NATIONAL PRODUCTIVITY COUNCIL

# Productivity

Vol. 58 April - June 2017 No. 1

## Focus: Manufacturing



Productivity • Vol. 58 April - June 2017 No. 1

# Productivity

A QUARTERLY
JOURNAL OF THE
NATIONAL PRODUCTIVITY COUNCIL

**PRODUCTIVITY published since Oct-Nov 1959 is the principal journal of National Productivity Council of India**



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Telephone : 91-11-45355555

**ISSN : 0032-9924**
**e-ISSN : 0976-3902**

**E-mail : contact@printspublications.com**
**www.printspublications.com**

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Vol. 58 • April – June 2017 • No. 1

Prints Publications Pvt Ltd
New Delhi

*Publishers & Distributors:*

**Prints Publications Pvt Ltd**
"Prints House", 11, Darya Ganj,
New Delhi-110 002
Phone : +91-11-45355555
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**ISSN : 0032-9924**
**e-ISSN : 0976-3902**

Published and printed on behalf of National Productivity Council, by Mr Pranav Gupta, **Prints Publications Pvt Ltd,** at Printext, New Delhi, India.

# Contents

# Twenty-five years of Economic Reforms and Employment Pattern in India: An Assessment of Organized Segment of Manufacturing

D. INDRAKUMAR

*Over the years there has been a steady increase in the total employment in the organized manufacturing sector in the country. It was 8.28 million in 1990–91 and it rose to 13.54 million in 2013–14. Especially after the reforms of 1991, the manufacturing industry has registered better growth in all aspects. The simplified process of licensing, liberalized process of market regulations are some of the factors which led to the expansion in the sector. The Indian manufacturing industries have become more competitive and viable in the global market after the reforms, however that has made many changes in the structural pattern of employment. The structural change in the economy due to the new economic reforms has made a shift of labour force from agriculture to industries and services sector.*

*D. Indrakumar, Deputy Director, National Institute of Labour Economics Research and Development (Formerly Institute of Applied Manpower Research), Delhi, India.*

## 1. Background

There was a fundamental shift in the Indian economy which slowly started in the middle of 1980s. Agricultural contribution to country's national income had started declining rapidly, however in employment generation agriculture had a major share. Agriculture's contribution to the country's gross domestic product (GDP) was 35.69 per cent in early 1980s and it declined to 29.53 per cent in 1990–91 and further declined to 22.26 per cent in the year 2000–01. The share of agriculture in the GDP reached the lowest level of 14.59 per cent in 2010–11. On the other hand, employment in the sector still holds a major portion of the country's workforce. It was around 70 per cent in 1980s and was recorded 51 per cent for the year 2009–10. The share of service sector and industries has shown steady increase since 1980s. Service sector has registered an impressive growth as compared to the industrial sector. Industrial sector's contribution to GDP was 25.66 per cent in 1980–81 and it rose to just around 30 per cent in 2010–11. With an aim to boost the industrial sector especially the manufacturing sector, many reforms have been announced since 1980s. Adoption of new economic policy in 1991 is the most significant milestone in the Indian industrial sector. There was a structural shift in the Indian economy after those reforms.

The manufacturing sector started shifting towards a more liberalized process of functioning from the highly controlled and regulated system, after the new economic reforms of 1991. The new economic reforms of 1991 lifted many formalities of license and registration checks and simplified the processes for new entrants. This attracted many new players into the sector and the manufacturing industries bloomed over the years. The reforms increased the productivity and competitiveness of the manufacturing sector (Singh, 2012). Due to the favourable conditions, the organized manufacturing industries continuously showed significant growth both in terms of output and employment. Relatively larger in size, use of more advanced technology, and locational advantages are some of the special features which contributed more output than unorganized manufacturing contribution (Bhalla, 2006).

Indian manufacturing sector continues to contribute to the national income and provides more employment opportunities. However, the sector's contribution to employment generation was stagnated at around 11–12 per cent during the period 1999–2000 to 2009–10. The share of manufacturing employment in the total workforce was 11.10 per cent (44.05 out of 396.76 million) in 1999–2000. Afterwards there was a sharp rise in the total workforce of the country and it reached 457.46 million in 2004–05 from 396.76 million in 1999–2000. Similarly, employment in the manufacturing sector also increased to 55.77 million in 2004–05. Despite the increase in the total workforce after 2004–05, employment in the manufacturing sector had come down to 50.74 million in 2009–10 (NSSO Reports 2001, 2006, 2011).

However, employment in the organized manufacturing shows a fluctuating trend during the post-reform period. In the year 1990–91, when the reforms were initiated, the employment was 8.23 million in the sector and it drastically increased to 9.23 million in 1994–95. Around one million new jobs were generated by the organized manufacturing sector within a period of five years. This positive trend did not continue and the employment in the organized manufacturing declined to 8.17 million in the year 1999–2000. The sector lost more than one million jobs within the next five years (between 1994–95 and 1999–2000). Since 1999–2000, there has been a rise in the employment in the sector and it reached 8.45 million in 2004–05 and further 11.79 million in 2009–10. The recent year (2012–13) data shows the sector's employment at 12.95 million. Similar trend was observed for composition of workers within the workforce of this sector. However, there has been a sharp rise in the proportion of contractual workers in the sector. In the year 1999–2000, the contractual workers were 1.24 million and the number increased to 1.75 million for 2004–05. Again, the number of contractual workers in the sector increased to 3.04 million in 2009–10 and reached 3.44 million in 2012–13.

Ministry of Labour and Employment Survey conducted at the end of 2008, indicates a loss of 0.5 million jobs in the manufacturing sector. This survey report also highlights that economic slowdown after the financial crisis in the USA and Europe had weakened the new job creation even in sectors which contributed more to the economy (GoI, 2009). The global economic slowdown which originated from the USA in August, 2007 had an impact on most of the economies in the world. Economic slowdown had also adversely impacted the Indian economy. During the second half of the financial year 2008–09, the economy decelerated resulting in the loss of employment (Labour Bureau, 2009). The Labour Bureau has made an assessment on the impact of global economic slowdown on Indian employment situation for a period of one year between 2010 and 2011 and the report points out an increase in employment in the country after 2010. The employment has increased by 0.91 million, particularly between 2010 and 2011 (Labour Bureau, 2012).

The present paper makes an assessment of the annual survey of industries (ASI) data for the analytical purpose. A state-wise assessment has been made for the better understanding of the sector's performance. The overall trend of organized employment in the country over the years has been presented immediately after this and followed by the empirical analysis of the ASI data. The recent global economic slowdown has made an impact on the Indian manufacturing segments especially on the export-oriented manufacturing industries. Therefore, the analysis has been made on the basis of the pre- and post-crisis of global economic slowdown. States' performance during the pre-crisis period up to 2006–07 and during the post-crisis period 2007–08 to 2012–13 has been analyzed.

## 2. Overview of the Organized Employment in the Country

At one point of time, the public sector (Government) dominated in providing formal/organized regular nature employment in the country. After the introduction of new economic reforms, the formal employment in the country started declining and registered a negative growth over the years. Especially the organized employment in the public sector manufacturing posted negative growth since 1991 along with the overall public sector organized employment. The total public sector organized employment between 1991–96 registered a slow growth of 0.39 per cent per annum, afterwards a negative growth was observed in the organized employment. On the other hand, there has been a steady rise in the private sector's organized employment since 1991. It was 7.68 million in 1991 and increased to 8.65 million for the 2001. Within a period of another decade (between 2001–11), the sector had contributed around 3 million additional jobs under the organized category (Table 1).

**Table 1: Organized Employment Public and Private**

| Sector | Total Organized Employment (in millions) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1981 | 1986 | 1991 | 1996 | 2001 | 2006 | 2011 |
| Public | 15.48 | 17.68 | 19.06 | 19.43 | 19.14 | 18.19 | 17.55 |
| Private | 7.23 | 7.37 | 7.68 | 8.51 | 8.65 | 8.70 | 11.42 |
| Organized Employment in Manufacturing (in millions) | | | | | | | |
| Public | 1.45 | 1.82 | 1.85 | 1.74 | 1.43 | 1.09 | 1.02 |
| Private | 4.43 | 4.44 | 4.48 | 5.05 | 5.01 | 4.55 | 5.40 |

*Source:* Economic Survey, referred various years, Ministry of Finance, Government of India, New Delhi

In the share of organized employment generated by the private sector, more than 50 per cent was in the manufacturing segment in early 1990s and it had started declining afterwards. It was 58.37 per cent in 1991 and reached 47.29 per cent in 2011. It clearly indicates that more number of organized employment created by the private sector was in the sectors other than manufacturing.

## 3. Status of Employment—Organized Manufacturing

There was a decline in the growth of employment in manufacturing sectors in 1980s, particularly in the number of workers in registered manufacturing units. Economists identified policy-indeed rigidities in the labour market as the main reasons for the decline in employment (Nagaraj, 1994). However, new economic reforms of 1991 had liberalized and simplified the registration process which led to an increase in the industrial units. After the introduction of new economic reforms in 1990s, the manufacturing sector especially the organized manufacturing registered a better growth both in terms of output and employment (Hoda and Rai, 2015).

In 1999–2000 there were 44.05 million employed in the manufacturing sector and the share of organized manufacturing in overall manufacturing was 18.5 per cent (8.17 million) of the total workers. It increased to 8.45 million out of 55.77 million workers for the year 2004–05. Again, the composition of organized employment in the total manufacturing employment showed an increase in the year 2009–10. Organized manufacturing sector contributed 11.41 million jobs out of 50.74 million manufacturing job opportunities (NSSO, 2001, 2006, 2011) in 2009–10. Total employment in the organized manufacturing sector has registered an increasing trend over the years since 1991.

### *3.1 Total Employment (Total Persons Engaged)*

The sector employed almost 13 million workers in 2012–13. Since the introduction of reforms in 1991, the total employment (total persons engaged) in sector has increased in all the years except for 2000–01. A similar trend was seen in the number of workers in the organized manufacturing sector (Figure 1).

The growth trend of the employment at national level stands at 4.38 per cent per annum for the period 2000–01 to 2012–13. However, the state-wise analysis indicates some excellent and poor performances during the reference period. States with larger share of employment did not make significant growth for the overall employment opportunities during the period 2000–01 to 2012–13. Tamil Nadu, Maharashtra, Gujarat, Andhra Pradesh and Karnataka are the states which have huge share of employment but none of these states featured with top rank for growth in the two periods of analysis. Small states and Union Territories achieved drastic growth in the total employment between 2000–01 and 2012–13. Tripura and other north eastern states like Manipur, Meghalaya and Nagaland together registered better growth from 2000–01 to 2006–07. Uttarakhand, Jammu & Kashmir and Dadra &

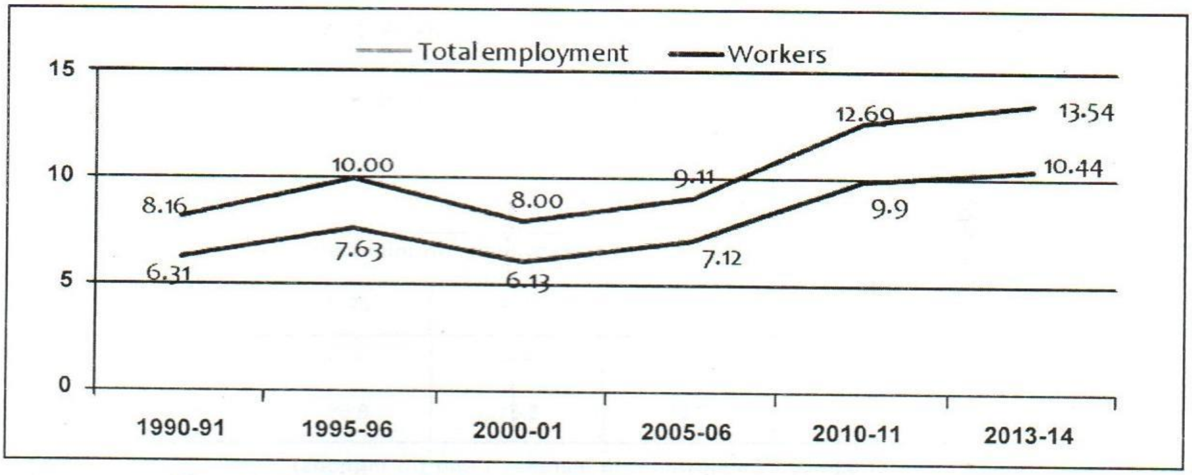


**Figure 1. Employment Trend in the Organized Manufacturing since 1990–91**

*Source:* Computed from Annual Survey of Industries for respective years.

Nagar Haveli and Daman & Diu together also achieved 14 and 13 per cent growth per annum during the period. Jharkhand, West Bengal and Madhya Pradesh registered a negative growth in total employment between 2000–01 and 2006–07. It is clear from the data that some states like Delhi, Goa, Punjab and Madhya Pradesh and West

**Table 2: Total Employment in the Sector since 2000–01**

| Growth Rate between 2000–01 and 2006–07 | | Growth Rate between 2007–08 and 2012–13 | |
|---|---|---|---|
| **Top 5 States** | | | |
| **States** | **CAGR** | **States** | **CAGR** |
| Tripura | 15.55 | Other NE States | 22.71 |
| Other NE states | 14.66 | Uttarakhand | 20.94 |
| Uttarakhand | 14.08 | Himachal Pradesh | 14.09 |
| Jammu & Kashmir | 12.76 | Bihar | 9.58 |
| Dadra & Nagar Haveli, Daman & Diu | 12.66 | Odisha | 7.36 |
| **Bottom 5 States** | | | |
| **States** | **CAGR** | **States** | **CAGR** |
| Jharkhand | (-)2.75 | Delhi | (-) 1.44 |
| West Bengal | (-)1.81 | Other UTs | (-) 0.73 |
| Madhya Pradesh | (-)1.10 | Punjab | 1.18 |
| Bihar | 1.05 | Kerala | 1.33 |
| Delhi | 127 | Goa | 1.89 |
| **National Averages** | | | |
| Big States | 4.29 | Big States | 4.44 |
| Small States | 3.55 | Small States | 1.96 |
| Union Territories | 9.57 | Union Territories | 4.01 |
| All India | 4.38 | All India | 4.38 |

*Source:* Computed from Annual Survey of Industries for respective years.

Bengal slowly lost their positions in the organized manufacturing sector (Table 2).

The share of contractual workers among the total persons engaged in industries of organized manufacturing is presented in Table 2. Again, Tripura stands at the top with around 80 per cent of the total share of contract workers among the total persons engaged. Number of contract workers was more than 50 per cent in Bihar after Tripura. However, the state has very little share in the total number of factories, with just 1.34 per cent of the total factories registered are located in the state. However, the state has registered a remarkable growth rate during the reference period. The state has achieved 13.41 per cent of annual growth between 2007–08 and 2012–13. Vast majority of the employment created during this period was contractual in nature. Altogether, 14 states have the maximum number of contractual workers which is higher than the national average of 25.8 per cent.

Delhi has the least percentage of contract workers with just 6.9 per cent among the total persons engaged in the organized manufacturing sector. Southern states like Kerala, Karnataka and Tamil Nadu also have less proportion of contract workers. About 13.1 per cent of the workers in Kerala, 14.5 per cent in Tamil Nadu and 14.7 per cent of the workers in Karnataka are contractual workers in the total persons engaged in the sector. Jharkhand also has limited proportion of contract workers (16.6 per cent) in the total persons engaged in the sector.

### *3.2 Workers' Composition*

As expected, the reforms did not boost workers' composition in the organized manufacturing industrial sector. Industrial growth between 2000–01 and 2006–07 stood at 2 per cent and it increased to around 9 per cent for the period 2007–08 to 2012–13. However, the growth of workers stagnated at 4.38 per cent for both the periods. Figure 2 gives a clear trend of the workers in the sector since 1980 to 2012–13. Complete scenario of workers in pre- and post-reforms period has been presented in the figure. There is a fluctuating trend in the composition of workers in the sector. It increased from (-)0.83 per cent between 1980–81 and 1985–86 to around 4 per cent during the period 1990–91 to 1995–96. It again declined to a negative rate of – 4.27 per cent for the period 1995–95 to 2000–01 (Figure 2). Afterwards the sector registered positive growth and achieved a maximum of around 7 per cent between 2005–06 and 2010–11.

Like total employment, Tamil Nadu has the maximum share (15.97 per cent) of workers among all the states, followed by Maharashtra with 12.27 per cent. Gujarat and Andhra Pradesh have 10 per cent of the total workers of

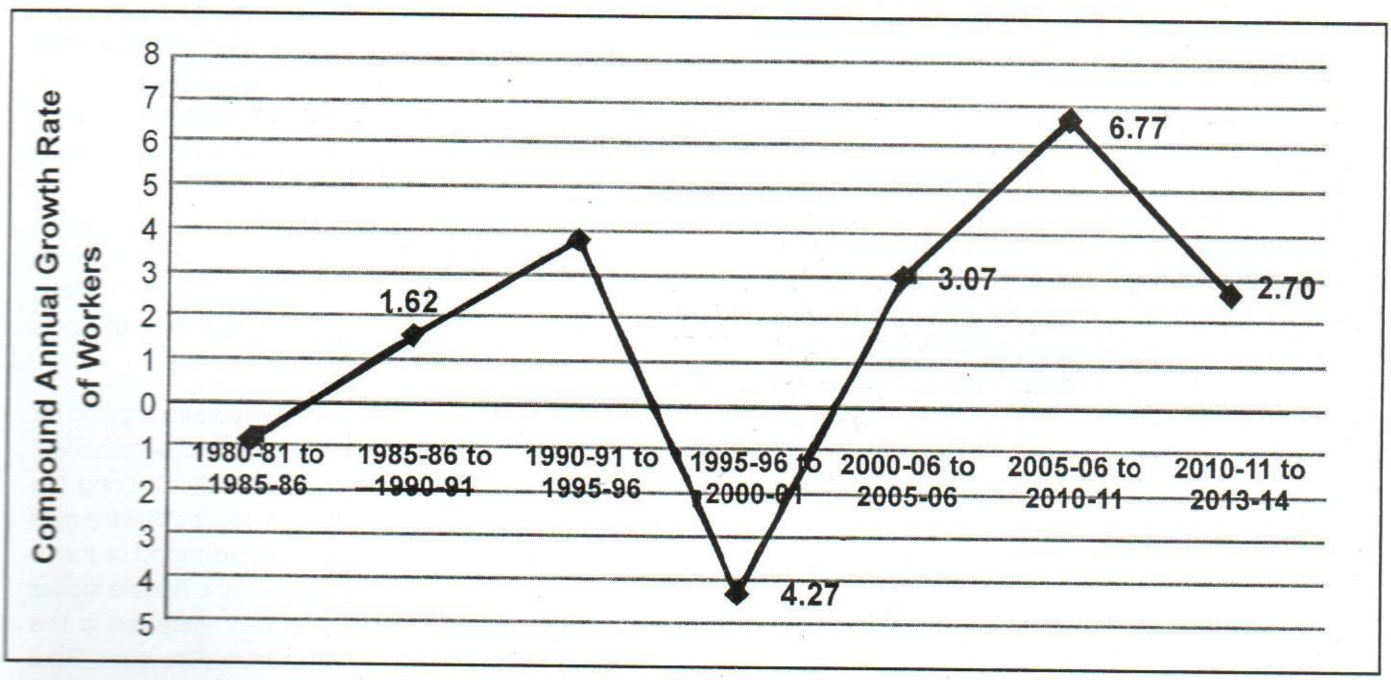


**Figure 2. Growth Trend of Workers from 1980–81 to 2013–14**

*Source:* Computed from Annual Survey of Industries for respective years.

the sector. These states together have half of the workers of the organized manufacturing sector. The analysis of data indicates that few states are losing their share in employment of workers over the years. Even industrially developed states like Maharashtra, Andhra Pradesh and West Bengal are showing a declining trend of workers' employment. Dadra & Nagar Haveli, Delhi, Jharkhand, Kerala and Madhya Pradesh also had shown the declining trend of the workers share between 2000–01 and 2012–13. Among all the states, Uttarakhand has shown a drastic change of increase in the share of workers. The state's share of workers has increased from 0.5 per cent in 2000–01 to around 3 per cent in 2012–13. Himachal Pradesh is at the second position with the highest increase in the share of workers at the national level. It's share has increased to 1.33 per cent in 2012–13 from 0.49 per cent in 2000–01. In addition, Tripura and other north eastern states, Jammu & Kashmir, Bihar and Odisha also showed increasing trend in the composition of workers in the organized manufacturing industries.

The analysis of growth trend between 2000–01 and 2012–13 exactly gives the volume of decrease or increase in the workers' share of each state. Between 2000–01 and 2006–07, Uttarakhand, Tripura and other north eastern states had achieved 16 per cent of annual growth regarding the composition of workers. Similarly, Jammu & Kashmir, Dadra & Nagar Haveli and Daman & Diu together had annual growth rate at 13 per cent. However, industrially developed states like Maharashtra, Tamil Nadu, Gujarat and Andhra Pradesh achieved a very little annual growth during the period. Among these states, only Tamil Nadu had reached 6 per cent annual growth followed by Gujarat at 5 per cent, Maharashtra at 3.5 per cent and Andhra Pradesh with just 1.61 per cent. On the other hand, the states positioned at the bottom of the growth are Jharkhand, West Bengal, Madhya Pradesh, Delhi and Andhra Pradesh. Jharkhand has lost around 3 per cent of its workers per annum between 2000–01 and 2006–07. West Bengal and Madhya Pradesh have also witnessed a negative growth in the workers' composition per annum during the same period.

During the period (2007–08 to 2012–13) of global economic crisis and post crisis, organized manufacturing industries in some states showed better growth. Uttarakhand and north eastern states showed more than 20 per cent growth per annum between 2007–08 and 2012–13. Surprisingly, Bihar and Odisha entered into the top five positions regarding the growth of workers. The national average stood at the same 4 per cent per annum.

Share of workers in the total persons engaged: Workers' proportion is more than one-third of the total persons engaged in the industries of organized manufacturing in the country. This proportion did not change significantly over the years. The workers' composition in 2000–01 was at 76.81 per cent of the total persons engaged, it was 76.30 per cent in 2006–07, 77.66 per cent in 2009–10 and 77.62 per cent in 2012–13. This proportion is highest for Tripura with 90.42 per cent and lowest for Delhi with 65.97 per cent in 2012–13. More than ten states have the workers' share of 80 per cent and above. However, there are not many differences among the states in the share of workers in the total persons engaged.

### *3.3 Contractual Workers*

New economic reforms of 1991 liberalized many rules and regulations exclusively for the industrial sector. To sustain in the domestic market and to make presence at the global market level, quality of the products was emphasized. It forced the manufacturing industries to move towards more sophisticated and technically advanced processes in the production techniques. Technical cooperation and collaboration led to another stage of outsourcing of specific activities of the production process of the factories. Outsourcing of particular activities to other agencies slowly became inner part of the industries—they started using outsourced labourers for particular jobs and responsibilities. These processes become common among the organized sectors either in private or even in the public sector. These kinds of labourers/workers were termed as 'contractual workers'. The globalized economy forced the Indian manufacturing sector to take more contractual workers in order to survive in the market (Rajeev, 2009). Organized manufacturing started sub-contracting its production activities in 1980 itself. Many production processes were given to unorganized segments (Goldar and Aggarwal, 2010).

Policy-makers and planners have been arguing for flexible labour laws. It poised out two types of perceptions, one favouring the industry while another favouring the workers. Those favouring the industry argued that the rigid or inflexible labour laws have had negative impact on them. On the other hand, those who opposed the flexible labour laws argued that there was a steady increase in the contractual employment in the country (Bhirdikar, Paul and Murthy, 2011). More use of contractual labour is a global phenomenon and Indian labour market has accepted the contractual jobs (Sincavage, Haub and Sharma, 2010). Labour regulation is one of the factors which caused the stagnation of employment in the manufacturing sector in the country. It is argued that there should be flexible regulations to increase or downsize the workers as per the demand and market conditions (Hoda and Rai, 2015).

The contractual workers are more prevalent in modern industrial establishments. Data on the prevalence of the contractual labourers in the Indian organized manufacturing industries shows an upward trend over the years. Since early 1990s, the employment structure of the organized industries in the country has undergone structural changes with steep rise in the contractual workers (Sengupta and Ray, 2013). Similarly, Saha and Sen (2014) and Sharma (2014) also indicate the rise in contractual employment in the country's manufacturing industries. The liberalization process of 1991 had given the firms the right to cut the jobs and wages in the manufacturing sector (Verma and Awasthi, 2010). Deregulation of employment and wages became a part of the industries' rights and led to more casualization of employments. It was observed from the data that the incidence of contractual workers increased in the sector in all the years. The share of contractual workers among the total persons engaged was below 20 per cent (16.58 per cent) in 2000–01 to 27 per cent in 2012–13. Similar trend was observed in the share of contractual workers among the total workers (Figure 3).

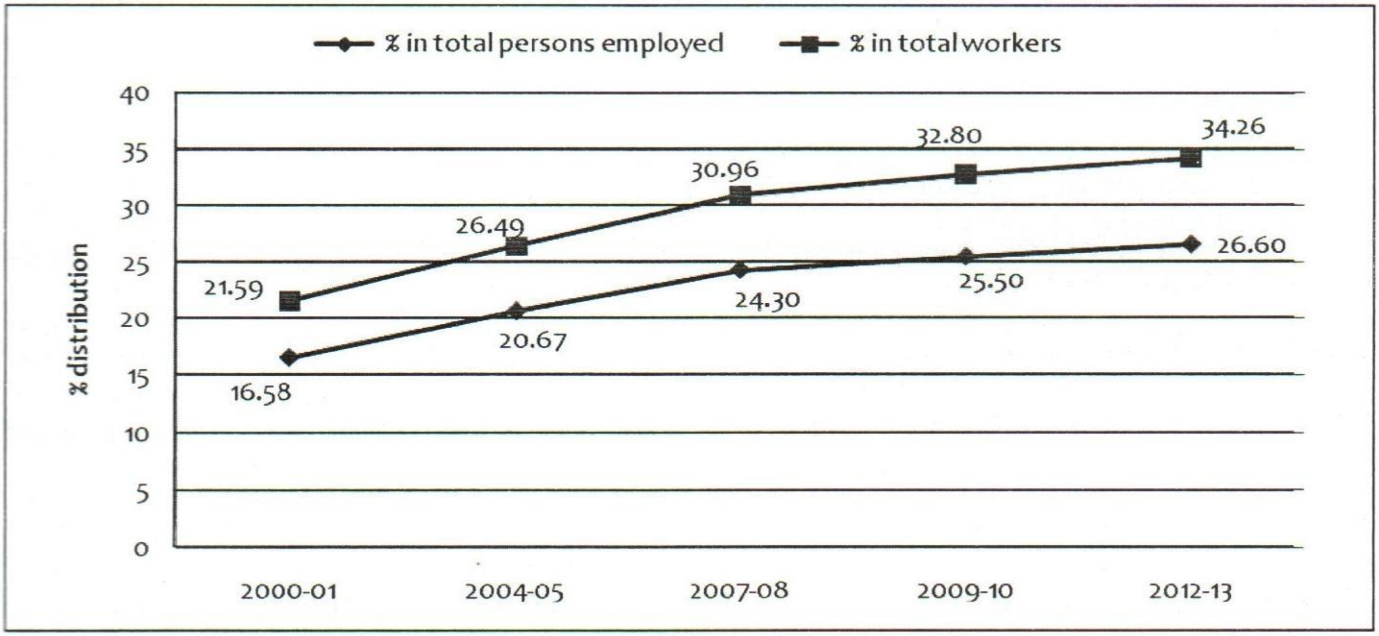


**Figure 3. Composition of Contractual Workers since 2000–01**

*Source:* Computed from Annual Survey of Industries for respective years.

### *3.3.1 Contractual Workers and Factories*

The data reveals some very interesting findings about the prevalence of contractual workers in the organized manufacturing sector. Almost all the states which have the maximum number of contractual workers per factory are small category states and industrially emerging new states. Tripura stands at first position with an average of 51 contractual employees per functional factory during the period 2000–01 to 2012–13. The alarming point is that the state is under the rule of trade union with strong hold of a communist party. It is very clear that the industrial establishments coming up in the states are opting for more jobs that are contractual in nature. States have no control over the labour regulations, nature of employment opportunities generated, rather states need industrial developments for creating more opportunities.

Haryana, Odisha and Uttarakhand follow Tripura in the number of contractual workers per factory with around 40 workers per factory. Small states are having more prevalence of contractual workers than the industrially developed and big states. Bihar, Goa, Chhattisgarh, north eastern states, Jammu & Kashmir all are emerging states which have more contractual workers than the national average of 18 workers per factory. Few industrially developed states also have the prevalence of contractual workers just around the national average. Andhra Pradesh, Gujarat, Maharashtra, Uttar Pradesh and West Bengal have the numbers which are almost equivalent to the national average.

Delhi followed by Kerala and Tamil Nadu has the least number of contractual workers in the organized manufacturing industrial establishments. An average of three persons in Delhi, eight persons in Kerala and nine persons in Tamil Nadu worked as contractual workers between 2000–01 and 2012–13. Only these three states have the single digit number of contractual workers in registered factories during the period. Remaining vast majority of the states has more number of contractual workers per factory. Empirical evidence significantly supports the data that the proportion of contractual workers in total workers at oil fields and petroleum refineries are 76.94 and 80.12 per cent respectively. The duration of employment of contract workers in these industries are too short in the length of service. At the national level, 68.15 per cent of contract workers have 1–3 years' length of service in oil fields. In petroleum refineries, 64.27 per cent oil contractual workers have less than one year of service (Labour Bureau, 2012). The proportion of contractual workers in top 82 companies in India stands at 34 per cent. Out of 3.2 million total employments in these top companies, 1.08 million workers are in jobs contractual in nature. Among these companies, automobile sector has the maximum share of 47 workers in contractual category (Ananthanarayanan, 2014).

### *3.3.2 Composition of Contractual Workers in Total Persons Employed*

As mentioned, there is an increase in the overall employment in the sector since 2000–01 to 2011–12. However, total employment in the organized sector has declined in 2012–13 by 0.5 million. A similar trend was observed in the share of contractual workers in the total employment of the sector. It was 16.58 per cent of the contractual employment in the total employment of the sector in 2000–01 and increased to 22.89 per cent in 2006–07. Further, the share increased to 25.5 per cent in 2009–10 and reached 26.90 per cent in 2011–12. Next year (2012–13), the employment composition of contractual labourers in the total employment went slightly down to 26.6 per cent. The state-wise interpretation gives a new twist in the analysis. All the top five states are from the category of industrially emerging new states by pushing back the industrially developed states. Tripura again stands at the top with 81.5 per cent of the share of contractual workers among the total persons employed in the sector. Bihar (60.50 per cent), other north eastern states (47.6 per cent), Odisha (47.3 per cent) and Uttarakhand (41.4 per cent) are the other states at the top five positions with Tripura for the year 2012–13.

### *3.3.3 Proportion of Contractual Workers among Total Workers*

The data clearly brings out the magnitude of contractual workers in the manufacturing sector. Almost one fourth (the data is available for 7 out of 32 States/UTs) states and union territories have the share of contractual workers around 50 and above, for 2012–13. Quite surprisingly, more than 90 per cent of the workers in the industries in Tripura are contractual in nature. The state's share of contractual workers in 2000–01 was 62.41 per cent. The percentage kept on increasing and reached the peak of 90 per cent in the recent year. Similarly, among the other top five states, Bihar stands at the second position with 70 per cent. Other north eastern states (includes Manipur, Meghalaya, Nagaland and Sikkim) and Odisha have 59 and 58 per cent of the contractual workers respectively. However, except Tripura all four states (Bihar, other north eastern states, Odisha and Uttarakhand) had little proportion of contractual workers in 2000–01. Only two states have the percentage of contractual workers among total workers at less than 20 per cent in 2012–13. Delhi and Kerala are the states with the least share of contractual workers, having 10.83 and 14.17 per cent respectively in 2012–13. However, except Karnataka, all the states have shown growth in the volume of contractual workers since 2000–01 (Table 3).

