Analysing the Electricity Consumption Patterns in High Value Manufacturing Industries: Case-Study of Three Indian States

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Abstract

This article delves into the concept of High Value Manufacturing (HVM) and identifies various metrics that define it. Using previous literature on industrial competitiveness, high-value industries have been using both 'outcome related dimensions' and 'enabling dimensions' indicators. Panel data from Annual Survey of Industries (ASI) has been used in the analysis for both the selection of illustrative states as well as the identification of HVM within them. Once the case-study states i.e. Gujarat, Maharashtra and Tamil Nadu as well as their HVM industries were identified, an examination of energy intensity patterns was done. Since by definition, these firms are at the forefront of financial, social, technological and employment creation dimension, it is hypothesized that they would reflect progressive behaviour in energy usage as well. Using unit-level details of firms with continuous data from 2000-01 to 2014-15, changes in electricity intensity of production i.e. kWh/output value (₹) were analysed and differences in the patterns for both HVM and other firms was observed.

Introduction

Energy is the most critical input to economic growth today. Global energy consumption is rising and India is no exception. According to the well-known international energy company BP, India's primary energy consumption rose by 4.6 per cent in 2017, forming a share of 5.6 per cent in the global primary energy consumption.[1] Furthermore, the Energy Statistics 2018[2] published by the

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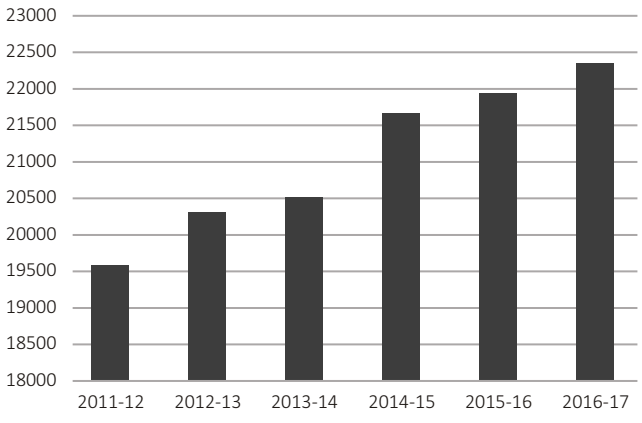
[1]https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/country-and-regional-insights/india.html

[2]http://mospi.nic.in/sites/default/files/publication_reports/Energy_Statistics_2018.pdf; Note: Per-capita Energy Consumption (PEC) during a year is computed as the ratio of the estimate of total energy consumption during the year to the estimated mid-year population of that year.

Figure 1: Per-capita energy Consumption (Mega Joules)



Source: Energy Statistics 2018, MoSPI

Ministry of Statistics and Programme Implementation (MoSPI) show that the per capita consumption of energy in the country has been rising (Figure 1).

In such a scenario, it becomes necessary to analyse the energy consumption patterns for various sectors of the economy, to better prepare for the growing energy needs of the country. The manufacturing sector forms one of the vital pillars to economic development in the country and has demonstrated higher energy needs as well as consumption rates than other sectors. Moreover, the manufacturing sector has experienced tremendous development as new and innovative ventures have emerged over the last few years. Traditionally, the manufacturing sector is defined as a sector that 'transforms a raw material into finished products', but the growing concerns over sustainable industrial development necessitate the sector to shift toward High Value Manufacturing (HVM). Despite several attempts at defining HVM, the concept of HVM has no universally accepted definition. Martinez et al., (2008) define HVM industries as those that create more than just financial value for their stakeholder groups by not merely competing on cost but by contracting for capability, triggering innovation, establishing higher standards etc. and eventually contributing to a sustainable society. The HVM industries, therefore, may encompass a large set of industries with a broad inclusion of various values – financial, strategic and social – created by the sector.

This study analyses the HVM set of industries in the manufacturing sector to study the changes in their energy consumption patterns and energy-output intensities. The analysis is based on HVM industries located in three states – Gujarat, Maharashtra and Tamil Nadu. The rest of the article discusses the state selection criteria, identification of HVM industries and the results obtained.

