Determinants of Inventory Trends in the Indian Automotive Industry: An Empirical Study

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Abstract

Inventory Management has emerged as one of the important tools to improve operational efficiency over the last 30-40 years across the globe. Japanese companies such as Toyota pioneered lean manufacturing, which emphasizes on the need to maintain low inventory levels across the supply chain through practices like JIT, Kanban and vendor managed inventory etc. Anecdotal evidence suggests that, inventory levels in general have been falling in the Indian manufacturing industries too in the recent past. The Japanese influence on the Indian manufacturing industry began with the entry of Suzuki into the Indian automobile industry in mid eighties. Since then, the principles of lean manufacturing have permeated across many industries, especially the automotive sector in India. However, there is scant empirical research in the literature that documents the inventory trends and the determining factors in India. The current study aims at filling this gap through a comprehensive inventory trend analysis in the Indian automotive industry during the 14 year period 1992-2005 with an objective to determine the inventory trends and identify the influencing factors. We use advanced econometric models to study the impact of various factors, such as the firm's cluster, tier, export and import intensity on inventory levels. The study finds that average inventory has been steadily declining, with all three inventory components, viz., raw material, work-in-process and finished goods inventory contributing to this decline. The results suggest that the efficient working capital management and the quality improvement efforts of Tier 1 firms have been one of the major contributions to the decline in average inventory levels in the Indian auto industry.

Keywords: Inventory Trends, Static Panel Data, Indian Automotive Industry, GLS

1. Introduction

Inventory reduction is touted to be one of the key strategic levers to improve productivity and profitability of the firm in theory and practice (Lieberman and Demeester 1999, Chen et al, 2005). Popularized by the Japanese manufacturing firms, such as Toyota, who attributed their success at home and away to the adoption of Just in Time (JIT) and lean manufacturing practices, inventory reduction became one of the primary means to achieve operational excellence for many world class firms across the globe since 1970's (Zipkin 1991, Lieberman and Demeester 1999). In the recent past, firms have begun to understand the need for efficient inventory management, not just at firm level, but across the entire supply chain to reap the full benefits. The popularity of concepts like the *bullwhip effect* and the rigorous measures being taken to reduce the bullwhip effect across the supply chain stem from this understanding (Cachon and Fisher 2000; Crosson and Donohue, 2006). In discrete industries like the automobiles, where the cost of raw material accounts for almost 50-60% of the cost of the final product, inventory levels can have a significant impact on firm profitability.

Consequently, the automobile industry presents a perfect opportunity to study the impact of inventory on firm performance at various levels not only due to the widespread diffusion of best practices like JIT, lean, kanban etc. in this industry but also due to its tiered structure involving multiple channel partners. There have been many studies, both empirical and case based, focused on automobile industries from the developed economies such as the US, Europe and Japan (Womack et al 1990, Lieberman and Asaba 1997, Lieberman and Demeester 1999) that explore the causal relations between inventory and performance at firm level. However, there is very little empirical work that investigates the percolation of best practices across the automotive supply chain through inventory related links amongst various tiers. One of the few studies that comes closest to addressing this issue is the empirical study of 52 Japanese automotive firms by Lieberman and Demeester (1999) that includes all auto assemblers and 41 first tier part suppliers, and finds that inventory reduction served as an important driver of process improvement and stimulated productivity gains for many of these sample firms. These findings in fact are expected, since it studies Japanese automobile industry, including Toyota and its suppliers, which is the pioneer of JIT and lean manufacturing. A prior study (Lieberman and Asaba 1997), which compares the Japanese and US auto industries, also finds significant inventory reductions and corresponding productivity gains for Japanese automakers and suppliers alike, however finds that while the US automakers have made substantial inventory reductions and enjoyed subsequent gains in productivity since the 1980s, the US automotive suppliers have stagnated along both these dimensions.

In the recent times, a significant share of global manufacturing, including the automobile industry, is being shifted gradually to the low cost locations, starting with the regional tie-ups with MERCOSUR, East European and ASEAN countries in the early 1980s to the recent outsourcing and establishment of marketing and production facilities in emerging economies such as China and India (Humphrey and Memedovic 2003). Many multinational automakers and their Tier 1 suppliers have established operations in India owing both to its market potential and low cost supplier base (Saranga, 2008). The Indian automobile industry subsequently, is touted to become the global hub for small car manufacturing, encouraged by the recent launch of the world's cheapest car (Tata Nano, costing $2,500) by a domestic automaker and subsequent plans by other automakers to make India as a base for small car production[1]. In this context, it is interesting to determine to what extent the global best practices such as the inventory reductions and the corresponding performance improvements have diffused into the Indian automobile industry, especially being a mixed economy with both private and public sector presence but under the protected regime until recently. India also presents a contrasting example to study due to its slow paced liberalization where despite the entry of Japanese automaker in the form of Suzuki during the partially liberalized era of 1983 – 1991, there was no pressure for change on the domestic firms since competition was minimum with a captive customer base; as against the case of the US and Western Europe, where the domestic automakers and the component suppliers were forced to adopt lean practices owing to the tremendous competition presented by the entry of Japanese automakers.

In the current empirical study we investigate the aggregate trends in inventory holdings and their impact on firm performance in the Indian auto industry. In order to capture the most appropriate phase of Indian economic

[1] http://www.ibef.org/artdisplay.aspx?tdy=1&cat_id=60&art_id=19879

liberalization which began in earnest in 1991, we use inventory data pertaining to the period 1992-2005. The findings indicate that there was significant reduction in inventory levels across the three tiers of the industry, viz., automakers (Tier 0), Tier 1 and Tier 2 suppliers. A subsequent decomposition of inventory into raw materials (RM), work in progress (WIP) and finished goods inventory (FGI) shows that all three components of inventory have reduced significantly across three tiers, except for Tier 2 which experienced an increase in FGI. The results are found to be robust when tested with more advanced econometric models and addition of macro level and firm specific control variables.

The rest of the paper is organized as follows. In section 2 we give a brief description of the Indian auto industry and develop the inventory trend hypotheses across tiers. In section 3 we describe the data and present the empirical methodologies. We discuss the results and their implications in section 4 and finally conclude in section 5.

2. The Inventory Trends in the Indian auto industry

The auto industry in India has been undergoing rapid changes in the post-liberalization phase which began in 1991, with the entry of significant number of multinational automakers and many new auto models available in the market (Balakrishnan et. al. 2007). A significant restructuring of the industry is taking place with the automakers, also known as the original equipment manufacturers (OEMs), looking to outsource as many components as possible on one hand and minimize the number of direct suppliers on the other hand. To meet the demands of OEMs the supplier industry in response is restructuring into distinct tiers following in the footsteps of the global auto component industry. There is already a clear distinction between a Tier 1, which supplies major assemblies and sub assemblies to the OEMs, a Tier 2 which supplies components to Tier 1 and an emerging Tier 3, which most often consists of very small players that carryout odd jobs like machining, welding and heat treatment of parts for Tier 2 (Okada, 2004). There is some empirical and anecdotal evidence to suggest that quality and operations related global best practices such as Quality Management Systems (QMS), Total Quality Management (TQM), Total Productive Maintenance (TPM), lean, JIT, cellular manufacturing etc. (Khanna et al, 2002; Seth and Tripathi, 2005; Iyer et al, 2008) have diffused into various tiers, especially in the downstream suppliers of the Indian auto industry post liberalization.