### *3.3.4. Growth Trend of Contractual Workers*

Table 3 shows the growth pattern of the contractual workers since 2000–01. It is very clear that only small and new emerging states occupied the top positions for all the three reference periods. Between 2000–01 and 2006–07, Uttarakhand showed maximum of 30.71 per cent annual growth in the employment of contractual workers, followed by Kerala. However, these states registered relatively less growth in the total employment during the period. Uttarakhand registered 14.08 per cent annual growth in

Table 3: Growth of Contractual Workers since 2000–01

| CAGR between 2000–01 and 2006-07 | | CAGR between 2007–08 and 2012–13 | | CAGR between 2000–01and 2010–11 | |
|---|---|---|---|---|---|
| **Top 5 States** | | | | | |
| Uttarakhand | 30.71 | Other NE States | 29.7 | Uttarakhand | 34.44 |
| Kerala | 25.62 | Uttarakhand | 27.82 | Himachal Pradesh | 21.01 |
| Assam | 24.63 | Himachal Pradesh | 18.11 | Other NE states | 19.60 |
| Dadra & Nagar Haveli, Daman & Diu | 23.69 | Odisha | 17.62 | Tripura | 18.81 |
| Other NE states | 22.87 | Jharkhand | 17.48 | Dadra & Nagar Haveli, Daman & Diu | 17.41 |
| **Bottom 5 States** | | | | | |
| Karnataka | (-) 3.38 | Other UT | (-) 0.69 | Karnataka | 1.39 |
| Delhi | (-) 0.89 | Goa | (-) 0.68 | Andhra Pradesh | 3.85 |
| Madhya Pradesh | 1.40 | Uttar Pradesh | 0. 90 | Madhya Pradesh | 5.48 |
| Jharkhand | 3.38 | Haryana | 1.00 | Jharkhand | 6.00 |
| Andhra Pradesh | 4.65 | Andhra Pradesh | 1.08 | Delhi | 6.71 |
| **Average** | | | | | |
| Big States | 9.90 | | 6.34 | | 9.57 |
| Small States | 15.21 | | 7.74 | | 15.07 |
| Union Territories | 1949 | | 2.68 | | 15.67 |
| National | 10.13 | | 6.29 | | 9.76 |

*Source:* Computed from Annual Survey of Industries for respective years.

the total employment against 30.71 per cent growth of contractual workers. Similarly, Kerala registered 1.59 per cent annual growth in the total employment, whereas the state achieved 25.62 per cent annual growth between 2000–01 and 2006–07. Only two states had reported the negative growth in the use of contractual workers. Quite surprisingly, Karnataka, one of the industrially developed states, showed a negative growth of 3.38 per cent per annum. Delhi had also shown a decline in the use of contractual workers between 2000–01 and 2006–07.

Between 2007–08 and 2012–13, the period of global economic crisis, vast majority of the Indian states reported more use of contractual workers. Again small and industrially emerging new states reported higher growth in contractual workers. Only three states (Himachal Pradesh, other north eastern states and Uttarakhand) had achieved double digit growth both in total employment and contractual employment. Remaining vast majority of the states reported very little growth in the total employment and higher growth in case of contractual employment. Odisha and Jharkhand states, which registered around 18 per cent growth in the contractual employment, showed only 7.36 and 4.26 per cent growth in the total employment per annum. Other Union Territories (includes Andaman & Nicobar Islands, Chandigarh and Puducherry) and Goa showed negative growth in the use of contractual workers. However, these two states had registered very minimal and negative growth in the total employment during 2007–08 to 2012–13.

Over the decade (between 2000–01 and 2010–11), Uttarakhand registered highest of 34.44 per cent of annual growth rate in contractual employment. Himachal Pradesh, Tripura and other north eastern states recorded the highest growth in use of contractual employment during the previous decade. Karnataka, Andhra Pradesh and Madhya Pradesh along with Jharkhand and Delhi stood at the bottom level in the growth chart. Karnataka had the least of 1.39 per cent growth in contractual employment among all the states, followed by Andhra Pradesh with 3.85 per cent. The average growth at national level is begged at 9.76 per cent during the period. A maximum of 15.67 per cent in Union Territories followed by 15.07 per cent in small states registered the growth.

Other north eastern states and Tripura, along with Uttarakhand and Himachal Pradesh, had registered the maximum annual growth rate (CAGR) on use of contractual workers during the last six years (2007–08 to 2012–13). And these states also registered a better growth in the number of functional factories. Tripura has registered around 20 per cent growth in the contractual workers per annum. This is the highest rate of growth achieved by any of the states during the period. Even industrially developed states could not achieve this much growth in the recent past. One way or other this is helping the labour force of the country by providing more number of employment opportunities rather focusing on job security or other social security measures. It is observed from the data that more jobs which are generated during the recent days are falling under contractual in nature. Further, new industries which are coming up during the reference period have moved towards new destinations. Tripura, Himachal Pradesh, Uttarakhand, Bihar, Assam and Jharkhand have registered better growth than the industrially developed states. With Tripura's 20 per cent, Himachal Pradesh and Uttarakhand also registered higher growth of 18 and 15 per cent respectively. Among the big states which had already established in the industrial base, only Tamil Nadu (11.87 per cent) and Andhra Pradesh (11.39 per cent) registered better growth rate. On an average, 8.7 per cent of annual growth rate was registered at the national level during 2007–08 to 2012–13.

## 4. Concluding Remarks

There is a steady and sharp increase in hiring of contractual labourers in the organized segment of manufacturing in the country. Especially during the recent years, every one-third of the employment in the sector is contractual in nature. While analyzing data from 2000–01 to 2012–14 of the organized manufacturing, it is evident that the sector is moving towards a new direction. Industries have started operating in small and new states which really need more industries rather than the already industrially developed states. Assam, Bihar, Chhattisgarh, Himachal Pradesh, Tripura, other north eastern states and Uttarakhand showed better growth in number of industries registered, total persons employed and total workers. There is an increase in the total employment (total persons employed), and workers' share in total employment over the years. The global economic crisis did not make a significant impact on the organized manufacturing sector in the country. It is clear from the data that the industries are opting or following more liberalized processes in labour/workers' policy. The higher and an increasing trend in the prevalence of the contractual labour is an evidence for such process.

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*"Perfection is not attainable, but if we chase perfection we can catch excellence."*

*– Vince Lombardi*

# Regional Concentration of Manufacturing Industries in India

ANAND SHARMA AND SANJOY SAHA

*Unbalanced spatial distribution of industries has always been linked with regional economic disparities in the literature. So, the information about the spatial concentration of industries is essential for the purposes of regional development policies. Therefore, the present study examines the trend and pattern of concentration of major two-digit industries across the 20 states during 2001–02 to 2011–12. Using location quotients, we find that geographical concentration exhibits a great deal of variation across the states. Specifically, the results show that northern states of India like Uttarakhand and Himachal Pradesh display an upward trend in concentration for majority of the industries. On the other hand, eastern states like Chhattisgarh, Jharkhand and Odisha have experienced a declining concentration of these industries. Therefore, these states need to formulate and effectively implement the industrial policies that attract more industries in these states.*

*Anand Sharma, Assistant Professor, Indian Institute of Management, Sirmaur, Himachal Pradesh, India.*

*Sanjoy Saha, Assistant Professor, Department of Economics, Debraj Roy College, Golaghat, Assam, India.*

## 1. Introduction

Geographical concentration of economic activity is one of the most interesting stylized facts of the modern world economy. For example, in India, people associate the diamond industry with Surat, movies production with Mumbai, woolen textiles with Ludhiana, IT sector with Bangalore and so on. Internationally, some famous examples of such concentration include the manufacturing belt in Detroit, Route 128 in Boston and fashion industry in Paris and Milan (Krugman, 1991; Rosenthal and Strange, 2004). Marshall (1890) explained that industries concentrate spatially because of the advantages which accrue from such concentration like labour market pooling, availability of specialized inputs and knowledge spillovers. He argued that a larger market creates forward and backward linkages for the firms so that it is easier to procure inputs from the suppliers and supply the final produce to the consumers. Similarly, labour market pooling benefits both the firm and workers by allowing better matching and reducing the transaction costs. Also, there are knowledge spillovers and technical transfers when firms locate in proximity to each other. These ideas were further developed by Krugman (1991) in his core-periphery model giving rise to a new field called 'new economic geography'.

The phenomenon of industrial concentration and agglomeration[1] has important implications for regional growth and development. Uneven distribution of industries may lead to regional disparities in income and growth (Fujita et al., 2001; Lall and Chakravorty, 2004). As reducing regional imbalances is one of the central goals of regional policy, an investigation of the concentration of industries provides useful information for policy formulation. Limited studies have examined this aspect in the Indian case (for example, Fernandes and Sharma, 2012; Kathuria, 2016; Lall and Chakravorty, 2004;, Saikia, 2016).

This paper examines the concentration pattern of six two-digit industries of the manufacturing sector. The selected industries are: food and beverages, tobacco, textiles, chemicals, basic metals and non-metallic mineral products. These industries are selected on the basis of their significant share in manufacturing value added and employment (see Table 5). The main objectives of this paper is to provide answers to questions like: Which of the selected two-digit industries are highly concentrated across the states? What has happened to this concentration over time? Why these industries concentrate in a particular state? Are there natural resource advantages, sector and region-specific policies at work? The first section provides an introduction. Section 2 briefly outlines the method and data used to measure industrial concentration. Section 3 discusses the trends and pattern of regional concentration of the selected industries. Section 4 presents a summary of the key findings and presents the main policy implications of this study.

## 2. Method and Data

We measure the concentration of an industry in a region with the help of a '*Location Quotient*'. Location quotient (L.Q.) is one of the most widely used measures of concentration and industrial agglomeration (Guimarães et al., 2009; Rivera et al., 2014; Tian, 2013). The L.Q. measures the concentration of an industry in a region. It is calculated as the ratio of an industry's share in a region's employment to that industry's share in the national employment. This index is very popular in the literature due to its simplicity and fewer data requirements (Rivera et al., 2014; Tian, 2013). If the value of this index is greater than 1, it means that a given industry is more concentrated in that region than the national average. The formula is given as:

$$L.Q._{i,s} = \frac{\frac{E_{ir}}{\sum E_{ir}}}{\frac{E_{in}}{\sum E_{in}}}$$

Where, $E_{ir}$ is employment in industry '*i*' in region '*s*' and $E_{in}$ is employment in industry '*i*' in the nation '*n*'.

The choice of benchmark region is very important in the L.Q. formula and it depends on the objectives of the study (Wang and Hofe, 2007). In this study, our benchmark region is the 'nation'. For example, if we want to study the concentration of an industry across districts in a state, then the benchmark region will be a 'state'. L.Q. can be based on employment, value added or fixed capital data. In this study, we have used employment data to calculate the location quotients for various two-digit industries across the 20 states. In the literature, the employment data is most widely used to calculate the L.Q. In case of India, it is difficult to use the value added data because for few state-industry pairs the published value added is negative for some years.

It is important to note that the analysis in this paper is based on 'state' as the geographical unit of analysis. Krugman (1991) computed locational Gini coefficients for the manufacturing sector of the US taking states as the unit of analysis. In this context, Krugman (1991) explains that states are not the ideal geographical units because they have an unequal population that may bias the comparison of industries. However, he argues that such analysis provides important information about the concentration of industries.[2] Fernandes and Sharma (2012) have studied the locational pattern of Indian manufacturing industries taking 'state' as the unit of analysis. Similarly, Batisse (2002) has also examined the concentration and dynamic externalities for the Chinese manufacturing industries taking 'province' as the geographical unit of analysis.

Most of the existing studies compute an index at two or three points of time and make a comparison. In this study, we have computed the index for all the years across the 20 states. We have followed Dholakia (2003) and used averages of the L.Q. index over 3–4 years. The present analysis is confined to two-digit industry groups which are very broad. Although we do appreciate that a disaggregated analysis could provide a more detailed picture of industrial concentration and agglomeration, the data availability considering our broad study objectives constrain us to take two-digit industry groups for the present study. The employment data for the selected two-digit industries is taken from Annual Survey of Industries (ASI).

## 3. Regional Concentration of Manufacturing Industries

This section explains the trend and pattern of spatial concentration of selected manufacturing industries during 2001–02 to 2011–12. It also attempts to explain the reasons for the observed pattern.

### *3.1 Regional Concentration of Food and Beverages Industry (15)*

Food and beverages industry forms an important linkage between the agriculture and manufacturing sectors of the economy. Food and beverages industry contributes significantly to manufacturing output and employment. For the period 2001–02 to 2011–12, the real value added and employment in this sector witnessed a compound annual growth rate of 6.67 per cent and 4.7 per cent respectively, compared to the overall manufacturing figures of 12.25 per cent and 5.55 per cent. Several scholars explain that the location of food manufacturing is chosen to promote the rural development strategy because of its favourable effects on agricultural earnings through backward linkages (Capps et al., 1988). Concentration of food and beverages industry in a region depends on many factors like availability of agricultural and other inputs, proximity to market, and infrastructural facilities like storage, transport, credit, etc.

In the case of India, food and beverages industry is highly concentrated in Kerala, Andhra Pradesh and Assam, as indicated by the value of location quotients. Table 1 shows that the L.Q. for food and beverages industry in Assam and Kerala exceeds 3. This implies that food and beverages industry is three times more concentrated in Assam and Kerala as compared to the national average. Kerala contributes one-fifth of India's food exports and has a comparative advantage in items like cashews, spices, tea, coffee, marine products, etc. (KINFRA, n.d.). This relative concentration of food and beverages sector is based on the natural-resource advantage and the geographic location of Kerala on sea coast and tropical climate.

Table 1 highlights that the concentration of food industry is less in Jharkhand, Odisha, Delhi and Gujarat. In the case of Jharkhand, the share of food industry as compared to its share of all industry is negligible. The main reason for this could be the lack of natural resources conducive to the growth of food products. In the case of Jharkhand, food industry lies low on both policy and factor advantage fronts (IBEF, 2010). Jharkhand has a rich mineral base and, as a result, industries like basic metals, iron and steel are placed in a better position to take advantage of these resources.

Over the years, northern states like Punjab, Haryana, Uttarakhand and Uttar Pradesh are moving away from food and beverages industry. Table 4 shows that the relatively high concentration of food industry (as shown by L.Q. of above 1) in Punjab, Uttarakhand and Uttar Pradesh has been declining over time. On the other hand, Kerala, Bihar, Assam and Andhra Pradesh are becoming more specialized over time and already high level of concentration of food and beverages industry is further increasing.

### *3.2 Regional Concentration of Tobacco Industry (16)*

Tobacco is one of the very important cash crops. It is a source of significant employment and revenue generation for the Indian economy. About Rs 20 billion income is generated by this industry every year (FAO, 2003). Tobacco industries in India are mostly concentrated in the southern part specially Andhra Pradesh and Kerala where the concentration is very high and still increasing. It is evident from Table 1 that the L.Q. value for Andhra Pradesh and Kerala exceeds more than 6 and around 3 respectively. It implies that tobacco industries are six times more concentrated in Andhra Pradesh and three times more in Kerala in comparison to the national average. On the other hand, concentration of these industries is also above national average in states like Maharashtra and Odisha but it is declining. Similarly, in states like Delhi, West Bengal and Chhattisgarh concentration of tobacco industries is relatively low in comparison to the other states but it is increasing gradually. In contrast, concentration of tobacco industries in states like Himachal Pradesh and Jharkhand is already low than the national average and falling gradually.

### *3.3 Regional Concentration of Textiles Industry (17)*

The textile industry has a prominent place in the Indian economy due to its potential to generate large employment. The regional concentration of textile industry depends on various factors like availability of raw material, infrastructural facilities, access to market and climate. In the case of India, concentration has tended to be raw-material specific (NMCC, 2010). The textile industry is highly concentrated in West Bengal, Tamil Nadu, Gujarat and Rajasthan. The primary reason for the concentration of textile industries in these states could be related to their proximity to the cotton belt (NMCC, 2010). Table 2 shows that for the entire time-period, the value of L.Q. of textile industry in these states exceeds one. Out of these states, the concentration of textile industry in West Bengal, Rajasthan and Gujarat appears to be declining over time (see Table 4), and it has remained fairly stable in Tamil Nadu and Punjab during this period. Table 2 shows that a relatively low concentration of textile industry is observed in the eastern states of Bihar, Jharkhand and Chhattisgarh. There is a negligible

Table 1: Location Quotients: Food & Beverages and Tobacco Products

| States | | Food & Beverages (NIC: 15) | | Tobacco (NIC: 16) | | |
|---|---|---|---|---|---|---|
| | 2001–02 to 2004–05 | 2005–06 to 2008–09 | 2009–10 to 2011–12 | 2001–02 to 2004–05 | 2005–06 to 2008–09 | 2009–10 to 2011–12 |
| Andhra Pradesh | 1.16 | 1.35 | 1.44 | 5.46 | 6.36 | 6.48 |
| Assam | 3.66 | 3.64 | 3.73 | 0.12 | 0.19 | 0.25 |
| Bihar | 1.21 | 1.18 | 1.29 | 0.74 | 0.82 | 0.73 |
| Chhattisgarh | 0.86 | 0.99 | 0.99 | 0.38 | 0.78 | 0.78 |
| Delhi | 0.41 | 0.46 | 0.93 | 0.06 | 0.11 | 0.12 |
| Gujarat | 0.56 | 0.57 | 0.57 | 0.12 | 0.11 | 0.11 |
| Haryana | 0.77 | 0.61 | 0.52 | 0.02 | 0.03 | 0.02 |
| Himachal Pradesh | 0.58 | 0.53 | 0.49 | 0.35 | 0.19 | 0.07 |
| Jharkhand | 0.08 | 0.12 | 0.14 | 0.67 | 0.38 | 0.31 |
| Karnataka | 0.92 | 0.89 | 0.91 | 0.20 | 0.22 | 0.21 |
| Kerala | 2.85 | 3.10 | 3.42 | 1.19 | 2.70 | 2.92 |
| Maharashtra | 0.92 | 1.04 | 1.12 | 1.14 | 0.69 | 0.83 |
| Madhya Pradesh | 0.81 | 0.97 | 0.94 | 0.91 | 1.12 | 1.11 |
| Odisha | 0.96 | 0.86 | 0.77 | 1.10 | 1.26 | 1.09 |
| Punjab | 1.53 | 1.37 | 1.31 | 0.00 | 0.00 | 0.00 |
| Rajasthan | 0.49 | 0.53 | 0.63 | 0.22 | 0.56 | 0.41 |
| Tamil Nadu | 0.71 | 0.65 | 0.70 | 0.07 | 0.05 | 0.06 |
| Uttarakhand | 1.63 | 0.98 | 0.65 | 0.00 | 0.00 | 0.00 |
| Uttar Pradesh | 1.65 | 1.60 | 1.48 | 0.37 | 0.35 | 0.45 |
| West Bengal | 0.67 | 0.89 | 0.96 | 0.51 | 0.80 | 0.68 |
| Coefficient of Variation (%) | 75.19 | 76.25 | 78.10 | 175.06 | 173.08 | 178.65 |

*Source:* Author's calculations using ASI data.

concentration of textile industry in Jharkhand and Chhattisgarh (L.Q. close to zero). This could be due to the absence of sources of raw materials and less market access in these states.

Within the textile sector, a dominant portion is occupied by the cotton textiles industry. The other segments in this industry are silk, woollen, readymade garments and jute. The cotton textile industry is relatively concentrated in Ahmedabad, Solapur, Nagpur, Indore and Coimbatore (Chand, n.d.). The availability of energy (for example, thermal power plant near Sabarmati; Pykara hydel project in Coimbatore), water bodies (Sabarmati river in Ahmedabad; Noyyal river in Coimbatore) and access to market provides some explanation for the location of cotton textile industry in these areas. Similarly, the jute textiles industry is concentrated in West Bengal due to the availability of raw materials, proximity to Hooghly river and

Table 2: Location Quotients: Textile Industry and Chemicals

| States | Textiles (NIC: 17) | | | Chemicals (NIC: 24) | | |
|---|---|---|---|---|---|---|
| | 2001–02 to 2004–05 | 2005–06 to 2008–09 | 2009–10 to 2011–12 | 2001–02 to 2004–05 | 2005–06 to 2008–09 | 2009–10 to 2011–12 |
| Andhra Pradesh | 0.44 | 0.47 | 0.43 | 0.69 | 0.95 | 1.10 |
| Assam | 0.16 | 0.11 | 0.08 | 0.44 | 0.62 | 0.62 |
| Bihar | 0.44 | 0.34 | 0.21 | 0.35 | 0.23 | 0.28 |
| Chhattisgarh | 0.11 | 0.08 | 0.04 | 0.18 | 0.26 | 0.16 |
| Delhi | 0.25 | 0.31 | 0.19 | 0.64 | 0.48 | 0.47 |
| Gujarat | 1.31 | 1.18 | 1.07 | 2.47 | 2.23 | 2.02 |
| Haryana | 0.63 | 0.70 | 1.19 | 0.41 | 0.37 | 0.37 |
| Himachal Pradesh | 2.09 | 1.14 | 0.64 | 1.01 | 2.80 | 3.39 |
| Jharkhand | 0.04 | 0.03 | 0.01 | 0.32 | 0.31 | 0.29 |
| Karnataka | 0.36 | 0.67 | 1.66 | 0.58 | 0.59 | 0.61 |
| Kerala | 0.54 | 0.37 | 0.48 | 0.59 | 0.56 | 0.49 |
| Maharashtra | 0.74 | 0.72 | 0.71 | 1.30 | 1.46 | 1.58 |
| Madhya Pradesh | 1.16 | 0.91 | 0.71 | 1.07 | 1.15 | 1.18 |
| Odisha | 0.22 | 0.11 | 0.05 | 0.69 | 0.54 | 0.39 |
| Punjab | 1.35 | 1.30 | 1.35 | 0.39 | 0.42 | 0.35 |
| Rajasthan | 1.98 | 1.63 | 1.41 | 0.73 | 0.69 | 0.68 |
| Tamil Nadu | 1.77 | 2.01 | 1.77 | 1.24 | 0.94 | 0.79 |
| Uttarakhand | 0.08 | 0.11 | 0.15 | 0.62 | 2.16 | 2.09 |
| Uttar Pradesh | 0.53 | 0.49 | 0.77 | 0.77 | 0.67 | 0.68 |
| West Bengal | 2.33 | 2.05 | 1.54 | 0.55 | 0.56 | 0.46 |
| Coefficient of Variation (%) | 88.92 | 85.71 | 82.23 | 66.93 | 80.14 | 89.82 |

*Source:* Same as Table 1.

humid climate (WBIDC, 2009–10). The woollen textile industry is concentrated in Punjab (Ludhiana), Maharashtra and Uttar Pradesh due to easier access to raw materials, access to power and energy.[3]

It is interesting to compare the concentration of textile industry in Haryana and Himachal Pradesh. Both these states are located in close proximity. In case of former, the relative concentration of this industry has been increasing over time (refer Table 4), whereas in case of the latter, the concentration has been declining over time. This could be due to initiatives like development of textile clusters, textile parks and increased investment in this sector by the Haryana government. The absence of such sector-specific policies in case of Himachal Pradesh may be one of the reasons for the decline in concentration. This suggests that the role of state government policies is important in influencing the concentration pattern.

### *3.4 Regional Concentration of Chemicals and Chemical Products (24)*

The capital-intensive chemical industry is a crucial component of Indian manufacturing industry (Dept. of Chemicals and Petrochemicals, 2014–15). The sustained growth of this industry is important for all the other sectors of the economy. During 2001–02 to 2011–12, the real value added and employment growth in this industry was 10.7 per cent and 4.8 per cent respectively.

Table 2 shows that the chemical industry is highly concentrated in Gujarat, Maharashtra and Uttarakhand. Further, the concentration has increased in Maharashtra, Andhra Pradesh and Himachal Pradesh during 2001–02 to 2011–12. Chemical industry requires raw materials like power, water, oil, coal and minerals. These are available in large quantities in states like Gujarat and Maharashtra that enable the location of chemical firms. Gujarat alone accounted for 51 per cent of India's total chemical production in 2010–11. In the case of Gujarat, the chemical industry is mainly located in Ankleshwar, Ahmedabad and Vapi (IBEF, 2013). There are petrochemicals SEZs located around Ahmadabad, Kutch and Bharuch (IBEF, 2013). The chemical cluster being developed by Gujarat government (known as 'Petroleum, Chemicals and Petrochemicals Integrated Region' [PCPIR]) at Dahej (IBEF, 2013) will further strengthen the concentration of chemical industries in Gujarat. In the case of Maharashtra, the oil wells near Mumbai led to a significant growth of chemical industries in the state. The important chemical hubs in the state are Thane, Mumbai, Pune and Wardha (IBEF, 2013). Moreover, the availability of other resources like water, power, land and well-functioning transport infrastructure explain the concentration of chemical industry in the state. The availability of ports in Gujarat and Maharashtra facilitate the import of chemicals and provide an opportunity to the firms in the chemical industry to cater to the foreign market.

A relatively low concentration of chemical industry is seen in the eastern states of Bihar, Chhattisgarh, Jharkhand and northern states of Punjab and Haryana (see Table 2). Lack of adequate infrastructure, the absence of port facilities and less investment could explain the low concentration of this industry in these states. Table 4 shows that Gujarat, Uttar Pradesh, Haryana and Karnataka have experienced a decline in the concentration of chemical industry during 2001–02 to 2011–12. The neighbouring states of Gujarat like Maharashtra and Madhya Pradesh have witnessed increasing trend in concentration. These states had distinct policies for chemical industry and could be an explanation for the observed pattern. Also, this industry is a highly polluting industry and the different state governments' environment and pollution laws also affect the concentration of this industry.

### *3.5 Regional Concentration of Non-metallic Mineral Products (26)*

Non-metallic mineral products include the production of glass, ceramics, cement and lime. This industry is labour-intensive in nature. During 2001–02 to 2011–12, the real value added and employment in this industry grew by 12 per cent and 7 per cent respectively. Table 3 shows that the non-metallic minerals industry is highly concentrated in Bihar, Jharkhand, Andhra Pradesh and Rajasthan. During 2001–02 to 2011–12, the concentration of this industry has increased in Bihar, Assam and Punjab. The main reason for the concentration of this industry in Bihar, Jharkhand, Andhra Pradesh and Rajasthan is the availability of minerals like mica, limestone, asbestos and kyanite. Large reserves of mica are found in Bihar, Jharkhand, Andhra Pradesh and Rajasthan (Chand, n.d.), which make these states favourable to carry out the extraction and manufacturing of non-metallic mineral products. Another important mineral used in this industry is asbestos, and only the states of Andhra Pradesh and Rajasthan produce this mineral in India. Similarly, kyanite deposits are located in Rajasthan, Andhra Pradesh and Jharkhand (Chand, n.d.). Therefore, the availability of these minerals could explain the concentration of non-metallic mineral industry in these states.

Table 3 shows that the non-metallic mineral industry has a relatively low concentration in Delhi, West Bengal and Maharashtra. The concentration of this industry has declined in West Bengal and Delhi during the period 2001–02 to 2011–12 (refer Table 4). The low level of concentration observed in Delhi could be due to the absence of raw materials and natural minerals. There are some mineral reserves located, but this industry has witnessed a declining concentration of non-metallic mineral industry in West Bengal.

Table 3: Location Quotients: Other Non-metallic Mineral Products and Basic Metals

| States | Non-metallic minerals (NIC: 26) | | | Basic Metals (NIC: 27) | | |
|---|---|---|---|---|---|---|
| | 2001–02 to 2004–05 | 2005–06 to 2008–09 | 2009–10 to 2011–12 | 2001–02 to 2004–05 | 2005–06 to 2008–09 | 2009–10 to 2011–12 |
| Andhra Pradesh | 0.44 | 0.47 | 0.43 | 0.69 | 0.95 | 1.10 |
| Andhra Pradesh | 1.56 | 1.22 | 1.39 | 0.53 | 0.75 | 0.63 |
| Assam | 2.25 | 2.95 | 3.33 | 0.16 | 0.16 | 0.22 |
| Bihar | 6.22 | 7.30 | 7.85 | 0.51 | 0.69 | 0.43 |
| Chhattisgarh | 1.27 | 1.01 | 0.91 | 8.20 | 7.49 | 7.42 |
| Delhi | 0.11 | 0.05 | 0.04 | 0.25 | 0.24 | 0.26 |
| Gujarat | 1.19 | 1.30 | 1.39 | 0.66 | 0.80 | 0.79 |
| Haryana | 0.85 | 0.52 | 0.36 | 0.61 | 0.49 | 0.41 |
| Himachal Pradesh | 1.38 | 0.89 | 0.66 | 0.30 | 0.47 | 0.50 |
| Jharkhand | 2.02 | 2.02 | 1.77 | 6.87 | 6.48 | 5.05 |
| Karnataka | 0.74 | 0.55 | 0.48 | 0.59 | 0.63 | 0.59 |
| Kerala | 0.82 | 0.66 | 0.73 | 0.26 | 0.32 | 0.20 |
| Maharashtra | 0.43 | 0.42 | 0.36 | 0.81 | 1.10 | 1.14 |
| Madhya Pradesh | 1.54 | 1.44 | 1.24 | 0.64 | 0.63 | 0.82 |
| Odisha | 1.88 | 1.63 | 1.29 | 5.34 | 6.55 | 7.49 |
| Punjab | 0.57 | 1.87 | 1.92 | 0.84 | 0.78 | 0.75 |
| Rajasthan | 3.13 | 3.01 | 2.85 | 0.84 | 0.91 | 0.87 |
| Tamil Nadu | 0.56 | 0.50 | 0.45 | 0.42 | 0.39 | 0.42 |
| Uttarakhand | 0.90 | 0.75 | 0.33 | 0.75 | 0.42 | 0.33 |
| Uttar Pradesh | 0.67 | 0.99 | 0.98 | 0.65 | 0.53 | 0.42 |
| West Bengal | 0.43 | 0.39 | 0.38 | 2.12 | 2.11 | 2.19 |
| Coefficient of Variation (%) | 94.43 | 107.93 | 120.88 | 149.17 | 144.23 | 147.97 |

*Source:* Same as Table 1.

### *3.6 Regional Concentration of Basic Metals (27)*

The three main components of basic metals industry are basic iron and steel, precious and non-ferrous metals and casting of metals. This industry is a crucial part of the manufacturing sector as it provides important intermediate inputs to a large number of industries. At present, this industry accounts for about 2.5 per cent of the GDP (NISTADS Report, 2014). Table 3 shows that the basic metals industry has a relatively high concentration in the eastern states of Jharkhand, Chhattisgarh, Odisha and West Bengal. This is reflected in very high values of L.Q. (in excess of five) of this industry in these states. The main reasons for this concentration are the availability of rich mineral resources in these states. For example, about 40 per cent of India's mineral resources are found in Jharkhand, and 16 per cent of India's coal reserves are found in Chhattisgarh (IBEF, 2013). Bauxite and iron ore are also available in abundance in Odisha and Chhattisgarh (IBEF, 2010) that enable the industries to concentrate their activities in these states. In addition to these, the availability of power, transport and other infrastructure necessary for the functioning of the metal industry is also a reason for the relatively higher concentration in these eastern states. The favourable government policies for metals industry in these eastern states could also provide some explanation for the observed high concentration. For example, the state government in Odisha is actively involving the private sector for projects related to the metal industry and also setting up metal-based SEZs (IBEF, 2013). Similarly, Chhattisgarh government has set up a 'metal industry park' in Raipur. These state government initiatives in these eastern states have provided an incentive to producers to concentrate their activities in these states. Table 4 shows that the concentration of this industry has been increasing in Madhya Pradesh, Himachal Pradesh, Odisha, West Bengal and Maharashtra over time. On the other hand, declining (and less than 1) values of L.Q in Chhattisgarh, Jharkhand, Uttar Pradesh and Uttarakhand imply a declining concentration of basic metals industry in these states.