State Selection Criteria

As previously mentioned, the analysis of the energy consumption patterns in the HVM industries is based on a set of industries in the states of Gujarat, Maharashtra and Tamil Nadu. These states were selected based on their existing industrial policies to promote innovation, competitiveness and create a

favourable environment for investments in manufacturing sector along with their aggressive energy policies to promote renewable energy and energy efficiency. Hence, the methodology included review of the energy and industrial policies of different states in India.

a) Industry Based Selection Criteria

Existing literature on total factor productivity[3], labour productivity, competitiveness etc. at regional level in India suggest that Gujarat, Maharashtra and Tamil Nadu have been the front runners in case of productivity levels in industrial sector. Many studies have highlighted these states for a well-built manufacturing sector and also, higher productivity than other states in the country. In a recent study on job creation in the manufacturing sector, Kapoor (2015) found regional disparities in the growth of the manufacturing sector in the country. Some states such as Maharashtra, Gujarat and Tamil Nadu observed a higher level of industrialization in contrast to others who lagged behind. This could also be deduced from the contribution of manufacturing sector to the gross state domestic product[4] (GSDP) in Maharashtra, Gujarat and Tamil Nadu in 2010-11 which stood at 20.69 per cent, 29.38 per cent and 21.2 per cent respectively. Moreover, these states also contributed a major share in the gross value added in the manufacturing sector during the same period, signifying a more active and prominent presence of the sector. These differences affect the competitiveness of the sector, thereby of the state.

In the papers that analyse firm level data, to understand the role of competitiveness related aspects and their impact on productivity, comparative performance of various states in India has been reported. Confederation of Indian Industry (CII) and World Bank used firm level data for the year 1999-00 with an objective to establish the vitality of investment climate as a key requirement for competitiveness across industries [World Bank - CII Study on Competitiveness, 2002]. In the analysis of firms from four major industries in the manufacturing sector, they examined firm environment to conclude that some states have performed better in terms of the investment climate and hence competitiveness in general. The western states – Maharashtra and Gujarat emerged as leaders and 'better states' followed by Tamil Nadu, Karnataka and Andhra Pradesh. Further with respect to labour productivity, Maharashtra takes the lead in terms of value added per worker, contributing to higher labour productivity in the state. Interestingly, the study also explored the linkage between

[3]Total Factor Productivity is defined as the portion of output which is not explained by the amount of inputs used in production.

[4]Gross State Domestic Product is defined as a measure, in monetary terms, of the volume of all the goods and services that are produced within the boundaries of the state during a given period of time, accounted without duplication.

higher energy costs and investment climate and observed that the high energy costs in most states in the country, severely affected the competitiveness quotient. The study also revealed that a high percentage of firms invest in private power generation capacities, irrespective of the differences in investment climate.

On similar lines, Goldar & Banga (2005) analyzed firm level data from the Annual Survey of Industries (ASI) to estimate the relationship between labour productivity and real wage rate in the organized manufacturing sector. The study found out that the state of Maharashtra, Gujarat, Himachal Pradesh and Uttar Pradesh have a higher growth rate of labour productivity than other states, however, the growth rate of real wage rate lagged behind.

There have been a number of studies examining Total Factor Productivity (TFP) and cost competitiveness to examine the productivity level in India. Trivedi (2004) conducted a similar analysis at state level to estimate average labour productivity level (APL). The study found variations across different states. During 1996-2001, Maharashtra and Gujarat had the highest and West Bengal and Andhra Pradesh had the lowest APL for the manufacturing sector. West Bengal even witnessed a negative rate of employment. For the period from 1992-93 to 2000-01, the study found evidence of deceleration in the TFP growth rate in the manufacturing sector of the country. On the state level, the growth rate was found to be the highest for Gujarat and lowest for Uttar Pradesh.

Mitra et al. (2002) further extended the TFP analysis to examine the effect of infrastructure on TFP in manufacturing industries by states. They utilized industry level data of 1976-92 for 17 industries and found out that some states contribute most to the value addition of manufacturing sector as a whole. The states of Maharashtra, Gujarat, Tamil Nadu and West Bengal were found to be the most industrialized states that generated 52 per cent of the value added. On the other hand Rajasthan, Assam, Uttar Pradesh, Andhra Pradesh and Orissa, were found to have least developed industrial sector contributing 21 per cent of the manufacturing value added.

