firms can enhance labour productivity by better training methods and use of better tools and equipment. Such practices also help in attracting highly skilled labour. Higher labour productivity also assures the management that capacity additions will be better utilised. Similarly, firms that utilise capital more productively find it less expensive to invest in capacity addition. So we expect positive association of investment growth with both labour and capital productivity (NVALAB and VADEP).

The variables considered in the operating cost category are logistics cost as measured by the ratio of sales and distribution cost to sales (DISTS), marketing and advertising expenditure as percentage of sales (MKTGS), finished goods inventory as percentage of sales (FGS) and total interest paid on long-term loans as percentage of long-term loans (INTL).

In addition to the variables that are directly related to the test of the hypotheses we include firm level control variables to control for factors that affect investment decisions. These include capital intensity, R&D expenditure, growth in value added, capital structure, holding pattern etc. These are briefly described below. Firms with high capital intensity are likely to make lumpy capacity additions. Lieberman (1987) suggests that firms with lumpy capacity will defer investments and will require higher rates of market growth and capacity utilisation before they make investments in building capacity. Thus, we expect negative association of investment growth with capital intensity (DEPSAL).

The variables considered in the product, market and financial position category are R&D expenditure as percentage of sales (RDS) and growth in net value added (VAG). We hypothesise that firms with high R&D expenditure are possibly investing towards developing new products and services. Therefore they may not invest in capacity expansion (Smiley, 1987). Firms with higher growth in value addition will require higher levels of investments to support the growth.

The variables considered in the risk category are debt—equity ratio (DER) and the percentage of export earnings to sales (FOREXS). Firms with higher DER might find it risky to invest. Firms with higher FOREXS have access to multiple markets that reduces risk. Such firms are likely to invest more freely. The other variables we consider are the shareholding pattern of investors as measured by percentage holding of Indian promoters (INDPROM), the age of the firm (AGE), and the location of the firm (LOC). According to Khanna and Palepu (2000) performance effects of group affiliations in India can be considered positive because groups can substitute missing and poorly functioning institutions. Khanna and Palepu (2004) comment that as a response to competition, at least some Indian families have tried to leverage internal markets for capital and talent inherent in business group structures to launch new ventures in environments where external factor markets are deficient. However, Kumar (2004) does not find any empirical evidence that difference in ownership structure affects firm performance, after controlling for observed firm characteristics and firm fixed effects. We, too, expect mixed results. INDPROM can be negatively associated with investment growth for some industries and positively for others.

LOC is a dummy variable that takes the values zero or one. The value '0' indicates that the firm is located in an unfavourable investment climate and '1' indicates location in a favourable investment climate (the investment climate classification is according to the study by the World Bank [2004]). According to the study, firms located in investment-friendly states tend to invest more. We chose not to include free cash flow as an independent variable for two reasons. The main reason is that our dependent variable already has a reserves and surplus component. The second is that there is ambiguity regarding the relevance of free cash flow. Fazzari, Hubbard, Blinder, and Poterba (1988) and Hsiao and Tahmiscioglu (1997) report significance of cash flow on investment decisions but Gomes (2001) suggests that cash flow may not be significant because of the measurement error of other variables like Tobin's q or capital stock.

Let $VAG_{it} = \Delta VA_{it}/VA_{it}$ and $DELL_{it} = \Delta L_{it}/L_{it}$, where VA_{it} = Net Value Added for the firm 'i' at time period 't', and L_{it} = salaries and wages for firm 'i' at time period 't'. The variable $DELL_{it}$ or delta labour measures the change in labour costs for firm 'i' in time period 't'. Thus our model takes the following form:

$$\begin{aligned} INVG_{i,t} = {} & \beta_0 + \beta_1 VAG_{i,t} + \beta_2 DELL_{i,t} + \beta_3 NVALAB_{i,t} + \beta_4 VADEP_{i,t} \\ & + \beta_5 DEPSAL_{i,t} + \beta_6 RDS_{i,t} + \beta_7 DISTS_{i,t} + \beta_8 MKTGS_{i,t} \\ & + \beta_9 FGS_{i,t} + \beta_{10} INTL_{i,t} + \beta_{11} DER_{i,t} + \beta_{12} FOREXS_{i,t} \\ & + \beta_{13} INDPROM_{i,t} + \beta_{14} AGE_{i,t} + \beta_{15} LOC_{i,t} t \\ & + \beta_{16} LNNFA_{i,t} + \lambda_i + \epsilon_t + u_{i,t} \end{aligned} \quad (1)$$

where 'i' is the index for firm and 't' is the index for time. The λ_i's are unobserved firm-specific variation, ϵ_t's are the unobserved time-specific variations and the $u_{i,t}$'s are the random disturbances that are assumed to be uncorrelated with the independent variables.

We added a dummy variable 'TYPE' for chemicals and electronics. The chemical dataset includes firms that work with alkalies, dyes and pigments, inorganic chemicals, organic chemicals and polymers. These sub-sectors have different process and market characteristics, so we use four TYPE dummies to account for possible differences amongst them. In electronics, we have firms that deal with consumer electronics, industrial electronics, telecom equipment and electronic components; we use three TYPE dummies for these.

Data

All three industries, auto component, electronics and chemicals, have experienced significant revenue growth in recent years. The turnover of the auto component sector

Table 2 Descriptive statistics of key variables for the panel data (2002—2006).