Various factors have influenced this diffusion of best practices, which began with the entry of Japanese automakers into the passenger and commercial vehicle segments in the early and mid 80's. Commencing the partial liberalization of the auto industry in the year 1983, the Indian government fostered a joint venture collaboration between Maruti Udyog Ltd (MUL), a public sector company, and the Japanese automaker, Suzuki Motor Corporation (SMC) for manufacturing small cars; and allowed four more Japanese automakers, viz., Toyota, Mitsubishi, Nissan and Mazda into the commercial vehicle segment through joint venture partnerships with privately owned Indian automakers (D'Costa, 1995). Three important factors ensured that the Indian auto component firms did not succumb to the denationalization trend that occurred in other developing nations such as Mexico and Brazil post the entry of multinational companies (MNC), but in fact developed into a strong supply chain that is now geared to integrate into the global auto chain. First being the Indian government's Phased Manufacturing Program (PMP) that mandated 70% local content within 5 years of market entry (Tewari 2001), while the second, the more interesting factor being the Japanese practice of subcontracting and long term supplier relationships, combined with the Indian government's stipulation of minority equity partnerships with foreign companies. The Japanese emphasis on quality and subcontracting coupled with the local content requirements forced them to forge joint venture partnerships between local suppliers and Japanese technology providers (D'Costa, 1995). The more established Indian suppliers took this opportunity to develop strong relationships with Japanese automakers and their Tier 1 suppliers in Japan and began upgrading their technological capabilities.

Inventory Trends in the Indian auto industry

When the full economic reforms came into effect in early 1990's, the Indian auto component industry was getting organized in anticipation of the entry of more MNCs and higher competition in the passenger car market, which till then was monopolized by the Maruti-Suzuki partnership. More importantly, the established domestic component manufacturers belonging to popular business groups such as TVS, Rane and Murugappa etc., who were already Tier 1 suppliers to the domestic auto market were in the process of implementing the global best practices in order to bag contracts from new entrants and integrate into the global supply chain. These initiatives include ISO quality certification, adoption of TQM principles, implementation of Toyota Production System (TPS) and TPM (Seth and Tripathi, 2005) etc. While the ISO and TQM established procedures and systems to monitor quality of processes and to minimize defects, TPS advocates lean manufacturing with special emphasis on (i) setup time reduction and (ii) pull production. All the above initiatives are known to reduce inventories, e.g., while pull production is associated with made to order, thus minimizing the FGI, reduced setup times allow for smaller lot sizes and hence lower WIP, improved machine maintenance through TPM decreases the need for buffer inventories and so do TQM efforts which reduce rework and scrap through lower number of defectives (Lieberman and Demeester, 1999).

Even the domestic automakers like the TELCO (renamed as Tata Motors recently), Mahindra & Mahindra, Eicher and Ashok Leyland who had presence in the commercial vehicle segment geared up for upcoming competition with similar initiatives that helped improve operational efficiencies and reduce WIP inventories. The first two of these automakers in fact made a successful entry into the passenger vehicle segment in the late nineties. As a result, Tata Motors today enjoys a market share of 12.7% in the passenger vehicle segment. The presence of Japanese companies in the Indian auto industry helped significantly to diffuse these best practices across the spectrum. The domestic OEMs, who until early nineties were more vertically integrated in comparison to their Japanese counterparts, realizing the benefits of outsourcing, began sourcing most of their component requirement from Tier 1 suppliers. This strategic shift has been attributed to the availability of quality conscious supplier base that is also cost effective thanks to the vendor development initiatives of Suzuki and other Japanese OEMs (Parhi, 2005). Over time, in line with global practices, the OEM industry is moving towards pure assembly operations delegating many production activities to Tier 1 suppliers, in fact embarking upon a modularized design that needs least amount of time for assembly. This in turn is transforming the role of Tier 1 suppliers into designers and assemblers of modules such as dash boards, seats, rear axel assemblies etc. (Humphrey, 2003) encouraging them to source sub modules and parts from Tier 2 suppliers. This strategic shift towards outsourcing coupled with streamlining of vendors into multiple tiers with inventories spread across possibly contributed to reduction of average raw material inventories carried by any one player in the chain.

The story is slightly different and more complicated for the FGI. While the industry is moving towards more customized products built to order that should reduce FGI, the mushrooming of a wide variety of models across the spectrum of automakers and increased competition is forcing the automakers to maintain higher FGI to increase the service levels. The higher buyer power of OEMs coupled with their insistence on JIT deliveries is expected to increase FGI levels at the Tier 1 end. On the other hand many Tier 1 firms have setup facilities in vendor parks, close to the OEM assembly lines, and have been aggressively implementing lean production initiatives in order to produce just in time, which if succeeded should reduce the FGI.

Hence we posit our first set of hypotheses:

> **Hypothesis 1a:** Average Inventory reduced significantly in the Indian auto industry, in OEM as well as the two supplier segments viz., Tier 1 and Tier 2.

Hypothesis 1b: All three components of inventory, namely, raw material, work in process and finished goods reduced significantly in the Indian auto industry, in OEM as well as the two supplier segments viz., Tier 1 and Tier 2.

Tier-wise Performance in Inventory Reduction

Taking advantage of the trade reforms of 1990's, which allowed majority foreign ownership many MNC automakers such as Daewoo, GM, Ford, Mercedes, Hyundai, Chrysler, Fiat, Toyota, Honda and Nissan made their entry into the Indian auto market. Following the global practice of follow sourcing, these MNC automakers encouraged their Tier 1 suppliers to setup production facilities in India. Although many large global Tier 1 firms like Delphi, Visteon and Denso have followed their customers into India - either through joint ventures with the domestic component firms or as wholly owned subsidiaries of their parent companies - other component manufacturers, especially from Tier 2 did not find Indian markets very attractive, owing especially to the lower volumes. Also, many a time the global designs had to be modified to meet local driving conditions, consumer preferences and purchasing power (Humphrey, 2003). These factors coupled with the need to meet local content requirements, forced the MNC OEMs and their follow sources to forge technology joint ventures and close ties with the domestic component firms. While the technology joint ventures help the domestic firms to leapfrog into production of new products without reinventing the wheel, the quality standards at competitive costs are a pre-requisite to bag these contracts. The serious TQM efforts of many domestic Tier 1 firms that began in late eighties and resulted in many quality awards including 10 Deming[2] application prizes have paved their way to attract MNC attention (Iyer *et al*, 2006). The domestic firms grabbed the new opportunities and reciprocated strongly by taking advantage of MNC's vendor development programs and internalizing their best practices to further improve their internal operations[3].