The overall competitiveness ranking of the Asia Competitiveness Institute (ACI) competitiveness index for 2010 by Khee Giap & Rao (2015) also highlighted high regional variability. Maharashtra scored highest on the index, followed by Delhi, Tamil Nadu, Karnataka and Gujarat to form the top 5 most competitive states in 2010. The north-eastern states and eastern states like Bihar, Jharkhand, Chhatisgarh and Odisha formed the bottom ten states.

Based on the above review of literature the states of Gujarat, Maharashtra and Tamil Nadu were chosen for the analysis.

b) Energy Based Selection Criteria

A large number of firms registered in India are

Table 1: Industry Summary Statistics for Selected States

	Number of Operating Firms		Value of Output (in ₹ Lakh Crore)	GVA (in ₹ Lakh Crore)
	In Frame	In Sample		
Gujarat	23506	5703	12.70	1.96
Maharashtra	28770	8953	11.19	2.39
Tamil Nadu	37959	10444	7.00	1.01
All India	231590	69029	68.8	11.64

Table 2: Electricity Consumption Trends for Selected States

	Own Generation (in '000 kWh)	Purchased from Grid (in '000 kWh)	Total
Gujarat	7010928	25554306	32565234
Maharashtra	6321253	26900711	33221964
Tamil Nadu	3256398	24243578	27499976
All India - ASI	86438134	231401615	317839749

located in these three states. Table 1 presents an overview of the importance of these three states in terms of number of operating firms, value of output and gross value added. It is thus important that energy, a critical input to the production process, provided is of high quality and is reliable and economical to ensure better productivity. This section provides an overview of the type of extant industries located in these states, their comparison with the rest of India as well as their electricity requirement. The data from the Annual Survey of Industries 2014-15 has been used for this analysis.

Using the ASI unit level data, the electricity consumption profiles show that firms located in the three states generated a total of 16588.6 GWH of electricity and purchased a total of 76698.595 GWH from the grid (Table 2); accounting for 19 per cent and 33 per cent respectively of the total demand of India.

After the selection of the states for analysis, HVM industries in these states were identified; the following sections explain the criteria and methodology for identification of high value manufacturing industries in these states.

Identification of HVM Industries

The identification of HVM industries is based on a methodology that combines two indicators to form an HVM index as used by Kathuria et al. (2014). These two indicators are defined as 'outcome related dimensions' and 'enabling dimensions'. These indicators have been combined together with the unit-level data from ASI (2010-11 to 2014-15) in this analysis.

a) Outcome Related Dimensions

Outcome related dimensions provide a quantitative measure of financial, social and strategic value. Perception of value will differ from stakeholder to stakeholder. The interest of a country will differ from an industry's or employee's interests. In this study, industry's perception of value has been examined.

i). Financial Value: Financial value can be explained in terms of revenue. However, since the concept of value added has been reported as the most common indicator of financial value, this study uses gross value added as a measure of financial value of a firm.

ii). Social Value: Social value can broadly be defined as the expenditure as a part of corporate social responsibility of a firm. However, when narrowed down to firm level and its employees, it has been defined to include welfare costs on employees by a firm. The share of welfare expenditures such as contribution to provident fund, etc. to total compensation of employees forms a strong indicator of the same and has been used as a measure for social value.

iii). Strategic Value: Strategic value, in true sense, measures the effect of industry activities on other sectors of the economy including sustainable employment creation. The study uses total number of employees as a measure for strategic value.

b) Value Enabling Dimensions

Value enabling dimensions essentially cover the skills and technology aspects of production. This approach results in identification of similar HVM products instead of similar industries. To estimate the level of skill, knowledge and technology in an industry, the study combines the data of education level of a person employed in a particular industry and the required level of education for that industry category. This analysis helped in identifying industry having higher education level requirements. In addition to this, the level of technology intensity defined as the combined share of investments on plant and machinery and computer equipment including software in relation to total fixed assets, is also computed.

Since, this study focuses on energy consumption patterns, the electricity input as a share of total input – as a measure of electricity intensity[5] – is used. The measure of electricity intensity would also help in identification of the industries that would potentially gain more from electricity supply improvement.

The derivation of HVM industries from available dataset was done in following steps:

Step 1: The HVM index was calculated for all firms in these three states by normalizing all indicators and arranging in increasing order from 0 to 100 and taking a simple average of the six values, identified earlier, assuming equal weights.