Variable		Auto components				Chemicals				Electronics			
		Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max
Investment growth	Overall	22.0	36.88	−58.00	257.69	8.54	29.6	−153.00	175.02	10.5	28.7	−163.50	190.67
	Between		19.81	−5.14	86.83		20.81	−108.10	97.09		16.71	−61.02	62.78
	Within		31.18	−76.40	210.89		21.17	−64.00	121.07		23.48	−92.06	138.36
Log of net fixed assets	Overall	4.00	1.06	1.41	7.15	4.25	1.31	0.84	6.96	2.67	1.84	−2.41	8.28
	Between		1.01	1.75	6.56		1.29	1.50	6.91		1.79	−0.95	8.10
	Within		0.32	3.10	5.12		0.23	3.20	5.62		0.44	−31.60	5.73
Labour productivity	Overall	2.49	1.19	−1.50	8.71	3.06	2.52	−8.93	13.38	2.20	2.47	−16.55	16.01
	Between		1.07	0.96	6.02		2.31	−5.90	11.19		1.93	−2.76	10.08
	Within		0.54	−0.03	5.22		1.05	−2.61	9.81		1.56	−11.58	11.48
Capital productivity	Overall	5.94	3.54	−4.29	22.95	4.74	4.39	−1.98	30.37	8.43	9.66	−13.79	64.14
	Between		3.18	2.00	19.72		4.07	−0.83	26.16		8.37	−0.01	34.85
	Within		1.59	−1.12	16.98		1.70	−5.82	15.37		4.89	−16.27	61.66
Capital intensity	Overall	0.53	0.33	0.05	1.55	1.01	1.09	0.07	7.94	0.63	0.91	0.00	7.70
	Between		0.32	0.06	1.45		1.03	0.07	7.04		0.86	0.03	5.25
	Within		0.07	0.20	0.93		0.38	−0.69	5.23		0.30	−1.33	3.08
Interest on long-term loans	Overall	6.24	5.36	0.00	23.19	8.19	7.37	0.00	47.49	5.86	7.24	0.00	37.48
	Between		4.47	0.00	18.12		5.59	0.00	23.69		5.66	0.00	27.25
	Within		2.99	−1.49	18.62		4.83	−11.83	36.97		4.54	−16.22	27.02

Note: The number of firms equals 66 for Auto Components and Electronics; and 86 for Chemicals. The between statistics are computed using firms averages and the within statistics are computed by taking deviations from firm averages.

has grown from US$3.1 billion to US$12.0 billion between 1997—1998 and 2005—2006. Most of the growth was spurred by exports and sales to original equipment manufacturers (OEMs). Investments in the industry during this period totaled approximately US$24 billion, with investments of US $4.4 billion in 2005—2006 alone. In 2005—2006, the manufacturing exports grew by 28% to reach US$2.1 billion (source: www.acmainfo.com). The Indian automotive component industry has made a sustained shift to sell to the global Tier 1 market (Balakrishnan et al., 2006). In the 1990s, the Indian auto components market was dominated by sales to the replacement market, with only 35% of exports sourced by Tier 1 OEMs. In 2006, Indian automobile component manufacturers supplied 75% of their exports to Tier 1 OEMs and only 25% to the aftermarket (source: www.ibef.org).

In 2005—2006, the turnover of the Indian chemical industry was around US$35 billion. The total investment in the chemical sector was approximately US$60 billion, and total employment around one million. The sector accounted for nearly 14% of total exports and 9% of total imports of the country. In terms of volume, the Indian chemical industry is the twelfth largest in the world and the third largest in Asia. Currently the per capita consumption of chemical products in India is about one-tenth of the world average, highlighting the potential for further growth (Working Group on Indian Chemical Industry, 2006).

In 2005—2006, the turnover of the electronics industry was US$13 billion and exports for the industry amounted to $1.8 billion, with the components sector contributing 48% of the total exports. The industry employs over 3.5 million people and if we include the people who indirectly support IT and electronics manufacturers by providing logistics, post-sales, maintenance and related support services, this number increases further by 2.5 million (AEDE, 2007).

The relevant data was collected for all firms in the three sectors for the years 2002—2006 from the Prowess database, developed by the Centre for Monitoring Indian Economy.[2] We chose 2002 as the starting year in order to avoid the downturn in the economy caused by the 2000 slump in the IT industry, and to capture the most recent sustained growth period of the manufacturing industries analysed.

Some of the key panel variables are summarised in Table 2. We find significant variation in investment patterns for firms within a sector and for each firm during the study period.

After dropping firms with missing data on variables in all three sectors, 'very small firms', 'high loss' making firms, firms that were significantly different from the rest of the sample in terms of products, markets and size, and those with abnormal values across variables, we ended up using data on 66 firms in auto components and electronics industries, and 86 firms in the chemicals industry.

Methodology and results

We use a paired '*t*' test with unequal variance to check whether the difference between the sales growth and the

[2] Prowess is a database of large and medium Indian firms that contains detailed information on over 10,000 firms. These comprise all the companies that are traded on India's major stock exchanges and several others, including the central public sector enterprises.

Table 3 Difference in sales growth and investment growth in auto components, chemical and electronics industries.