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[2] Deming Application Prize is one of the most prestigious quality award granted by Japanese Union for Scientist and Engineers (JUSE) for implementation of TQM that results in significant process improvements.

[3] Eventually many domestic Tier 1 firms became preferred suppliers, in some cases, sole suppliers of a specific module/component to the MNC OEMs. Sundaram Fasteners, a manufacturer of radiator caps, for

The most popular quality initiative adopted by many auto component firms in the early 90's was the ISO 9000 quality certification, which was considered mandatory for auto component firms across the globe to get supply and export contracts from the OEMs (Corbett, 2006). A firm seeking ISO 9000 certification needs to design procedures to ensure quality is constantly measured and appropriate corrective actions are taken whenever defects occur. These procedures instill a quality discipline in the certified firm and enable them to identify defects/mistakes at an early stage (Corbett *et al*, 2004), which results in lower processing time ultimately reducing the WIP inventory. The benefits of TQM are typically attributed to better process and materials management, fewer line defectives, lesser amount of rework, continuous improvement and incremental innovation (Deming, 1982; Seth and Tripathi, 2005). Better understanding of process performance by shop floor employees coupled with the relevant training helps identify production problems such as machine failures and defective production. Once the problem becomes visible, the TQM training of workers in continuous improvement methods like Plan-Do-Check-Act (PDCA) enables them to determine root cause of the problem and design, test and implement a solution, which drastically reduces the number of defectives at the end of the line (Lieberman and Demeester 1999). Reduction in number of line defectives obviously lead to lesser wastage and savings in terms of material, worker time, machine time etc. and help improve the reliability of the process. Improvements in process reliability and reduction in setup times usually reduce need for buffer inventories resulting in shorter cycle times which in turn allow one to further cut down on the WIP levels.

However, the interviews with the OEMs and component firms reveal that the best practices did not percolate upstream into the Tier 2 firms as much. These findings are not surprising since Tier 2 firms are not in direct contact with the OEMs and Tier 1 firms themselves being in a state of transformation would not have the abilities or the resources to influence Tier 2 significantly. Most Tier 2 firms belong to the small scale sector which

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example, became single source supplier for General Motors, supplying their entire global requirement from a plant located in Chennai, India.

is even today considerably unorganized further hampering any efforts of upgrading by the Tier 1 (Kumaraswami *et al*, 2008).

Thus we expect the Tier 1 firms who seem to have implemented effective quality initiatives to be associated with greater reductions in WIP inventory levels than the other two tiers and posit our second hypothesis as follows:

Hypothesis 2: Tier 1 is more efficient in work in process (WIP) inventory management than Tier 0 and Tier 2.

3. Data Description and Methodology

3.1 Dataset

We built our dataset on 58 firms in the auto components industry over a 14 year period beginning from 1992 by accessing a detailed India specific industry database *Prowess,* maintained by the Center for Monitoring Indian Economy (CMIE)[4]. Prowess is a database of large and medium sized Indian firms containing detailed information on over 9,300 firms comprising all companies traded on India's major stock exchanges and several others including the central public sector enterprises. The Prowess database covers all listed companies and public limited companies in India, irrespective of their size. It provides detailed up-to-date information on each company for over ten years. The data includes a normalized database of the financials covering 1,500 data items and ratios for each firm. Data is collected by Prowess from annual reports that are publicly available in case of public limited companies. Data on market-share, stock price etc. is also collected for the listed companies from two stock exchanges in India, namely, the National Stock Exchange (NSE) and the Bombay Stock Exchange (BSE). Prowess also provides quantitative information on production, sales, consumption of raw material and energy.

One of the main limitations of the Prowess database is that it stores data on publicly traded companies and listed companies; hence the set of privately owned

[4] http://www.cmie.com

http://www.cmie.com/products/index.htm

companies that are not listed in any of the stock exchanges are not in our sample. Prowess also does not provide data on firms in the unorganized sector, which consists of very small firms that mainly cater to the spare part market. Since all our data comes from Prowess database, our sample does not represent these sectors of the auto component industry. Under the 'Transport Equipment' category for Indian Manufacturing firms, Prowess reports data on over 300 companies. However, this is not a complete listing with omissions for some variables as well as of firms in some years. Thus, we focus on a subset of 58 firms for which we have data on dimensions of interest for this study for every year between 1992 and 2005.

In this sense, our panel is balanced with complete observations on a number of real and financial variables for each of these auto-component firms. Traditional panel data structures usually have two or three years of time series data on a large number of cross-sectional units; our dataset however departs from this structure by having not only a large set of cross-sectional units, but a large number of time-series observations on each of the cross-sectional units (14 repeated observations on each firm) that allows us to investigate very rich specification for temporal as well as cross-sectional dependence within the data.

Since the Indian auto industry is mainly concentrated in 3 specific regions of India, one in the North around Delhi/Gurgaon area; one in the West around Mumbai/Pune area and the third in the South, around Chennai/Bangalore/Sri Perumbudur/Coimbatore area (Kumaraswami *et al*, 2008). Many earlier studies have explored the network externalities due to clustering effects in the Indian auto component industry (Okada, 2004; Parhi, 2005). Using the location data from the Prowess database on of each sample unit, we have divided the full sample into three different clusters, viz., South cluster, North cluster and West cluster. Please see Table 10 in Appendix for corresponding share of each cluster in our sample. In order to control for any possible variation in inventory holdings in different clusters, we use cluster dummies in our empirical study. Another important classification we wanted to study is the tierization of the industry. However to our knowledge, there is neither a database nor any other data source that provides the tierization in the Indian auto industry. Therefore we undertook a detailed study to categorize all the firms in the Prowess database into three different tiers, viz., Tier 0 (OEMs), Tier 1 and Tier 2. It is relatively easier to identify the Tier 0 firms from the publicly available data on automakers. However, the categorization of component firms into Tier 1 and Tier 2 is not that straight forward, since many component firms supply to both OEMs and Tier 1s.

In the global auto industry, a firm that supplies directly to the OEMs is considered as Tier 1, while a firm that supplies to Tier 1 is considered Tier 2 and so on. We too carryout tierization of the Indian auto component firms based on this definition. For Tier 1 and Tier 2, we carried out the classification in two stages. In the first stage, we collected the data on the customer base of all component firms and classified the firms whose major share (60% or more) of the customer base constitutes Tier 0 (OEM) as Tier 1 (since some firms in the Indian context still supply to both OEMs as well as Tier 1s). On the other hand if a majority of a firm's customer base constitutes Tier 1 then it is classified as Tier 2. We also asked two industry experts (each one separately), with more than 15 years experience in the automobile industry to do the classification based on their knowledge of dealing with vendors. In the second stage, we compared our classification which was based on a firm's customer base with the classifications of the two industry experts. Whenever there were discrepancies (which were very few) between the 3 classifications, we went with the classification that matched at least in 2 sets, otherwise went to a third industry expert for second opinion. This exercise resulted in classification of our sample of 58 firms into 13 Tier 0 firms (OEMs); 36 Tier 1 and 9 Tier 2 firms. Since we are using a panel dataset consisting of 14 year time period, the size of the each sub sample is big enough for us to carryout the empirical tests. We report the descriptive statistics of the full sample and sub samples corresponding to each of the three tiers below.