Step 2: All state firms were sorted in descending order and top 1000 firms were

[5]Electric Intensity is the strength of electric field at a point.

selected.

Step 3: Frequency distribution of all selected firms were tabulated and the top industrial groups were selected.

Table 3: List of Selected HVM Industries

Gujarat	Maharashtra	Tamil Nadu
Working of diamonds and other precious and semi-precious stones	Manufacture of diverse parts and accessories for motor vehicles	Preparation and spinning of cotton fibre including blended cotton
Manufacture of organic and inorganic chemical compounds	Manufacture or refining of sugar (sucrose) from sugarcane	Manufacture of diverse parts and accessories for motor vehicles
Manufacture of allopathic pharmaceutical preparations	Manufacture of allopathic pharmaceutical preparations	Manufacture of leather footwear such as shoes, sandals
Manufacture of bearings, gears, gearing and driving elements	Distilling, rectifying and blending of spirits	Printing of magazines and other periodicals, books and brochures
Manufacture of other agrochemical products n.e.c.	Manufacture of parts and accessories of bodies for motor vehicles	Manufacture of knitted or crocheted wearing apparel
Manufacture of medicinal substances used in the manufacture of pharmaceuticals	Manufacture of parts and accessories of three wheelers and motorcycles	Manufacture of parts and accessories of three wheelers and motorcycles
Manufacture of diverse parts and accessories for motor vehicles	Preparation and spinning of cotton fibre including blended cotton	Manufacture of all types of textile garments and clothing accessories
Manufacture of dyes and pigments from any source in basic form	Printing of newspapers	Manufacture of Portland cement, aluminous cement, slag cement and similar products
Manufacture or refining of sugar (sucrose) from sugarcane	Manufacture of bearings, gears, gearing and driving elements	Manufacture of parts and accessories of bodies for motor vehicles
Preparation and spinning of cotton fibre including blended cotton	Manufacture of other special-purpose machinery n.e.c.	Distilling, rectifying and blending of spirits

The final state wise list of HVM industries analysed in the study are as indicated in Table 3.

Estimation of Energy Consumption Changes

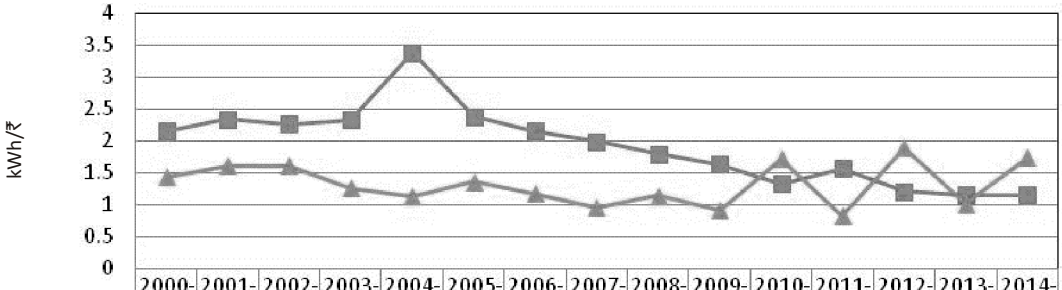
Firm-level data provided by the ASI has been used to create a larger industrial database for the analysis. ASI data with panel IDs for a fifteen-year timeframe of 2000-01 to 2014-15 (3965 firms) have been used for the analysis. The analysis has been done for 1381 firms located in these three states for which continuous 15-year data was present. Using the criteria defined in the previous section, 478 of these firms were identified as belonging to the HVM category.

Changes in electricity consumption have been evaluated using ASI firm level data. While ASI records the quantity of electricity consumed from both self-generation as well as the grid, it only records the value of electricity purchased from the grid. Therefore, electricity quantity from both the grid as well as self-consumption have been used for the analysis. The main idea behind the analysis is to look at the electricity consumption trends for industries over time and test the hypothesis that HVM firms, that are the front runners of what ideal manufacturing patterns look like, also show 'sustainable' production trends. The study defines industrial sustainability by the metric of electricity intensity i.e. electricity consumption per unit output and based on this definition the performance of selected firms and industries over a period of time has been analysed.