Industry	Mean difference (Sales growth-investment growth)	Std. deviation (Sales growth-investment growth)	't'value (df)	'p'value at 95% significance level for Ha: mean(diff) $\neq$ 0	'p' value at 95% significance level for Ha: mean(diff) $<$ 0	'p' value at 95% significance level for Ha: mean(diff) $>$ 0
Auto components	1.23	42.45	0.473 (263)	0.64	0.68	0.32
Chemicals	12.29	62.98	3.62 (343)	0.0003	0.9998	0.0002
Electronics	21.34	140.58	2.47 (263)	0.0143	0.9929	0.0071

Note: Data was pooled for years 2002—2006. $N = 66$ for Auto Components and Electronics and $N = 86$ for Chemicals.

investment growth was significant in each of the three sectors. The results are shown in Table 3. For the auto components industry, we cannot reject the null hypothesis that there is no significant difference between sales growth and investment growth whereas for the electronics and chemicals sectors, we reject the null hypothesis in favour of the alternate hypothesis that sales growth is greater than investment growth.[3]

We provide an overview of the analysis before presenting the results. There are several independent variables in our model that do not vary over time. These variables automatically get excluded in a fixed effects (FE) model, where only the within-firm variation is analysed and the data is reduced by mean over time. To study the impact of time-invariant variables on investment we can use a random effects model if the unobserved firm effects are uncorrelated with the regressors. In our analysis, we check for the suitability of the random effects model over pooled Ordinary Least Squares (OLS) using the Breush Pagan Lagrange Multiplier (BP—LM) test. Then, the Hausman specification test is used to test for orthogonality of the random effects and the regressors. Under the null hypothesis of this test, both OLS in the fixed effects model and Generalised Least Squares (GLS) in the random effects model are consistent. Under the alternative, the random effects model, OLS is consistent but GLS is not. We used the Hausman test to choose between the fixed effects and the random effects models. But both the fixed effects and the random effects models have their own limitations: the fixed effects model is inefficient and does not allow us to consider time-invariant variables; a major shortcoming of the random effects model is that it assumes the unobserved firm-specific effects u_i to be uncorrelated with the regressors (Greene, 2003). The Hausman and Taylor's instrumental variable estimator allows us to capture the effect of time-invariant variables. This has the added benefit of addressing the possible endogeneity of LNNFA to the unobserved firm-specific variations. For example, if the management of large firms was of superior quality or if larger firms had better access to factors of production, then we would expect such correlation. We also check for consistency between the coefficients found using the fixed effect model and the coefficients produced using the Hausman—Taylor estimator, which uses the Hausman specification test. In order to construct the Hausman—Taylor estimator, we redefine the model in (1) as follows:

$$\mathrm{INVG}_{i,t} = \beta_0 + \beta_1 X1_{i,t} + \beta_2 X2_{i,t} + \delta_1 Z1_i + \mu_i + \lambda_t + \epsilon_{i,t} \quad (2)$$

where *X1* comprises of VAG, DELL, NVLAB, VADEP, DEPSAL, RDS, DISTS, MKTGS, FGS, INTL, DER, FOREXS, AGE and INDPROM; *X2* equals LNNFA; and $Z1_i$ equals LOC.

The covariates in X are time varying and the covariates in Z are time invariant. X is decomposed into two parts, where covariates in *X1* are assumed to be uncorrelated with μ_i, λ_t and $\epsilon_{i,t}$, and those in *X2* are allowed to be correlated with μ_i and λ_t but not with ϵ_{it}. For chemicals and electronics, TYPE is included in *Z1*.

We now discuss the results for each sector, followed by a summary of results for all sectors. The results for the auto components industry are shown in Table 4. For this industry, both firm and time effects are jointly significant. So we decided against using pooled OLS. The result of the Hausman test comparing the coefficients from the fixed effects model and the random effects model indicates that the individual effects are not correlated with the regressors. Thus, both the fixed effect model and the random effect model are consistent but the fixed effect model is inefficient. The Hausman test comparing the fixed effect model and the Hausman—Taylor estimates confirms that the individual effects are not correlated with regressors and that the Hausman—Taylor estimates are consistent. We present the results for the random effect model, the Hausman—Taylor instrumental variable estimator and the two-way fixed effects model.

Only two variables, INTL and LNNFA, are significant in all the three models while VADEP is significant for the random effect model with Hausman—Taylor estimation at 0.1 percent. As anticipated, the coefficients of LNNFA and VADEP are positive and that of INTL is negative.

In the auto components industry, the effect of capital productivity (VADEP) is positive and significant while those

[3] An associate editor suggested that the data be 'analysed by a 3 (Industry) $\times$ 5 (Years 2002 through 2006) $\times$ 2 (sale growth vs. investment growth) ANOVA with repeated measures on the last two factors'. However, as sales growth and investment growth do not have different levels for the same variable, we are unable to run a 3 $\times$ 5$\times$2 ANOVA. We have used the PROC MIXED procedure in SAS for running the repeated measures ANOVA. We have run the models separately for sales growth and investment growth with repetitions by year. The results show that for sales growth only 'year' effects are significant while for investment growth both industry and year effects are significant.

Table 4 Results for the auto component industry explaining variation in investment growth.