**Table 4: Industry-wise Concentration in States: Summary**

| NIC | Industry Description | High and Rising | High and Falling | Low and Rising | Low and Falling |
|---|---|---|---|---|---|
| 15 | Food Products and Beverages | Assam, Kerala, Bihar | Punjab, Uttar Pradesh, Uttarakhand | Jharkhand, Rajasthan, Gujarat | Tamil Nadu, Himachal Pradesh, Odisha |
| 16 | Tobacco Products | Andhra Pradesh, Kerala | Maharashtra, Odisha | Delhi, Madhya Pradesh, Chhattisgarh | Himachal Pradesh, Jharkhand |
| 17 | Textiles | Tamil Nadu, Punjab | West Bengal, Gujarat, Rajasthan, Himachal Pradesh, Madhya Pradesh | Uttar Pradesh, Uttarakhand, Haryana, Karnataka | Jharkhand, Chhattisgarh, Odisha, Bihar |
| 24 | Chemicals and Clinical Products | Himachal Pradesh, Uttarakhand, Maharashtra, Madhya Pradesh | Gujarat, Tamil Nadu | Karnataka, Andhra Pradesh and Assam | Bihar, Chhattisgarh, Jharkhand, Haryana, Punjab |
| 26 | Other Non-Metallic Mineral Products | Bihar, Assam, Punjab, Andhra Pradesh | Jharkhand, Rajasthan, Chhattisgarh, Himachal Pradesh, Madhya Pradesh, Odisha | Uttar Pradesh, Punjab | Delhi, West Bengal, Haryana, Maharashtra, Uttarakhand |
| 27 | Basic Metals | Odisha, West Bengal | Chhattisgarh, Jharkhand | Andhra Pradesh, Assam, Delhi, Himachal Pradesh, Madhya Pradesh, Maharashtra | Bihar, Kerala, Punjab, Uttarakhand, Uttar Pradesh |

*Source:* Compiled using Tables 1, 2 and 3.

**Table 5: Share in Manufacturing Employment of Selected Two-digit Industries: State-wise**

| States | NIC 15 | | NIC 16 | | NIC 17 | | NIC 24 | | NIC 26 | | NIC 27 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2001–02 | 2011–12 | 2001–02 | 2011–12 | 2001–02 | 2011–12 | 2001–02 | 2011–12 | 2001–02 | 2011–12 | 2001–02 | 2011--12 |
| Andhra Pradesh | 20.22 | 20.19 | 35.43 | 22.03 | 8.11 | 7.11 | 6.68 | 3.51 | 7.68 | 8.90 | 3.70 | 5.34 |
| Assam | 64.30 | 50.07 | 0.36 | 1.14 | 3.77 | 1.18 | 3.20 | 5.60 | 13.28 | 24.41 | 1.09 | 2.43 |
| Bihar | 20.37 | 20.90 | 4.86 | 1.64 | 7.28 | 3.28 | 5.51 | 0.59 | 38.18 | 59.15 | 3.00 | 1.66 |
| Chhattisgarh | 12.68 | 14.29 | 1.01 | 2.66 | 2.56 | 0.69 | 2.05 | 1.13 | 8.91 | 5.99 | 61.38 | 60.42 |
| Delhi | 8.35 | 7.57 | 0.53 | 0.33 | 2.73 | 1.91 | 6.48 | 1.00 | 0.86 | 0.16 | 1.78 | 1.23 |
| Gujarat | 9.30 | 7.23 | 0.68 | 0.37 | 20.58 | 18.59 | 25.11 | 12.07 | 8.28 | 10.31 | 4.31 | 7.49 |
| Haryana | 13.65 | 6.46 | 0.17 | 0.09 | 8.75 | 7.63 | 3.92 | 1.54 | 6.01 | 2.53 | 5.79 | 4.24 |
| Himachai Pradesh | 10.16 | 7.64 | 2.08 | 0.24 | 36.14 | 9.59 | 7.83 | 7.70 | 8.95 | 4.27 | 2.64 | 3.81 |
| Jharkhand | 1.38 | 1.81 | 4.52 | 1.37 | 0.86 | 0.26 | 4.49 | 2.59 | 12.50 | 11.29 | 47.32 | 38.17 |
| Karnataka | 17.04 | 12.48 | 1.20 | 0.88 | 6.23 | 2.34 | 6.08 | 2.50 | 5.16 | 3.54 | 4.48 | 5.59 |
| Kerala | 49.30 | 49.70 | 5.99 | 8.81 | 8.95 | 7.20 | 6.52 | 2.76 | 5.37 | 5.15 | 1.77 | 1.38 |
| Maharashtra | 16.19 | 13.81 | 8.75 | 2.59 | 12.33 | 8.41 | 12.42 | 6.21 | 2.88 | 2.53 | 5.37 | 8.52 |
| Madhya Pradesh | 11.97 | 14.41 | 5.47 | 2.80 | 19.48 | 12.74 | 10.11 | 5.79 | 11.42 | 7.79 | 4.32 | 6.38 |
| Odisha | 17.04 | 9.01 | 1.42 | 4.67 | 4.74 | 0.99 | 6.75 | 3.37 | 12.54 | 8.71 | 29.51 | 61.79 |
| Punjab | 26.60 | 16.32 | 0.00 | 0.00 | 21.73 | 18.86 | 3.87 | 1.64 | 1.99 | 14.72 | 6.65 | 5.81 |
| Rajasthan | 8.64 | 8.49 | 1.41 | 1.47 | 32.52 | 21.10 | 6.23 | 5.31 | 18.94 | 20.40 | 6.11 | 6.49 |
| Tamil Nadu | 12.36 | 9.93 | 0.61 | 0.22 | 25.81 | 17.55 | 13.37 | 6.17 | 4.05 | 3.36 | 2.54 | 3.47 |
| Uttarakhand | 25.69 | 8.50 | 0.00 | 0.00 | 2.52 | 2.18 | 5.26 | 5.03 | 6.12 | 2.44 | 5.24 | 2.10 |
| Uttar Pradesh | 28.86 | 19.83 | 2.28 | 2.00 | 7.96 | 4.69 | 8.89 | 4.51 | 4.84 | 7.11 | 4.96 | 3.66 |
| West Bengal | 10.53 | 13.18 | 3.25 | 1.96 | 34.88 | 27.54 | 6.17 | 2.94 | 2.54 | 2.60 | 16.27 | 17.79 |

*Note:* Industry description according to NIC, 2004 is as follows: 15: Food products and beverages; 16: Tobacco products; 17: Textiles; 24: Chemicals and chemical products; 26: Other non-metallic mineral products; 27: Basic metals.

Table 3 also depicts that Andhra Pradesh, Kerala, Delhi and Bihar have a low concentration of metals industry. One of the possible reasons for this low concentration could be the absence of mineral resources in these states. The basic metals industry is capital-intensive in nature, and the nature of manufacturing activities in all these states is highly labour-intensive. Therefore, this industry is less prominent in these states. Moreover, these states do not have a separate dedicated SEZ for the basic metals industry. Therefore, a combination of factors like mineral resources, infrastructure availability and sector and region-specific policies tend to explain the regional concentration of the basic metals industry.

## 4. Summary and Conclusion

The preceding analysis implies that regional concentration of an industry is a dynamic process and it keeps changing over time. Therefore, static analysis of industrial concentration at a single point of time may not reveal the correct picture. The use of averaged values in our analysis allows us to covers all the years and presents a more comprehensive story.

From the above analysis, it is clear that the concentration of an industry in a region depends on multiple factors like natural resource advantages, access to the market, availability of labour and intermediate inputs. For example, basic metals industry is highly concentrated (agglomerated) in Jharkhand, Chhattisgarh and Odisha due to the availability of mineral, oil and coal reserves. The non-metallic minerals industry has a relatively high concentration in Bihar and Andhra Pradesh due to the availability of minerals like mica, limestone, kryanite, etc.

However, the above analysis also highlights that the concentration of an industry in a given region not only depends on the availability of natural resources and raw materials but also on the presence of infrastructural facilities, availability of skill and favourable government policies in the region. These factors determine the comparative advantage of different regions and thus affect industrial agglomeration in a region. This is clearly highlighted by Uttarakhand, Himachal Pradesh and Gujarat. For example, the governments of Uttarakhand and Himachal Pradesh have provided special tax concessions and benefits to firms in food and pharmaceuticals sector. There are investments by the state government in improving the infrastructure facilities in the states. These initiatives have fostered the concentration of these industries.

Prior to the economic reforms, industrial location was entirely decided by government. The goal was to attain a balanced regional distribution of industries by locating industrial units in all parts of the country. However, the economic reforms and liberalization have changed this and the industry location decisions are guided by profit motive. Businesses and industrial units tend to locate in regions which have good infrastructure facilities, connectivity to ports and availability of skilled human capital. The literature has established that new industries tend to locate where there is an existence of industries (Lall and Chakravorty, 2004). This implies that less industrialized eastern and north-eastern states of India are at a serious disadvantage. There is also a link in the literature between uneven geographical concentration and regional disparities in income and growth (Fujita et al., 2001). The eastern states of Bihar, Jharkhand, Chhattisgarh and Odisha have low concentration in case of most of the two-digit industries.

Further, the concentration of a large number of industries is declining in these states (as shown by a declining value of L.Q.). This implies that economic growth could get adversely affected as these states lag behind the relatively industrialized states. Therefore, it is important that governments in these states should formulate policies that attract firms to these states. These policies could take the form of tax benefits, assuring the availability of power, water and energy at subsidized rates, availability of skilled human capital and better infrastructural facilities. On the other hand, states like Uttarakhand, Gujarat, Maharashtra and Andhra Pradesh have a large number of industries in which they specialize. The increasing values of L.Q. for the majority of industries in these states confirm this trend. It is important for the less industrialized states to follow the footsteps of Gujarat, Maharashtra, Himachal Pradesh and Uttarakhand, which have managed to achieve a high concentration in a large number of industries for reasons beyond the natural advantages.

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**Notes :**

[1] The terms industrial concentration and industrial agglomeration are related but not the same. Industrial concentration is concerned with the scale of individual firms whereas industrial agglomeration is concerned with the scale of specific industry in a geographical place (Li and Xiang, 2006). Concentration and agglomeration are, however, used interchangeably in the literature (Tian, 2013).

[2] The regional economics literature views the 'industrial specialization of regions' and 'geographical concentration of industries' as closely interrelated to each other (Chowdhury and Ghosh, 2014; Goschin et al., 2009).

[3] Internet Source: Growth and Problems faced by woollen textiles industry in India (http://www.yourarticlelibrary.com/industries/growth-and-problems-faced-by-woollen-textiles-industries-in-india/19694/).

*The country that is more developed industrially only shows, to the less developed, the image of its own future.*

*– Karl Marx*

# Intra-State Concentration of Unorganized Manufacturing Enterprises in India

**DILIP SAIKIA**

*The objective of this paper is to examine the intra-state concentration of unorganized manufacturing enterprises in India. Using a unique data-set of 394 districts of 16 states, drawn from Enterprise Survey data of National Sample Survey (NSS) 1994–95 and 2005–06 'thick' rounds, we have ranked the districts based on a composite index of district level development of unorganized manufacturing enterprises and measured the intra-state concentration by employing the Herfindahl index. The findings reveal that the most 'lagging' industrial districts are present not only in backward states but in developed states also. Intra-state concentration is found to be highest in Maharashtra, followed by Gujarat and Himachal Pradesh, whereas relatively low in Bihar, Andhra Pradesh, Uttar Pradesh, Tamil Nadu, Assam, Kerala, Odisha and West Bengal. Between 1994–95 and 2005–06, intra-state concentration has declined in Madhya Pradesh, Gujarat, Haryana, Uttar Pradesh, Tamil Nadu, Punjab, Bihar and Odisha, whereas it has increased in Himachal Pradesh, Rajasthan, West Bengal, Assam, Karnataka and Andhra Pradesh. However, there is evidence for within state $\beta$–convergence in all the states, except Himachal Pradesh. Our analysis also shows that intra-state concentration of unorganized manufacturing enterprises is positively associated with the level of economic and industrial development.*

*Dilip Saikia, Assistant Professor, Department of Commerce, Darrang College, Tezpur, Assam, India.*

## 1. Introduction

The regional disparities in economic development have been widely acknowledged to be a cause of concern to the policymakers in India since the commencement of planning in 1950–51. The issue received more attention in the post-reform (post-1991) period as inter-state disparities in per capita income and other socio-economic indicators, which were already high, have been observed to be steadily rising in the last three decades (see, for instance, Ahluwalia, 2000, 2011; Bhattacharya and Sakthivel, 2004; Kurian, 2000; Planning Commission, 2008, 2013). Ahluwalia (2000) estimates Gini coefficient for 14 major states from 1980–81 to 1997–98, and finds that the inter-state inequality was fairly stable for most of the 1980s, but began to increase starting from the late 1980s and even more in the 1990s. In a recent study, Ahluwalia (2011) finds that the average Gini coefficient of per capita gross state domestic product (GSDP) has increased from 0.15 during 1981–1990 to 0.19 during 1991–2000 and 0.224 during 2001–2010.

While a large body of literature focuses on inter-state disparities in India, it seems to overlook the disparities across different regions within the states. The fact that Indian states are large and heterogeneous in terms of size, geography, history, natural resource endowments, human capital, political economy, culture and so on, intra-state disparities might perhaps be more intense. Moreover, what is true of rising inter-state disparities could also be true of spatial disparities within the states. The 12$^{th}$ Five Year Plan highlights the fact that 'there are considerable regional disparities in socio-economic development not only between states but also within states' and that 'intra-state disparities are as much a cause of concern as inter-state disparities' (Planning Commission, 2013). Debroy and Bhandari (2003) find that districts with the highest poverty ratios lie not just in backward states like Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh, but also in developed states like Gujarat, Maharashtra, Karnataka and Tamil Nadu. Chaudhuri and Gupta (2009) estimate per capita monthly consumption expenditure, poverty ratio and inequality for all the districts of 20 major Indian states based on National Sample Survey (NSS) Consumer Expenditure Survey data from 61st round (2004–05), and find that there was wide spatial disparity in the level of living across the districts, and that the range of disparity at the district-level within a state was more serious than the disparity between the states.

Very few studies have been attempted to analyze intra-state disparities in India. Most of them were either for a particular state [for instance, Shaban (2006) and Hatekar and Raju (2013) for Maharashtra; Chakraborty (2009) for Kerala; Raychaudhuri and Haldar (2009) for West Bengal; Diwakar (2009) for Uttar Pradesh; Tsujita et al. (2010) for Bihar], or for a few selected states [for instance, Suryanarayana (2009) for Karnataka and Maharashtra; Dubey (2009) for Gujarat, Haryana, Kerala, Odisha and Punjab; Bhattacharya (2009) for Bihar, Jharkhand, Madhya Pradesh, Chhattisgarh, Uttar Pradesh and West Bengal]. These studies have analyzed the intra-state disparities in terms of income level, consumption expenditure, incidence of poverty, human development and government expenditure for the respective selected states, and provide adequate evidence of wide spatial disparity across the districts within the states.

Studies on intra-state disparities in industrial development in India are even fewer. Awasthi (2000) examines the pattern and trend of new industrial investments flow in the top 40 talukas[1] in Gujarat from 1985–86 to 1995–96, and finds that investment was concentrated in and around eight major industrial poles. Chakravorty et al. (2003) examine spatial clustering of organized manufacturing industries at pin code level within the metropolitan areas of Mumbai, Kolkata and Chennai for 1998–99, and find that intra-metropolitan concentration is high in Kolkata than in Mumbai and Chennai, and that state regulations relating to land-market play a significant role in guiding intra-metropolitan industrial locations. However, none of the studies have analyzed the intra-state concentration of industries even for the major states of India and intra-state concentration of unorganized manufacturing enterprises even for a single state. Therefore, this paper attempts to fill this gap in the literature and aims to examine the intra-state concentration of the unorganized manufacturing enterprises for 16 major states of India. The unorganized manufacturing enterprises, defined as the manufacturing enterprises which employ less than ten workers with the use of electricity and less than twenty workers without using electricity,[2] account for more than 99 per cent of manufacturing enterprises, over 80 per cent of manufacturing workers, 25–30 per cent of manufacturing value added, and 40–45 per cent of manufacturing exports, and thus, occupy a considerable place in India's industrial sector.

The salient feature of the study is worth highlighting. The uniqueness of our study is that we use district-level data, which allows us to provide a relatively comprehensive view of spatial concentration of the unorganized manufacturing enterprises within the states. This study may be considered among the first studies to analyze the intra-state concentration of industries, especially the unorganized manufacturing enterprises, for the major states of India.

The rest of the paper is organized in the following sections: data source, ranking of the districts at the national level, intra-state concentration, analysis of convergence/divergence, concentration and level of development and conclusion.

## 2. Data Source

The data for this analysis were drawn from the enterprise survey data of the 51st (1994–95) and 62nd (2005–06) 'thick' rounds of the National Sample Survey (NSS) on unorganized manufacturing enterprises in India. These two rounds of NSS surveys provide enterprise level information on different characteristics of unorganized manufacturing enterprises for 451 and 581 districts respectively. Using this data, we have estimated district level values of number of enterprises, employment, gross value added and fixed capital. Employment refers to the total number of employees, which includes both workers and supervisory staff; gross value added is the additional value created by the process of production by an enterprise and is calculated as the difference between total receipts and total operating expenses; and fixed capital is the value of fixed assets owned by the enterprise.

For the analytical purpose, we have selected 16 major states: Andhra Pradesh, Assam, Bihar (including Jharkhand), Gujarat, Haryana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh (including Chhattisgarh), Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh (including Uttarakhand) and West Bengal. These states have different levels of development conditioned by geographic location, agro-climatic conditions and level of industrialization, and also represent a wide regional coverage: four states each from northern and southern regions, three from eastern region, two each from central and western regions and one from north-eastern region.

There were substantial changes in the districts' boundaries between the two time points. Therefore, we have constructed consistent district identities by merging the newly created districts with the districts from which they had been carved out. While some districts were cleanly partitioned into multiple districts between these periods, some districts experienced complex boundary changes. In the case of districts which were created by partitioning multiple districts, we use population weights for merging the new districts with the multiple parent districts, following Kumar and Somanathan (2009). Finally, we matched these districts with the NSS district definitions and obtained 394 districts for the selected 16 states. The number of districts by state considered for analysis is reported in Table 1.

### 3. Ranking of the Districts at the National Level

Before moving on to the analysis of intra-state concentration, it is worthwhile to have a look at the state- and district-level profile of the complete sample. In Table 2, we present data on a select number of indicators of industrial and economic development for the 16 selected states in 2005–06. These states account for over 87 per cent of total geographical area and 96 per cent of total population of India as per Census 2001. More than

**Table 1: Number of Districts and Districts Available for Analysis**

| States | Total Number of Districts | | Number of Districts Available for Analysis |
|---|---|---|---|
| | 1994–95 | 2005–06 | |
| Andhra Pradesh [AP] | 23 | 23 | 23 |
| Assam [AS] | 22 | 23 | 22 |
| Bihar [BIH] | 42 | 55 | 42 |
| Gujarat [GUJ] | 19 | 25 | 19 |
| Haryana [HAR] | 16 | 19 | 16 |
| Himachal Pradesh [HP] | 12 | 11 | 11 |
| Karnataka [KAR] | 20 | 27 | 20 |
| Kerala [KER] | 14 | 14 | 14 |
| Madhya Pradesh [MP] | 45 | 61 | 45 |
| Maharashtra [MAH] | 30 | 35 | 30 |
| Odisha [ODI] | 13 | 30 | 13 |
| Punjab [PUN] | 12 | 17 | 12 |
| Rajasthan [RAJ] | 27 | 32 | 27 |
| Tamil Nadu [TN] | 21 | 30 | 20 |
| Uttar Pradesh [UP] | 63 | 83 | 63 |
| West Bengal [WB] | 17 | 18 | 17 |
| All India | 451 | 581 | 394 |

*Source:* Tabulated from unit level record of enterprise survey data of NSS 51st and 62nd rounds.

93 per cent of the total Net State Domestic Product (NSDP) originates in these states. It appears that Gujarat, Maharashtra, Haryana, Tamil Nadu, Punjab and Karnataka are the industrialized (that is, states with share of manufacturing in NSDP above the national average) and industrially developed states (that is, states with per capita NSDP from manufacturing above the national average). These are also the better-off states (that is, states with per capita NSDP above the national average), along with Kerala, Himachal Pradesh and Andhra Pradesh. On the other hand, Bihar, Assam, Odisha, Uttar Pradesh, Madhya Pradesh, Rajasthan and West Bengal are the least industrialised and industrially as well as economically backward states.

In order to capture the level of development of unorganized manufacturing enterprises at the district-level, we have constructed a composite index using nine indicators: (i) share of the district in number of enterprises, (ii) share of the district in employment, (iii) share of the district in gross value added, (iv) share of the district in fixed capital, (v) number of enterprises per 100 sq km in the district, (vi) employment per 100 sq km in the district, (vii) employment per 1,00,000 population in the district, (viii) per capita gross value added in the district, and (ix) per capita fixed capital in the district. To arrive at a composite index, we have combined the above indicators by assigning equal weight after standardizing the indicators by constructing the classic z-score, which is defined as

**Table 2: Selected Indicators at the State Level, 2005–06**

| States | Per capita manufacturing NSDP | | Share of manufacturing in NSDP | | Share of unorganized manufacturing in NSDP | | Per capita NSDP | | Percentage of total NSDP | Comment |
|---|---|---|---|---|---|---|---|---|---|---|
| | Rs. | Rank | Share (%) | Rank | Share (%) | Rank | Rs. | Rank | | |
| Gujarat | 8569 | 1 | 23.74 | 1 | 6.02 | 4 | 36102 | 3 | 7.28 | Industrialized quarter |
| Maharashtra | 8406 | 2 | 20.53 | 2 | 6.10 | 3 | 40947 | 1 | 15.74 | |
| Haryana | 7736 | 3 | 19.19 | 3 | 5.96 | 6 | 40313 | 2 | 3.44 | |
| Tamil Nadu | 5947 | 4 | 17.51 | 4 | 6.96 | 2 | 33968 | 6 | 8.14 | |
| Punjab | 4817 | 5 | 14.28 | 6 | 8.25 | 1 | 33741 | 7 | 3.30 | Upper-middle quarter |
| Karnataka | 4318 | 6 | 14.76 | 5 | 3.68 | 11 | 29265 | 8 | 6.05 | |
| Himachal Pradesh | 3420 | 7 | 9.84 | 12 | 2.11 | 16 | 34741 | 5 | 0.85 | |
| Andhra Pradesh | 2715 | 8 | 9.88 | 11 | 3.38 | 13 | 27486 | 9 | 8.15 | |
| Kerala | 2487 | 9 | 7.14 | 16 | 4.14 | 10 | 34837 | 4 | 4.26 | Lower-middle quarter |
| Rajasthan | 2298 | 10 | 11.82 | 9 | 5.96 | 5 | 19445 | 11 | 4.44 | |
| West Bengal | 2043 | 11 | 8.59 | 13 | 4.89 | 8 | 23799 | 10 | 7.45 | |
| Madhya Pradesh | 1861 | 12 | 11.21 | 10 | 3.67 | 12 | 16594 | 14 | 5.43 | |
| Uttar Pradesh | 1721 | 13 | 12.30 | 8 | 5.93 | 7 | 13986 | 15 | 9.86 | Least Industrialized quarter |
| Odisha | 1477 | 14 | 8.22 | 14 | 2.48 | 14 | 17964 | 12 | 2.57 | |
| Assam | 1380 | 15 | 8.09 | 15 | 2.36 | 15 | 17050 | 13 | 1.79 | |
| Bihar | 1336 | 16 | 13.31 | 7 | 4.75 | 9 | 10039 | 16 | 4.42 | |
| States in Sample | 3451 | | 14.52 | | 5.22 | | 23764 | | 93.18 | |
| All India | 3462 | | 14.11 | | 5.13 | | 24537 | | 100.0 | |

*Source: Handbook of Statistics on Indian Economy 2010–11.*
*Note:* NSDP values are at 2004–05 constant prices.

the value of an observed variable minus the variable mean divided by its standard deviation.

Based on the composite index, we have ranked the districts at the national level. A list of top-25 districts is given in Table 3 and another list of bottom-100 districts is given in the Annexure-1, supplemented by a summary in Table 4 (results for all the districts are not reported, but are available upon request).

It appears that the most 'lagging' districts in unorganized manufacturing enterprises in India lie not only in backward states, such as Assam, Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh, but also in

**Table 3: Top-25 Districts in Unorganized Manufacturing Enterprises**

| S. No. | 1994–95# | 2005–06† |
|---|---|---|
| 1 | Greater Mumbai MAH [1] | Greater Mumbai MAH [1] |
| 2 | Surat GUJ [12] | Kolkata WB [17] |
| 3 | Bhavnagar GUJ [56] | Thane MAH [29] |
| 4 | Bankura WB [191] | South 24-Parganas WB [19] |
| 5 | Varanasi UP [61] | Coimbatore TN [18] |
| 6 | Maldah WB [39] | Kamarajar TN [30] |
| 7 | Sambalpur ODI [76] | Medinipur WB [32] |
| 8 | Howrah WB [11] | Chennai TN [16] |
| 9 | Mayurbhanj ODI [21] | Bangalore (U) KAR [25] |
| 10 | Moradabad UP [37] | Ahmedabad GUJ [39] |
| 11 | Keonjhar ODI [99] | Howrah WB [8] |
| 12 | Pratapgarh UP [208] | Surat GUJ [2] |
| 13 | Salem TN [26] | Thiruvannamalai TN [125] |
| 14 | Jaunpur UP [74] | Murshidabad WB [24] |
| 15 | Bhopal MP [178] | Nadia WB [38] |
| 16 | Chennai TN [8] | Dakshina Kannada KAR [56] |
| 17 | Kolkata WB [2] | North Arcot TN [26] |
| 18 | Coimbatore TN [5] | Amreli GUJ [311] |
| 19 | South 24-Parganas WB [4] | North 24-Parganas WB [22] |
| 20 | Madurai TN [77] | Anantapur AP [87] |
| 21 | Panipat HAR [62] | Mayurbhanj ODI [9] |
| 22 | North 24-Parganas WB [19] | Karimnagar AP [127] |
| 23 | Barddhaman WB [88] | Tirunelveli TN [43] |
| 24 | Murshidabad WB [14] | Yamunanagar HAR [321] |
| 25 | Bangalore (U) KAR [9] | West Dinajpur WB [169] |

*Source:* Author's calculation from unit level data of NSS 51st and 62nd rounds.

*Notes:* The ranking of the districts is based on the composite index.

# Figures in the parenthesis indicate the rank of the districts in 2005–06.

† Figures in the parenthesis indicate the rank of the districts in 1994–95.

developed states such as Maharashtra, Gujarat, Haryana and Karnataka. The disparity across district is severe in case of Maharashtra. On the one hand, there are Greater Mumbai—the first ranked district—and a total of three districts among top-50 districts and six districts among top-100 districts, while on the other hand, nine districts of the state have appeared in the list of bottom-100 districts.[3] Similarly, advanced states like Gujarat, Karnataka, Tamil Nadu, Haryana, Himachal Pradesh and Andhra Pradesh have some of the most 'lagging' industrial districts of India.[4] Then again, backward states like Bihar, Madhya Pradesh, Odisha and Uttar Pradesh have some of the most 'leading' industrial districts (Tables 3 and 4).

It is observed that in some states, a majority of the districts are among the most 'lagging' districts and only a few districts are among the 'leading' districts. For instance, Assam, Bihar, Madhya Pradesh and Rajasthan together accounted for 50 of the bottom-100 districts in 1994–95 and 62 in 2005–06, whereas these states have only two districts in the top-50 districts in 1994–95 and four in 2005–06. Including Uttar Pradesh, these states have 63 districts in 1994–95 and 75 districts in 2005–06 in the bottom-100 list. Conversely, in some other states, a majority of the districts are among the most 'leading' districts and only a few districts are among the 'lagging' districts. For instance, Gujarat, Maharashtra, Tamil Nadu, Karnataka, Haryana, West Bengal and Andhra Pradesh accounted for about 60 of the top-100 districts, whereas they accounted for only 15 of the bottom-50 districts in 1994–95 and seven in 2005–06 (Table 4).

The disparity across the districts has declined between 1994–95 and 2005–06. We have computed the coefficient of variation across the districts in terms of all the nine indicators of the composite index, and found that

**Table 4: State-wise Number of Top-50, Top-100, Bottom-100 and Bottom-50 Districts**

| States | Top-50 | | Top-100 | | Bottom-100 | | Bottom-50 | |
|---|---|---|---|---|---|---|---|---|
| | 1994–95 | 2005–06 | 1994–95 | 2005–06 | 1994–95 | 2005–06 | 1994–95 | 2005–06 |
| Andhra Pradesh | 1 | 3 | 11 | 8 | 2 | 0 | 2 | 0 |
| Assam | 0 | 0 | 1 | 0 | 10 | 12 | 4 | 4 |
| Bihar | 1 | 2 | 5 | 3 | 5 | 17 | 3 | 7 |
| Gujarat | 5 | 4 | 6 | 6 | 3 | 5 | 1 | 2 |
| Haryana | 2 | 4 | 3 | 7 | 7 | 1 | 3 | 1 |
| Himachal Pradesh | 0 | 0 | 0 | 1 | 3 | 4 | 0 | 0 |
| Karnataka | 1 | 4 | 10 | 9 | 4 | 3 | 1 | 1 |
| Kerala | 1 | 3 | 2 | 5 | 3 | 0 | 3 | 0 |
| Madhya Pradesh | 1 | 1 | 2 | 5 | 28 | 25 | 14 | 19 |
| Maharashtra | 3 | 3 | 6 | 6 | 9 | 9 | 6 | 3 |
| Odisha | 4 | 1 | 8 | 5 | 2 | 1 | 0 | 0 |
| Punjab | 2 | 1 | 3 | 2 | 1 | 0 | 0 | 0 |
| Rajasthan | 0 | 1 | 1 | 2 | 7 | 8 | 3 | 4 |
| Tamil Nadu | 10 | 8 | 14 | 12 | 2 | 0 | 1 | 0 |
| Uttar Pradesh | 8 | 5 | 15 | 17 | 13 | 13 | 8 | 9 |
| West Bengal | 11 | 10 | 13 | 12 | 1 | 2 | 1 | 0 |

*Source:* Same as Table 3.
*Note:* The tabulation is based on the composite index.

coefficient of variation has declined in 2005–06 compared to 1994–95 in terms of seven indicators, while increased in terms of two indicators.[5]

These findings provide clear evidence to confirm what we have postulated in the earlier section that even within highly developed states there are districts which are comparable to those of the poorest districts in the most backward states. For instance, in Gujarat and Maharashtra, the two most industrialized states, there are districts such as Dang, Valsad, Kachchh, Panch Mahals, Gandhinagar (all are in Gujarat), Latur, Gadchiroli, Jalgaon, Jalna, Buldana, Parbhani, Wardha, Chandrapur and Yavatmal (all are in Maharashtra), which were among the most 'lagging' industrial districts in India. This reveals the extent of intra-state concentration of unorganized manufacturing enterprises in India. For further details of such incidence, we need to explore the spatial disparity across districts within each state.

## 4. Intra-State Concentration

Keeping the findings from the preceding section on inter-district disparity in the unorganized manufacturing enterprises for the country as a whole in the background, in this section we examine the intra-state concentration of these enterprises in 16 selected states in 1994–95 and 2005–06. We define intra-state concentration as the extent to which a given industry is concentrated in a few districts within a state.