Results

Figure 2 shows the trend of energy intensity over time for both HVM and non-HVM firms. Remarkable decline in energy intensity of HVM firms is clearly visible. The energy intensity fell to the level of 1.146 kWh/₹ in 2014-15 from 2.143 kWh/₹ in 2000-01. The trends for non-HVM firms however were

Figure 2 : Tracking Energy Intensity of HVM Firms



	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
HVM	2.143	2.332	2.254	2.319	3.382	2.377	2.148	1.986	1.788	1.622	1.326	1.559	1.203	1.151	1.146
Others	1.426	1.602	1.609	1.256	1.13	1.356	1.173	0.943	1.138	0.913	1.72	0.819	1.893	1.006	1.736

quite erratic. While an overall fall in energy intensity can be seen, the situation post 2010 seems to be irregular. In fact, in the last couple of years in the analysis timeframe, an increase in energy intensity is observed.

In case of states, a dissimilarity in trends is observed. In Gujarat, it was found that the HVM industry has steadily maintained a low energy intensity profile throughout from 2000-01 to 2014-15 and the trend for non-HVM firms have been erratic for the state (Figure 3). On the other extreme, Tamil Nadu shows HVM firms to have a comparatively higher energy intensity as compared to Gujarat and Maharashtra, however it has been declining (Figure 4). The energy intensity of production of non-HVM firms within the state has however remained more or less constant. Maharashtra shows trends that are more in the middle of the range as compared to the other two states. While HVM firms have shown falling trends, the energy intensity figure after 2006-07 shows a very gentle downward slope. Energy intensity for non-HVM firms in Maharashtra remained constant for the longest time. However,

Figure 3: Gujarat HVM Results

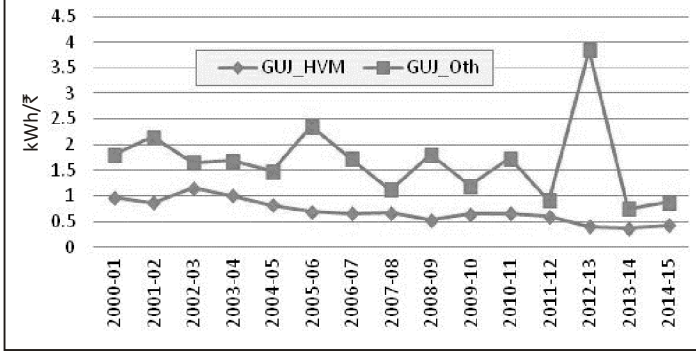


Figure 4: Tamil Nadu HVM Results

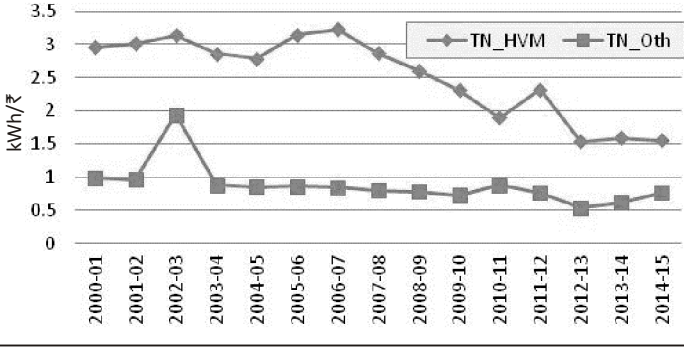
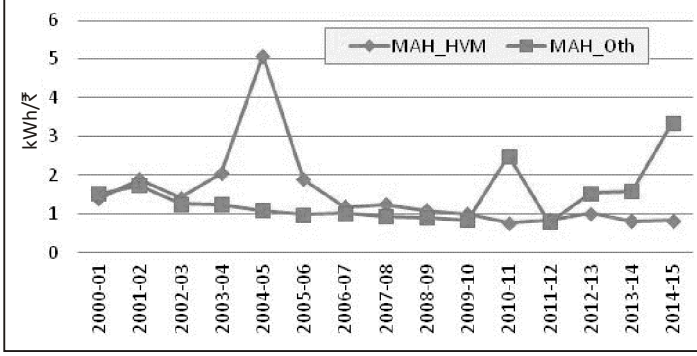