Table 1 Descriptive Statistics for the Full Sample

Variable	**Number of Observations**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
Average Inventory Days	812	71.52	42.35	4.75	345.30
Average Raw Material Inventory Days	812	58.71	41.53	2.43	351.85
Average Finished Goods Inventory Days	812	15.09	15.33	0.00	130.87
Average Work in Process	812	18.26	20.19	0.65	155.39

Inventory Days					
Age of the Firm	812	30.62	20.53	1.00	104.00
Cost of Sales	812	487.20	1365.00	2.05	15114.06
Total Assets	812	495.19	1397.41	5.22	13849.19
Average Days of Debtors	812	58.11	33.62	2.83	260.29
Average Days of Creditors	812	65.09	31.24	2.23	209.80
Exports as % Sales	812	6.43	9.94	0.00	82.93
Imports as % Sales	812	8.67	7.63	0.00	61.81
Return on Capital Employed	812	26.60	32.27	-85.76	792.08
Gross Value Added (Rs Crores)	812	118.78	313.68	0.08	3339.55
Standardized Value Added (GVA/Cost of Sales)	812	0.30	0.14	0.00	0.96
PBDIT as % Sales	812	13.22	6.99	-10.89	44.20
PAT as % Sales	812	3.50	5.80	-28.60	19.15
Growth in Sales (%)	812	18.49	33.44	-64.41	718.40
Return on Investment	812	16.25	8.78	-14.94	46.84

Table 1 provides descriptive statistics for our sample on key variables used in our analysis. While Table 1 presents data for the aggregate sample, Table 2, Table 3 and Table 4 disaggregate the sample by the tiers of the auto-component firms, viz., Tier 0 (OEMs), Tier 1 and Tier 2. As may be noted from the mean Cost of Sales and Total Assets values in Table 2; Tier 0, the OEMs are typically large firms, with high average turnover and are highly capital intensive. On the other hand, as may be noted from the mean statistics of Tables 3 & 4, while Tier 1 firms are big and better established auto-component firms with the highest return on investment (ROI), Tier 2 firms are smaller firms that operate with lower assets, which validates our classification of Tier 1 and Tier 2 firms. The average age of all three tiers seem to be around the same range of 30 years; however, component firms from both tiers seem to be exporting more than the OEMs, which is again in line with the statistics from industry reports[5]. Amongst the three tiers, the evidence from the descriptive statistics suggests that the Tier 1 seems to be outperforming others in terms of returns and profit margins.

[5] http://www.acmainfo.com/#stat

Table 2 Descriptive Statistics - Tier 0 (OEMs)

Variable	**Number of Observations**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
Average Inventory Days	182	65.38	39.15	10.22	206.52
Average Raw Material Inventory Days	182	55.25	53.47	7.77	351.85
Average Finished Goods Inventory Days	182	16.00	13.27	0.00	64.21
Average Work in Progress Inventory Days	182	10.86	12.21	0.76	81.85
Age of the Firm	182	31.12	16.47	8.00	60.00
Cost of Sales	182	1813.17	2454.50	8.82	15114.06
Total Assets	182	1805.13	2536.31	11.82	13849.19
Average Days of Debtors	182	42.85	42.18	2.83	260.29
Average Days of Creditors	182	66.10	29.05	8.03	200.13
Exports as % Sales	182	4.28	3.73	0.00	17.48
Imports as % Sales	182	7.63	5.84	0.00	27.95
Return on Capital Employed	182	26.91	22.32	-28.88	97.77
Gross Value Added	182	419.69	564.26	0.88	3339.55
Standardized Value Added (GVA/Cost of Sales)	182	0.23	0.12	0.01	0.83
PBDIT as % Sales	182	10.67	5.41	-9.59	24.32
PAT as % Sales	182	3.22	5.29	-24.70	14.82
Growth in Sales (%)	182	16.06	23.68	-64.41	118.40
Return on Investment	182	13.46	10.78	-14.94	46.84

Table 3: Descriptive Statistics - Tier 1 Firms

Variable	**Number of Observations**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
Average Inventory Days	504	69.46	43.08	4.75	345.30
Average Raw Material Inventory Days	504	56.93	36.89	2.43	266.66
Average Finished Goods Inventory Days	504	11.78	13.27	0.00	130.87
Average Work in Progress Inventory Days	504	20.45	22.46	0.65	155.39
Age of the Firm	504	30.72	23.15	1.00	104.00
Cost of Sales	504	118.29	121.76	2.05	888.07
Total Assets	504	131.66	178.05	7.92	1679.69
Average Days of Debtors	504	58.59	29.90	4.90	190.82
Average Days of Creditors	504	61.88	31.31	2.23	209.80

Exports as % Sales	504	6.73	10.35	0.00	82.93
Imports as % Sales	504	9.54	8.12	0.00	38.77
Return on Capital Employed	504	27.22	37.66	-85.76	792.08
Gross Value Added	504	36.12	41.59	0.08	408.15
Standardized Value Added (GVA/Cost of Sales)	504	0.32	0.13	0.00	0.96
PBDIT as % Sales	504	14.01	6.33	-10.89	32.53
PAT as % Sales	504	3.78	5.92	-28.60	19.15
Growth in Sales (%)	504	20.66	38.07	-40.02	718.40
Return on Investment	504	17.34	7.74	-13.68	45.53

Table 4: Descriptive Statistics -Tier 2 Firms

Variable	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
Average Inventory Days	126	88.66	39.79	21.26	207.31
Average Raw Material Inventory Days	126	70.88	37.37	10.29	208.14
Average Finished Goods Inventory Days	126	27.05	19.30	0.87	92.16
Average Work in Progress Inventory Days	126	20.18	17.23	1.71	71.07
Age of the Firm	126	29.50	13.57	1.00	62.00
Cost of Sales	126	47.59	43.77	8.86	270.01
Total Assets	126	57.18	49.08	5.22	227.40
Average Days of Debtors	126	78.22	20.26	33.19	142.85
Average Days of Creditors	126	76.51	31.48	25.89	183.18
Exports as % Sales	504	6.73	10.35	0.00	82.93
Imports as % Sales	504	9.54	8.12	0.00	38.77
Return on Capital Employed	126	23.67	17.82	-42.71	90.21
Gross Value Added	126	14.81	11.74	1.13	55.33
Standardized Value Added (GVA/Cost of Sales)	126	0.34	0.16	0.08	0.86
PBDIT as % Sales	126	13.77	10.06	-9.15	44.20
PAT as % Sales	126	2.76	6.00	-19.10	15.34
Growth in Sales (%)	126	13.32	23.54	-38.09	113.29
Return on Investment	126	15.92	8.59	-14.60	40.26

3.2. Methodology

As discussed earlier, to test our two sets of hypotheses we investigate trends in inventory holding in our sample of firms during the time period 1992-2005 using parametric panel data analysis methods. Let ID_{it} denote the average number of inventory days for firm *i* in year *t*. We look at a standard one-way error component model given by equation (1) that allows us to control for unobserved firm specific effects that are invariant over time. Note that the vector $\mathbf{X}_{it}$ consists of all independent firm specific variables that vary over time as well as a linear time trend that captures the change in inventory holding over the 14 year study period. The key variable of interest in Equation (1) is the coefficient on time that is a linear counter for each year of observation going from 1 to 14. The coefficient on time would give the change in the average number of days of inventory holding for an additional year of being in business.