First, let us have a look at the 'leading' and 'lagging' industrial districts within each state to understand the spatial disparity within the states. Table 5 reports the 'leading' and 'lagging' industrial districts in each state, based on the composite index. For the country as a whole, Greater Mumbai district of Maharashtra appeared as the 'leading' industrial district in 1994–95 and 2005–06,

**Table 5: State-wise 'Leading' and 'Lagging' Districts based on Composite Index**

| States | 1994–95 | | 2005–06 | |
|---|---|---|---|---|
| | 'Leading' district | 'Lagging' district | 'Leading' district | 'Lagging' district |
| Andhra Pradesh | Prakasam | Adilabad | Anantapur | Nalgonda |
| Assam | Karimganj | Dhemaji | Kamrup | North Cachar Hills |
| Bihar | Muzaffarpur | Godda | Sahibganj | Khagaria |
| Gujarat | Surat | Gandhinagar | Ahmedabad | Dang |
| Haryana | Panipat | Hisar | Faridabad | Rewari |
| Himachal Pradesh | Hamirpur | Kinnaur | Una | Chamba |
| Karnataka | Bangalore(U) | Kodagu | Bangalore(U) | Uttara Kannada |
| Kerala | Alappuzha | Wayanad | Alappuzha | Wayanad |
| Madhya Pradesh | Bhopal | Jhabua | Sagar | Panna |
| Maharashtra | Greater Mumbai | Gadchiroli | Greater Mumbai | Jalgaon |
| Odisha | Sambalpur | Sundargarh | Mayurbhanj | Phoolbani |
| Punjab | Ludhiana | Faridkot | Ludhiana | Faridkot |
| Rajasthan | Ajmer | Dhaulpur | Jaipur | Jhalawar |
| Tamil Nadu | Salem | Nilgiri | Coimbatore | Ramanathapuram |
| Uttar Pradesh | Varanasi | Tehri Garhwal | Meerut | Garhwal |
| West Bengal | Bankura | Darjiling | Kolkata | Koch Bihar |
| All India | Greater Mumbai [Maharashtra] | Kodagu [Karnataka] | Greater Mumbai [Maharashtra] | Garhwal [Uttar Pradesh] |

*Source:* Same as Table 3.

whereas Kodagu district of Karnataka and Garhwal district of Uttar Pradesh respectively appeared as the 'lagging' industrial district in 1994–95 and 2005–06. Between 1994–95 and 2005–06, the 'leading' and 'lagging' industrial districts have changed in all the states, except Karnataka, Kerala, Maharashtra and Punjab in case of 'leading' districts, and Kerala and Punjab in case of 'lagging' districts.

We also look at the 'leading' and 'lagging' industrial districts in each state in terms of per capital gross value added, which is also a component of the composite index, and measure the extent of intra-state disparity by comparing the ratios of per capita gross value added of the 'leading' district to the 'lagging' district (Table 6). The results are not surprising in the context of what we have presented in the preceding section, but they are quite effective in making the point that there has been wide spatial concentration of unorganized manufacturing enterprises within the states. For instance, in 1994–95, the ratio of per capita gross value added of the 'leading' district to the 'lagging' district was as high as 103.7 in Madhya Pradesh, 81.5 in Maharashtra, 72 in Haryana, 59.8 in Uttar Pradesh, 42.4 in Gujarat, and 32.8 in Karnataka. By 2005–06, the gap between the 'leading' and 'lagging' districts has declined in all the states, except Bihar, Odisha and Rajasthan; but the gap still remained too large in the states like Uttar Pradesh, Maharashtra, Bihar, Gujarat, Madhya Pradesh, West Bengal, Himachal Pradesh, Rajasthan and Karnataka.

**Table 6: 'Leading' and 'Lagging' Districts based on Per Capita Gross Value Added**

| States | Per capita value added | 'Leading' District | | 'Lagging' District | | Min./Max. |
|---|---|---|---|---|---|---|
| | | District Name | Per Capita value added | District Name | Per Capita value added | |
| **1994–95** | | | | | | |
| Andhra Pradesh | 218 | Prakasam | 586 | Adilabad | 31 | 19.0 |
| Assam | 146 | Bongaigaon | 386 | Tinsukia | 43 | 9.0 |
| Bihar | 158 | West Singhbhum | 492 | Begusarai | 30 | 16.4 |
| Gujarat | 737 | Surat | 3204 | Gandhinagar | 76 | 42.4 |
| Haryana | 401 | Panipat | 2653 | Sonipat | 37 | 72.0 |
| Himachal Pradesh | 216 | Solan | 412 | Shimla | 137 | 3.0 |
| Karnataka | 297 | Bangalore (U) | 653 | Kodagu | 20 | 32.8 |
| Kerala | 200 | Alappuzha | 373 | Kasaragod | 61 | 6.1 |
| Madhya Pradesh | 183 | Bhopal | 3302 | Bastar | 32 | 103.7 |
| Maharashtra | 512 | Greater Mumbai | 2088 | Gadchiroli | 26 | 81.5 |
| Odisha | 233 | Sambalpur | 503 | Sundargarh | 89 | 5.7 |
| Punjab | 401 | Ludhiana | 904 | Faridkot | 83 | 10.9 |
| Rajasthan | 198 | Dungarpur | 507 | Banswara | 65 | 7.8 |
| Tamil Nadu | 601 | Madurai | 1598 | Nilgiri | 79 | 20.3 |
| Uttar Pradesh | 315 | Moradabad | 1596 | Tehri Garhwal | 27 | 59.8 |
| West Bengal | 404 | Kolkata | 1316 | Darjiling | 48 | 27.6 |
| All India | 334 | Bhopal | 3302 | Kodagu | 20 | 165 |
| **2005–06** | | | | | | |
| Andhra Pradesh | 617 | Anantapur | 1638 | Rangareddi | 182 | 9.0 |
| Assam | 513 | Kamrup | 1002 | Karbi Anglong | 134 | 7.5 |
| Bihar | 312 | Deoghar | 1833 | Saran | 60 | 30.8 |
| Gujarat | 1264 | Amreli | 4153 | Valsad | 138 | 30.1 |
| Haryana | 1293 | Yamunanagar | 2671 | Rewari | 344 | 7.8 |

*(Contd.)*

| | | | | | | |
|---|---|---|---|---|---|---|
| Himachal Pradesh | 923 | Solan | 5166 | Shimla | 290 | 17.8 |
| Karnataka | 1078 | Gulbarga | 2676 | Bellary | 220 | 12.2 |
| Kerala | 1071 | Thrissur | 1869 | Pathanamthitta | 400 | 4.7 |
| Madhya Pradesh | 414 | Seoni | 1975 | Morena | 74 | 26.7 |
| Maharashtra | 1432 | Greater Mumbai | 5763 | Latur | 147 | 39.1 |
| Odisha | 523 | Kendujhar | 1328 | Phoolbani | 215 | 6.2 |
| Punjab | 941 | Ludhiana | 2189 | Faridkot | 442 | 5.0 |
| Rajasthan | 672 | Jaipur | 1647 | Jhalawar | 112 | 14.7 |
| Tamil Nadu | 1336 | Kamarajar | 3202 | South Arcot | 402 | 8.0 |
| Uttar Pradesh | 585 | Moradabad | 2025 | Garhwal | 40 | 50.4 |
| West Bengal | 1036 | Kolkata | 3320 | Koch Bihar | 176 | 18.9 |
| All India | 775 | Greater Mumbai | 5763 | Garhwal | 40 | 114 |

*Source:* Same as Table 3.

In order to measure the degree of intra-state concentration of unorganized manufacturing enterprises, we have employed the Herfindahl index (hereafter, H-index), which is one of the widely used measures of spatial concentration. The H-index is defined as the sum of squared output (here, gross value added) shares of all districts in the state:

$$H = \sum_{k=1}^{n} (S_k / S)^2$$

where, $S_k$ and $S$ respectively are the gross value added of the $k^{th}$ district and all the districts in the state. To normalize the effect of the number of districts ($n$), the normalized H-index (H*) is computed as:

$$H^* = \frac{(H - 1/n)}{1 - 1/n}; \text{ for } n > 1$$

The value of the normalized H-index lies between zero and one. The highest value is one when the industry is located only in a single district and the lowest value is zero when all districts have equal shares. An H* value below 0.15 indicates least concentration, between 0.15–0.25 indicates moderate concentration, and above 0.25 indicates high concentration.

Figure 1 reports the results of the normalized H-index for the 16 states in 1994–95 and 2005–06. It appears that intra-state concentration is highest in Maharashtra in both the years, while it is moderate in Gujarat in 1994–95 and Himachal Pradesh in 2005–06, and relatively low in the remaining states, especially in Bihar, Andhra Pradesh, Uttar Pradesh, Tamil Nadu, Assam, Kerala, Odisha and West Bengal. We have also computed the share of four 'leading' districts in gross value added, the so called concentration ratio, for each state (results are not reported, but are available upon request), and found that the top four districts accounted for more than 75 per cent of gross value added in Maharashtra, and more than 50 per cent in Gujarat, Himachal Pradesh, Punjab, Haryana, Karnataka, Odisha and Kerala.

By 2005–06, intra-state concentration has declined in Madhya Pradesh, Gujarat, Haryana, Uttar Pradesh, Tamil Nadu, Punjab, Bihar and Odisha, whereas it has increased in Himachal Pradesh, Rajasthan, West Bengal, Assam, Karnataka and Andhra Pradesh, and remained unchanged in Maharashtra and Kerala.

## 5. Analysis of Convergence/Divergence

The forgoing discussion indicates within state absolute convergence (σ–convergence) in Bihar, Gujarat, Haryana, Madhya Pradesh, Odisha, Punjab, Tamil Nadu and Uttar Pradesh, and absolute divergence in Andhra Pradesh, Assam, Himachal Pradesh, Karnataka, Rajasthan and West Bengal. We also attempt to examine the presence of β–convergence/divergence within the states during 1994–95 to 2005–06. While σ–convergence refers to fall in the dispersion of real per capita income across a cross-section of economies over time, β–convergence refers to a negative relation between the growth rate of per capita income and the initial level of income (Sala-i-Martin, 1996). Thus, there will be β–convergence if the 'lagging' districts grow faster than the 'leading' districts. Although different, the two concepts of convergence are related, and β–convergence is a necessary (but not sufficient) condition for σ–convergence.[6]

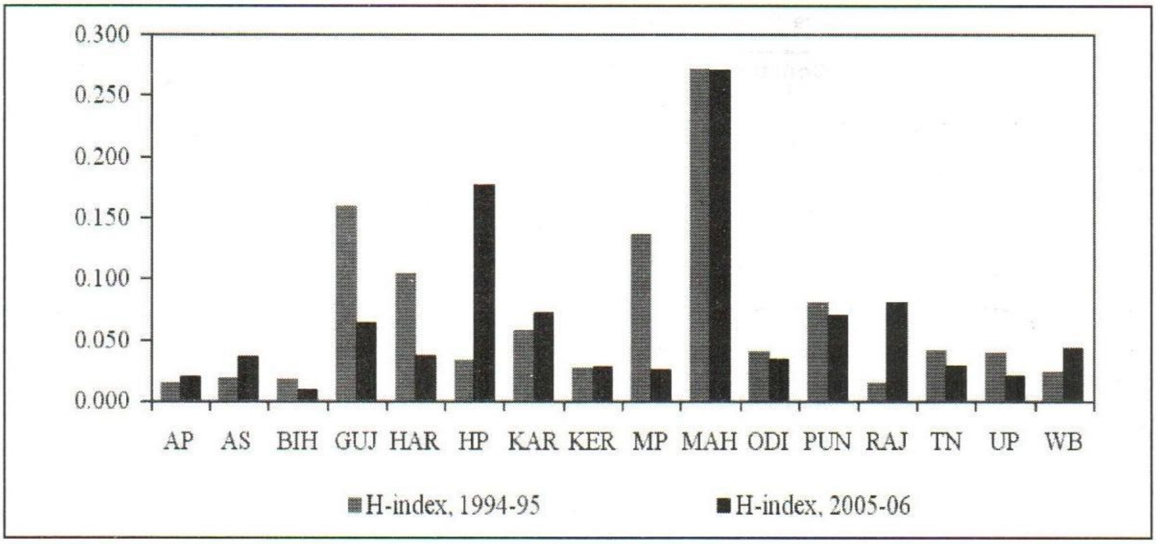


**Figure 1. Intra-State Concentration (H-index)**

*Source:* Same as Table 3.

*Note:* See Table 1 for the state codes.

In order to examine β–convergence, we have regressed the difference in per capita gross value added (log scale) between 1994–95 and 2005–06 on the per capita gross value added (log scale) in 1994–95. The empirical implementation of the convergence regression takes the following form:

$$\ln(PCGVA_{i,t}) - \ln(PCGVA_{i,t-\tau}) = \alpha + \beta \ \ln(PCGVA_{i,t-\tau}) + \mu_{i,t}$$

where, *ln* denotes natural logarithmic transformation, *i* the cross-sectional units (here, district), *t* the final time period, τ the initial time period, PCGVA the per capita gross value added, α and β are constants and μ is the error term, capturing the unobservable factors. The parameter β measures the rate of convergence if negative or divergence if positive. A higher value of β (with a negative sign) corresponds to a greater tendency for convergence.

The results of the regression estimates for the aggregate unorganized manufacturing enterprises for each of the state are reported in Table 7. The convergence coefficients are negative and statistically significant at the

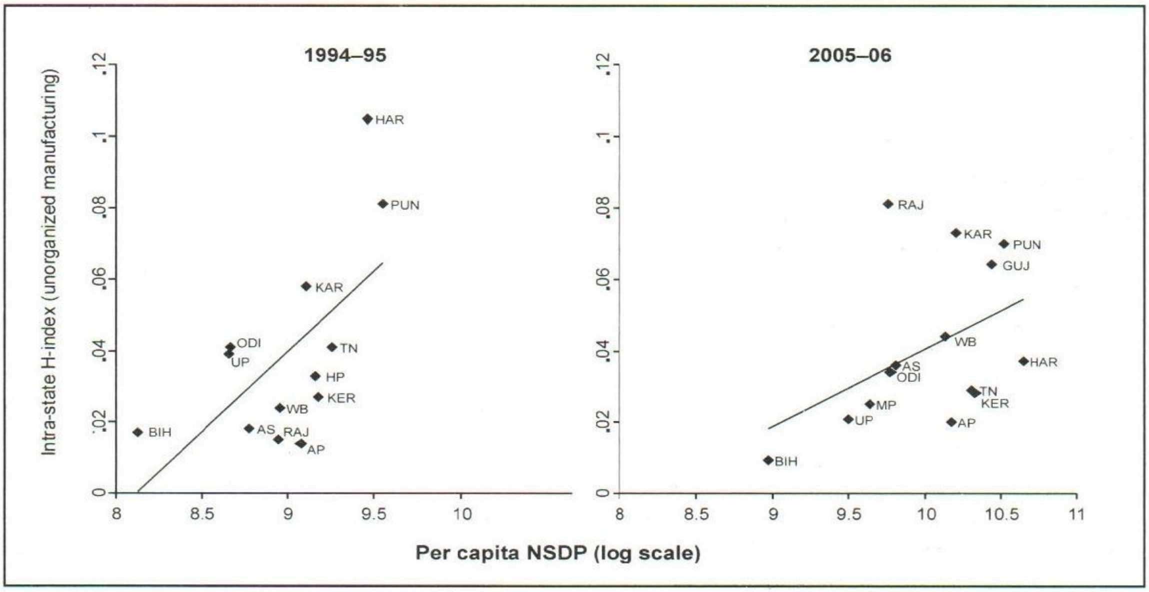


**Figure 2. Intra-State Concentration and Per Capita NSDP**

*Source:* Author's estimation.

*Note:* See Table 1 for the state codes.

**Table 7: Regression Results for Absolute β–Convergence**

| State | N | Constant | Convergence Parameter | R-squared | Comment |
|---|---|---|---|---|---|
| Andhra Pradesh | 23 | 6.788***<br>*(1.0337) | –1.102***<br>(0.2042) | 0.595 | Convergence<br>(Significant) |
| Assam | 22 | 6.199***<br>(0.6677) | –1.031***<br>(0.1448) | 0.605 | Convergence<br>(Significant) |
| Bihar | 42 | 5.822***<br>(0.8824) | –1.046***<br>(0.1772) | 0.493 | Convergence<br>(Significant) |
| Gujarat | 19 | 4.344***<br>(1.0593) | –0.617***<br>(0.1558) | 0.330 | Convergence<br>(Significant) |
| Haryana | 16 | 6.355***<br>(0.7800) | –0.891***<br>(0.1537) | 0.752 | Convergence<br>(Significant) |
| Himachal Pradesh | 11 | 2.2975<br>(5.2462) | –0.2114<br>(1.0076) | 0.010 | Convergence<br>(Not significant) |
| Karnataka | 20 | 5.286***<br>(0.8784) | –0.766***<br>(0.1646) | 0.341 | Convergence<br>(Significant) |
| Kerala | 14 | 5.160***<br>(0.9533) | –0.679***<br>(0.1876) | 0.444 | Convergence<br>(Significant) |
| Madhya Pradesh | 45 | 4.487***<br>(0.5117) | –0.751***<br>(0.1116) | 0.373 | Convergence<br>(Significant) |
| Maharashtra | 30 | 3.144***<br>(0.8902) | –0.417**<br>(0.1749) | 0.226 | Convergence<br>(Significant) |
| Odisha | 13 | 5.013***<br>(0.5279) | –0.782***<br>(0.1096) | 0.522 | Convergence<br>(Significant) |
| Punjab | 12 | 3.790***<br>(0.6737) | –0.499***<br>(0.1261) | 0.563 | Convergence<br>(Significant) |
| Rajasthan | 27 | 5.224***<br>(1.3561) | 0.832***<br>(0.2610) | 0.339 | Convergence<br>(Significant) |
| Tamil Nadu | 20 | 5.177***<br>(0.9255) | –0.700***<br>(0.1532) | 0.510 | Convergence<br>(Significant) |
| Uttar Pradesh | 63 | 3.562***<br>(0.5126) | –0.531***<br>(0.0951) | 0.343 | Convergence<br>(Significant) |
| West Bengal | 17 | 3.907***<br>(0.9105) | –0.535***<br>(0.1596) | 0.399 | Convergence<br>(Significant) |

*Source:* Author's estimation.

*Notes:* ***, ** refer to significant at 1 per cent and 5 per cent level respectively.

Figures in parenthesis are the robust standard errors.

**Table 8: Rank Correlation between Intra-state Concentration and Level of Development**

| | 1994–95 | 2005–06 |
|---|---|---|
| Between H-index and Per Capita NSDP (log scale) | 0.561** | 0.574** |
| Between H-index and Per Capita Manufacturing NSDP (log scale) | 0.621** | 0.550** |

*Source:* Author's estimation.

*Note:* ** refers to significant at 5 per cent level of significance.

conventional level for all the states, except Himachal Pradesh. This provides evidence for within state β–convergence in all states, except Himachal Pradesh. The rate of convergence is highest in Andhra Pradesh followed by Bihar and Assam, and lowest in Maharashtra followed by Punjab, Uttar Pradesh and West Bengal.

## 6. Concentration and Level of Development

Given the results discussed above, an important question is: does intra-state concentration of unorganized manufacturing enterprises vary with the level of development of the states? To find the average degree of association between intra-state concentration of unorganized manufacturing enterprises and level of development of the states, we have plotted the intra-state H-index (for the aggregate unorganized manufacturing enterprises) against per capita NSDP (log scale) of the states. If the relationship is positive then the estimated linear regression line will be upward slopping, and the line will be downward slopping if the relationship is negative. The results presented in Figure 2 indicate that intra-state concentration is positively associated with the level of per capita NSDP, which corroborates the fact that the advanced states, on an average, have high intra-state concentration than the backward states. For further confirmation of this relationship, we have computed the rank correlation coefficient between intra-state H-index and level of economic development (measured as log of per capita NSDP) and industrial development (measured as log of per capita manufacturing NSDP) of the states. The results reported in Table 8 show that the rank correlation coefficients turned out to be fairly high and statistically significant with positive sign, providing further evidence of the positive relationship between intra-state concentration of unorganized manufacturing enterprises and level of economic as well as industrial development.

## 7. Conclusion

The aim of this article has been to examine the intra-state concentration of unorganized manufacturing enterprises for 16 major states of India for the period 1994–95 to 2005–06. The findings reveal that spatial concentration of unorganized manufacturing enterprises within states is quite glaring. We find that the most 'lagging' industrial districts are present not only in backward states such as Assam, Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh, but also in developed states such as Maharashtra, Gujarat, Haryana and Karnataka. The intra-state concentration of unorganized manufacturing enterprises is highest in Maharashtra followed by Gujarat and Himachal Pradesh, whereas relatively low in Bihar, Andhra Pradesh, Uttar Pradesh, Tamil Nadu, Assam, Kerala, Odisha and West Bengal. On an average, intra-state concentration is found to be positively associated with the level of economic and industrial development of the states. Between 1994–95 and 2005–06, while spatial disparity across the districts for the country as a whole has declined, intra-state concentration has declined in Madhya Pradesh, Gujarat, Haryana, Uttar Pradesh, Tamil Nadu, Punjab, Bihar and Odisha; and increased in Himachal Pradesh, Rajasthan, West Bengal, Assam, Karnataka and Andhra Pradesh. Our convergence/divergence analysis shows evidence for within state β–convergence in all the states, except Himachal Pradesh.

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***Notes :***

[1] A 'taluka', also known as 'tehsil' or 'mandal', is an administrative division in India and also in some South Asian countries. It is the second layer of the local self government/Panchayati Raj system, above which are the districts and below which are the gram panchayats. The term 'tehsil' is used to some extent in all states, whereas the term 'taluka' is more common in Gujarat, Karnataka and Maharashtra, and 'mandal' is more common in Andhra Pradesh and Telangana.

[2] The formal definition of unorganized manufacturing enterprises, used by the National Sample Survey Organisation (NSSO), include all the manufacturing units except– (i) those registered under sections 2m (i) and 2m (ii) of the Factories Act, 1948 and Bidi and Cigar Workers (Condition of Employment) Act, 1966 and (ii) those run by government (central government, state governments, local bodies)/public sector enterprises (NSSO, 2008).

[3] These districts are Aurangabad, Bid, Gadchiroli, Nanded, Raigarh, Ratnagiri, Sindhudurg, Wardha and Yavatmal in 1994–95 and Buldana, Chandrapur, Gadchiroli, Latur, Jalna, Jalgaon, Parbhani, Wardha and Yavatmal in 2005–06.

[4] These districts are Gandhinagar, Panch Mahal, Kachchh, Valsad and Dang in Gujarat; Bellary, Kodagu and Uttara Kannada in Karnataka; Dharmapuri and Nilgiri in Tamil Nadu; Rewari in Haryana; Chamba, Bilaspur, Hamirpur and Shimla in Himachal Pradesh; and Khammam and Adilabad in Andhra Pradesh.

[5] The coefficient of variation declined from 1.28 to 1.22 in terms of share in number of enterprises, from 1.36 to 1.25 in terms of share in employment, from 2.13 to 2.10 in terms of share in gross value added, from 3.92 to 2.20 in terms of share in fixed capital, from 1.16 to 0.89 in terms of employment per 1,00,000 population, from 1.36 to 1.02 in terms of per capita gross value added, and from 1.60 to 1.24 in terms of per capita fixed capital during 1994–95 to 2005–06; whereas it increased from 2.99 to 3.75 in terms of enterprises per 100 sq km and from 3.72 to 4.94 in terms of employment per 100 sq km during the same period.

[6] Quah (1993) and Friedman (1992) argue that σ–convergence is of greater interest because it speaks directly as to whether the distribution of income across economies is becoming more equitable. However, Sala-i-Martin (1996) contends the Quah–Friedman argument, and argues that both the concepts of convergence are relevant and should be analyzed empirically.

*Productivity is never an accident. It is always the result of a commitment to excellence, intelligent planning, and focused effort.*

*– Paul J. Meyer*

Annexure-1. Bottom-100 Districts in Ascending Order

| Rank | District Name | | Rank | District Name | |
|---|---|---|---|---|---|
| | 1994–95 | 2005–06 | | 1994–95 | 2005–06 |
| 295 | Aurangabad MAH | Dibrugarh AS | 345 | Nanded MAH | Jhabua MP |
| 296 | Seoni MP | Golaghat AS | 346 | Ratnagiri MAH | Durg MP |
| 297 | Balangir ODI | Bilaspur MP | 347 | Jalor RAJ | Nawada BI |
| 298 | Sonitpur AS | Gandhinagar GUJ | 348 | West Nimar MP | Bundi RA |
| 299 | Tumkur KAR | Hazaribag BIH | 349 | Wardha MAH | Godda BI |
| 300 | Damoh MP | Chamba HP | 350 | Dholpur RAJ | Darbhanga BIH |
| 301 | Karnal HAR | Bilaspur HP | 351 | Palakkad KER | Karimganj AS |
| 302 | Sibsagar AS | Bhilwara RAJ | 352 | Kasaragod KER | Betul MP |
| 303 | Budaun UP | Panch Mahals GUJ | 353 | Banswara RAJ | Vaishali BIH |
| 304 | Pithoragarh UP | Chamoli UP | 354 | Ujjain MP | Kanpur Dehat UP |
| 305 | Yavatmal MAH | Yavatmal MAH | 355 | Dhubri AS | Rewa MP |
| 306 | East Nimar MP | Rajnandgaon MP | 356 | Darjiling WB | Chhatarpur MP |
| 307 | Nalbari AS | Sonitpur AS | 357 | Maharajganj UP | Mandla MP |
| 308 | Sirohi RAJ | Cachar AS | 358 | Surguja MP | Mainpuri UP |
| 309 | Bellary KAR | Hamirpur HP | 359 | Mandsaur MP | Rewari HAR |
| 310 | Uttara Kannada KAR | Madhepura BIH | 360 | Bid MAH | Jalgaon MAH |
| 311 | Amreli GUJ | Shimla HP | 361 | Mandla MP | Nalbari AS |
| 312 | Sundargarh ODI | Mathura UP | 362 | Uttarkashi UP | Fatehpur UP |
| 313 | Etawah UP | Ethah UP | 363 | Raigarh MP | Hoshangabad MP |
| 314 | Dharmapuri TN | Chandrapur MAH | 364 | Narsimhapur MP | Gadchiroli MAH |
| 315 | Raigarh MAH | Wardha MAH | 365 | Sidhi MP | Chhindwara MP |
| 316 | Hoshangabad MP | Darrang AS | 366 | Almora UP | Sitamarhi BIH |
| 317 | Sagar MP | Nalanda BIH | 367 | Khammam AP | Siddharthnagar UP |
| 318 | Sonbhadra UP | Dewas MP | 368 | Chamoli UP | Pithoragarh UP |
| 319 | Lakhimpur AS | Bhojpur BIH | 369 | Sindhudurg MAH | Latur MAH |
| 320 | Bilaspur MP | Phoolbani ODI | 370 | Jalaun UP | Uttara Kannada KAR |

*(Contd.)*

| | | | | | |
|---|---|---|---|---|---|
| 321 | Yamunanagar HAR | Dhemaji AS | 371 | Adilabad AP | Balaghat MP |
| 322 | Dehradun UP | Araria BIH | 372 | Darrang AS | Dungarpur RAJ |
| 323 | Dang GUJ | Parbhani MAH | 373 | Morena MP | Karbi Anglong AS |
| 324 | Shahdol MP | Madhubani BIH | 374 | Nilgiri TN | Almora UP |
| 325 | Rajgarh MP | Kachchh GUJ | 375 | Gorakhpur UP | Valsad GUJ |
| 326 | Sirmaur HP | Bellary KAR | 376 | Gandhinagar GUJ | Datia MP |
| 327 | Panna MP | Sehore MP | 377 | Dhemaji AS | Tehri Garhwal UP |
| 328 | Khagaria BIH | Hailakandi AS | 378 | Tinsukia AS | Vidisha MP |
| 329 | Shimla HP | Purnia BIH | 379 | Kaithal HAR | Saran BIH |
| 330 | Bundi RAJ | Koch Bihar WB | 380 | Dhar MP | Bhind MP |
| 331 | Madhepura BIH | Jalaun UP | 381 | Sonipat HAR | West Nimar MP |
| 332 | Tonk RAJ | Mandsaur MP | 382 | Begusarai BIH | Sirohi RAJ |
| 333 | Chhatarpur MP | Buldana MAH | 383 | Shivpuri MP | Dang GUJ |
| 334 | Dibrugarh AS | Saharsa BIH | 384 | Deoghar BIH | Guna MP |
| 335 | Kurukshetra HAR | Sawai Madhopur RAJ | 385 | Wayanad KER | Uttarkashi UP |
| 336 | Vidisha MP | Shajapur MP | 386 | Shajapur MP | Shahdol MP |
| 337 | Ratlam MP | Bongaigaon AS | 387 | Raisen MP | Raisen MP |
| 338 | Golaghat AS | Jalor RAJ | 388 | Jhabua MP | Morena MP |
| 339 | Bastar MP | Banswara RAJ | 389 | Godda BIH | Jhalawar RAJ |
| 340 | Durg MP | Lohardaga BIH | 390 | Hisar HAR | Shivpuri MP |
| 341 | Faridkot PUN | Muzaffarpur BIH | 391 | Tehri Garhwal UP | Panna MP |
| 342 | Bhiwani HAR | Kodagu KAR | 392 | Garhwal UP | North Cachar Hills AS |
| 343 | Kinnaur HP | Darjiling WB | 393 | Gadchiroli MAH | Khagaria BIH |
| 344 | Sawai Madhopur RAJ | Jalna MAH | 394 | Kodagu KAR | Garhwal UP |

*Source:* Same as Table 3.
*Note:* See Table 1 for the state codes.
The ranking of the districts is based on the composite index.

# Manufacturing Productivity Growth in India: Revisiting Verdoorn's Law

D. P. PRIYADARSHI JOSHI AND SUSANTA KUMAR SETHY

*The literature concerning the study of manufacturing productivity has resorted to the Total Factor Productivity (TFP) to examine the dynamism within the manufacturing sector. But in contrast to the conventional practice, the Smithian generalization of 'Division of labour' to Young's critique to the concept as well as the promotion of increasing returns to scale, gives us a different dynamic view of looking at the productivity change and technical progress. The paper intends to look into the vulnerability of the basic Verdoorn's law in the present post-reform scenario which gives a strong back-up to the righteous conceptualization of the classical and the cumulative causation theorist.*

*D.P. Priyadarshi Joshi, Ph.D. research scholar at School of Economics, University of Hyderabad, Hyderabad, India.*

*Susanta Kumar Sethy, Ph.D. research scholar at School of Economics, University of Hyderabad, Hyderabad, India.*

## 1. Introduction

Conventional studies on productivity are in essence applications of neo-classical theory of distribution. However, since the marginal productivity theory has been discredited for long, it is not surprising that current applied work should rely increasingly on developments in the field of econometrics. In terms of economic methodology, the studies set up two key problems. First, a given quantum of product must be imputed unambiguously to individual 'factors' of production. Secondly, in a dynamic context, a shift in the economy's technological frontier must be identified independent of factors accumulation.

In contrast to this dominant mode of productivity analysis, we can locate in the classical economics of Adam Smith a distinct approach. Unhindered by aforesaid theoretical and methodological difficulties, this approach places the problem of productivity of labour at the center of economic growth and accumulation. In fact, productivity of labour and growth are bound together in a circular and cumulative process of change. There is no logical separation of labour from non-labour means of production or technical change. On the other hand, there is no logical connection between income distribution as such and productivity. By lending transparency to the forces promoting or limiting productivity, the classical approach affords a better guide for policy.

A number of studies have been conducted to examine the dynamism within the manufacturing sector and perusal of relevant literature reveals that the studies are centered on total factor productivity (TFP). The economic theory that backs these studies is mainly based on neo-classical assumptions such as constant returns to scale, perfect competition, continuous Solow-type production function, a smooth substitution between the factors of production and so on. But these assumptions are not operational in the case of manufacturing sector. From the classical and cumulative causation literature it is very much evident that the manufacturing sector operates with increasing returns to scale and there is a tendency towards oligopoly within manufacturing to take advantage of increasing returns and economies of scale.

Further, the neo-classical production function advocates that the factors like technical progress and advancement in skill form the TFP growth, while technical progress is usually embodied within the new capital which goes into production. As one cannot separate out the portion produced by capital and the portion produced by technology, these factors combined together produce output. In this context, the neo-classical assumption of smooth substitution between capital and labour is problematic and has also been ignored.