Variable	Random effects model	Two way fixed effects model	Hausman—Taylor IV
VAG	10.5*	5.42	6.48
DELL	0.18	0.11	0.10
NVALAB	0.18	3.31	−0.19
VADEP	3.83***	4.34	5.44***
DEPSAL	11.7	18.50	8.09
RDS	−0.67	0.16	−0.66
DISTS	−2.8	−0.81	−1.32
MKTGS	−2.6**	−3.81	−2.17
FGS	0.64	0.42	0.75
INTL	−1.5***	−2.90***	−2.06***
DER	−1.18	−5.78	−1.89
FOREXS	0.142	−0.32	0.004
LNNFA	5.85*	40.45***	20.00***
INDPROM	−0.09		0.03
AGE	−0.07		−0.28
LOC	−10.3		−17.2
TIME 1		2.88	
TIME 2		2.5	
TIME3		−18.67***	
R-Squared	0.26	0.40	

Note: ***, ** and * denote significance at 0.1%,1% and 5% significance level, respectively. The Chi-squared value of 101.46 for the Hausman—Taylor IV estimation with degrees of freedom 16 was significant at 0.1% level. The variables Time 1, 2 and 3 are the three dummy variables for the time periods.

of labour productivity and capital intensity are not significant.[4] It is interesting to note the absence of significance of labour productivity. Most Indian auto component manufacturers undertook sustained efforts to improve process efficiency, quality and productivity prior to the study period (Iyer et al., 2006). They obtained quality improvement and productivity gains due to these initiatives. Our results suggest that firms are consequently more likely to consider the productive use of capital as one of the criteria for making capital investments.

The results of the chemical industry are shown in Table 5. For this industry, the BP—LM test shows that the individual effects are significant. Time effects are not significant. The Hausman test comparing the coefficients produced by the fixed effects and the random effects model confirms that the individual error terms are correlated with the regressors. Hence, the random effect model is not consistent. The Hausman test comparing the coefficients of the fixed effect model and the Hausman—Taylor estimate shows that individual error terms are no longer correlated with regressors. Thus, the Hausman—Taylor estimator is consistent. Below we report the results of the fixed effects model and the Hausman—Taylor instrumental variable estimation.

For chemicals, LNNFA and INTL are significant in both the models while VADEP and DEPSAL are significant only in the Hausman—Taylor estimate. The chemical industry data comprises firms that belong to the alkalies, inorganic, organic, dyes and pigments and polymers sub-sectors. These fall under the broad category of basic chemicals and it is fair to conclude that the majority of these firms operate in a commoditised business. Thus, in this industry, firms that have been able to improve capital productivity (VADEP), for example by optimising their product mix or by reducing bottlenecks in their processes, find it easier to invest. The chemicals industry is also the most capital intensive of the three. We expect investments in this industry to be lumpy. This might result in firms postponing their investment decisions and thus accounting for the negative coefficient attached to DEPSAL. As expected, the coefficients of LNNFA are positive and those of INTL are negative.

The results for the electronics industry are shown in Table 6. For this industry, time effects are not significant. The Hausman test comparing the coefficients of the fixed effect and the random effect models confirms that the individual effects are not correlated with regressors. The Hausman test comparing the fixed effects model and the Hausman—Taylor estimator also shows that the individual effects are not correlated with regressors and that the

[4] For auto components, we find that VAG is significant in the Random Effects model. We re-ran the model with VAG as dependent variable and INVG as one of the independent variables. INVG turned out to be significant when VAG was treated as dependent variable. This showed signs of possible endogeneity between VAG and INVG. Testing for endogeneity requires finding suitable instruments. But practically it is very difficult to find such instruments. Hence we did not run any formal test for endogeneity. But as we suspect some possible endogeneity for the model for auto components, we re-ran the Hausman—Taylor IV model treating both LNNFA and VAG as endogeneous. LNNFA, INTL, VADEP turned out to be the significant variables as in the Hausman—Taylor IV model reported in Table 4 but the coefficients of the significant variables changed to 26.72, −1.90 and 5.41 respectively.

Table 5 Results for the chemical industry explaining variation in investment growth.

Variable	Fixed effects model	Hausman—Taylor IV
VAG	−0.29	0.11
DELL	0.06	0.07
NVALAB	1.96	1.69
VADEP	1.97	1.88*
DEPSAL	−3.61	−5.13*
RDS	−1.56	−1.21
DISTS	0.09	−0.05
MKTGS	−1.58	−1.61
FGS	0.24	0.34
INTL	−1.59***	−1.56***
DER	1.31	2.28
FOREXS	−0.04	−0.03
LNNFA	17.6*	14.80**
INDPROM		−0.14
AGE		−0.002
LOC		−4.45
TYPE1		8.89
TYPE2		24.80
TYPE3		18.30
TYPE4		4.56
R-Squared	0.23	

Note: ***, ** and * denote significance at 0.1%, 1% and 5% significance level. The Chi-squared value of 95.1 for the Hausman—Taylor IV estimation with degrees of freedom 20 was significant at 0.1% level. Type 1,2,3 and 4 are four dummy variables for the five sub-sectors within the chemical industry, which we have used for our analysis, e.g., alkalies, dyes and pigments, inorganic chemicals, organic chemicals and polymers.

Table 6 Results for the electronics industry explaining variation in investment growth.