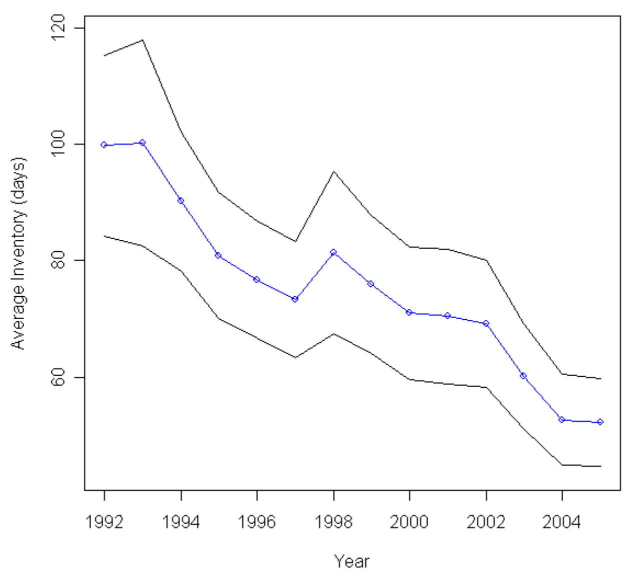
$$ID_{it} = \boldsymbol{\beta}\mathbf{X}_{it} + \mu_i + \nu_{it} \qquad (1)$$

We use the standard static panel regression model with various specifications and with somewhat differing subsets of our data (for example across tiers or clusters) to investigate how our estimated coefficients vary in these subsets of our data. We also look at the robustness of our results to various forms of failure of the independence and identically distributed error term assumption (iid) that is the benchmark static panel model. Briefly, equation (1) is the standard static panel data model where $\mathbf{X}_{it}$ are the various correlates for average inventory days. μ_i is the firm specific unobserved effect for each firm across all years, and ν_{it} is the idiosyncratic unobserved error term that varies by time and year. The implicit assumption needed to identify this model is that ν_{it} is distributed identically and independently (iid assumption). Driscoll and Kraay (1998) have generalized the standard covariance–variance matrix under iid to allow for heteroskedastic, and autocorrelated and correlated panels using nonparametric methods that are not sensitive to misspecification problems and are determined by the data itself. We use these Driscoll-Kraay corrected standard errors in our panel data models to ensure that our regression coefficients are consistent.

4. Results and Discussion

A cursory look at the average inventory levels over the years, as may be noted from Figure. 1 shows that inventory holding has been declining in the entire Indian Auto industry for the past decade and a half. The decline over this fourteen year period has been almost steady, except for in 1998 when inventory stocks went up across all manufacturing sectors due to the then ongoing economic slowdown due to the Asian financial crisis. The decline has not been perfectly linear but steady and halved by the end of the 1992-2005 period. Interestingly, the standard deviation has also declined over the same period to suggest that gains in inventory holding were distributed across the entire distribution of auto-component firms.

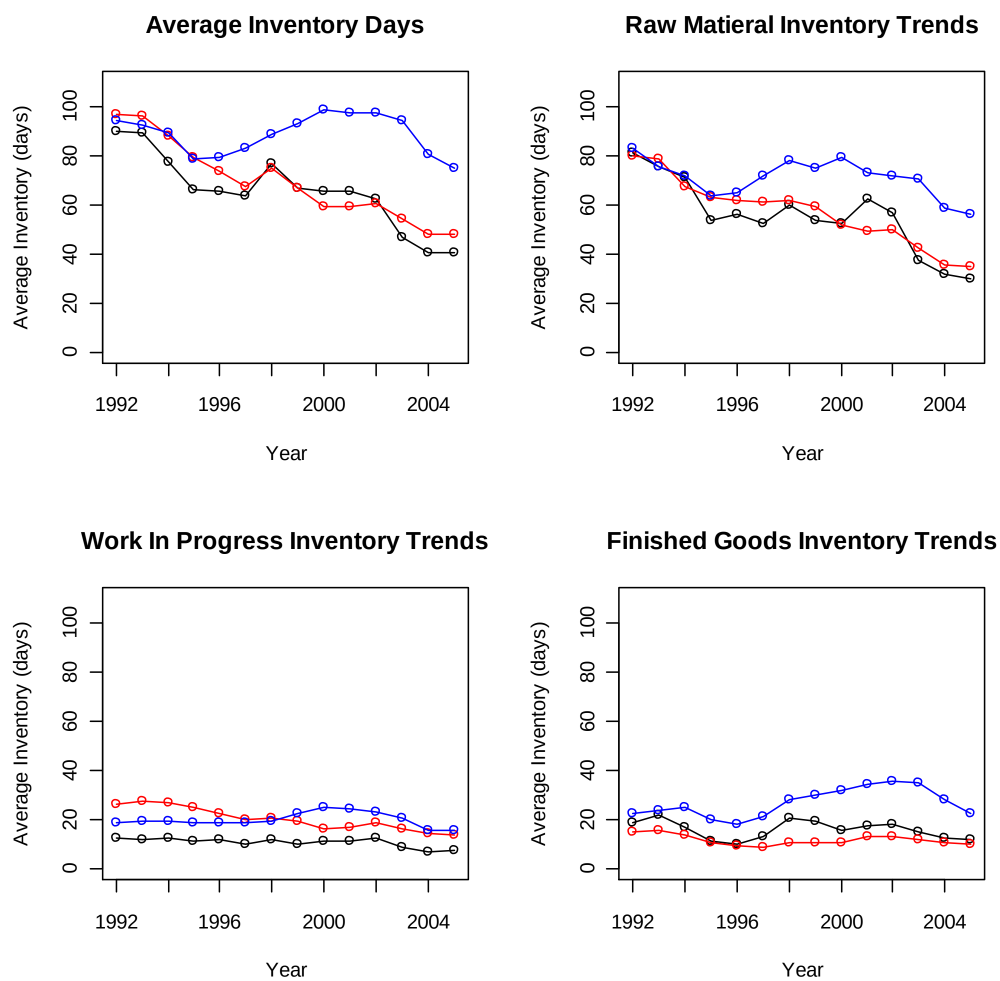
Figure 1: Mean Inventory for the Auto components Industry with 95% Confidence Interval



Note: The blue line plots the sample average of inventory days in the sample while the black lines plot the upper and lower 95% confidence interval limits.