The two methods which are being used by most of the researchers are the growth accounting and the production function approach. But both these methods are critically debated in the literature which led the space for a more imperative and simple index of productivity growth. Growth accounting is applied to time-series data on output and input growth to calculate growth in the residual known as technical change. The residual in the estimation may be due to measurement error, omitted variables, aggregation bias and model specification. The method demands the decomposition of output growth into contributions of input accumulation and technical change. The application of growth accounting may go wrong when the method is undertaken without ascertaining the form of production function underlying the data. The application of this methodology to US data, have yielded bewildering results as it was found that only a small fraction of output growth can be attributed to input growth. Abramovitz (1989) has claimed that the enhancement of productivity of the factor and management skill should involve expenditure. So the expenditure might reduce the value of residual. Further, any errors in the measurement of data will affect the residual. Abramovitz has also found that alternative definitions of output and capital results in greatly different estimates. Growth accounting method is designed to measure the proximate sources of increase in output. This method is based on the questionable assumption of separability of factor inputs as it is very natural to believe that factors are feeding one another in the production process. The existence of mutual interdependence between the growth of input and growth of technological progress adds to the limitation of growth accounting as a method. Again, the growth accounting assumes technical progress is costless which is far from correct. Most of the advances in knowledge, technical innovation, improvement of skills, training are compensated. The capital theory debates, popularly known as the Cambridge capital controversies, raised the problems associated with measuring capital. Being a heterogeneous factor, capital can only be measured by multiplying its quantities with its prices. Labour, on the other hand, has a natural unit of measurement—such as man days and can be measured independent of its price.

The aggregate production function has been employed in neo-classical economics to explain both income distribution as well as economic growth. When trying to explain income distribution, the theory runs into circular reasoning because income distribution is used to explain prices and to determine prices one requires income distribution since capital has no natural unit of measurement. Moreover, there are serious issues relating to aggregation when constructing an aggregate production function (Felipe and Fisher, 2003). In strict terms, it is perhaps impossible to separate the effects on productivity into a labour one and a capital one because the contributions made by improved machinery and better skilled workers are neither additive nor separable. TFP is 'pure technological progress' disembodied from the labour and capital equipment. After all, by virtue of being a residual, the higher the number of inputs into production, the less the TFP is. Hence, the TFP estimates can change wildly with changes in the specification of the aggregate production function.

The simple decomposition of per head output growth into employment growth and productivity growth solves the problem of explaining the growth process. While the productivity growth is the prime factor in the determination of the per head output growth, the employment growth depends upon the structure of the production process and the use of type of capital. In the literature of economics, the explanation for the growth of labour productivity has acquired a significant place. Smith (1776) in his explanation argued that the cause behind the labour productivity growth is the division of labour. The simplification of production procedure by splitting down the whole activity into several simple activities will enhance the average product of the labour.

Later, the cumulative causation theorists (Young, 1928; Kaldor, 1957) have added another dimension, of the division of labour, for their analysis. Division of labour is not just the change in the occupational structure of the economy, but it is also the explanation of the operation of the scale economies. The cumulative causation theorists are convinced that the manufacturing sector has increasing returns to scale. The capitalistic mode of production, increasing returns to scale and the demand dynamics are some of the factors affecting the productivity growth.[1]

### 1.1 Objectives

The objectives of the paper are:

1. To analyze the trend and growth of labour productivity in Indian Manufacturing (Registered) sector during the period 1980–81 to 2012–13.
2. To identify factors affecting the growth of labour productivity.
3. To measure the degree of jobless growth in Indian manufacturing.

### 1.2 Data Base and Methodology

Annual Survey of Industries (ASI) is the source of data for different variables used in this study. The EPW research foundation (EPWRF) has produced two volumes of concordance and consistence time series database on ASI for the period 1973–74 to 1998–99 and 1973–74 to 2003–04. In the second volume, the data are made concordance and consistent according to the National Industrial Classification (NIC) 1998. For the years 1980–81 to 2003–04, the data of the volume have been collected and for the remaining years, i.e., from 2004–05 to 2012–13 the data are collected from the summary results of ASI available on the website of the Ministry of Statistics and Programme Implementation.

As per the ASI, the manufacturing in this study the net value added (NVA) has been taken as the proxy for the output variables.[2] Total person engaged is used to represent the employment variable. The time period is taken from 1980–81 to 2012–13. GDP deflator at 2004–05 prices is calculated for the manufacturing sector from the National Accounts Statistics.

#### 1.2.1 The ratios used in the study:

The main ratios used in the study are labour productivity and capital intensity. *Labour productivity* is defined as the real net value added per person engaged. The ratio is adjusted for inflation by deflating the net value added by implicit GDP deflator at 2004–05 prices.

$$\text{Labour Productivity (LP)} = \frac{\text{Net Value Added (Real)}}{\text{Total person engaged}}$$

*Capital intensity* is defined as fixed capital per person engaged. The fixed capital used in this study is real and is deflated by GDP deflator at 2004–05 prices.

$$\text{Capital Intensity } (K/L) = \frac{\text{Fixed capital}}{\text{Total person engaged}}$$

#### 1.2.2 Growth Rates

The annual growth rate is the growth of that variable on an annual basis. It is calculated as follows:

$$g_t = \frac{y_t - y_{t-1}}{y_{t-1}},$$

Where $g_t$ = annual growth rate, y = variable, t = time.

The Trend Growth Rate is calculated by fitting a semi-log regression line. The equations estimated are of the form: $\log Y = a + bT$, here Y is the variable and T refers to the number of years in the period for which the growth rate is calculated. Then in the second step, anti-logarithm of the relevant coefficient minus one gives the trend growth rate.

## 2. Trend and Growth of Labour Productivity in Registered Manufacturing

Discrediting the TFP as a non-existent entity gives a very strong reason to analyze the labour productivity growth. Studies on productivity in Indian manufacturing suggest an increasing TFPG during post-liberalization period. As in the classical economics, labour productivity growth triggers output growth and the advancement of technology is an embodied one, it is very much essential to analyze labour productivity and capital intensity (capital labour ratio) growth simultaneously.

Figure1 depicts the trend of labour productivity and the capital intensity (capital labour ratio) in the manufacturing sector. The dominant feature from the figure is that the long term trend of labour productivity and capital intensity are increasing in the post-reform period. They almost go parallel during the period but the growth rate is higher in the case of labour productivity. A sharp increase in the capital intensity is accompanied by a moderately rising labour productivity up to the mid-80s (Ahluwalia, 1991). So it is confirmed that the rise in capital intensity is pulling the labour productivity to incline.

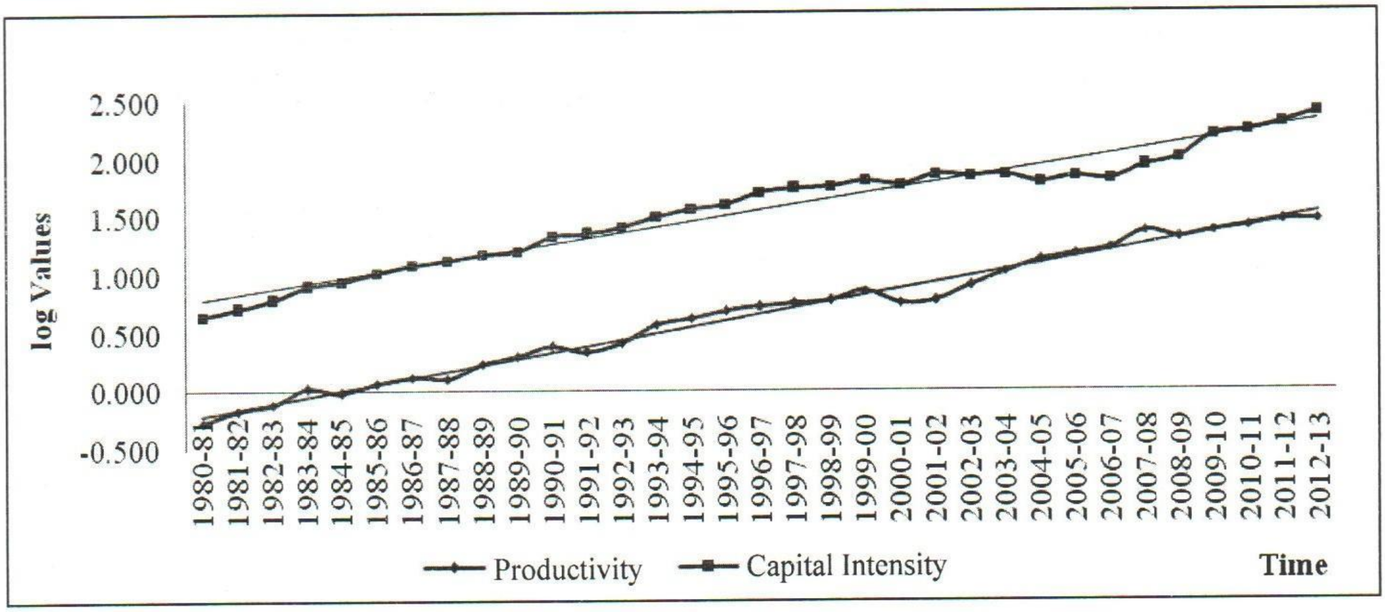



**Figure 1: Growth of Labour Productivity & Capital Intensity**

*Note:* Logarithm values of labour productivity and capital intensity are taken to do up the scale problem in diagram.
*Source:* Calculated from ASI Database.
*Deflator:* GDP Deflator at 2004–05 prices.

The labour productivity increased at 5.57 per cent per annum during the study period, whereas the capital intensity increased at 4.93 per cent. In the 1980s, the growth rate of capital intensity was 6.68 per cent in comparison to 5.9 per cent labour productivity. In the post-reform period, capital intensity growth was very slow in comparison to labour productivity. During the study period, the employment growth was very slow but the real NVA and real fixed capital growth were at a significant rate of 6.92 per cent and 6.27 per cent respectively (see Table 1). The trend of capital–labour ratio for the organized manufacturing has shown an overwhelming increase in the capital intensity over the study period. The capital per unit of labour has increased about three times over the period. The capital intensity has recorded a growth from 1.92 lakh in 1980–81 to 10.99 lakh in 2011–12. The growth rate of capital–labour ratio was 4.93 per cent per annum for the whole manufacturing industry during the study period (see Table 1). The increasing trend has been very smooth throughout the post-liberalization period[3].

**Table 1: Growth Rate**

| S. No. | Variables | 1980–81 to 2012–13 | 1980–81 to 1989–90 | 1990–91 to 2012–13 | 1990–91 to 1999–2000 | 2000–01 to 2012–13 |
|---|---|---|---|---|---|---|
| 1 | Labour Productivity | 5.57 | 5.90 | 5.41 | 5.92 | 6.45 |
| 2 | Capital Intensity | 4.93 | 6.68 | 4.09 | 5.88 | 5.03 |
| 3 | NVA | 6.92 | 5.92 | 7.15 | 6.65 | 12.13 |
| 4 | Total Person Engaged | 1.28 | 0.02 | 1.65 | 0.69 | 5.34 |
| 5 | Fixed Capital | 6.27 | 6.71 | 5.81 | 6.61 | 10.63 |

*Note:* The figures are compound annual growth rates showing the anti-logarithms of the relevant regression coefficient minus one when the equations are of the form log Y = a + b T and T refers to time.

*Source:* Calculated from ASI. All values are at 2004–05 prices. Deflator used: GDP Deflator.

### 2.1. Use-based Classification

A detailed level of disaggregation in the form of use based sector gives an economically meaning full analysis to the productivity and growth. The manufacturing sector has been dividing into four sectors, i.e., basic goods, capital goods, intermediate goods and consumer goods. The use-based classification is based on the IIP classification. From the policy prospective it is very much important to analyze productivity and growth according to their use. For a high growth of consumer goods it is very much important to have a developed intermediate and capital goods sector. Various plans (for example, Nehru–Mahalanobis model) have been formulated to increase the base for the basic goods industries. During the 5th plan, emphasis has been put on the growth of consumer goods sector.

From Figure 2, we get a view of labour productivity trend in different manufacturing sectors in different use-based activity. The largest use-based sector in the organized manufacturing in India is the consumer goods sector which consists around 33 per cent in 2012–13. Among the consumer goods, the consumer non-durable is predominant. The intermediate sector had a share of around 27 per cent in 2012–13. A look at the trend of these use-based sector will confirm a declining tendency of the intermediate sector during the study period. It is the most important sector because of its input into the other manufacturing sector. The consumer goods sector included very important industries like food processing & beverages, textile, paper, jewellery and leather. Most of these industries are labour-intensive industries. The capital goods sector is very important from the point of view of technology induction which has long-term effect on the productivity growth. The important manufacturing sectors in this group are machineries, electrical machineries, transport equipment, non-metallic products and petroleum products. So, it is important to look at the productivity trend of these use-based sector. Figure 2 shows that the labour productivity of all the use-based sector has grown in the study period, but the growth in the basic goods sector is very alarming. The labour productivity is very low during the pre-reform period but it has gained pace in the second half. During the first phase, i.e., pre-reform period, the divergence between labour productivity among the sectors is almost negligible, but the gap increased in the basic goods sector. The trend of labour productivity of capital goods sector shows a widening gap than the intermediate and consumer goods.

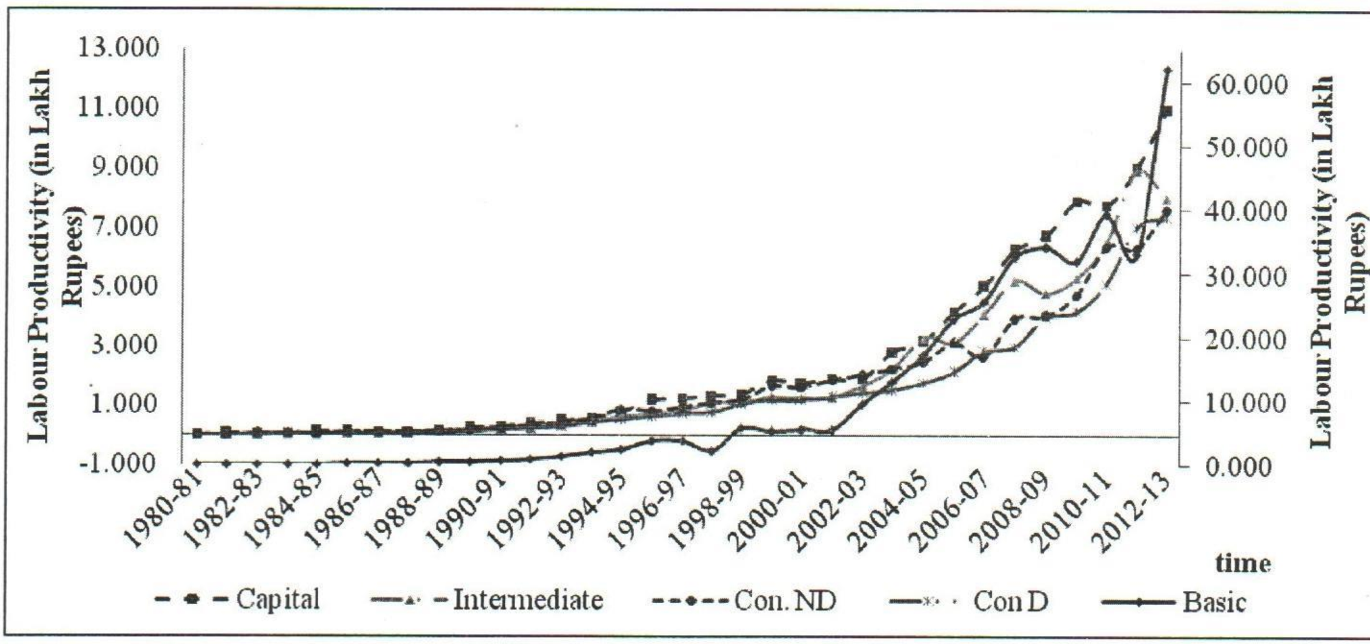



**Figure 2. Labour Productivity (Use-based)**

*Note:* The secondary vertical axis is only meant for the basic goods sector. All other sectors are labelled on the primary vertical axis.
*Source:* Author's own calculation. Data collected from ASI database.
*Deflator:* GDP Deflator at 2004–05 prices.

## 3. Factors Explaining Labour Productivity Growth

### *3.1 Increasing Returns to Scale*

The growth of per capita output depends upon the growth of productivity and the growth of share of working population in the total population. The demand for the labour is very much associated with the technique of production and the type of capital used. If the technique of production is labour-augmenting then the share will be high and there will be a rise in the output growth. So the output growth is caused directly by the growth of labour productivity. In the pursuit of explaining the causes of growth of labour productivity, Adam Smith has given a chain of cumulative causation in his literature[4]. He has attributed division of labour as the prime cause of labour productivity growth which operates with splitting down the complex activities. Kaldor identified several facts like oligopolistic structure of manufacturing, spatial concentration of the industrial activity, sustained difference between the rate of output and productivity growth. These facts are well explained by increasing returns. Kaldor has argued that the manufacturing sector is subjected to the increasing returns. The increasing returns arise within the plant and enterprise. Average plant cost per unit of output decreases with the size of operation. The large multi-product firms arose from their capacity to capture the growing market. The oligopolistic nature of the manufacturing does not allow the market to become competitive when its size increases.

An increase in the level of aggregate output permits the greater division of labour and also the use of capital-intensive technology. The circular and cumulative relation between increasing returns and growth of output has been the basis of persistent income disparity. The learning by doing (Adam Smith has notified it as inventions and innovation induced by experience) encompasses both incremental improvement in efficiency and generation of new technology. The technological changes are taken as by-product and are endogenously introduced through new capital in contrast to the neo-classical proposition where these are treated as exogenous.

The manufacturing labour productivity by size of labour employment shows that the medium (50–499) employment size factories have a high labour productivity in comparison to the low employment size factories and large employment size factories (refer to Figure 3). The labour productivity of the low employment factory was 0.24 crore per thousand persons in the year 1980–81 which increased to 13.8 crore per thousand rupees in the year 2002–03. In the medium employment size, the productivity increased from 0.38 crore to 30.95 crore per thousand person rupees during the referred period. In high employment factories, the labour productivity increased from 0.309 crore per thousand person rupees in year 1980–81 to 18.99 crore per thousand person rupees in the year 2002–03. The productivity level of the medium (50–499) employment size factories was higher than the total

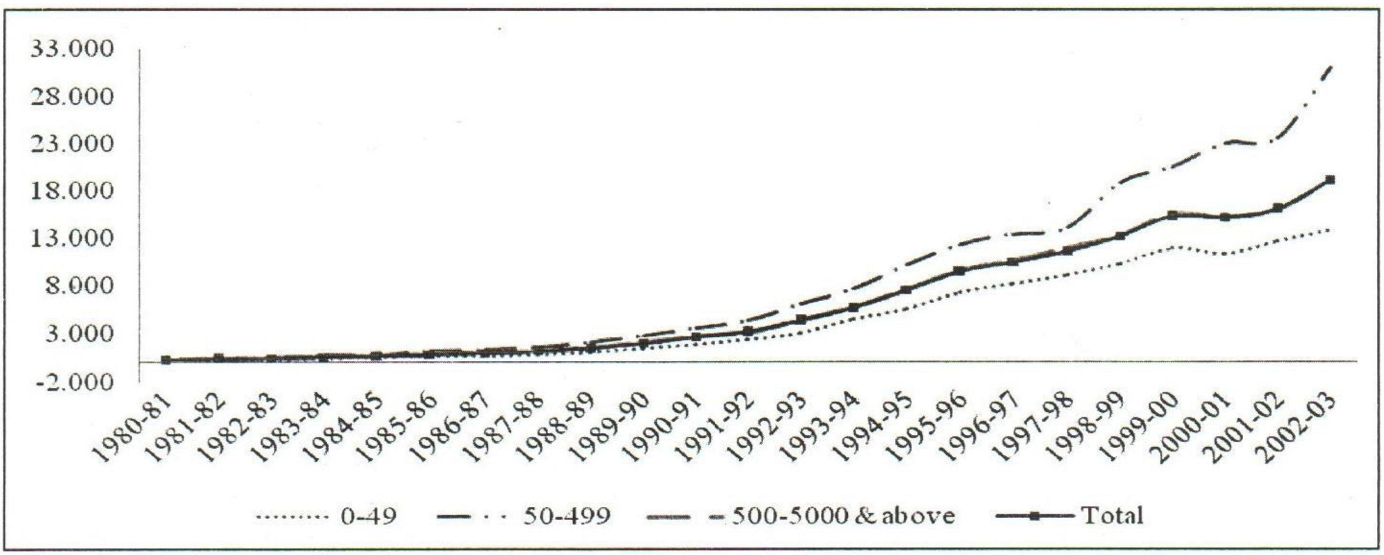



**Figure 3. Labour Productivity (by employment size) (in crore per thousand persons)**

*Note:* Data is available up to the year 2002–03 according to the employment size.

*Source:* Author's own calculation. Data collected from ASI Database.

*Deflator:* GDP deflator at 2004–05 prices.

manufacturing and the growth of the productivity in these plants was high. The small factories in terms of employment are mainly labour-intensive sectors and these sectors do not have access to improved technology. The medium scale sectors which are predominant in case of Indian manufacturing are growing at a significant rate. The access to the new capital and enlarged market due to the opening up of the economy, help these factories to grow rapidly.

The labour productivity of the manufacturing industry according to the size of capital provides evidences of increasing returns to scale (see Figure 4). According to the capital size, the factories are defined in four scales: micro industries, small scale industries, medium scale industries and the large scale industries. The division is made according to the definition given by MSMED Act, 2006. The productivity of the elite capital employed factories is continuously higher than the low-capital size factories over the years. The large capital size factories had a labour productivity of 0.346 lakh rupees in the year 1989–90 and it has increased up to 3.89 lakh rupees in the year 2002–03. The high capital size factories enjoyed a favourable regime. High capital investments were encouraged and the foreign capitals were also allowed in the manufacturing sector. The higher capital firms have had larger productivity due to the operation of increasing returns to scale. During this period, the low and medium capital size firms also achieved higher labour productivity but they did not enjoy the upper hand. In these factories, the productivity did not grow as rapidly as the higher capital size factories.

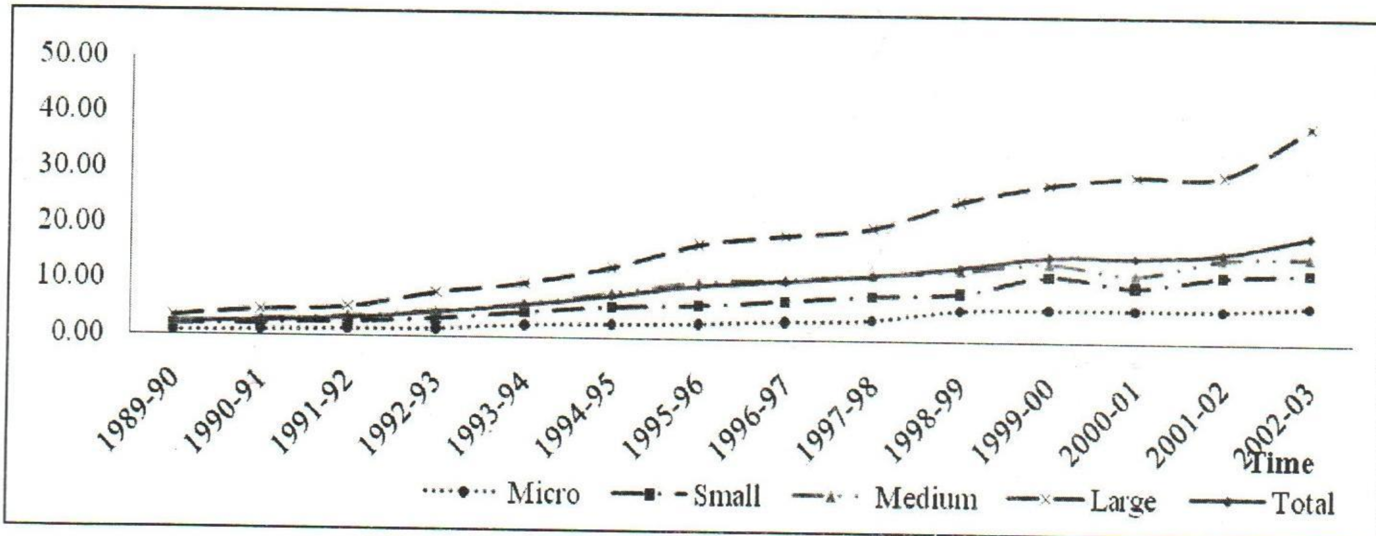



**Figure 4. Labour Productivity by Size of Capital (in '0000 Rs)**

*Note:* Data is available up to the year 2002–03 according to the capital size.

*Source:* Author's own calculation. Data collected from ASI database.

*Deflator:* GDP deflator at 2004–05 prices.

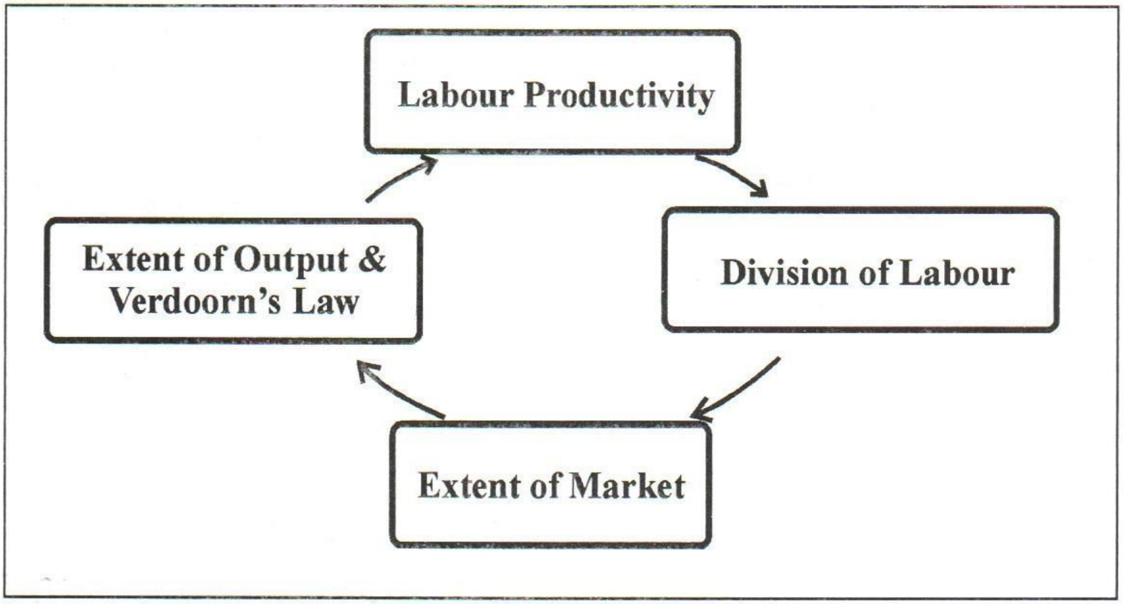
### *3.2 Verdoorn's Law and Kaldor's Technical Progress Function*

Verdoorn's law describes the relationship between productivity and output growth. As the growth of output rises, the growth of labour productivity increases. The labour productivity grows with output due to learning by doing. The law is an outcome of the operation of increasing returns to scale. Higher productivity and the availability of more productive capital goods are dependent on the cumulative output. High growth rate of output and productivity can take place only if new products are introduced and the demand for them increases significantly.

The positive feedback from output to demand results in higher productivity and gets reflected on competitiveness, endogenous specialization. But the productivity growth can be observed if the new product can be sold successfully in the extended market. The expansion in the demand of the market is backed by the growth of output. The Verdoorn's law is defined as 'Productivity levels are higher in those sectors which are experiencing faster growth of output'.

The classical causation can be summarized as growth occurs when the per capita income rises. The total income is the multiplication of productivity and the total labour employed. Division of labour gives rise to productivity and it comes from the extent of market. To this series of causation if we add the Verdoorn's law then there will be a circular causation (Chart 1). This causation continues with the cycles and the economy will grow in a circular spiral diverging net.

**Chart 1**




### 3.2.1 *Circular Causation Model 1*

The Verdoorn's law assumed a positive relationship between the growth of labour productivity and growth of output. The law can be stated as,

$$\delta(LP) = \alpha_1 + \beta_1 \delta(V) \qquad (1)$$

Here, the growth ($\delta$) rates are annual growth rate.

$$\delta(LP) = 0.02 + 0.55\ \delta(V)$$

P ($\beta_1$) = 0, Adjusted-$R^2$ = 0.54, D-W Statistics = 2.38, F-Stat = 37.63

From the regression run to fit the model stating the Verdoorn's law, we get that the relation described by the Verdoorn's law is true in Indian manufacturing industry. The $\beta_1$ coefficient, which signifies the relation between the growth of productivity and growth of output (output here is NVAR), is 0.55 and is significant even at 1 per cent level for the overall manufacturing. The adjusted $R^2$ satisfies the condition of a good-fit. The D-W statistics confirms the absence of autocorrelation in the model specified above (for details, see Appendix, 'Equation 1').

The neo-classical idea between a movement along a production function (due to relative price changes) and shifts in the production function (due to exogenous technological change) is rejected. Technical progress is embodied in new capital goods and the rate of growth output per worker is determined by the rate of growth of capital–labour ratio. 'The recognition of the existence of a functional relationship between the proportionate growth in capital and the annual proportionate growth in productivity shows the futility of regarding the movements in the capital/output ratio as dependent upon the technical character of the stream of inventions according as they are predominantly "labour saving" or "capital saving" in character' (Kaldor, 1957).

He has defined a position of long-run equilibrium at the point where the growth of capital and the growth of output are equal. Anything right to that point will be regarded as the accumulation of capital-saving technical and that to the left will be regarded as the labour saving technical progress. This relationship can be examined by running a regression from growth of capital–labour ratio to growth of labour productivity.

$$\delta(LP) = \alpha_2 + \beta_2 \delta(K/L) \quad (2)$$

$$\delta(LP) = 0.04 + 0.21\delta(K/L)$$

$P(\beta_2) = 0.32$, Adjusted-$R^2 = 0.001$, D-W Statistics = 2.08, F-Stat = 1.02

From the regression run from the growth of capital–labour ratio to the growth of labour productivity, it is found that the Kaldor's technological progress function does not hold good for the Indian manufacturing industries. The $\beta_2$ coefficient which defines the relationship is 0.21 and is insignificant. The adjusted $R^2$ of the model is 0.001, which means the model is not a good fit. The F-stat is also very low 1.02, which means the model is insignificant itself (for details, see Appendix, 'Equation 2').

From the above practice of running regression, it is clear that the Verdoorn's law is found to be true and the Kaldor's primitive technological progress function is false. So, to make a better explanation of productivity growth, we have resorted to a regression which gives a combined representation of both Verdoorn's law and the Kaldor's primitive technological progress function. The model of the regression is

$$\delta(LP) = \alpha + \beta_1 \delta(V) + \beta_1 \delta(K/L) \quad (3)$$

$$\delta(LP) = 0.004 + 0.55(V) + + 0.21\ \delta(K/L)$$

$P(\beta_1) = 0$, $P(\beta_2) = 0.15$, Adjusted-$R^2 = 0.55$, D-W Statistics = 1.95, F-Stat = 20.63

The manufacturing industry is subjected to the increasing returns and the Verdoorn's law is based on the same proposition. Again Kaldor through his cumulative causation theory brings the positive causal relationship between growth of capital–labour ratio and growth of productivity. Here, the combined effect of both the laws is examined for the manufacturing industry as a whole. The regression result confirms that the Verdoorn's law as well as the Kaldor's proposition holds for the manufacturing in India. The coefficient of growth of NVA ($\beta_1$) is 0.55 and is significant for the manufacturing industry at 1 per cent level. Like also the coefficient of growth of capital–labour ratio ($\beta_2$) is 0.21 and is significant at 15 per cent level. The F-statistics shows that the model gives a significant result and is a good-fit (for details, see Appendix, 'Equation 3').