Variable	Random effects model	Hausman—Taylor IV
VAG	0.53	1.2
DELL	0.06	−0.005
NVALAB	2.87**	3.27***
VADEP	0.44*	0.37
DEPSAL	−3.87	−9.36*
RDS	1.36	0.57
DISTS	−2.56*	−2.55
MKTGS	0.52	0.56
FGS	−0.08	−0.19
INTL	−0.80***	−0.85**
DER	−2.66	0.22
FOREXS	0.06	−0.02
LNNFA	2.77*	7.00**
INDPROM	−0.08	−0.07
AGE	0.05	−0.05
LOC	0.73	2.93
TYPE1	6.91	0.25
TYPE2	3.45	3.33
TYPE3	−8.91	−12.4
R-Squared	0.23	

Note: ***, ** and * denote significance at 0.1%, 1% and 5% significance level, respectively. The Chi-squared value of 46.21 for the Hausman—Taylor IV estimation with degrees of freedom 19 was significant at 0.1% level.

Hausman—Taylor estimator is consistent. Below we report the results of the random effects model and the Hausman—Taylor instrumental variable estimation.

For electronics, NVALAB, INTL and LNNFA are significant in both the models. DEPSAL is significant only in the Hausman—Taylor estimate while DISTS and VADEP are significant only in the random effects model. Thus the consideration of endogeneity of LNNFA with firm-specific effects renders two independent variables insignificant. Electronics is a labour-intensive industry with the exception of seven firms in our sample that have high capital intensity (average DEPSAL of 2.64 against an average of 0.40 for the remaining 59 firms). Thus, labour productivity (NVALAB) is significant in this industry unlike in the auto components industry. As expected, the coefficient of LNNFA is positive and that of INTL is negative.

The Hausman—Taylor instrumental variable estimate is consistent for all the three industries. Therefore, we summarise the results using those estimates in Table 7 for the purpose of cross-industry comparison.

We thus find mixed support for hypotheses 1a and b. Factors related to capital or labour productivity are found to explain a significant amount of variation within firms. Specifically, labour productivity seems to be important in the electronics industry and productivity of capital in the other two industries studied. We comment on these findings following the analysis of outlier companies.

We find support for both hypotheses 2 as well as 3. High interest rates on long-term loans act as an impediment to growth for all three industries. In this regard, both firms as well as the government can take some definite steps to reduce the cost of raising capital (we discuss these steps below). Our analysis shows that for all three industries, firm size has a significant positive impact on investment growth. This might also be linked to better access to credit and better credit terms for larger firms. It is surprising that we do not find support for hypotheses 4. We discuss the finding below.

As investment growth can be an indicator for growth in future value addition, we also ran our model with leading VAG as one of the independent variables. The results shown in Table 8 indicate that the only difference is that capital intensity (DEPSAL) is no longer significant for both the chemicals and electronics industries. This perhaps confirms the impact of the lumpiness of investments in these two sectors. Therefore, these firms might be lagging behind growth in their timing of investments.

Discussion and analysis of outliers

Factors related to capital or labour productivity are seen to explain a large amount of variation within firms. The significance of labour and capital productivity suggests three things: First, firms should treat productivity improvement initiatives as much as drivers of future growth as for operational efficiency, firms should attempt to use the right mix of labour and capital and, thirdly, industry associations can play a key role in transforming

Table 7 The significant variables from Hausman—Taylor estimates for predicting investment growth.

Industry	Significant variables	Coefficients from Hausman—Taylor IV	Robust std error
Auto components	Capital productivity (VADEP)	5.44***	1.37
	Interest on long-term loans (INTL)	−2.06***	0.54
	Log of net fixed assets (LNNFA)	20.00***	5.14
Chemicals	Capital productivity (VADEP)	1.88*	0.77
	Capital intensity (DEPSAL)	−5.13*	2.54
	Interest on long-term loans (INTL)	−1.56***	0.22
	Log of net fixed assets (LNNFA)	14.8**	4.96
Electronics	Labour productivity (NVALAB)	3.27***	0.96
	Capital intensity (DEPSAL)	−9.36*	3.77
	Interest on long-term loans (INTL)	−0.85**	0.29
	Log of net fixed assets (LNNFA)	7.00**	2.67

Note: ***, ** and * denote significance at 0.1%, 1% and 5% significance level, respectively.

the industries by educating the companies according to the particular needs of the industry. Executives drive productivity improvements from operating efficiency perspectives. But improved capital and labour productivity can also provide the necessary impetus required for future investments and growth. However, blindly focusing on increasing both capital and labour productivity might not impact growth. Productivity priorities need to be aligned with the requirements of business strategy (Crandall & Wooton, 1978, Judson, 1984, Wheelwright, 1981).

Capital productivity is also associated with good operating and maintenance practices. An efficiently maintained plant can produce the right quality and quantity of product to yield high capital productivity (Raouf, 1994). For continuous process plants as in the chemicals industry, unplanned shutdowns due to maintenance issues are major sources of productivity loss with high impact on both capital and labour productivity. Companies using cross-functional teams of production, maintenance, and quality assurance personnel, and following autonomous and planned maintenance are more likely to have superior spares and maintenance planning and thus avoid such unplanned shutdowns. Hence such companies will have higher throughput and higher capital productivity. Our results also suggest that companies in the electronics industry have significant opportunities for implementing productivity improvement initiatives to drive growth. The effort made by the Automotive Component Manufacturers Association of India (ACMA) in this regard is well documented and can

Table 8 Summary of Hausman—Taylor estimates with leading value added growth (VAG) as an independent variable for predicting investment growth.