The first quadrant in Figure 2, which provides the average inventory trend across three tiers shows that there is fair degree of heterogeneity within the sample. While Tier 0 and Tier 1 firms show a declining trend that of Tier 2 is much more ambiguous. The change in Tier 2 inventory levels is non-linear with increasing and decreasing trends during various sub periods of the study period. One could in fact conjecture a bullwhip effect that might have magnified the 3- year stagnation in Tier 0 inventories followed by a slight increase in Tier 0 and Tier 1 inventories due to the Asian financial crisis of 1998 into a significant accumulation of inventories at Tier 2 for a prolonged period beyond 1998. However, this is beyond the scope of our current study and hence we do not divulge further into this conjecture.

Figure 2: Trends* in mean Inventory days, RM days, WIP days and FGI days of Tier 0, 1 & 2 segments in the Auto components Industry



*The Black is Tier 0 (OEMs), the Red is Tier 1, and the Blue is Tier 2. (Above is the mean days and below is the median days).

Subsequent panels of Figure 2 look at the inventory trends in RM, WIP and FGI holdings across the three tiers in the next three graphs of Figure 2. These graphs indicate that the reductions in average inventory holdings of Tier 0 and Tier 1 have in fact come about mainly due to the reduction in their average RM inventory over time, while the absolute decline in the number of days WIP inventory and FG inventory have been far smaller. On the other hand, the lack of decline in Tier 2's average inventory is not only seen in the total inventory holding, but is also true for each of the three components, although there is slight decline in RM and WIP and an increase in FGI levels. In order to statistically justify these apparent trends, we first carried out simple correlations and then the pooled Ordinary Least Squares (OLS) model (see appendix).

Table 5: Fixed Effects Models for Average Inventory Days

Variables	Full	South	North	West	Tier 0	Tier 1	Tier 2
	FE'	FE'	FE'	FE'	FE'	FE'	FE'
Year	-2.98***	-1.79***	-3.44***	-2.70***	-3.15***	-3.33***	-0.64
	0.19	0.28	0.27	0.18	0.16	0.29	0.54
Growth (%)	-0.09***	-0.07***	-0.01	-0.19***	-0.36***	-0.04*	-0.21***
	0.02	0.02	0.08	0.02	0.04	0.02	0.05
Average days of Creditors	0.38***	0.37***	0.88**	0.17**	0.26**	0.42***	0.26*
	0.07	0.1	0.34	0.06	0.09	0.11	0.12
Average days of Debtors	0.21***	0.22**	-0.02	0.27***	0.1	0.29***	0.12
	0.03	0.08	0.2	0.07	0.06	0.05	0.09
Exports as % of Sales	0.18	-0.52***	0.22	0.58***	-0.56**	0.26**	-0.21*
	0.11	0.12	0.33	0.08	0.22	0.13	0.11
Imports as % of Sales	0.11	-0.27	0.54	-0.03	0.18	0.05	0.05
	0.34	0.53	0.32	0.34	0.42	0.45	0.24
Constant	56.43***	62.48***	27.19**	64.53***	74.75***	50.21***	68.13***
	4.05	5.99	12.2	7.95	4.61	6.55	8.29
Observations	812	294	266	252	182	504	126
Number of Firms	58	21	19	18	13	36	9
Within R-squared	0.3923	0.3474	0.5421	0.4904	0.6175	0.4153	0.2006

Note: *** p<0.01, ** p<0.05, * p<0.1 Here we use Driscoll-Kraay standard errors and these are reported below each coefficients. The asterisks are placed on the coefficients. Full is the entire sample while subsequent models are either restricted to a specific cluster or a specific tier.

As always a couple of concerns remain about the validity of inferences from pooled OLS models when the underlying data structure is a panel dataset. To guard against these we look at static panel versions of this regression equation, described in section 3.2, controlling for all possible firm level differences. We use fixed effects models for our specification because Hausman tests show systematic differences between the fixed effects regression coefficients and the random effects regression coefficients for all the major specifications we were interested in. The results corresponding to the fixed effects model with average inventory days as dependent variable are reported in Table 5. As one may note from the results listed in the row corresponding to the year variable, we find strong support for our hypothesis 1a. After controlling for all firm level factors, heteroscedasticity and auto correlation, we find there was a decline of close to 3 days of inventory per year during the 14 year study period for the full sample at 1% level of significance. The evidence also indicates there was significant decline in average inventory in each of the three clusters, though at different rates. The tier-wise results however show both Tier 0 and Tier 1 enjoying significant decline in their inventory levels of 3.15 and 3.33 days per year (very strong support at 1% level), while Tier 2, though finds slight decline, does not find it significant. These findings are in fact in line with our conjectures that the best practices might not have percolated to Tier 2.

Table 6: Fixed Effect Models for Raw Material Inventory Days

Variables	Full	South	North	West	Tier 0	Tier 1	Tier 2
	FE'	FE'	FE'	FE'	FE'	FE'	FE'
Year	-2.81***	-2.41***	-3.03***	-2.81***	-3.47***	-3.11***	-1.75***
	0.19	0.54	0.2	0.19	0.39	0.11	0.47
Growth (%)	-0.10**	-0.09*	-0.02	-0.22***	-0.37***	-0.06*	-0.26**
	0.04	0.05	0.07	0.03	0.07	0.03	0.09
Average days of Creditors	0.20***	0.03	0.65**	0.12**	0.11	0.21**	0.18
	0.07	0.13	0.27	0.05	0.18	0.08	0.13
Average days of Debtors	0.18*	0.29	0.03	0.07	0.21	0.13**	0.08
	0.09	0.19	0.1	0.04	0.17	0.06	0.1
Exports as % of Sales	0.20*	0.09	0.24	0.25***	-1.36***	0.23	0.13
	0.11	0.17	0.25	0.07	0.3	0.15	0.08
Imports as % of Sales	0.41***	0.45**	0.40*	-0.23	-0.44	0.51***	0.31*
	0.13	0.21	0.21	0.37	0.63	0.11	0.15
Constant	52.99***	67.23***	24.41**	66.84***	79.87***	54.97***	64.27***
	5.94	10.09	10.65	5.73	16.83	6.85	9.83
Observations	812	294	266	252	182	504	126
Number of Firms	58	21	19	18	13	36	9

Within R-squared	0.327	0.221	0.583	0.413	0.372	0.391	0.178

Note: *** p<0.01, ** p<0.05, * p<0.1 Here we use Driscoll-Kraay standard errors and these are reported below each coefficients. The asterisks are placed on the coefficients. Full is the entire sample while subsequent models are either restricted to a specific cluster or a specific tier.