Figure 5: Maharashtra HVM Results



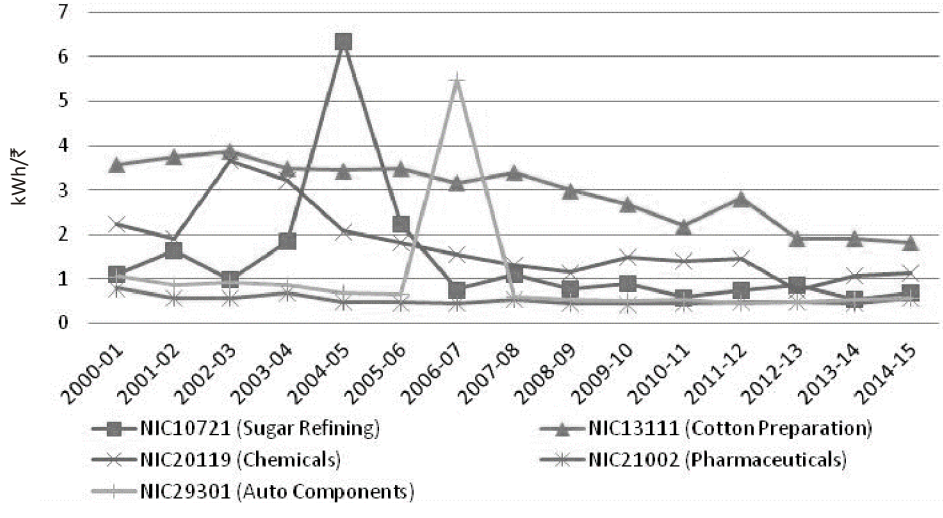
after 2009-10 they show an increasing trend (Figure 5).

A mapping and subsequent analysis of the energy intensity by industrial classification helps us link these industry-level results to the state-level trajectories as discussed earlier. In view of their importance and composition in the sample, there are five key HVM industries that are shown in Figure 6. These include cotton preparation and spinning, sugar refining, organic and inorganic chemicals, pharmaceuticals and auto-components. Matching these firms against the states that they are largely in, throws up some interesting facts. Sugar refining, prevalent largely in Maharashtra and to some extent in Tamil Nadu, shows a gentle downward trend. Cotton preparation, however, that is prevalent almost entirely in Tamil Nadu, shows a significantly higher energy intensity with a decreasing energy intensity trend. This is also mirrored in the overall HVM results for the state of Tamil Nadu. A falling trend is also observed in the case of chemicals. Trends for both pharmaceuticals and auto-components, despite some surges, have remained more or less constant over time.

Conclusion

Keeping industrial vibrancy and electricity demand in centre, the study looked into the industrial consumption patterns in three Indian states – Gujarat, Maharashtra and Tamil Nadu. Using various metrics for both 'outcome related dimensions' (value added, welfare expenditure and employment creation) and 'enabling dimensions' (skills embodied and technology orientation), a set of high value manufacturing industries were identified for these states.

Figure 6: Energy Intensity Trends amongst HVM Firms



Hypothesising that high value manufacturing firms would show sustainable production patterns as well, the study found wide variation between the performance patterns of HVM and non-HVM firms. The study used unit-level details of firms with continuous data from 2000-01 to 2014-15 from the Annual Survey of Industries and analysed changes in electricity intensity of production i.e. kWh/output value (₹) as its main variable of observation. The results showed that while the pattern for non-HVM firms has been widely varying over time and has an increasing trend in recent periods, the trends for HVM firms have been remarkable with respect to the decrease that they have been able to manage. The electricity intensity of production in kWh/₹ reduced from 2.14 in 2000-01 to 1.14 in 2014-15.

The story however gets a bit muddled in case of state specific patterns. The declining trend of HVM electricity consumption-production intensity was observed for all three states. However, there were stark difference between how HVM and non-HVM firms have performed on a comparative scale. For certain states HVM firms had higher intensities compared to non-HVM firms (Tamil Nadu), for some non-HVM was higher (Gujarat); while for others it was broadly the same (Maharashtra). The core of this state story was obviously governed by the performance of industries that constituted the HVM category in each state. To investigate deeper into this, comparative performance of HVM firms from five key industries was looked at – Cotton preparation, Chemicals, Pharmaceuticals, Auto components and Sugar refining.

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