Industry	Significant variables	Coefficients from Hausman—Taylor IV	Robust std error
Auto components	VADEP	3.24**	1.19
	INTL	−1.04*	0.41
	LNNFA	11.3**	4.16
Chemicals	INTL	−1.16***	0.25
	LNNFA	16.70*	6.56
Electronics	NVALAB	2.31*	0.96
	RDS	5.21*	2.6
	INTL	−0.82**	0.32

serve as a model for other industries (Iyer et al., 2006). As in the automotive industry, electronics industry associations and other manufacturing industry associations could take a leadership role in helping companies improve in these areas. Focused training efforts based on the type of productivity improvement required in each industry might be beneficial to firms. As our analysis suggests, each company within an industry is likely to have different gaps and opportunities and firms need to identify the specific areas in their operations which will require productivity improvements. Focused training effort based on the type of productivity improvement required in each industry might be beneficial to firms.

The significance of capital intensity (the ratio of depreciation to wages) for the chemical industry suggests that firms should attempt to use the correct mix of labour and capital[5]. These findings support the concerns raised by the working group on the Indian chemical industry set up by the Planning Commission of the Government of India; namely that plants in the industry are not built on a global scale; rather they are dispersed over a vast geographical area and operate on a scale suitable to service local demand. The working group also commented that many firms in the industry have ageing equipments and obsolete technology (Working Group on Indian Chemical Industry, 2006).

High interest rates on long-term loans act as an impediment to growth in all three industries. The NMCC report (2006) mentions that 'High interest rates and availability of credit are problems which hinder growth of industry'. It goes on to suggest that real interest rates will never be as low as global interest rates, although some parts of the Indian corporate sector are now allowed to borrow globally. Does it mean companies themselves have little to do in this regard? Will they depend on the government to take definite measures to reduce their interest burden? Our research shows that companies have large opportunities to pursue better financing of growth and lower cost of capital. Companies need to show consistent results and sound financial practices to gain investor confidence. They need to identify opportunities where they can reduce their risks and interest costs.

For all the three industries, firm size has the largest significantly positive impact on investment growth. This finding might be linked to better access to funds and better credit terms for large firms. Size might also be important for obtaining business from large customers. The implication for policy is two-fold: large firms can be encouraged to support development and growth of their suppliers and a mechanism can be created to identify and support innovative small firms, for example via an analysis of outliers based on performance data. This might enable a consortium of innovative firms to have better access to capital. The larger firms can be encouraged to invest in their ancillary development activities and work closely with their suppliers to develop their products and processes. This will not only ensure quality and timely delivery but will also develop the scale and breadth of capabilities in the innovative smaller firms. Thus, the larger firms will be able to better plan their product development efforts and bring products faster to the market. Building long-term relationships with suppliers and investing in their development will help the bigger firms and their suppliers in their growth and market expansion plans, (Ittner & Larcker, 1997). Here again, the automotive industry has led from the front. Most of the Indian and multinational automotive OEMs have invested in developing the capabilities of their suppliers, which have created growth opportunities for all the firms (Wielgat, 2002; www.tata.com/tata_motors/releases/20050505).

Surprisingly, we do not find DELL (change in labour cost) to be a significant factor for investment growth for any of the industries; moreover, its coefficient is positive in two industries and negative and close to zero in one industry. This might be because of unfavourable labour laws in India that do not allow retrenchment. Both the World Bank survey and NMCC report mention unfavourable labour laws as preventing growth. Our results attest to this. Apparently, firms shy away from use of labour to expand capacity. A follow-up study on the choice of technology and methods used for expansion vis-à-vis the available labour is necessary to verify this conjecture.

Our results suggest that distribution and logistics costs do not act as an impediment for investments. Though infrastructural bottlenecks need to be removed, firms have been able to grow despite the bottlenecks. Similarly firms' spending on marketing and R&D also do not impact investment decisions. To further understand these findings, we studied the factors that impact variations in investment growth *between* firms. The results (not shown) indicate that selling and distribution expenses as percentage of sales (DISTS), marketing and advertising expenses as percentage of sales (MKTGS) and R&D expenses as percentage of sales (RDS) do not affect even investment growth between-firm variations. One way of interpreting this result is that these factors are immaterial for making investment. However, the survey findings of the World Bank and our discussions with managers lead us to conjecture that there might be another explanation: Any advantage or disadvantage that firms possess due to logistics, marketing, R&D or location cannot be easily capitalised to expand their share of the market. Thus, a firm that is excellent at distributing products locally might be unable to do so nationally. Similarly, locating in a favourable state might still limit growth because of saturation in these states, high cost of land and labour, etc. A study focused on the relationship between the advantages conferred by these factors and the ability to increase revenue will help confirm or disprove this conjecture.

Hayes (1992) noted that in a rapidly changing environment, a close understanding of the outliers would be more useful in understanding what is going on rather than ascertaining the central tendencies and trends of the data. Analysis of outliers helped us to determine why some firms

[5] Discussions with managers indicate that there is a shortage of skilled labour as well as qualified engineers to manage in these industries. One of the authors worked for a firm that used their engineers and consultants to make innovations and initiate new projects at the operational levels in several chemical industries. Thus, the correct mix might simply mean employing better qualified workers and engineers and paying higher salaries and wages to retain them, who in turn ensure better productive utilisation of assets.

Table 9 Analysis of outliers with regard to investment growth.