Next, we look at component-wise inventory trends in Tables 6-8 to test our hypothesis 1b. The results in Table 6, corresponding to the year variable suggest that, a major share of the decline in average inventory of the full sample is in fact contributed by the decline in raw material inventory (2.81 days) at 1% level of significance. All three clusters as well as all three tiers seem to have reduced their raw material inventory levels significantly at 1% level, though at different rates. The results in Table 7 corresponding to the WIP inventory also indicate significant reductions for the full sample, however at a lower magnitude of 0.68 days. Since the average WIP days (from Table 1) is only 18.26, as against the average raw material days of 58.71, this relatively lower decline in WIP is nevertheless noteworthy and may have a greater impact on the efficiency and productivity levels of auto/component firms. Going further down the year row in Table 7, we find that firms in all three clusters have reduced the WIP levels significantly at 1% level and so did the Tier 0 and Tier 1 firms. However, the Tier 2 seems to have failed in this aspect with very slight decline (0.04), which is not found to be significant.

Table 7: Fixed Effects Models for Work-in-progress Inventory Days

Variables	Full	South	North	West	Tier 0	Tier 1	Tier 2
	FE'	FE'	FE'	FE'	FE'	FE'	FE'
Year	-0.68***	-0.76***	-0.52***	-0.40***	-0.37***	-0.85***	-0.04
	0.06	0.12	0.07	0.11	0.1	0.12	0.2
Growth (%)	-0.03*	-0.04*	0	-0.05***	-0.04*	-0.02	-0.06***
	0.02	0.02	0.03	0.01	0.02	0.02	0.02
Average days of Creditors	0.12***	0.12*	0.23*	0.06***	0.02*	0.17***	0.05
	0.04	0.06	0.12	0.02	0.01	0.05	0.05
Average days of Debtors	0.10***	0.14***	0	0.06***	0.06*	0.20***	-0.08**
	0.02	0.04	0.11	0.02	0.03	0.05	0.03
Exports as % of Sales	-0.03	-0.33***	0.26	0.15***	-0.05	0.01	0.01
	0.05	0.11	0.16	0.04	0.07	0.05	0.04
Imports as % of Sales	0.06	0.23	-0.06	-0.02	-0.1	0.19	-0.11
	0.09	0.16	0.09	0.08	0.12	0.12	0.09
Constant	10.23***	11.87**	3.54	12.64***	11.02***	3.12	24.24***

	1.9	4.33	4.01	2.22	2.97	2.32	3.31
Observations	812	294	266	252	182	504	126
Number of Firms	58	21	19	18	13	36	9
Within R-squared	0.202	0.26	0.199	0.228	0.228	0.3	0.039

Note: *** p<0.01, ** p<0.05, * p<0.1 Here we use Driscoll-Kraay standard errors and these are reported below each coefficients. The asterisks are placed on the coefficients. Full is the entire sample while subsequent models are either restricted to a specific cluster or a specific tier.

Finally, we look at the trends in FGI levels from Table 8, which are quite unexpected. The FGI levels for full sample seems to have declined very slightly (0.03) but not at a significant level. The results corresponding to clusters are mixed, with South cluster in fact increasing their FGI by 0.69 days, while North Cluster did manage to reduce them by 0.45 days, both at 1% significance level; and the West cluster does not show any change. The results for Tiers are similar to that of clusters, with Tier 0 managing to reduce FGI levels by 0.29 days, while Tier 2 has increased their FGI levels by 0.72 days, both at 5% significance levels; and Tier 1 does reduce them slightly (0.09 days) but not significant enough.

Therefore, it seems, we do find complete support for our hypothesis 1b w.r.t raw material days, which were reduced across the spectrum. While these reductions in case of OEMs may be attributed to their shift towards modular designs and outsourcing higher share of component requirement, the reduction by the Tier 1 and Tier 2 seems to have occurred due to higher outsourcing coupled with restructuring of the component industry into definite tiers and a longer supply chain. We find partial support w.r.t the remaining two components, namely WIP and FGI, while WIP was reduced in both Tier 0 and Tier 1, only Tier 0 seems to have been successful in FGI reduction. The efforts of OEMs, such as technology upgrades with higher automation and shift towards JIT production to become more efficient and survive the onslaught of MNC competition seems to have paved way towards WIP reduction. The Tier 1 firms too, as mentioned earlier, through adoption of global best practices in internal process improvements, seemed to have managed to cut down on their WIP, despite the higher value addition that requires longer process times.

The results of FGI corresponding to all three tiers on the other hand seem to suggest that, the phenomenon of pushing the inventories to upstream suppliers by the downstream customers in order to become more efficient locally, is occurring in the Indian context. The higher buyer power of OEMs and their efforts towards JIT production seems to be pushing the FGI levels down and towards Tier 1. Whereas, the large distances between some Tier 1s and their OEM customers may be forcing the Tier 1s to maintain at least some portion of FGI levels in their warehouses close to each customer, while in other instances they try to offload their inventories onto Tier 2s. This explains the insignificant reductions in Tier 1's FGI levels. However, Tier 2, being the weakest amongst the three is forced to carry the highest FGI, resulting in a significant increase in FGI levels, as the industry reshaped into definite tiers with higher share of outsourcing post liberalization. Thus, although there is an overall decline in average inventory levels, we do find some reallocation of inventories across tiers.

Table 8: Fixed Effects Models of Finished Goods Inventory Days

Variables	Full	South	North	West	Tier 0	Tier 1	Tier 2
	FE'	FE'	FE'	FE'	FE'	FE'	FE'
Year	-0.03	0.69***	-0.45***	0	-0.29**	-0.09	0.72**
	0.12	0.18	0.07	0.08	0.11	0.12	0.27
Growth (%)	-0.02	-0.01	-0.04	-0.07***	-0.14***	0	-0.11***
	0.02	0.01	0.03	0.02	0.02	0.01	0.03
Average days of Creditors	0.13***	0.12***	0.37**	0.05	0.09*	0.14**	0.07**
	0.04	0.04	0.15	0.03	0.04	0.06	0.03
Average days of Debtors	0.04*	0.02	-0.11	0.13***	-0.01	0.05*	0.11
	0.02	0.02	0.1	0.04	0.04	0.03	0.07
Exports as % of Sales	0.09*	-0.10*	-0.15	0.22***	-0.02	0.12**	-0.14**
	0.05	0.06	0.28	0.03	0.09	0.05	0.05
Imports as % of Sales	-0.13	-0.34**	-0.01	-0.17	-0.19	-0.09	-0.22
	0.1	0.12	0.13	0.15	0.19	0.1	0.21
Constant	5.62***	4.66	0.03	8.34*	16.77***	1.13	11.87**
	2.04	3.2	5.6	4.37	2.37	2.44	4.57
Observations	812	294	266	252	182	504	126
Number of Firms	58	21	19	18	13	36	9
Within R-squared	0.12	0.201	0.293	0.283	0.203	0.118	0.27

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.1$ Here we use Driscoll-Kraay standard errors and these are reported below each coefficients. The asterisks are placed on the coefficients. Full is the entire sample while subsequent models are either restricted to a specific cluster or a specific tier.