The positive effect of output growth in the increasing productivity is dependent upon the operation of increasing returns to scale. The circular causation in the Verdoorn's law is very much dependent on the extent of market. The size of demand leads to an extension of output. The scale economies of large production and the use of intensive roundabout methods allow the manufacturer to allow for more productivity growth. So the concepts of increasing returns to scale and Verdoorn's law make the way for greater division of labour and greater productivity growth.

### *3.3 Productivity by Types of Organisation*

Labour productivity of the manufacturing sector differs according to the type of organization. The productivity of the corporate sector is very high while the unincorporated manufacturing sector has a low labour productivity. The thrust of the eighth plan in case of the manufacturing sector is to initiate the removal of policy control, private de-reserving, de-licensing. So basically the aim was to provide an important role to the corporate sector. The division of the manufacturing sector by types of the organization can be incorporated as one of the explanations for the operation of scale economies. The corporate sector manufacturing can resort to the large scale operation in terms of factor employment. The size and scale of operation in the manufacturing by co-operative societies and unincorporated organization is generally small in comparison to the corporate sector.

In the study period, the labour productivity of the corporate sector was very high (see Figure 5). It was 0.039 crore rupees per thousand person in the year 1980–81 which increased to 12.41 crore rupees per thousand in the year 2012–13. The productivity of the unincorporated enterprises as well as the co-operative society did not increase much as compared to the productivity of corporate enterprises.

## 4. Jobless Growth

The manufacturing sector is very important in the field of employment generation and absorption of abundant non-skilled workforce. The changes in the occupational structure, i.e., shift of employment from primary to secondary then to the tertiary sector explains the process and characteristics of growth. In the post-independent India, the agriculture & allied sector comprises the majority of employment around 49 per cent in 2011. During this period, the share in manufacturing sector has remained almost constant at 14 per cent. If we consider the organized manufacturing sector, the employment growth was a negative 0.17 per cent per annum and that of the share is around 23 per cent during the study period.

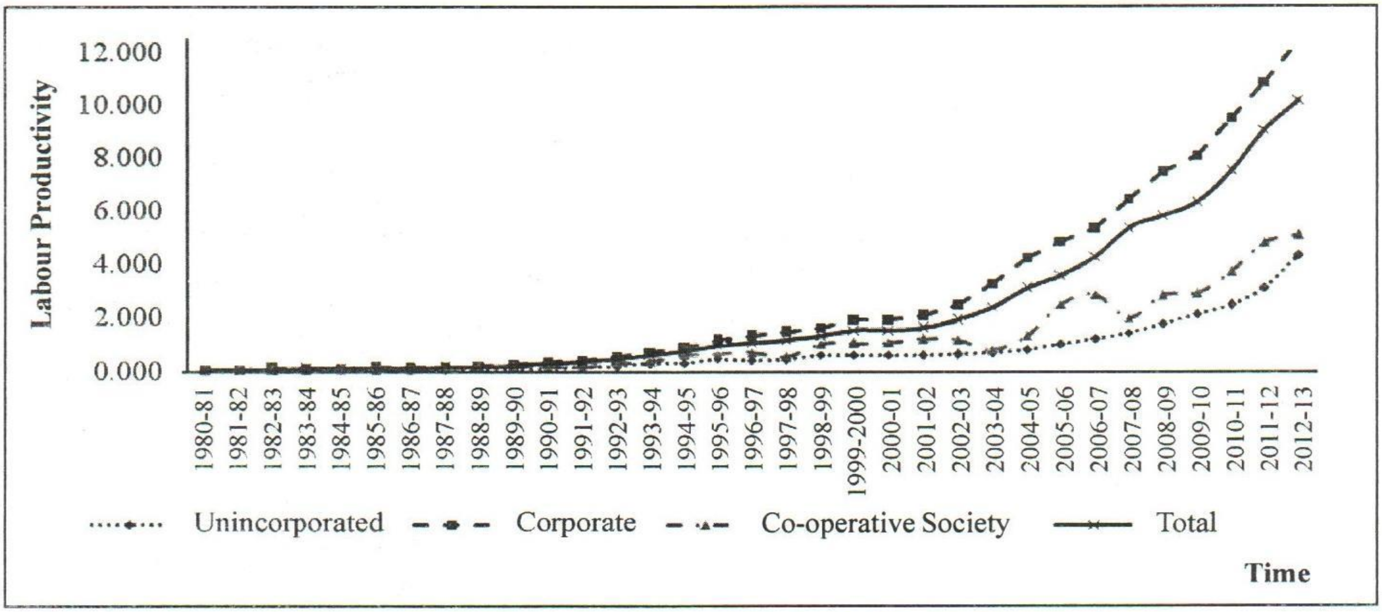



**Figure 5. Labour Productivity (Type of Organisation) (in Rs Crore per Thousand Persons)**

*Source:* Author's own calculation. Data collected from ASI database.
*Deflator:* GDP deflator at 2004–05.

Although the total number of persons engaged in the organized manufacturing is rising, the growth rates are not uniform during the study period. Job security regulation, sharp hike in real wages, capital deepening strategy and less labour intensive industries have contributed to the slow employment growth (Goldar, 2000). Lessening of labour market rigidity and introduction of Industrial Dispute Act caused late revival during recent years (Goldar, 2011). Mainly four causes for inadequate employment growth have been identified. First, the nature of transition from inward-looking regulating economy to an open competitive economy has resulted in job losses in inefficient enterprises; second, there is a sharp shift towards capital intensive technique; third, presence of inappropriate labour market regulation affecting labour cause and labour movement; and finally, the wage elasticity of registered sector labour market happened to be the causes of comparatively low employment growth (Alessandrini, 2009; ILO, 2005, 2009; Dasgupta and Singh, 2005; Sharma, 2006). In the present paper, the authors look to the degree of jobless growth and not to the causes of the issues.

**Table 2: Employment Elasticity**

| Model : ln (*L*)= $\alpha + \beta$ ln *NVA* | | |
|---|---|---|
| | β - Coefficients | t-stat |
| 1980–2013 | 0.22 | 9.25 |
| 1980–1990 | 0.03 | 0.55 |
| 1991–2013 | 0.29 | 7.57 |
| 1991–2000 | 0.24 | 2.47 |
| 2001–2013 | 0.45 | 15.32 |

*Source:* Author's own calculation. Data collected from ASI database.
Deflator: GDP Deflator at 2004–05 prices.

From Table 2, we get the 'β' coefficient which gives the elasticity of employment to the change in output. The coefficient gives an idea whether the change in output affects the change in employment and also gives a degree of response to the change. It is found that the 'β' coefficient is only '0.22' during the study period. The t-statistics confirm the significance of the parameter. The value suggests that if there is a change of Rs 1 lakh of value added, the employment will change only by 0.22. The breaks in the study period suggest that the employment growth in response to the value added growth was very slow (0.03) during the pre-reform period. It has improved during the post-reform period. During the 2nd phase of post-reform, i.e., from 2001–13 the elasticity is found out to be 0.45. We may find some positives of increasing elasticity of employment in manufacturing but it is still very small. This suggests a prevalence of jobless growth in the manufacturing sector.

## 5. Conclusion

The analysis above has aimed to take 'labour productivity' to the forefront in contrast with the conventional methodology. This paper stands by the classical and cumulative causation theory to examine the growth in productivity. So, this paper appeals to look into the issue of productivity through a different heterodox theory rather than the aggregate production function and the growth accounting method.

The growth and trend of labour productivity in the post-liberalization period has been increasing. The roundabout methods of production and high degree of demand for these products have been the driving force behind the productivity growth. The increasing returns to scale, the use of roundabout production process, and introduction of new machineries, demand dependency, privatization and inflow of investments are the main causes affecting productivity growth. The operation of the increasing returns to scale in the factor employment has played a significant role in determining the size of productivity. The elite industries employing larger labour or larger capital have enjoyed an upper hand in the productivity rise. These elite factories have a larger increase in productivity compared to their other counterpart. In the period of liberalization the corporate enterprises have grown at a rapid pace which hints at the operation of scale economies.

*The authors would like to acknowledge Prof. G. Omkamath for giving valuable suggestions during the M.Phil. course.*

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## Notes :

[1] Adam Smith in his '*Wealth of Nations*' has attributed the productivity growth to the increased division of labour. He has further explained that the division of labour is limited by the extent of market. This view was later taken up by Kaldor in his cumulative causation theory. For details see, Smith (1776, Book 1, Chap. 3, p. 31) and Toner (1999, Chap. 7).

[2] Here arises a question as why to use value added measures instead of gross output. The answer to this question is: (i) The value added based measure reflects an industry's capacity to translate technical change into income and into a contribution to final demand. The gross output based productivity measures are less sensitive to the degree of outsourcing; (ii) In comparison to the labour productivity based on gross output, the growth rate of value added based labour productivity is less dependent on any change in the ratio between intermediate inputs and labour or the degree of vertical integration. For example, when outsourcing takes place, labour is replaced by intermediate inputs. This leads to a fall in the value added based labour productivity, measures tend to be less sensitive to the process of substitution between materials plus services and labour than gross output based measures.

[3] Author's own calculation from ASI data. For further details see, Joshi (2012, Chap. 3).

[4] Adam Smith in his magnum opus '*Wealth of Nations*' has given a detailed explanation of productivity caused by increasing division of labour. The simple example of Pin factory is a great demonstration of how the division of labour helps in raising the production.

[5] This is a design of circular and cumulative causation model of growth. See Toner (1999, Chap. 6, p. 134).

## Appendix

### Equation 1

Dependent Variable: LP
Method: Least Squares
Date: 12/09/15 Time: 14:07
Sample: 1 32
Included observations: 32

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.015879 | 0.010186 | 1.558946 | 0.1295 |
| V | 0.551097 | 0.089838 | 6.134374 | 0.0000 |
| R-squared | 0.556413 | Mean dependent var | | 0.057699 |
| Adjusted R-squared | 0.541627 | S.D. dependent var | | 0.063233 |
| S.E. of regression | 0.042811 | Akaike info criterion | | -3.403589 |
| Sum squared resid. | 0.054983 | Schwarz criterion | | -3.311980 |
| Log likelihood | 56.45742 | Hannan-Quinn criter. | | -3.373223 |
| F-statistic | 37.63055 | Durbin-Watson stat | | 2.387025 |
| Prob (F-statistic) | 0.000001 | | | |

### Equation 2

Dependent Variable: LP
Method: Least Squares
Date: 12/09/15 Time: 14:07
Sample: 1 32
Included observations: 32

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.045465 | 0.016463 | 2.761603 | 0.0097 |
| K/L | 0.212918 | 0.210438 | 1.011785 | 0.3197 |
| R-squared | 0.032998 | Mean dependent var | | 0.057699 |
| Adjusted R-squared | 0.000764 | S.D. dependent var | | 0.063233 |
| S.E. of regression | 0.063209 | Akaike info criterion | | -2.624281 |
| Sum squared resid. | 0.119861 | Schwarz criterion | | -2.532672 |
| Log likelihood | 43.98849 | Hannan-Quinn criter. | | -2.593915 |
| F-statistic | 1.023708 | Durbin-Watson stat | | 2.081171 |
| Prob(F-statistic) | 0.319732 | | | |

**Equation 3**

Dependent Variable: LP
Method: Least Squares
Date: 12/09/15 Time: 14:07
Sample: 1 32
Included observations: 32

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.004131 | 0.012789 | 0.323005 | 0.7490 |
| V | 0.550048 | 0.088142 | 6.240457 | 0.0000 |
| K/L | 0.205860 | 0.139838 | 1.472133 | 0.1518 |
| R-squared | 0.587258 | Mean dependent var | | 0.057699 |
| Adjusted R-squared | 0.558793 | S.D. dependent var | | 0.063233 |
| S.E. of regression | 0.042002 | Akaike info criterion | | -3.413158 |
| Sum squared resid. | 0.051160 | Schwarz criterion | | -3.275746 |
| Log likelihood | 57.61053 | Hannan-Quinn criter. | | -3.367610 |
| F-statistic | 20.63089 | Durbin-Watson stat | | 1.951431 |
| Prob(F-statistic) | 0.000003 | | | |

*Manufacturing is more than just putting parts together. It's coming up with ideas, testing principles and perfecting the engineering, as well as final assembly.*

*– James Dyson*

# Implementation of Material Flow Cost Accounting (MFCA) in Manufacturing SME: A Case Study

ABHISHEK R. TAILOR, BHAVIK C. SOLANKI, NIRAV J. PADARIYA, PARTH V. PATEL AND SHASHANK J. THANKI

*This research aims to apply the material flow cost accounting (MFCA–ISO 14051) for improving the production process of the target products, PVC heat shrinks and BOPP self-adhesive tapes, manufactured by Arihant Gujarat Plastic Industries in Bharuch, Gujarat. The data collection was carried out for all the processes and analysis was based on the MFCA procedure. The results of the MFCA calculations showed that the highest negative product cost occurred during the cutting process. The operations of the process were then analyzed using fishbone technique in order to minimize the negative cost of the product. In the final section of the study, possible improvement solutions have been proposed.*

*Abhishek R. Tailor, UG Student at Mechanical Engineering Department, S.V.M.I.T., Bharuch, Gujarat, India.*

*Bhavik C. Solanki, UG Student at Mechanical Engineering Department, S.V.M.I.T., Bharuch, Gujarat, India.*

*Nirav J. Padariya, UG Student at Mechanical Engineering Department, S.V.M.I.T., Bharuch, Gujarat, India.*

*Parth V. Patel, UG Student at Mechanical Engineering Department, S.V.M.I.T., Bharuch, Gujarat, India.*

*Shashank J. Thanki, Associate Professor at Mechanical Engineering Department, S.V.M.I.T., Bharuch, Gujarat, India.*

## 1. Introduction

Making profit is imperative to every kind of industry today, as it is directly linked to its reputation in the market. The best way to maximize the profits of an industry is through a concept called Material Flow Cost Accounting (MFCA), which is used for cost reduction, lead time reduction and minimization of the waste. MFCA is developed for the organizations (Nakajima et al., 2009) or industries to get a better understanding of the cost, energy and finances used (Kasement et al., 2013) during the production processes. The details of MFCA are addressed in many sources and published as an international standard ISO 14051:2011 as well (Christ et al. 2016).

MFCA analysis includes the cost of raw material, labour cost, energy consumption and waiting time, etc. Due to the MFCA, waiting time gets reduced, which ultimately results in the minimization of the lead time of production and hence ensures an increase in the profit. MFCA analysis also helps in the better utilization of floor space, which is one of the important factors for an organization, and therefore increases the storage capacity of the material and prevents the shortage of material.

Based on the MFCA concept, the cost can be classified as: material cost (cost of both direct and indirect material); system cost (cost of operating production system); energy cost (cost of energy used in the production system) and waste management cost (cost of waste treatments).

MFCA is an analysis in which both positive and negative products are accounted for. The negative product is a type of waste produced during the production process, which can bring losses for the industry. The MFCA concept is helpful in improving the financial conditions of an organization, which happens due to the increased productivity of the industry. Negative or material loss cost is the loss incurred at each stage of the production process. Positive or product cost is the cost attached with the output of each process. Cost allocation between the positive and negative costs is carried out based on the portion from material balancing between input and output materials. Finally, the operations with high negative cost are identified and improved in order to reduce the negative cost.

## 2. Implementation of MFCA in Case Organization

MFCA methodology and implementation framework:

***Implementation steps of MFCA***

Implementation of MFCA requires application of Plan–Do–Check–Act (PDCA) cycle to clarify directions, increase learning, aligning efforts and improving results to achieve the overall MFCA goals of 'reduced environmental impacts' and to 'improve business efficiency'.

***PDCA cycle for MFCA implementation***

**A. PLAN**: Who? What? When?

PLAN phase focuses on building the awareness, capability and acceptability in the organization for implementation of MFCA methodology.

The PLAN phase involves management in the determination of the necessary expertise for the study, the specification of a study boundary and a time period for the MFCA data collection activities, as well as the determination of appropriate quantity centers. A quantity center is a selected part or parts of a process for which inputs and outputs are quantified in physical and monetary units.

- *Step 1: Management involvement*

  The most important part of MFCA is the planning phase. The ISO norms suggest starting with involving the company's top level management employee and then determining whether the staff/employees are in suitable number and whether they fully accept being involved in the precise data collection.

- *Step 2: Determination of necessary expertise*

  The determination of necessary expertise is a key step within the PLAN phase.

- *Step 3: Specification of a boundary and a time period*

  For the modelling of material and energy flows system, boundaries have to be specified. Basically, the boundaries can span a single or several processes, the whole organization or even entire supply chains. Time period can be, for example, a month or a year or the time which is needed for the manufacturing of the production lot.

- *Step 4: Establishment of quantity center*

  The final planning step within the PDCA cycle is the determination of the quantity centers. Quantity centers are spatial or functional units which store process or otherwise transform materials and which are connected by material flows, processes for example receiving, cutting, assembling and packing, etc., can be defined as quantity centers as well as material storages.

**B. DO**: ***Model Material and Financial Flows***

The DO phase involves sub-processes such as identification of the inputs and outputs for each quantity center within the MFCA boundary, and quantification of material flows in physical and monetary units. Costs in the model are divided into four types: material costs, energy costs, system costs and waste management costs. Material costs represent the costs for a substance that enters and/or leaves a quantity center. Energy costs include costs for electricity, fuel, steam, heat and compressed air. System costs are the costs incurred during the in-house handling of material flows other than material costs, energy costs and waste management costs. Waste management costs are the costs of handling material losses generated in a quantity center.

- *Step 5: Identification of inputs and outputs for each quantity center*

  As the first 'DO'-step, for each quantity center, inputs (e.g., materials, energy) and outputs (products, material and energy losses) have to be identified.

- *Step 6: Quantification of the material flows in physical units*

  The quantification of material flows is the second step of the DO module. Based on the flow structure, material flows have to be quantified in physical units such as mass, volume or number of pieces. By using a single standardized unit (e.g., mass), for every quantity center, a material balance can be created.

- *Step 7: Quantification of the material flows in monetary units*

  Within the last step of the DO module, material flows are quantified in terms of monetary units and in order to evaluate them, the costs are differentiated into material, energy, system and waste management costs.

**C. CHECK: *Interpret—communication***

The CHECK phase contains two sub-steps: MFCA data summary and interpretation, and the communication of the MFCA results. Quantity centers with material losses that were environmentally or financially significant could be identified as the root causes of the material losses.

- *Step 8: AIFCA data summary and interpretation*

  The CHECK module of the PDCA-cycle concludes the MFCA data summary and interpretation, e.g., using material balances, material flow cost matrices.

- *Step 9: Communication of MFCA results*

  A chart combining positive and negative product costs throughout the processes based on the above flowchart including calculation data is called a 'material flow cost matrix'.

**D. ACT: *Improve***

During the ACT phase, which combined the analysis of the second stage, the focus was on the identification and assessment of improvement opportunities. As a result of the MFCA analysis, the magnitude, consequences and drivers of material use and losses could be identified and described.

- *Step 10: Identification and assessment of improvement opportunities*

  Based on the created transparency of material and energy flows, finally, improvement opportunities for reducing wastage have to be identified and assessed within the ACT phase and decisions regarding the implementation improvement opportunities have to be made before the cycle starts again.

  A successful MFCA programme involves continual implementation of PDCA cycle which becomes PDCA spiral, where in one PDCA cycle inputs to the next PDCA cycle to keep on improving.

### 3. Identification of Improvement Areas

The company manufactures PVC Heat Shrink Sleeves & BOPP Self-adhesive Tapes by following the given process (see Figure 1 and Table 1):

*Step 1:* Raw material is added to mixing machine.

*Step 2:* Mixing of all the raw material is done in the mixing machine through mixing process.

*Step 3:* Mixed material is then compounded in the compounding machine.

*Step 4:* Compounded material is then feeded to the extruder.

*Step 5:* In the extruder, Plastic rolls are manufactured.

*Step 6:* Plastic rolls are cut in required shape and then packed.

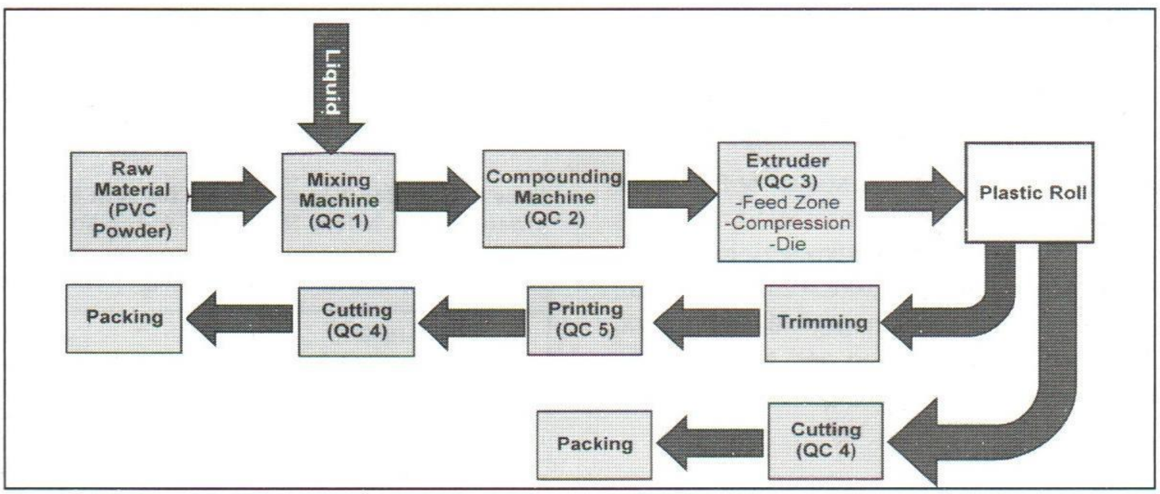



**Figure 1: Material Flow Diagram**

Table 1: Materials/Tools Required

| Materials required for manufacturing the plastic rolls | Additives |
|---|---|
| PVC (POLY VINYL CHLORIDE) | OXIDIZED POLYETHYLENE |
| NORMAL BYUTAYLE STEARATE | PARALOYED PLASTIC |
| KANATOL | POLYMER BLUE |
| OXYMOL-11 | |
| STABILIZER | |

*Step 7:* Plastic rolls are printed and then cut and packed.

The production type is make-to-order. The number of employees work in the industry is twenty-five to thirty mainly. The workers work in the industry in the area located for their work. The results obtained from the MFCA implementation in the case study are presented.

**1. PLAN:**

*Step 1:* During the planning phase, successful MFCA implementation requires support from the top management and necessary expertise for the monitoring process.

*Step 2:* During this step, we consider processes of plastic manufacturing for MFCA analysis.

***Five main processes:***

1. Mixing: mixing two or more material
2. Compounding: Compounding is a process of melt blending plastics with other additives
3. Extruder: It is a process of manufacturing long product of constant cross-section
4. Cutting: the final product is converted into the required size using the cutter
5. Printing: design of labels are printed using combination of different colours

*Step 3:* We have analyzed manufacturing processes of the above products for MFCA implementation for 7 months.

*Step 4:* Quantity centers (QC) are spatial or functional units which store process or otherwise transform materials and which are connected by material flows. Here we have selected four quantity centers for MFCA implementation analysis. In the mixing process negligible loss occurs, so combining two process mixing and compounding defining as QC 1 and remaining are 2, 3 and 4.

QC 2: compounding

QC 3: extruder

QC 4: cutting

QC 5: printing

**2. DO:**

The DO phase involves sub-process such as identification of the inputs and outputs for each quantity center within the MFCA boundary, and the quantification of material flows in physical and monetary units.

*Step 5:* Identification of inputs and outputs for each quantity center

We have identified inputs (e.g., materials, energy), waste and outputs (product, material and energy losses) for each quantity center in process.

*Step 6:* Quantification of the material flows in physical units

The quantification of material flow is carried out in 7 months. Based on the flow structure, material flows model has to be quantified in physical units for number of pieces and mass. Finished products are considered as positive product and waste material are considered as negative products.

Material flow model for all quantity center should provide detail about input, waste material in detail in terms of quantity for each quantity center. Material flow model can help you to find out positive product (final product) and negative product (waste) from raw material (Table 2).

**Table 2: Quantification of Material for each quantity centre in physical units before MFCA implementation**

| QC | Input (kg) | Waste (kg) | Output (kg) |
|---|---|---|---|
| 1 | 11609.12 | 81.2 | 11527.9 |
| 2 | 11529 | 519.23 | 11009.8 |
| 3 | 2057.1 | 391.83 | 1665.27 |
| 4 | 4663.15 | 388.6 | 4274.55 |

*Step 7:* Quantification of the material flows in monetary units

Within the last step of the DO module, material flows are quantified in terms of monetary units and in order to evaluate them, the costs are differentiated into material, energy, system and waste management costs. Raw material PVC powder of 25 kg of price Rs 1500.

Table 3 provides consumption of raw materials in terms of physical and monetary units for number of quantity. Total quantity produced has 28477.74 kg of positive product and 1380.86 kg of negative product. Costs of positive and negative products are Rs 2256683.603 and Rs 126478.236.

Table 4 shows material cost, energy cost and system cost for positive and negative products on the basis of composition in case industry does not incur any cost for handling waste.

**Table 3: Material Flow Cost Matrix before MFCA Implementation for Individual Process**

| | | Material Cost | Energy Cost | System Cost | Total |
|---|---|---|---|---|---|
| Compounding Machine (.70%) | positive product | 818317.40 | 3723.75 | 20956.43 | 842997.58 |
| | negative product | 5768.60 | 26.25 | 147.73 | 5942.58 |
| | total | 824086.00 | 3750.00 | 21104.17 | 848940.17 |
| Extruder (4.5%) | positive product | 781522.00 | 17891.92 | 51669.48 | 851083.40 |
| | negative product | 36858.00 | 843.08 | 2434.68 | 40135.76 |
| | total | 818380.00 | 18735.00 | 54104.17 | 891219.17 |
| Cutting Machine (19.04%) | positive product | 118211.16 | 16394.40 | 68090.73 | 202696.29 |
| | negative product | 27814.39 | 3855.60 | 16013.43 | 47683.42 |
| | total | 146025.55 | 20250.00 | 84104.17 | 250379.72 |
| Printing Machine (8.33%) | positive product | 303433.79 | 20625.75 | 35846.79 | 359906.33 |
| | negative product | 27584.85 | 1874.25 | 3257.38 | 32716.48 |
| | total | 331018.68 | 22500.00 | 39104.17 | 392622.85 |

**Table 4: Material Flow Cost Matrix before MFCA Implementation**

| Cost | Unit | Material Cost | Energy Cost | System Cost | Waste Management Cost |
|---|---|---|---|---|---|
| positive product | Rs | 2021484.35 | 58635.82 | 176563.43 | NIL |
| | % | 95.38 | 89.88 | 88.99 | |
| negative product | Rs | 98025.84 | 6599.18 | 21853.22 | |
| | % | 4.62 | 10.12 | 11.01 | |

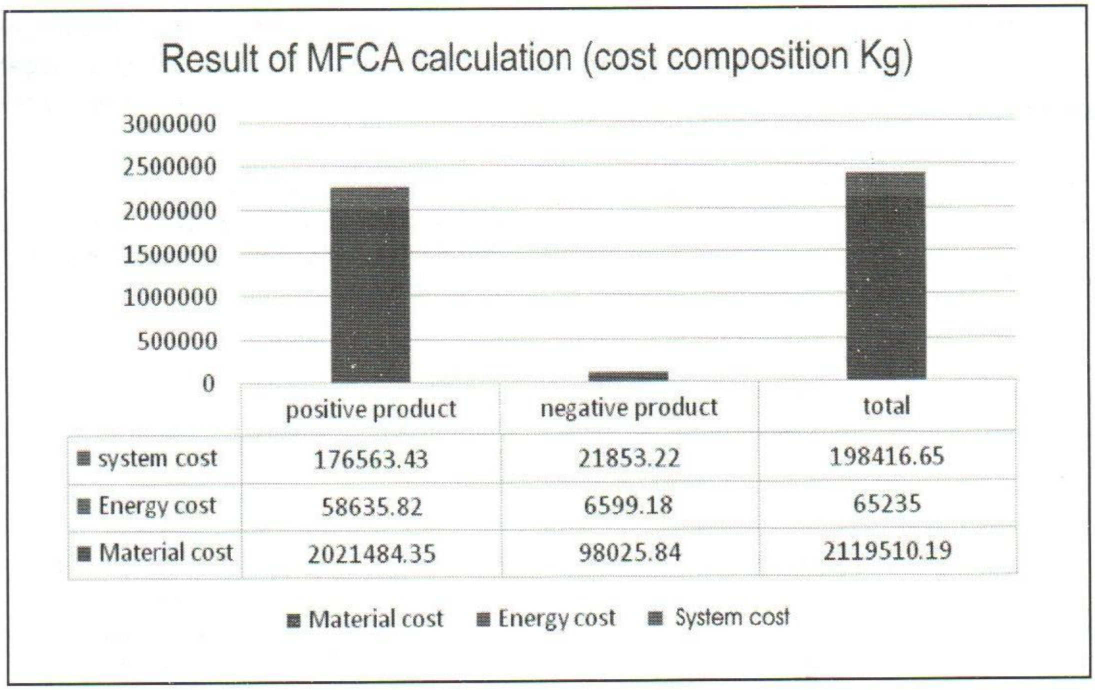



Chart 1

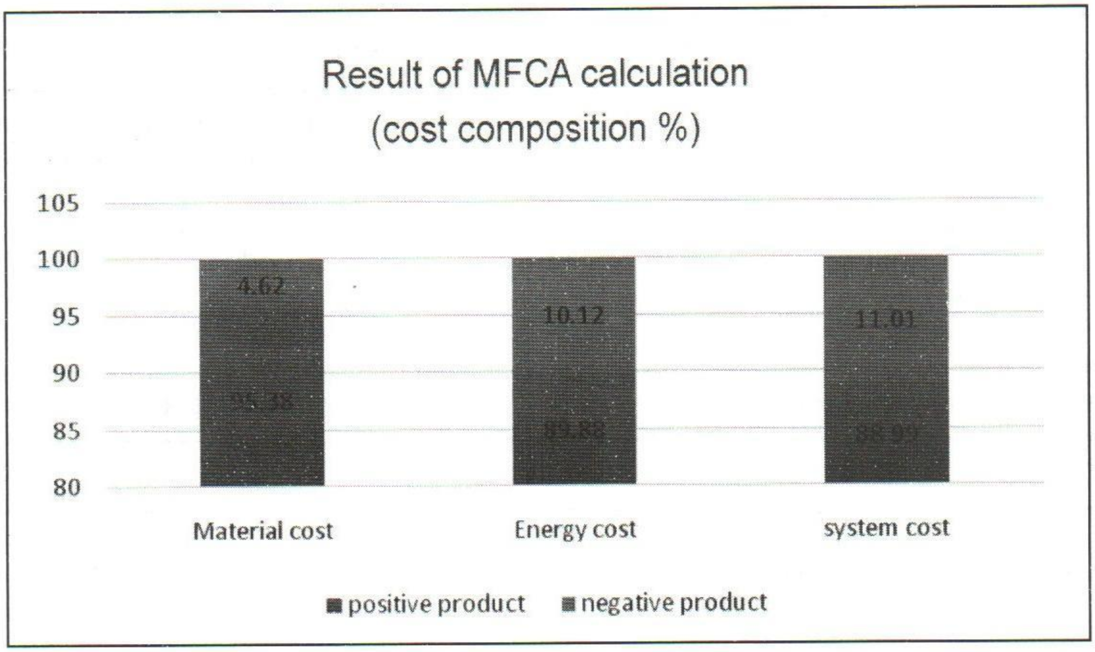



Chart 2

## 3. CHECK

The CHECK phase consists of two sub-steps; MFCA data summary and interpretation, and communication of the MFCA results.