Auto components				
Variables	Industry average	Firm A average	Firm B average	Firm C average
VADEP	5.94	6.52	11.47	3.07
INTL	6.23	4.71	5.96	11.11
LNNFA	4	6.56	2.46	4.56
INVG	22.01	54.69	53.22	−2.77

Chemicals			
Variables	Industry average	Firm A average	Firm B average
VADEP	4.75	3.59	4.96
DEPSAL	1.01	0.94	0.19
INTL	8.19	7.79	10.27
LNNFA	4.25	5.96	5.25
INVG	8.54	33.98	−23.39

Electronics			
Variables	Industry average	Firm A average	Firm B average
NVALAB	2.2	3.12	0.81
DEPSAL	0.64	0.32	0.86
INTL	5.87	2.62	10.77
LNNFA	2.67	1.26	4.67
INVG	10.47	62.78	−5.47

performed better (or worse) than others with regard to investment growth during the study period. We isolated outlier firms based on the criteria described below. The names of firms are concealed. We identified the extreme residual values from the Hausman—Taylor estimation and also obtained the Cook's *d* and studentised residuals from pooled OLS regressions. The firms represented in the table showed up as outliers according to both statistics. The analysis is given in Table 9. The first two firms in the auto components industry outperform the rest whereas the firm in the last column is an underperformer. For chemicals and the electronics industries, the first firm outperforms others while the second firm is an underperformer.

The outlier analysis for the auto component industry generates some interesting insights. Firm A is a very large company that manufactures forged components. It has lower interest costs and higher capital productivity compared to the industry average and is thus able to invest aggressively. Firm B makes industrial valves. Despite its small size it has been able to invest aggressively due to its high capital productivity. Firm C makes electrical components. Due to its low capital productivity and high interest costs, it has been forced to cut down on its investments.

In the chemicals industry, Firm A is a soda ash manufacturer using state-of-the-art technology. With regard to capital productivity, it is not in a very favourable position compared to the industry average, but its size and lower interest on long-term loans might have created enough incentive to invest. Firm B manufactures industrial solvents and rubber chemicals. After a continuous decline in investment growth for three consecutive years, the firm has posted investment growth of 45.8% in 2005—2006. It is in a favourable position with respect to the industry average on all significant variables except interest on long-term loans. Thus, high cost of capital might have created enough deterrence for the firm not to invest.

In the electronics industry, Firm A makes telecom equipment. It is smaller than the industry average but its high labour productivity and lower interest costs probably enable it to invest aggressively. Firm B makes components for consumer durable products. It is a big firm and it has not been able to invest probably because of low labour productivity and high interest costs. We see that the predictions based on analysis of outliers are more or less in line with the main findings. Thus, the qualitative analysis supports the quantitative findings.

Limitations and scope for future work

There are several limitations to our study. The study has focused on three sectors in manufacturing. Though the results are consistent, the findings cannot be generalised across the manufacturing sector in India. Also, the industries in India are only now getting exposed to intense competition and, at the same time, facing growing demand for new products and services. Thus, this study might have failed to capture data on investment projects that are at the planning stage. Finally, states that have been labelled as having an unfavourable investment climate might be making attempts to woo investors through subsidies, grants of land and other incentives. These factors are not included in the study.

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References

AEDE,Asia Eco Design Electronics. (May 2007). *Country report on the Indian electronics sector*.

Ahluwalia, I. J. (1985). *Industrial growth in India*. Delhi: Oxford University Press.

Ahluwalia, I. J. (1991). *Productivity and growth in Indian manufacturing*. Delhi: Oxford University Press.

Arntzen, B. C., Brown, G. G., Harrison, T. P., & Trafton, L. L. (1995). Global supply chain management at digital equipment corporation. *Interfaces, 21*(5), 69—93.

Balakrishnan, K., Iyer, A., Seshadri, S., & Sheopuri, A. (2006). Indian auto supply chain at the cross-roads. *Interfaces, 55*(5), 866—875.

Baldwin, C. Y., & Clark, K. B. (1992). Capabilities and capital investment: new perspectives on capital budgeting. *Journal of Applied Corporate Finance, 5*(2), 67—82.

Barney, J. (1986). Strategic factor markets: expectations, luck and business strategy. *Management Science, 32*(10), 1231—1241.

Berry, W. L., Hill, T., & Klompmaker, J. E. (1999). Aligning marketing and manufacturing strategies with the market. *International Journal of Production Research, 37*(16), 3599—3618.

Chandra, P. (2009). Competitiveness of Indian manufacturing: findings of the third National manufacturing survey. *Report Submitted to the National Manufacturing Competitiveness Council, March 2009*. http://www.iimb.ernet.in/~chandra/NMCC%20Report%202009.pdf.

Crandall, N. F., & Wooton, L. M. (1978). Developmental strategies of organizational productivity. *California Management Review, 21*(2), 37—46.

Dhawan, R. (2001). Firm size and productivity differential: theory and evidence from a panel of US firms. *Journal of Economic Behavior and Organization, 44*(3), 269—293.

Dierickx, I., & Cool, K. (1989). Asset stock accumulation and sustainability of competitive advantage. *Management Science, 35*(12), 1504—1511.

Dixit, A. (1980). The role of investment in entry deterrence. *The Economic Journal, 90*, 95—106.