In order to test our second hypothesis regarding the internal efficiencies of Tier 1 vis-à-vis other tiers, which enable them to enjoy comparatively higher reductions in WIP levels, we look at the results corresponding to WIP levels in Table 7. As one may note, Tier 1 in fact has highest decline in WIP with a beta coefficient of -0. 85 that is significant at 1% level, while the Tier 0, although has a significant decline at 1% level too, has a coefficient of -0.37, which is less than half of Tier 1's coefficient. On the other hand, Tier 2, as noted earlier, has very little decline in WIP levels with a coefficient of -0.04 that is found to be statistically not significant at all. Hence we do find strong support for our hypothesis 2, that Tier 1, through their effective TQM initiatives have in fact become more efficient in managing their internal processes and as a result managed to reduce the WIP inventories much more than both their customers (Tier 0) and suppliers (Tier 2). One would expect these internal efficiency gains to spillover and force significant reductions in their raw material and finished goods inventories as well. However the results in Tables 6 and 8 corresponding to the raw material and FGI respectively indicate that it is the OEMs (Tier 0) that are doing better than the Tier 1's on these two counts. The results are not entirely surprising though, since there are many other external factors such as the buyer power, market demand, imported raw material and the need to maintain FGI levels in geographically dispersed locations to satisfy the JIT delivery requirements of customers etc. that define the raw material and FGI levels, which are not entirely under a firm's control.

We next briefly discuss the impact of control variables on the average inventory and its components. As one may note from Tables 5-8, the growth of the firm is almost always negatively correlated to average inventory and its components. The support is very strong for OEMs and the Tier 2 (at 1% level most of the time) and so is the magnitude of reduction in inventories. This is quite unexpected, since one would expect firms with higher growth rates to maintain higher inventories. Through qualitative analysis of industry structure and practices, we could determine a possible cause for these counterintuitive empirical results. The auto industry is highly capital-intensive, with assembly operations having a *Most Productive Scale* (MPS) that ranges anywhere from 50 to 200 thousand vehicles per year depending upon the type of vehicle, while, many component firms have even higher MPS. Apart from the production costs, which typically impact the WIP levels, there are other scale factors, such as transportation costs, warehousing costs and other logistic costs that impact the raw material and FGI inventory holding levels at different tiers. However, owing to high variety and low volume business in the Indian market, most OEMs and component manufacturers are eternally functioning in the increasing returns to scale (IRS) region. Hence, the firms with higher growth opportunities must have been able to use up the slack present in the system garnering benefits of IRS and therefore managed to reduce the inventory levels.

The next set of firm level controls we use are related to a firm's working capital management, viz., average days of creditors (payables) and average days of debtors (receivables). We find both these variables are positively and significantly correlated to the average inventory levels and its components, with the exception of Tier 2, which has a negative and significant correlation between its WIP and debtor days, while other inventories are not found to be significant. The relationship is as expected for average creditor days, since the higher credit a firm receives from its suppliers, the more likely they are to keep higher inventories. However the findings are counterintuitive for average days of debtors, since firms that are giving higher days of debt are expected to offload their inventories to their customers and hence maintain lower inventory levels. The only possible explanation for such phenomenon is the disconnect between the payables and receivables in Indian firms coupled with their anxiousness to please the customers, resulting in inefficient management of their working capital cycle. The only segment that seems to be efficient in this respect is the Tier 2, which has a negative and significant correlation between average days of debtors and WIP inventories. With regard to Exports and Imports, we find mixed results which are mostly not statistically significant. The only highly significant result (at 1% level) corresponds to raw material inventory which is positively correlated to imports is as expected, since the transport costs would induce firms to import in bulk to benefit from scale economies.

5. Conclusions

The economic reforms brought in technology, foreign capital, new products and most importantly, the much needed competitiveness to the Indian manufacturing. Competition was essential to shatter the complacency of domestic firms and to remove slack that had accumulated over the years into their systems and processes. However, it was equally important to ensure that the domestic industry does not get completely annihilated by the highly sophisticated multinational adversaries, but become competitive through absorption of global best practices. To a certain extent the current empirical study of the Indian auto industry establishes that the gradual nature of Indian economic reforms with partial relaxation of trade restrictions and local content requirements etc. has in fact succeeded in supporting the domestic industry to become competitive and integrate it into the global supply chain. We find evidence that the slack in terms of excess inventories in the auto industry has come down significantly since the liberalization and adoption of global best practices have contributed to these efficiency gains. The empirical results also corroborate the anecdotal evidence that the Tier 1 firms have improved their internal processes significantly and hence are reaping benefits in terms of better inventory management and subsequent efficiency and productivity gains. However, the results also point out to the need to create a proper mechanism to diffuse these best practices into the lower tiers to garner the complete benefits of efficiencies through inventory management across the supply chain.

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Appendix

Table 9. Simple OLS results

Regression	Average Inventory			Raw Materials	Work in Progress	Finished Goods
Coefficients	(1)	(2)	(3)	(4)	(5)	(6)
Year	-3.08***	-3.02***	-2.85***	-2.74***	-0.60***	-0.01
	0.35	0.32	0.3	0.31	0.15	0.12
Growth		-0.11***	-0.04	-0.09**	0.02	-0.03*
		0.04	0.04	0.04	0.02	0.01
Located in the North Cluster		-17.25***	-10.56***	-22.34***	-3.17*	2.71**
		3.3	3.24	3.31	1.62	1.26
Located in the West Cluster		-8.71***	-3.01	-14.62***	-1.96	4.13***
		3.23	3.06	3.13	1.53	1.19
Firm is a Tier 0 firm		-6.37**	2.12	6.00*	-6.60***	3.69***
		3.23	3.15	3.22	1.57	1.23
Firm is a Tier 2 firm		5.93	3.34	-0.29	-7.88***	12.38***
		3.9	3.66	3.74	1.82	1.42
Average days of Creditors		0.41***	0.26***	0.12***	0.08***	0.11***
		0.04	0.04	0.04	0.02	0.02
Average days of Debtors			0.47***	0.37***	0.24***	0.07***
			0.04	0.04	0.02	0.02
Exports as % of Sales			-0.15	-0.1	-0.05	-0.01
			0.13	0.13	0.06	0.05
Imports as % of Sales			0.51***	1.21***	-0.26***	-0.20***
			0.17	0.17	0.08	0.07
Constant	94.66***	78.57***	49.17***	52.07***	10.06***	1.71
	3	4.63	5.2	5.31	2.59	2.02
Observations	812	812	812	812	812	812
R-squared	0.086	0.257	0.353	0.297	0.292	0.253

Note: *** p<0.01, ** p<0.05, * p<0.1.

The above table 9 reports the pooled OLS estimates for trends in average inventory and its components. Briefly, it suggests that over the years the average inventory holding number of days has declined by about three days for an additional year. The finding is robust to addition of various covariates to the model. This finding is also true for raw material inventory holding. For work in progress there is a statistically observed decline, but far smaller, while for finished goods there is no statistically observed decline. A key problem in solely depending on pooled OLS estimates is that it doesn't correct for the obvious panel data structure and unobserved variables, such as firm culture, management etc. which may bias these estimates.

Table 10. Classification of Clusters and their share in the sample

Variable	Total Sample Size	Share of the cluster
South cluster	812	0.36
North cluster	812	0.33
West cluster	812	0.31