**Table 5: Overall Cost of Positive and Negative Product**

| | Negative Product (Rs) | Positive Product (Rs) |
|---|---|---|
| Raw Material | 126478.236 | 2256683.603 |

*Step 8:* MFCA overall cost of positive and negative product (Table 5)

The CHECK module of PDCA cycle concludes the MFCA data summary and interpretation, e.g., using material balances, material flow cost matrices.

*Step 9:* Communication of MFCA results

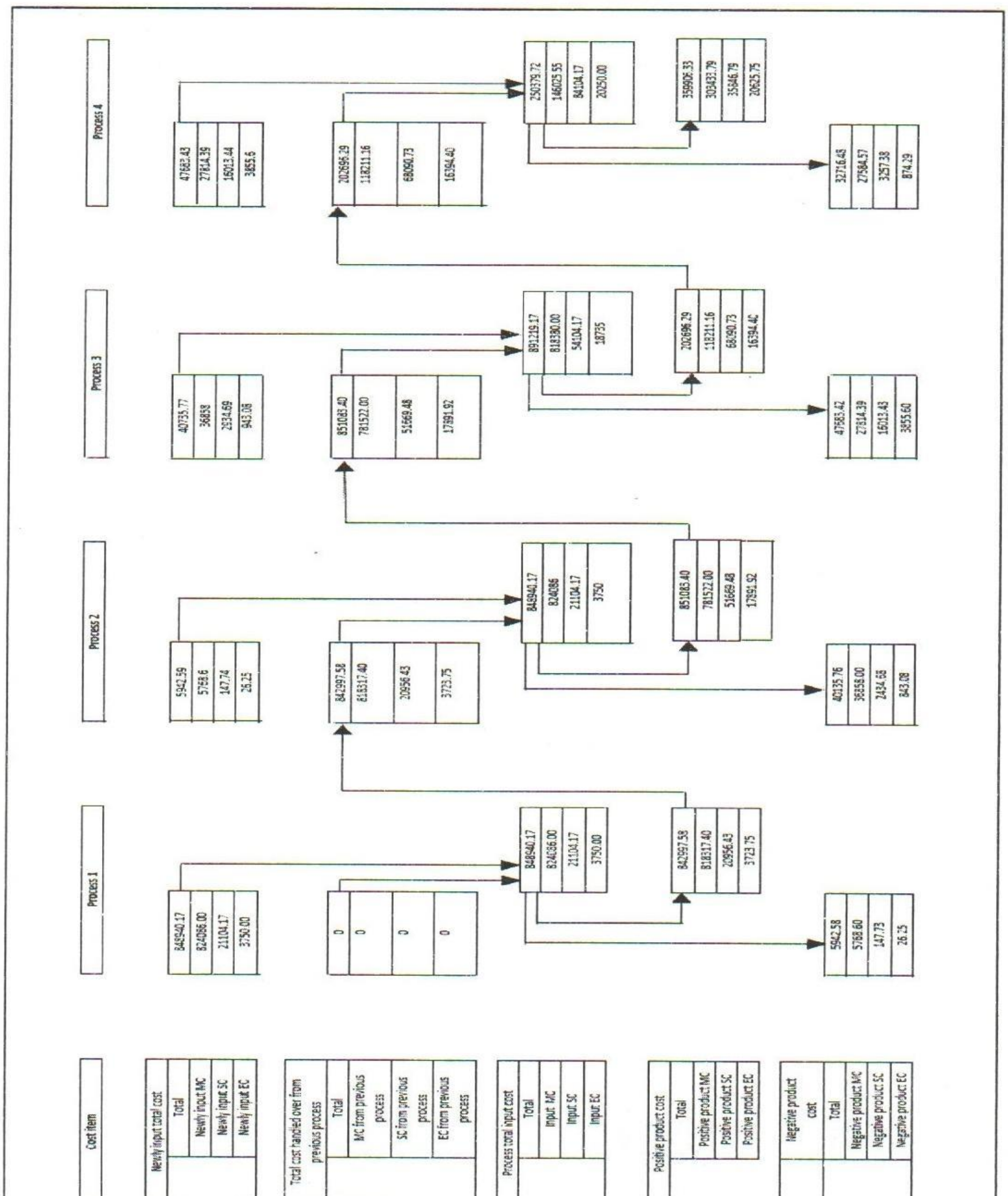
A chart combining positive and negative costs throughout all the processes based on the above flowchart including calculation data is called a 'material flow matrix'.

We can observe that overall cost, positive product cost and negative product cost is Rs 2119510.19, Rs 2021484.35 and Rs 98025.84 respectively (Table 6).

**Table 6: Product Analysis Percentage-wise Based on Material Cost**

| Product | Material Cost | % |
|---|---|---|
| Positive product | 2021484.35 | 95.38 |
| Negative product | 98025.84 | 4.62 |
| Total | 2119510.19 | 100 |

**Table 7: MFCA Cost allocation**



Here we can see that 95.38 per cent is associated with positive product cost and 4.62 per cent cost is associated with the negative product (Table 7).

## 4. ACT

During the ACT phase, the focus is on the identification and assessment of implementation opportunities for each quantity center and feasible improvement opportunities are implemented.

*Step 10:* Identification and assessment of improvement opportunities.

From CHECK step, we find out the possible improvement opportunities based on MFCA. Before suggesting measures for process improvement, we have to analyze

**Table 8: Identification of Maximum Negative Product**

| Quantity Centre | Positive Product | | Negative Product | | Total | |
|---|---|---|---|---|---|---|
| | kg | Rs | kg | Rs | kg | Rs |
| QC 2 | 11609.12 | 842997.58 | 81.2 | 5942.58 | 11527.92 | 848940.17 |
| QC 3 | 11529 | 851083.4 | **519.23** | **40135.76** | 11009.77 | 891219.17 |
| QC 4 | 2057.1 | 202696.29 | **391.83** | **47683.42** | 1665.27 | 250379.72 |
| QC 5 | 4663.15 | 359906.33 | **388.6** | **32716.48** | 4274.55 | 392622.85 |

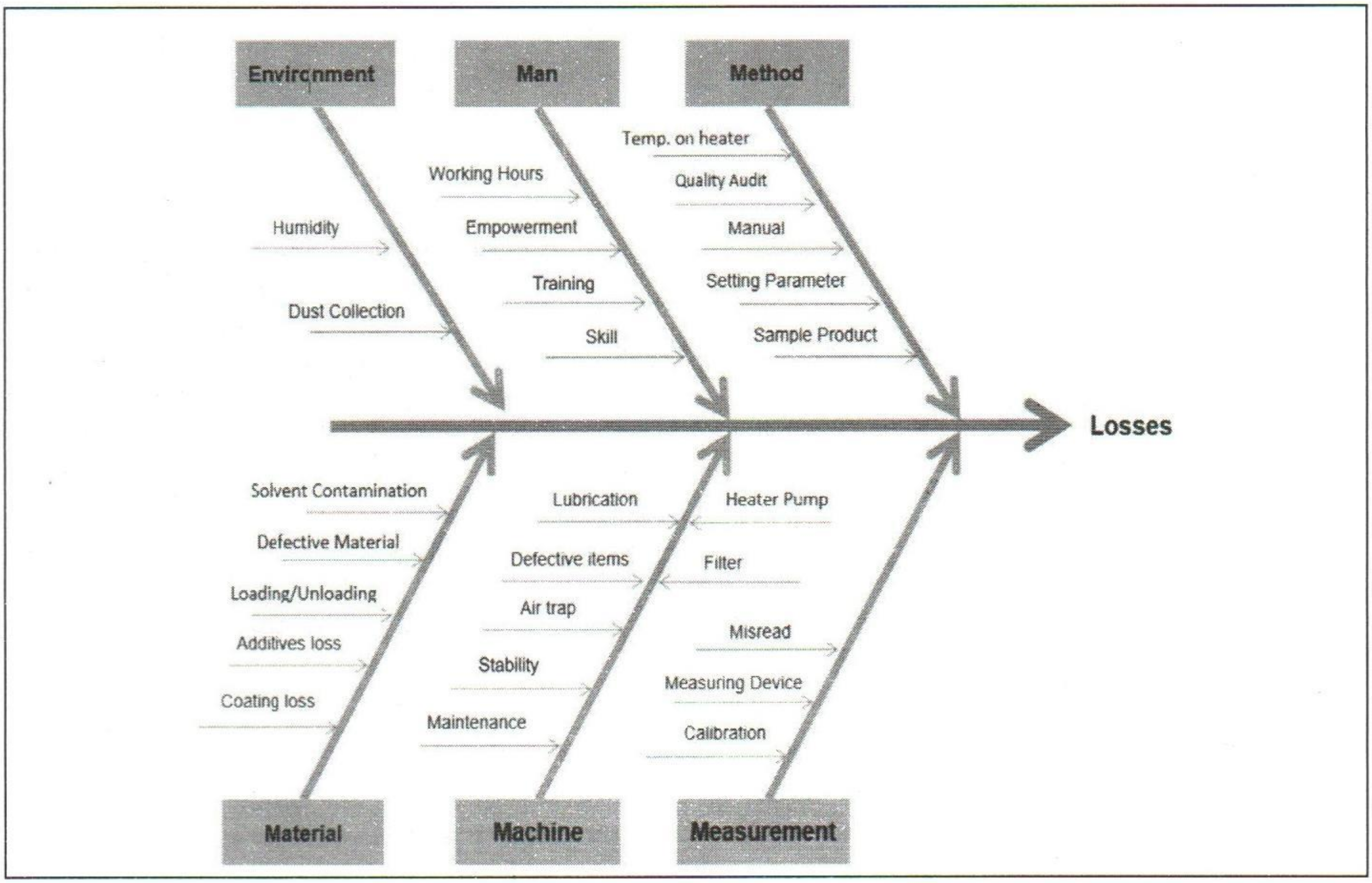



**Figure 2. Fishbone Diagram**

summary result report of CHECK phase which shows highlight of data for different selected quantity centers (Table 8).

**Fishbone Technique** *(see Figure 2)*

Most common problems/losses occur in various processes which can be improved, as followed:

**CUTTING**

- Replace cutting machine by CNC OR try to set exact length to decrease losses.
- Maintain stable speed. (The reason for low processing speed was resin viscosity and colouring density. Increasing processing speed made stable production difficult, leading to an increase in material loss.)
- Cello-tape cutting: Feasible combinations of required widths.

**PRINTING**

- Set proper timing for each die OR use advance machine for avoiding such problem.
- Stable the speed of printing machine by choosing proper resin viscosity and colouring density.

**EXTRUDER**

- Maintain a consistent regrind form. Maintaining a consistent shape prompts bulk density, improves flow in feedhoper, and gives a consistent conveyance in the screws feed section. All of these factors influence the screws output stability.
- The additives were currently input monthly. Improved blending method will enable the recycler to curtail the amount of the additives. However, change in the blending method requires replacement of facilities. This will increase system costs; cost-effectiveness from the increased productivity by the new facility (i.e., reduced system costs) was recommended to be considered as well.
- Adjust feed throat temperature. When processing, the feed throat should be warm to the touch. It improves processing by enhancing solids conveying, and reduces energy by not displacing heat through the feed throat water discharge.
- Align extruder barrels as part of the maintenance procedure. Be sure an experienced firm does the alignment. This should be done every six months or once a year so you have a history of the condition of the equipment. It also needs to be done each time a barrel, feed throat, or gearbox is mounted to the extruder and when an extruder is being relocated. A properly performed barrel alignment reduces the risk of these components failing.
- Frequent replacement of the extruder filter.
- Choose a screw supplier with an extrusion lab where you can bring in trials. That allows extruders to customize and change screws more quickly, especially when working with new materials.
- Have the capability to run a variety of resins and tubing sizes. Extruders may have multiple screw designs for one machine because there's no such thing as a 'one screw fits all' scenario.

**OTHER:**

- Colouring inspection by preceding samples.
- Prioritization for manufacturing of repeatedly ordered products.
- Further operational management in a supply chain.

In Table 9, suggestions for process improvement are identified and proposed to be implemented in the immediate, short-term and long-term basis for improvement.

## 4. SUMMARY OF MFCA RESULT

Material Flow Cost Accounting (MFCA) is an emerging tool for waste identification, waste minimization and cost saving which leads to operational and environmental performance improvement. MFCA tool shows clear CT scan image of any organization in terms of physical and monetary units for material and material loss. From MFCA material flow model and material cost matrix data can help in identification of opportunities and solve hidden problems.

From CHECK phase result of MFCA calculation based on cost composition shows positive product cost and negative product cost are 91.42 and 8.58 respectively.

From CHECK step possible suggestion for improvement will be implemented at QC-3(extruder), QC-4(cutting), QC-5 (printing) and in between process.

1. MFCA solution should be implemented at QC-3 by using standard temperature chart as provided by manufacturer guidelines for different components

**Table 9. Suggestions for Process Improvement**

| Process Description | Proposed Solution for Implementation |
|---|---|
| Cutting plastic rolls into specific length using cutting machine by manual setting. | Replace cutting machine by CNC OR try to set exact length to decrease losses. |
| Fluctuation in speed of printing machine. | Stable the speed of printing machine by choosing proper resin viscosity and colouring density. |
| Improper temperature setting during operation in various components of extruder like heater, feed throat, etc. | Use standard temperature chart as provided by manufacturer guidelines for different components of extruder. |
| Conventional measurement equipments are used for weighting and mixing process. | Use modern measurement equipments like digital measuring device for higher accuracy. |
| Only water is used in water-cooled barrel system. | Adding glycol in water system can increase its effectiveness to cool because the glycol changes the flash point of the water. |
| Manual handling of materials (loading and unloading) take place between processes. | Use automatic conveyors, so material handling is easy and speedy. |

of extruder. Waste would reduce from 4.5 per cent to approx. 3 per cent.

2. MFCA solution should be implemented at QC-4 by replacing cutting machine by CNC or try to set exact length to decrease losses, which would reduce waste from 19.04 per cent to approx. 14 per cent.
3. MFCA solution should be implemented at QC-5 by making the speed of printing machine stable, by choosing proper resin viscosity and colouring density. This would reduce waste from 8.33 per cent to 6.5 per cent.
4. MFCA is a new methodology that will lead to improvement in economic and environmental performance by reducing material flows within process operations as well as lead to a greater understanding of how these flows relate to different process in monetary term.

## 5. CONCLUSION

MFCA is applied in a case industry to analyze operational and environmental, waste generated during manufacturing process.

It has been identified that material waste has a huge impact on the environment, and performance of the company is also adversely affected by the energy consumption and the system-related cost.

We studied the aims of MFCA to present the application of MFCA in the process of plastic roll packaging industry as a case study. From the observation table and collection data, we classified material loss as defective products. In MFCA we cover the procedure for improvement for reduced defective products. We get the result after the improvement increases the positive material cost and reduces the negative material cost.

By applying the MFCA, we get its benefits to convert production losses to monetary terms. MFCA techniques' main focus is on reducing negative product costs. We conduct the loss analysis to identify the negative product cost by using the following breakdown:

1. Types of negative products
2. Losses at each quantity centers
3. Types of losses

Without the use of MFCA application, producers will not prepare for controlling normal loss because producers think that it is the behaviour of the system process that cannot be improved upon.

Effect towards process improvement which regulates lower amount of input material without compromising the output quality will lead to operational and environment performance improvement of the company.

The result proved that it is an effective tool that can be used to improve the company's performance and profitability by reducing the negative products (material loss).

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*"Almost all quality improvement comes via simplification of design, manufacturing... layout, processes, and procedures."*

*– Tom Peters*

# Managing Agility via Fuzzy Logic: A Case Study of Machine Tool Industry

G. S. DANGAYACH, ALOK KHATRI AND D. GARG

*Owing to fluctuating market demand, manufacturing with agile philosophy can be very useful to gain profit with less investment. This paper aims to measure agility of a machine tool organization using fuzzy logic method. The agility has been classified as management strategic agility, workforce agility, competence agility, manufacturing and technological agility. These four types of agility have been further sub-divided into their agile ability and capability. The data has been gathered on weight of variables and rate of these variables in the organization. The linguistic term of variables has been assigned fuzzy numbers and then fuzzy agility index and level of agility of organization has been calculated. The main obstacles have been identified and improvement plan for complete extreme agile organization has been suggested. The results of the study are expected to facilitate the firms interested in operating in agile environment.*

*G.S. Dangayach, Professor, Department of Mechanical Engineering, Malaviya National Institute of Technology, Jaipur, India.*

*Alok Khatri, Associate Professor, Department of Mechanical Engineering, Govt. Engineering College, Ajmer, India.*

*D. Garg, Professor, Department of Mechanical Engineering, National Institute of Technology, Kurukshetra, India.*

## 1. Introduction

The mass manufacturing is now shifting towards mass customization and agile manufacturing is very much appropriate for dealing with fluctuating and unpredictable dynamic demands. Mass production systems are being seriously questioned for their viability in challenging the changing nature of the business environment (Sharifi and Zhang, 1999, p. 8). The main driving force behind agility is change (Yusuf et al., 1999, p. 34). Agility is different from planned mass production. Increasing competition forces the organizations to transform their paradigm of manufacturing (Vinodh and Devadasan, 2011, p. 1219). The measurement of agility in linguistic term needs to be measured in numeric value for better understanding of aspects. Fuzzy logic is a good way to explain linguistic parameters. Instead of binary system 0&1, fuzzy analyzes 0 to 1. So this logic is closer to human behaviour. In India, it is quite well-known that customer and God can come at any time so to deal with unexpected demands, agile manufacturing is very useful tool and fuzzy logic can frame the thoughts of customer in engineering language. A multi-grade fuzzy assessment method is used to evaluate the mass customized organization (Yang and Li, 2002, p. 643) and the Agility level of $i^{th}$ company with $j^{th}$ capability defined as below (Lin et al., 2006, p. 354).

$$\text{Agility}_i = \sum_{i=1}^{n} \text{Aij}$$

Further agility index of any organization has been calculated as

$$\text{Agility}_{\text{Index}} = \sum_{i=1}^{n} \text{Ri} * \text{Wi}$$

Where, $R_i$ and $W_i$ are agility index and weight of each agility capability and the sum of weight for all capabilities will remain unity.

Let A be a universal set of agility which describes the agility:

$$A= (Ai,Aij,Aijk)$$

Let F (A) denotes the set of all fuzzy sets of A and FAI is the fuzzy agility index that can be calculated by assigning performance rating and importance weights of different agility capabilities. Triangular fuzzy number is used to define any linguistic term. The linguistic parameters have been given a triangular fuzzy number and the subjective variable has been given one mathematical value by triangular fuzzy number.

## 2. Literature Survey

Many researchers have developed measurement methods on agility. Different methodologies and mathematics have been introduced by the researchers for measurement of agility. Fuzzy logic method is one of the best methods for measurement of agility of an organization. A multi-grade fuzzy assessment for mass customized product manufacturing organization has been developed by Yang and Li in 2002. The authors took opinion of five experts of Xi Dian Casting limited company for performance rating and weight of agility capabilities and to find out level of agility on the basis of agility index. Lin et al., in 2006, developed a framework to measure organizations' agility using fuzzy logic, fuzzy agility index (FAI), and fuzzy performance importance index (FPII) have been calculated on the basis of rating and weight of agility variables given by the five experts. On the basis of the FPII authors suggested areas which need improvement in gaining extreme agility. Agility in supply chain was also investigated by Lin et al. in 2006. Chandna (2008) discussed knowledge-based framework for assessment of manufacturing agility.

Yaghoubi et al. (2011) assessed the agility of Saipa Yadak car company, Iran using fuzzy approach with Goldman methodology. The authors used single grade system instead of multi-grade system used by Lin et al. (2006). The fuzzy agility index has been compared on nine point agility level and observed that company is very agile. Vinodh and Devadasan (2011) measured agility of an Indian electronic switch manufacturing organization on the basis of twenty criteria and found the organization to be very agile on the basis of Euclidean distance computation. Besides computing agility index, authors identified weaker areas for further improvement. Shahraki et al. (2011) developed a framework for evaluation of agility needs level of organization using fuzzy agility index. The need level was calculated on the basis of agility drivers, i.e., change factors of market, need, competition, technology and policies. Zandi and Madjid (2011) developed a fuzzy quality function deployment model for agility assessment. Ustyugova and Noskievicova (2013) developed a fuzzy logic model for evaluation of integration of lean and agile manufacturing on four infrastructure factors. The criterion used by authors is different in all these papers and the number of sub-variables used is very limited. An attempt has been made in the present study to develop a model for measurement of agility using fuzzy logic method with high number of sub-variables and weak sections of an Indian machine tool industry has been identified.

## 3. Method for Agility Measurement

A framework has been shown in Figure 1 for the agility measurement. A conceptual model as shown in Figure 2 and Table 1 has been developed for measurement of agility of an organization discussed in the next section. Khatri et al. (2014) have also developed a framework for measurement of agility. The agility of H.M.T. Machine Tool, Ajmer, India has been assessed in linguistic terms by the senior managers. The weight and performance rating of agile parameters in linguistic terms for the type of agility, main variables and sub-variables via judgement method has been collected and tabulated as shown in Annexure 1. These linguistic terms have been assigned a fuzzy number as shown in Annexure 2. By the use of mathematic operations of assigned weight and ratings, fuzzy agility index and fuzzy performance improvement index of the organization have been calculated. The fuzzy agility index has been matched with linguistic level of agility and Euclidean distance to know the level of agility of the organization. Finally fuzzy performance improvement index of all variables have been calculated to identify the principal obstacles of agility that need improvement for achieving extreme agility level.

## 4. Conceptual Model

A conceptual model is shown in Figure 2. The agility has been categorized in four major types: management strategic agility, workforce agility, competence agility, manufacturing and technological agility. Further, these four have been sub-divided into ten main categories. The management strategic agility that generally depends on the decision of top level management for the short and long term benefits of organization has been further

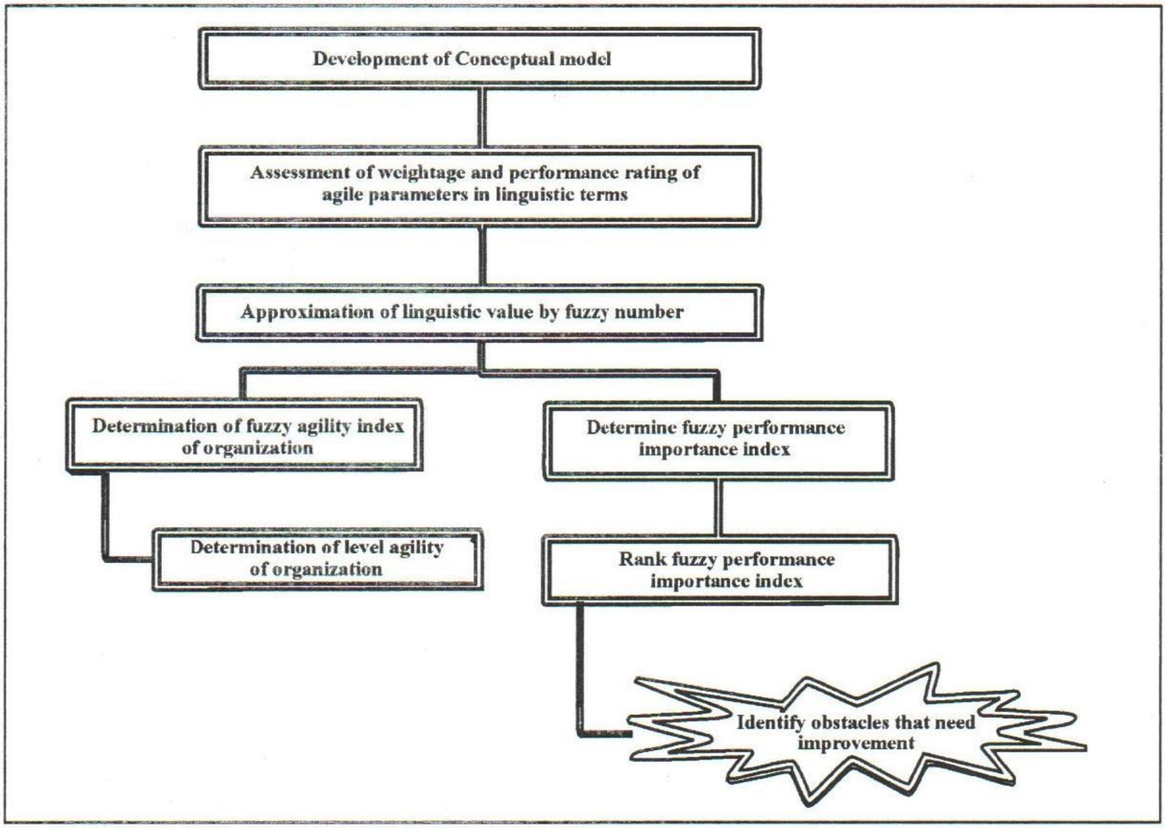


**Figure 1. Framework for Agility Measurement**

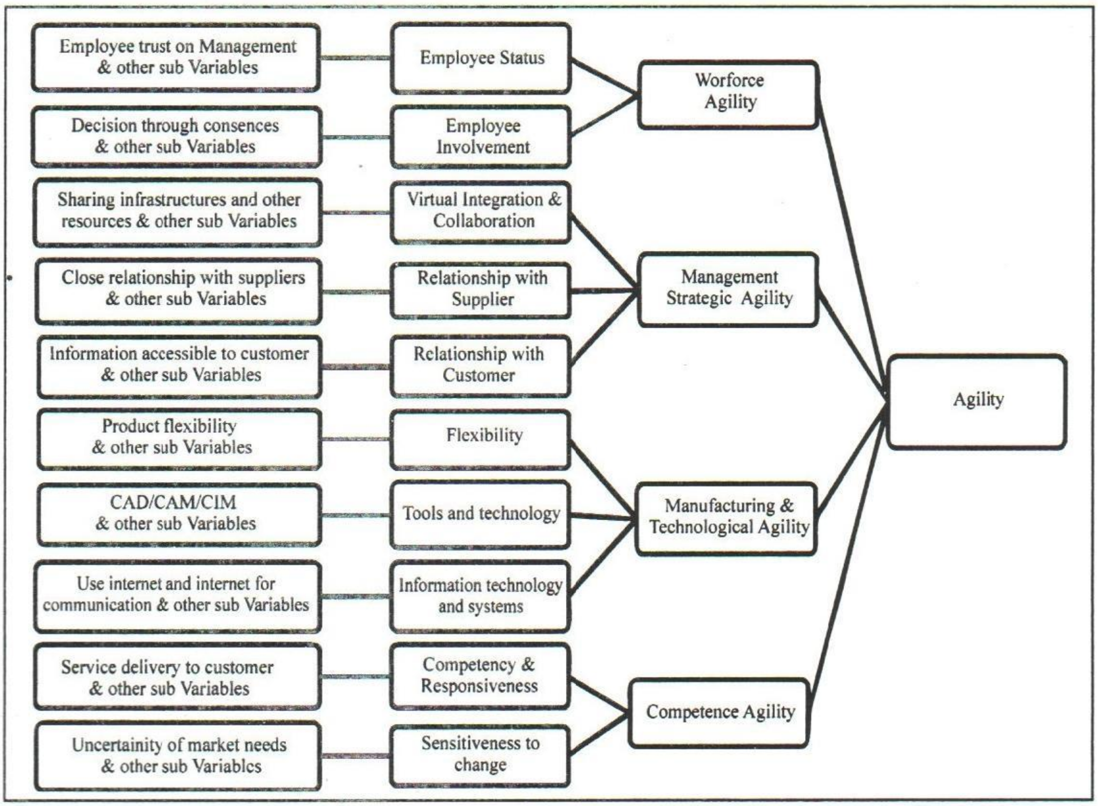


**Figure 2. Conceptual Model for Agility Measurement**

Table 1: Criteria for Evaluation Agility

| Type of Agility | Syl. Ai | Main Agility Variables | Syl.Aij | Sub-variables | Symbol Aijk |
|---|---|---|---|---|---|
| Management Strategic Agility | A1 | Relationship with Customer | A11 | Information accessible to customer | A11.1 |
| | | | | Trust based & Strategic relationship with customers | A11.2 |
| | | | | Customer satisfaction | A11.3 |
| | | | | Long term collaboration with customer | A11.4 |
| | | | | Involving customers in designing the new products | A11.5 |
| | | | | Customers feedback | A11.6 |
| | | | | Customer service | A11.7 |
| | | | | Real time information to customer | A11.8 |
| | | | | On-time delivery to customer | A11.9 |
| | | Relationship with Supplier | A12 | Close relationship with supplier | A12.1 |
| | | | | Trust based & Strategic relationship with supplier | A12.2 |
| | | | | Long term collaboration with supplier | A12.3 |
| | | | | Involving supplier in short and long term planning | A12.4 |
| | | | | Supplier development | A12.5 |
| | | | | Retention of old suppliers | A12.6 |
| | | | | Involving supplier in product development | A12.7 |
| | | Virtual Integration and Collaboration | A13 | Sharing infrastructures and other resources | A13.1 |
| | | | | Sharing of financial resources | A13.2 |
| | | | | Sharing of R&D and concepts | A13.3 |
| | | | | Sharing of customers and market | A13.4 |
| | | | | Computer based data integration with other companies | A13.5 |
| | | | | Temporary alliances | A13.6 |
| | | | | Rapid partnership formation | A13.7 |
| | | | | Joint and multi venture formation | A13.8 |
| | | | | Subcontractor formation | A13.9 |
| Workforce Agility | A2 | Employee involvement | A21 | Decision through consensus | A21.1 |
| | | | | Cross functional teams | A21.2 |
| | | | | Employees' empowerment | A21.3 |
| | | | | Team across company | A21.4 |
| | | | | Employee involvement & rewarding | A21.5 |
| | | | | Commitment of the personnel | A21.6 |
| | | Employee Status | A22 | Employees trust on management | A22.1 |
| | | | | Multi-skilled and flexible people | A22.2 |
| | | | | Continuous motivation of manpower | A22.3 |
| | | | | Employees' satisfaction | A22.4 |
| | | | | Continuous training and development | A22.5 |
| | | | | Resistance to change | A22.6 |

Contd

| | | | | | |
|---|---|---|---|---|---|
| Competence Agility | A3 | Sensitiveness to change | A31 | Uncertainty of market needs | A31.1 |
| | | | | National and International political changes | A31.2 |
| | | | | Changes in customer anticipated & unanticipated need | A31.3 |
| | | | | Changes in technology | A31.4 |
| | | | | Changes in social factors | A31.5 |
| | | | | Changes in Government policies | A31.6 |
| | | | | Changes in Competition / competitors | A31.7 |
| | | Competency and Responsiveness | A32 | Service delivery to customer | A32.1 |
| | | | | New product introduction time to market | A32.2 |
| | | | | Rate of new products introduction | A32.3 |
| | | | | Research and development (R&D) & Innovations | A32.4 |
| | | | | Cost effectiveness | A32.5 |
| | | | | Quality over product life | A32.6 |
| | | | | First time right design | A32.7 |
| | | | | Development cycle time | A32.8 |
| | | | | Continuous improvement | A32.9 |
| | | | | Learning organization | A32.10 |
| | | | | Sufficient and appropriate technological ability | A32.11 |
| | | | | Rapid design change | A32.12 |
| | | | | Rapid volume change | A32.13 |
| | | | | Delivery lead time | A32.14 |
| Manufacturing & Technological Agility | A2 | Information technology and systems | A41 | Use of intranet and internet for communication | A41.1 |
| | | | | Use of enterprises resource planning in the organization | A41.2 |
| | | | | Use of electronic data interchange in conducting the business operations | A41.3 |
| | | | | Information accessible to employees | A41.4 |
| | | | | Information system interface with suppliers | A41.5 |
| | | | | Information system interface with customers | A41.6 |
| | | | | Data accuracy | A41.7 |
| | | Flexibility | A42 | Product flexibility | A42.1 |
| | | | | Process flexibility | A42.2 |
| | | | | Amount of production/product volume flexibility | A42.3 |
| | | | | Product specification/configuration flexibility | A42.4 |
| | | | | Manpower/Employee Flexibility | A42.5 |
| | | | | Manufacturing systems flexibility | A42.6 |
| | | | | Product model flexibility | A42.7 |
| | | | | Logistics flexibility | A42.8 |
| | | | | Organizational flexibility | A42.9 |
| | | | | Flexibility of decision making | A42.10 |

| | | | | | |
|---|---|---|---|---|---|
| | A3 | Tools & Technology | A43 | Computer aided design, manufacturing (CAD/CAM) & Computer integrated manufacturing (CIM) systems | A43.1 |
| | | | | Computerized numerical control (CNC) machines | A43.2 |
| | | | | Group technology (GT) | A43.3 |
| | | | | Computer aided process planning (CAPP) | A43.4 |
| | | | | Automated assembly line (ASL) | A43.5 |
| | | | | Automated storage & retrieval systems (AS/RS) | A43.6 |
| | | | | Total quality & productivity management systems | A43.7 |
| | | | | Quality Function Deployment (QFD) systems | A43.8 |
| | | | | Failure mode and effect analysis (FMEA) | A43.9 |
| | | | | Management information systems (MIS) | A43.10 |
| | | | | Material requirement & resource planning | A43.11 |
| | | | | Just in time manufacturing (JIT) | A43.12 |
| | | | | Rapid prototyping | A43.13 |
| | | | | Supply chain management (SCM) | A43.14 |

classified as relationship with customer, relationship with supplier and virtual integration and collaboration. The second type of agility is workforce agility which is further sub-divided into two main categories as employee status and employee involvement. The third agility is termed as competence agility, it shows how responsive the firm is, firms' quickness to respond to the changing needs and it has been categorized as sensitiveness to change and competency and responsiveness. The fourth agility, termed as manufacturing and technological tools, is further sub-classified as tools and technology and information technology. This is the era of information technology, the world has been connected by web technology and the boundary of this IT hub is the complete world. The information flows from lower management level to upper management level and vice versa at high speed and leading firms to agile, the inter and intra net becomes very useful for information flow. Today, automation of every system in industry is enhancing quality products, rate of production and also reducing the production cost. R&D and innovations are giving new ways of manufacturing technologies and philosophies day by day. These ten variables have been sub-divided into their related sub-variables. One sub-variable has been shown in the conceptual model and all these sub-variables, main variables and type of agility has been tabulated in Table 1 with their symbols. All the variables of agility have been divided into three layers and presented in Table 1.