Fazzari, S., Hubbard, G., Peterson, B. C., Blinder, A. S., & Poterba, J. M. (1988). Financing constraints and corporate investment. *Brookings Papers on Economics, 1988*(1), 141—206.

Funk, M., & Strauss, J. (2000). The long-run relationships between productivity and capital,. *Economics Letters, 69*, 213—217.

Gimenez, C., & Ventura, E. (2005). Logistics-production, logistics-marketing and external integration: their impact on performance. *International Journal of Operations and Production Management, 25*(1), 20—38.

Goldar, B. N. (1986). *Productivity growth in Indian industry*. New Delhi: Allied Publishers.

Gomes, J. (2001). Financing investment. *The American Economic Review, 91*(5), 1263—1285.

Grant, R. M. (1991). The resource-based theory of competitive advantage: implications for strategy formulation. *California Management Review, Spring 1991*, 114—135.

Greene, W. H. (2003). *Econometric analysis* (Fifth Edition).. New Jersey: Pearson Education, Inc.

Hayes, R. S. (1992). Production and operations management's new "requisite variety. *Production and Operations Management, 1* (3), 249—253.

Hendricks, K. B., VSinghal, R., & Wiedman, C. I. (1995). The impact of capacity expansion on the market value of the firm. *Journal of Operations Management, 12*, 259—272.

Hsiao, C., & Tahmiscioglu, A. K. (1997). A Panel analysis of liquidity constraints and firm investment. *Journal of the American Statistical Association, 92*(No 438), 455—465.

Ittner, C. D., & Larcker, D. F. (1997). The performance effects of process management techniques. *Management Science, 43*(4), 522—534.

Iyer, A., Saranga, H., & Seshadri, S. (2006). *Productivity and technical changes in the Indian auto component industry, working paper Stern School of Business*. NY: New York University.

Judson, A. S. (1984). Productivity strategy and business strategy: two sides of the same Coin. *Interfaces, 14*(1), 103—115.

Khanna, T., & Palepu, K. (2000). Is group affiliation profitable in emerging markets? An analysis of diversified Indian business groups. *Journal of Finance, 55*(2), 867—891.

Khanna, T., & Palepu, Krishna (2004). *The evolution of concentrated ownership in India—broad patterns and a history of the Indian software industry*. NBER Working paper No. 10613.

Krugman, P. (1994). The myth of Asia's miracle. *Foreign Affairs, November/December, 1994*.

Kumar, J. (2004). Shareholding pattern and firm performance. http://econpapers.repec.org/paper/wpawuwpfi/0409008.htm.

Lee, H. L., Padmanabhan, V., & Whang, S. (1997). Information distortion in a supply chain: the Bullwhip effect. *Management Science, 43*(4), 546—558.

Lieberman, M. B. (1987). Excess capacity as a barrier to entry: an empirical appraisal. *The Journal of Industrial Economics, 35*(4), 607—627.

Lieberman, M. B., & Montgomery, D. B. (1987). *First mover advantages*. Research Paper No. 969. StanfordBusiness School.

Love, Inessa. 2001. *Essays on financial development and financing constraints*. Phd dissertation, ColumbiaUniversity

NMCC. (2006). *The national strategy for manufacturing*. New Delhi: Government of India National Manufacturing Competitiveness Council.

Porter, M. E. (1985). *Competitive advantage: Creating and sustaining superior performance*. New York,: The Free Press.

Porter, M. E. (1990). *The competitive advantage of nations*. New York: The Free Press.

Pradhan, G., & Barik, K. (2000). Sustainability of output growth in Indian manufacturing: a decomposition analysis of selected industries. *Economics Working Paper Series, 2000*, 14.

Raouf, A. (1994). Improving capital productivity through maintenance. *International Journal of Operations and Production Management, 14*(7), 44—53.

Samuelson, P. A. (1947). *Foundations of economic analysis* (1983 edition).. Cambridge, Massachusetts: Harvard University Press.

Schmenner, R., & Swink, M. (1998). On theory in operations management. *Journal of Operations Management, 17*(1), 97—113.

Schroeder, R. G., Bates, K. A., & Junttila, M. A. (2002). A resource-based view of manufacturing strategy and the relationship to manufacturing performance. *Strategic Management Journal, 23* (2), 105—117.

Skinner, W. (1986). The productivity paradox. *Harvard Business Review, July—August*, 55—59.

Smiley, R. (1987). Empirical evidence on strategic entry deterrence. *International Journal of Industrial Organization, 6,* 167—180.

Stock, G. N., Greis, N. P., & Kasarda, J. D. (1998). Logistics, strategy and structure —a conceptual framework. *International Journal of Operations and Production Management, 18*(1), 37—48.

Wheelwright, S. C. (1981). Japan-where operations are really strategic. *Harvard Business Review, 59*(4), 67—74.

Wielgat, A. (2002). "Manufacturing the Mahindra way: India's largest SUV maker turns the design, development and testing reigns over to its suppliers. Could mainstream OEMs be next?". *Automotive Industries, October 2002*.

Working Group on Indian Chemical Industry. (2006). *Indian chemical industry scenario*.

World Bank and International Finance Corporation. (2004). *Investment climate assessment-India: Investment climate and manufacturing industry.*

Websites

http://acmainfo.com/

http://www.ibef.org/industry/autocomponents.aspx

www.tata.com/tata_motors/releases/20050505.htm "Tata Motors to introduce India's first mini truck", May 5, 2005.