## 5. Measurement of Fuzzy Agility Index (FAI)

The weight and performance rating of variables have been assessed by group of managers. It has been tabulated in Annexure 1 in linguistic terms and then these linguistic variables have been assigned a fuzzy number as shown in Table 2.

The fuzzy index of type of agility and main variables have been calculated as per fuzzy rule

$$\text{Agility}_{\text{Index}} = \sum_{i=1}^{n} \text{Ri} * \text{Wi}$$

$F_{11}$ = (3 * 0.3 + 3 * 0.3 + 2 * 0.2 + 3 * 0.3 + 3 * 0.5 + 5 * 0.3 + 2 * 0.2 + 2 * 0.2 + 2 * 0.2) / (0.3 + 0.3 + 0.2 + 0.3 + 0.5 + 0.3 + 0.2 + 0.2 + 0.2 )

= (2.92, 4.63, 6.41)

Similarly other fuzzy index have been calculated for all type of agility and main variables of agility and it has been tabulated in Table 3. Finally, fuzzy agility index of organization have been calculated as:

FAI = [(3.75 * 0.3 + 3.09 * 0.3 + 3.55 * 0.3 + 3.12 * 0.2) / (0.3 + 0.3 + 0.3 +0.2), (4.22 * 0.5 + 4.84 * 0.5 + 4.93 * 0.5 + 4.78 * 0.35) / (0.5 + 0.5 + 0.5 +0.35), (5.93 * 0.7 + 6.60 * 0.7 + 6.81 * 0.7 + 6.57 * 0.5) / (0.7 + 0.7 + 0.7 +0.5)]

FAI= (3.4, 4.8, 6.5)

Table 2: Fuzzy Numbers for Approximation of Linguistic Variables

| Weight /Importance (W) | | | Performance rating (R) | | |
|---|---|---|---|---|---|
| Linguistic variable | Symbol | Fuzzy number | Linguistic variable | Symbol | Fuzzy number |
| Very Low | VL | 0,0.05,0.15 | Worse | W | 0,0.5,1.5 |
| Low | L | 0.1,0.2,0.3 | Very Poor | VP | 1,2,3 |
| Fairly Low | FL | 0.2,0.35,0.5 | Poor | P | 2,3.5,5 |
| Medium | M | 0.3,0.5,0.7 | Fair | F | 3,5,7 |
| Fairly High | FH | 0.5,0.65,0.8 | Good | G | 5,6.5,8 |
| High | H | 0.7,0.8,0.9 | Very Good | VG | 7,8,9 |
| Very High | VH | 0.85,0.95,1.0 | Excellent | E | 8.5,9.5,10 |

The linguistic values of agility have been categorized as shown in Table 4. These linguistic levels have been matched with fuzzy agility index of the organization and it is found that FAI is the member of Agile Agility level since FAI (3.4, 4.8, 6.5) is almost near to Agile agility level, i.e., (3.5,5,6.5), therefore the organization is said to be Agile. Same can also be proved by Euclidean distance method. The minimum distance shows the closeness to fit. The Euclidean distance has been calculated and these distances are as follows:

D (FAI,EA) = 3.65

D (FAI,VA) = 2.15

D (FAI,A) = 0.167

D (FAI,FA) = 1.85

D (FAI,SA) = 3.35

The Euclidean distance between fuzzy agility index and agility level of agile is the lowest, i.e., 0.167, so the organization is said to be Agile.

## 6. Measurement of Fuzzy Performance Importance Index (FPII)

To identify the main obstacles of agility, fuzzy performance index has been calculated for all sub-variables then these have been ranked. Ranking methods proposed by Lee-

Table 3: Fuzzy Index of Type of Agility and Main Agility Variables

| Ai | Fi | Aij | Fij |
|---|---|---|---|
| A1 | 3.75,4.22,5.93 | A11 | 2.92,4.63,6.41 |
| | | A12 | 5.47,4.45,6.26 |
| | | A13 | 2,3.5,5 |
| A2 | 3.09,4.84,6.60 | A21 | 3.26,5.08,6.91 |
| | | A22 | 2.64,4.41,6.18 |
| A3 | 3.55,4.925,6.81 | A31 | 3.56,4.8,7.11 |
| | | A32 | 3.54,5.05,6.52 |
| A4 | 3.12,4.78,6.57 | A41 | 3.72,5.26,6.91 |
| | | A42 | 3.00,4.64,6.51 |
| | | A43 | 2.70,4.52,6.34 |

Table 4: Agility Level and their Fuzzy Number

| S. No. | Agility Level | Symbol | Fuzzy Number |
|---|---|---|---|
| 1 | Extremely Agile | EA | 7,8.5,10 |
| 2 | Very Agile | VA | 5.5,7,8.5 |
| 3 | Agile | A | 3.5,5,6.5 |
| 4 | Fairly Agile | FA | 1.5,3,4.5 |
| 5 | Sluggishly Agile | SA | 0,1.5,3.0 |

Kwang and Lee (1999), Chen and Hwang (1992), have been used for the same. The fuzzy performance importance index in terms of fuzzy number is presented in Table 5. The FPII for all sub variables can be calculated by:

$$FPII_{ijk} = W'_{ijk} * R_{ijk}$$

Where, $W'_{ijk} = [(1, 1, 1) - W_{ijk}]$

To neutralize the weight of variable it has been subtracted from (1, 1, 1) and the fuzzy subtraction principle is as follows,

$$[(1, 1, 1) - (a, b, c)] = [(1-c), (1-b), (1-a)]$$

$$FPII_{11.1} = [\{(1, 1, 1) - (0.3, 0.5, 0.7)\} * (3, 5, 7)]$$

$$FPII_{11.1} = (0.9, 2.5, 4.9)$$

Similarly, FPII values of all sub-variables have been calculated and presented in Table 5. These FPII values have been defuzzify and ranked using Chen and Hwang's left and right fuzzy ranking method. For defuzzifying a fuzzy number, the fuzzy maximizing, minimizing set and triangular fuzzy number FPII is defined as:

$$f_{max}(x) = \{x,\ 0 \leq x \leq 10\} \text{ or } \{0, \text{otherwise}\}$$

$$f_{min}(x) = \{10 - x,\ 0 \leq x \leq 10\} \text{ or } \{x, \text{otherwise}\}$$

$f_{FPII} : R \rightarrow [0,10]$ with triangular membership function, their left and right and total score can be obtained by :

$$U_R(FPII) = \sup_x [f_{FPII}(x) \wedge f_{max}(x)]$$

$$U_L(FPII) = \sup_x [f_{FPII}(x) \wedge f_{min}(x)]$$

$$U_T(FPII) = [U_R(FPII) + 10 - U_L(FPII)] / 2$$

$U_T$ of all FPII have been calculated and tabulated as ranking score in Table 5.

To identify critical factors, the ranking score has been analyzed and the critical factors have been identified. Same is presented in Table 6. Twelve factors have been analyzed as critical. Threshold score 2.5 has been selected and the variables having scored less than this value are assumed critical that need attention. The low score means that the factor has more weight but less importance has been provided by the organization. The new product introduction time to market has scores less than 1.5 therefore it is the most critical factor for organization. Two factors, automated assembly line (ASL) and automated storage & retrieval systems (AS/RS) scores more than 1.5 but less than 2.0 are found very critical and nine variables scored more than 2.0 but less than 2.5 are involving customers in designing the new products, resistance to change, uncertainty of market needs, national and international political changes, changes in customer anticipated and unanticipated need, changes in government policies, research and development (R&D) & innovations, development cycle time and continuous improvement are critical in state. It shows that organization's response to change and competency is poor and needs improvement.

## 7. Conclusion

In the situation of fluctuating demand, the organizations need to be agile and they are trying to be agile but still there is a gap between required agility and organizational current agility. Number of techniques has been developed by the researcher for the measurement of agility. Fuzzy logic based agility measurement is one of them and very useful for measurement of agility and also for identifying obstacles of agility. In this study, fuzzy agility index of an Indian machine tool industry has been calculated and it was observed that the organization is agile and lying in the middle level of agility. Fuzzy performance importance index of organization was also calculated to identify the main obstacles of agility and to identify factors that needed

Table 5: Fuzzy Performance Importance Indexes of Agility Attributes

| Agility Attribute | Aggregated fuzzy performance rating | Wijk Fuzzy No. | W'= {(1,1,1) – Wijk} | FPII | Ranking Score |
|---|---|---|---|---|---|
| A11.1 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A11.2 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A11.3 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A11.4 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A11.5 | 3,5,7 | 0.5,0.65,0.8 | 0.2,0.35,0.5 | 0.6,1.75,3.5 | 2.304 |
| A11.6 | 5,6.5,8 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 1.5,3.25,5.6 | 3.679 |
| A11.7 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A11.8 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A11.9 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A12.1 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A12.2 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A12.3 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A12.4 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A12.5 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A12.6 | 3,5,7 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.5,3.25,5.6 | 3.679 |
| A12.7 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A13.1 | 2,3.5,5 | 0.1,0.2,0.3 | 0.7,0.8,0.9 | 1.4,2.8,4.5 | 3.125 |
| A13.2 | 2,3.5,5 | 0.1,0.2,0.3 | 0.7,0.8,0.9 | 1.4,2.8,4.5 | 3.125 |
| A13.3 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A13.4 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A13.5 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A13.6 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A13.7 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A13.8 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A13.9 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A21.1 | 3,5,7 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.5,3.25,5.6 | 3.679 |
| A21.2 | 3,5,7 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.5,3.25,5.6 | 3.679 |
| A21.3 | 5,6.5,8 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 1.5,3.25,5.6 | 3.679 |
| A21.4 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A21.5 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A21.6 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |

*(contd)*

| | | | | | |
|---|---|---|---|---|---|
| A22.1 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A22.2 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A22.3 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A22.4 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A22.5 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A22.6 | 3,5,7 | 0.5,0.65,0.8 | 0.2,0.35,0.5 | 0.6,1.75,3.5 | 2.304 |
| A31.1 | 3,5,7 | 0.5,0.65,0.8 | 0.2,0.35,0.5 | 0.6,1.75,3.5 | 2.304 |
| A31.2 | 3,5,7 | 0.5,0.65,0.8 | 0.2,0.35,0.5 | 0.6,1.75,3.5 | 2.304 |
| A31.3 | 3,5,7 | 0.5,0.65,0.8 | 0.2,0.35,0.5 | 0.6,1.75,3.5 | 2.304 |
| A31.4 | 5,6.5,8 | 0.5,0.65,0.8 | 0.2,0.35,0.5 | 1.0,2.28,4.0 | 2.719 |
| A31.5 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A31.6 | 3,5,7 | 0.5,0.65,0.8 | 0.2,0.35,0.5 | 0.6,1.75,3.5 | 2.304 |
| A31.7 | 5,6.5,8 | 0.5,0.65,0.8 | 0.2,0.35,0.5 | 1.0,2.28,4.0 | 2.719 |
| A32.1 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A32.2 | 3,5,7 | 0.7,0.8,0.9 | 0.1,0.2,0.3 | 0.3,1.0,2.1 | 1.409 |
| A32.3 | 3,5,7 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.5,3.25,5.6 | 3.679 |
| A32.4 | 1,2,3 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 0.5,1.3,2.4 | 1.675 |
| A32.5 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A32.6 | 5,6.5,8 | 0.5,0.65,0.8 | 0.2,0.35,0.5 | 1.0,2.28,4.0 | 2.719 |
| A32.7 | 5,6.5,8 | 0.5,0.65,0.8 | 0.2,0.35,0.5 | 1.0,2.28,4.0 | 2.719 |
| A32.8 | 3,5,7 | 0.5,0.65,0.8 | 0.2,0.35,0.5 | 0.6,1.75,3.5 | 2.304 |
| A32.9 | 3,5,7 | 0.5,0.65,0.8 | 0.2,0.35,0.5 | 0.6,1.75,3.5 | 2.304 |
| A32.10 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A32.11 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A32.12 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A32.13 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A32.14 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A41.1 | 5,6.5,8 | 0.5,0.65,0.8 | 0.2,0.35,0.5 | 1.0,2.28,4.0 | 2.719 |
| A41.2 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A41.3 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A41.4 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A41.5 | 3,5,7 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.5,3.25,5.6 | 3.679 |
| A41.6 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |

*(contd)*

| | | | | | |
|---|---|---|---|---|---|
| A41.7 | 5,6.5,8 | 0.5,0.65,0.8 | 0.2,0.35,0.5 | 1.0,2.28,4.0 | 2.719 |
| A42.1 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A42.2 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A42.3 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A42.4 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A42.5 | 3,5,7 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.5,3.25,5.6 | 3.679 |
| A42.6 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A42.7 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A42.8 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A42.9 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A42.10 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A43.1 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A43.2 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A43.3 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A43.4 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A43.5 | 1,2,3 | 0.1,0.2,0.3 | 0.7,0.8,0.9 | 0.7,1.6,2.7 | 1.875 |
| A43.6 | 1,2,3 | 0.1,0.2,0.3 | 0.7,0.8,0.9 | 0.7,1.6,2.7 | 1.875 |
| A43.7 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A43.8 | 3,5,7 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.5,3.25,5.6 | 3.679 |
| A43.9 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A43.10 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A43.11 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A43.12 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |
| A43.13 | 2,3.5,5 | 0.2,0.35,0.5 | 0.5,0.65,0.8 | 1.0,2.28,4.0 | 2.719 |
| A43.14 | 3,5,7 | 0.3,0.5,0.7 | 0.3,0.5,0.7 | 0.9,2.5,4.9 | 3.0 |

Table 6: Level of Criticality

| S. No. | Ranking Score value | Symbol | Sub-variable | Level of Criticality |
|---|---|---|---|---|
| 1 | Less than 1.5 | A 32.2 | New product introduction time to market | Most critical |
| 2 | Less than 2.0 | A 43.5 | Automated assembly line (ASL) | Very critical |
| 3 | Less than 2.0 | A 43.6 | Automated storage & retrieval systems (AS/RS) | Very critical |
| 4 | Less than 2.5 | A 11.5 | Involving customers in designing the new products | Critical |
| 5 | Less than 2.5 | A 22.6 | Resistance to change | Critical |
| 6 | Less than 2.5 | A 31.1 | Uncertainty of market needs | Critical |
| 7 | Less than 2.5 | A 31.2 | National and International political changes | Critical |
| 8 | Less than 2.5 | A 31.3 | Changes in customer anticipated & unanticipated need | Critical |
| 9 | Less than 2.5 | A 31.6 | Changes in Government policies | Critical |
| 10 | Less than 2.5 | A 32.4 | Research and development (R&D) & Innovations | Critical |
| 11 | Less than 2.5 | A 32.8 | Development cycle time | Critical |
| 12 | Less than 2.5 | A 32.9 | Continuous improvement | Critical |

to be improved. Twelve factors were found critical and needed improvement. These were new product introduction time to market, automated assembly line (ASL), automated storage & retrieval systems (AS/RS), involving customers in designing the new products, resistance to change, uncertainty of market needs, national and international political changes, changes in customer anticipated and unanticipated need, changes in government policies research and development (R&D) & innovations, development cycle time and continuous improvement. New production time to market was observed to be the most critical factor, and it is concluded that the organization's response to change and competency is poor and needs improvement.

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## Annexure 1

### Performance Rating (R) and Weight (W) of Agility Parameters

| Ai | Wi | Aij | Wij | Aijk | Wijk | Rijk |
|---|---|---|---|---|---|---|
| A1 | M | A11 | FL | A11.1 | M | F |
| | | | | A11.2 | M | F |
| | | | | A11.3 | FL | P |
| | | | | A11.4 | M | F |
| | | | | A11.5 | FH | F |
| | | | | A11.6 | M | G |
| | | | | A11.7 | FL | P |
| | | | | A11.8 | FL | P |
| | | | | A11.9 | FL | P |
| | | A12 | M | A12.1 | M | F |
| | | | | A12.2 | M | F |
| | | | | A12.3 | FL | P |
| | | | | A12.4 | FL | P |
| | | | | A12.5 | FL | P |
| | | | | A12.6 | FL | F |
| | | | | A12.7 | M | F |
| | | A13 | FL | A13.1 | L | P |
| | | | | A13.2 | L | P |
| | | | | A13.3 | FL | P |
| | | | | A13.4 | FL | P |
| | | | | A13.5 | FL | P |
| | | | | A13.6 | FL | P |
| | | | | A13.7 | FL | P |
| | | | | A13.8 | FL | P |
| | | | | A13.9 | FL | P |
| A2M | | A21 | FH | A21.1 | FL | F |
| | | | | A21.2 | FL | F |
| | | | | A21.3 | M | G |
| | | | | A21.4 | M | F |
| | | | | A21.5 | FL | P |
| | | | | A21.6 | M | F |
| | | A22 | M | A22.1 | M | F |
| | | | | A22.2 | FL | P |
| | | | | A22.3 | M | F |
| | | | | A22.4 | FL | P |
| | | | | A22.5 | FL | P |
| | | | | A22.6 | FH | F |
| A3M | | A31 | FL | A31.1 | FH | F |
| | | | | A31.2 | FH | F |
| | | | | A31.3 | FH | F |
| | | | | A31.4 | FH | G |
| | | | | A31.5 | FL | P |
| | | | | A31.6 | FH | F |
| | | | | A31.7 | FH | G |

*(contd)*

| | | | | | | |
|---|---|---|---|---|---|---|
| | | A32 | FL | A32.1 | M | F |
| | | | | A32.2 | H | F |
| | | | | A32.3 | FL | F |
| | | | | A32.4 | FL | VP |
| | | | | A32.5 | M | F |
| | | | | A32.6 | FH | G |
| | | | | A32.7 | FH | G |
| | | | | A32.8 | FH | F |
| | | | | A32.9 | FH | F |
| | | | | A32.10 | M | F |
| | | | | A32.11 | FL | P |
| | | | | A32.12 | FL | P |
| | | | | A32.13 | FL | P |
| | | | | A32.14 | FL | P |
| A4 | FL | A41 | FL | A41.1 | FH | G |
| | | | | A41.2 | FL | P |
| | | | | A41.3 | M | F |
| | | | | A41.4 | M | F |
| | | | | A41.5 | FL | F |
| | | | | A41.6 | FL | P |
| | | | | A41.7 | FH | G |
| | | A42 | M | A42.1 | M | F |
| | | | | A42.2 | M | F |
| | | | | A42.3 | FL | P |
| | | | | A42.4 | M | F |
| | | | | A42.5 | FL | F |
| | | | | A42.6 | M | F |
| | | | | A42.7 | M | F |
| | | | | A42.8 | FL | P |
| | | | | A42.9 | M | F |
| | | | | A42.10 | FL | P |
| | | A43 | FL | A43.1 | M | F |
| | | | | A43.2 | M | F |
| | | | | A43.3 | M | F |
| | | | | A43.4 | M | F |
| | | | | A43.5 | L | VP |
| | | | | A43.6 | L | VP |
| | | | | A43.7 | FL | P |
| | | | | A43.8 | FL | F |
| | | | | A43.9 | M | F |
| | | | | A43.10 | M | F |
| | | | | A43.11 | FL | P |
| | | | | A43.12 | M | F |
| | | | | A43.13 | FL | P |
| | | | | A43.14 | M | F |

**Annexure 2**

**Performance Rating (R) and Weight (W) of agility parameters with linguistic terms approximated by fuzzy numbers**

| Ai | Wi Fuzzy No. | Aij | Wij Fuzzy No. | Aijk | Wijk Fuzzy No. | Rijk |
|---|---|---|---|---|---|---|
| A1 | 0.3,0.5,0.7 | A11 | 0.2,0.35,0.5 | A11.1 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A11.2 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A11.3 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A11.4 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A11.5 | 0.5,0.65,0.8 | 3,5,7 |
| | | | | A11.6 | 0.3,0.5,0.7 | 5,6.5,8 |
| | | | | A11.7 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A11.8 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A11.9 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | A12 | 0.3,0.5,0.7 | A12.1 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A12.2 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A12.3 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A12.4 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A12.5 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A12.6 | 0.2,0.35,0.5 | 3,5,7 |
| | | | | A12.7 | 0.3,0.5,0.7 | 3,5,7 |
| | | A13 | 0.2,0.35,0.5 | A13.1 | 0.1,0.2,0.3 | 2,3.5,5 |
| | | | | A13.2 | 0.1,0.2,0.3 | 2,3.5,5 |
| | | | | A13.3 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A13.4 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A13.5 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A13.6 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A13.7 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A13.8 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A13.9 | 0.2,0.35,0.5 | 2,3.5,5 |
| A2 | 0.3,0.5,0.7 | A21 | 0.85,0.95,1.0 | A21.1 | 0.2,0.35,0.5 | 3,5,7 |
| | | | | A21.2 | 0.2,0.35,0.5 | 3,5,7 |
| | | | | A21.3 | 0.3,0.5,0.7 | 5,6.5,8 |
| | | | | A21.4 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A21.5 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A21.6 | 0.3,0.5,0.7 | 3,5,7 |
| | | A22 | 0.3,0.5,0.7 | A22.1 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A22.2 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A22.3 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A22.4 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A22.5 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A22.6 | 0.5,0.65,0.8 | 3,5,7 |
| A3 | 0.3,0.5,0.7 | A31 | 0.2,0.35,0.5 | A31.1 | 0.5,0.65,0.8 | 3,5,7 |
| | | | | A31.2 | 0.5,0.65,0.8 | 3,5,7 |
| | | | | A31.3 | 0.5,0.65,0.8 | 3,5,7 |
| | | | | A31.4 | 0.5,0.65,0.8 | 5,6.5,8 |
| | | | | A31.5 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A31.6 | 0.5,0.65,0.8 | 3,5,7 |
| | | | | A31.7 | 0.5,0.65,0.8 | 5,6.5,8 |

*(contd)*

| | | | | | | |
|---|---|---|---|---|---|---|
| | | A32 | 0.2,0.35,0.5 | A32.1 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A32.2 | 0.7,0.8,0.9 | 3,5,7 |
| | | | | A32.3 | 0.2,0.35,0.5 | 3,5,7 |
| | | | | A32.4 | 0.2,0.35,0.5 | 1,2,3 |
| | | | | A32.5 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A32.6 | 0.5,0.65,0.8 | 5,6.5,8 |
| | | | | A32.7 | 0.5,0.65,0.8 | 5,6.5,8 |
| | | | | A32.8 | 0.5,0.65,0.8 | 3,5,7 |
| | | | | A32.9 | 0.5,0.65,0.8 | 3,5,7 |
| | | | | A32.10 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A32.11 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A32.12 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A32.13 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A32.14 | 0.2,0.35,0.5 | 2,3.5,5 |
| A4 | 0.2,0.35,0.5 | A41 | 0.2,0.35,0.5 | A41.1 | 0.5,0.65,0.8 | 5,6.5,8 |
| | | | | A41.2 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A41.3 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A41.4 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A41.5 | 0.2,0.35,0.5 | 3,5,7 |
| | | | | A41.6 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A41.7 | 0.5,0.65,0.8 | 5,6.5,8 |
| | | A42 | 0.3,0.5,0.7 | A42.1 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A42.2 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A42.3 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A42.4 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A42.5 | 0.2,0.35,0.5 | 3,5,7 |
| | | | | A42.6 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A42.7 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A42.8 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A42.9 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A42.10 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | A43 | 0.2,0.35,0.5 | A43.1 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A43.2 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A43.3 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A43.4 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A43.5 | 0.1,0.2,0.3 | 1,2,3 |
| | | | | A43.6 | 0.1,0.2,0.3 | 1,2,3 |
| | | | | A43.7 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A43.8 | 0.2,0.35,0.5 | 3,5,7 |
| | | | | A43.9 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A43.10 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A43.11 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A43.12 | 0.3,0.5,0.7 | 3,5,7 |
| | | | | A43.13 | 0.2,0.35,0.5 | 2,3.5,5 |
| | | | | A43.14 | 0.3,0.5,0.7 | 3,5,7 |

*If you define the problem correctly, you almost have the solution."*

*– Steve Jobs*

# Impact of Working Capital Performance on Profitability of Dairy Industry in Andhra Pradesh

P. SARVESWARA RAO AND N. MADHAVA RAO

*Dairy industry is an important component of Indian economy; it is supplementary to the agricultural sector providing additional income to the farmers. Working capital is the lifeblood of any firm. Keeping in view of this fact, working capital analysis is made for seven units across the undivided Andhra Pradesh state for seven years from 2005–06 to 2011–12. Working capital is estimated for all the sample units using regression technique. The average working capital turnover ratio is more than '8' times in the case of Sangam, Heritage, Krishna, Tirumala, Nandi and Mulukanoor dairy units and confirms their excellent performance. In the case of Vijaya Dairy, the average working capital turnover ratio is less than '5', which indicates poor performance. To study the intensity of the linear relationship between the working capital ratios and profitability, coefficient of correlation has been computed.*

*P. Sarveswara Rao, Assistant Professor of Commerce, SR&BGNR Govt. Arts & Science College, Khammam, Telangana, India.*

*N. Madhava Rao, Assistant Professor of Commerce, SR&BGNR Govt. Arts & Science College, Khammam, Telangana, India.*

## 1. Introduction

In this paper, an attempt has been made to analyze the working capital performance in the select dairy units with the help of various ratios. It covers aspects such as dairy-wise analysis of net working capital and their comparison and also the impact of working capital performance on profitability.

## 2. Working Capital Ratios

The working capital performance is analyzed with the help of various ratios such as current ratio, quick ratio, inventory to current assets ratio, inventory turnover ratio and working capital turnover ratio. These ratios have been calculated for each of the dairy units.

### *2.1. Current Ratio*

Current ratio indicates the firm's ability to pay its current liabilities. Donald Miller describes the current ratio as one, which is generally recognized as the patriarch among ratios. He states that at one time it commanded such widespread respect that many businessmen regarded it as being endowed with the infallibility of the nature's law. It was a law of gravity applied to the balance sheet. By using the current ratio, a credit manager or lending officer can lay aside his 'Flipping coins', and arrive at decisions based on some figures of logic and accuracy (Rathnam, *Financial Management*, p. 553). This ratio can be calculated as follows.

$$\text{Current ratio} = \frac{\text{Current assets}}{\text{Current liabilities}}$$

### *2.2. Liquid Ratio*

It is the ratio between quick or liquid assets and quick liabilities. It is also called 'Acid Test Ratio', 'Quick Ratio' or 'Near money ratio'. The normal for such ratio is taken to be 1:1. As a tool for the assessment of liquidity position of firms, it is considered to be much better and reliable than the current ratio as it eliminates the snags, since it indicates the relationship between strictly liquid assets, whose realisable value is almost certain on the one hand, and strictly liquid liabilities on the other. Liquid assets comprise all the current assets minus stock, and liquid liabilities comprise all the current liabilities minus bank overdraft. Stock is excluded from current assets on the ground that it is not converted into cash in the immediate future and at the same time, the bank overdraft is excluded on the ground that it is not required to be paid off in the immediate future (Paul, 2012, p. 325). The formula to calculate liquid ratio is given below.

$$\text{Liquid Ratio} = \frac{\text{Liquid assets}}{\text{Liquid / Current liabilities}}$$

(or)

$$\frac{\text{Current assets - Stock}}{\text{Current liabilities - Bank overdraft}}$$

### *2.3. Inventory to Current Assets Ratio*

This ratio just attempts to study the composition of current assets. It expresses the relationship between inventory and current assets. It highlights as to how much amount per rupee of the current asset is represented by stock. The higher the value of this ratio, the poorer shall be the efficiency of current assets. Too much stock in total current assets is not a good sign (Gupta, 2002, p. 85). The formula may be as under:

$$\text{Inventory to current assets ratio} = \frac{\text{Inventories}}{\text{Current assets}}$$

### *2.4. Inventory Turnover Ratio*

This ratio indicates the number of times inventory is replaced during the year. It measures the relationship between the cost of goods sold and the inventory level. This ratio can be computed by dividing the cost of goods sold by the average inventory at cost (Khan and Jain, 1994, p. 111).

$$\text{Inventory turnover ratio} = \frac{\text{cost of goods sold}}{\text{Average inventory}}$$

### *2.5. Working Capital Turnover Ratio*

This ratio indicates the velocity of utilization of net working capital. This ratio indicates the number of times the working capital is turned over in the course of an year. This ratio measures the efficiency with which the working capital is being used by a firm. A higher ratio indicates efficient utilization of working capital and a lower ratio indicates otherwise (Sharma and Gupta, 1997, p. 431). This ratio can be calculated as:

$$\text{Working capital turn over ratio} = \frac{\text{Net Sales}}{\text{Net working capital}}$$

## 3. Analysis of Net Working Capital in Select Dairy Units

### *3.1. Sangam Dairy*

The working capital of Sangam Dairy has been analyzed by using five select ratios and the results are shown in Table 1.

It is evident from the Table 1 that the current assets of Sangam Dairy which stood at Rs 3039.24 lakh in 2005–06 increased to Rs 5300.15 lakh in 2011–12. There was a decreasing trend in current assets during 2007–08 and 2008–09 due to fluctuations in the current assets.

The current liabilities of Sangam Dairy which stood at Rs 751.49 lakh in 2005–06 increased to Rs 2115.81 lakh in 2011–12. The highest current liabilities are noticed in the year 2009–10 to the extent of Rs 2293.05 lakh.

The net working capital of Sangam Dairy shows a mixed trend during the study period. It was highest in the year 2011–12, i.e., Rs 3184.34 lakh and the least in the year 2009–10, i.e., Rs 1213.6 lakh.

The current ratio of Sangam Dairy varied between 4.04 and 1.53 during the study period, with an average of 2.83. The overall solvency position of the firm in terms of current ratio was above the standard norm of 2:1.

The quick ratio of Sangam Dairy varied between 1.09 and 0.40, with an average of 0.81. It is below the standard norm of 1:1 except in 2005–06. It shows that the liquidity position of the dairy in terms of quick ratio is not up to the mark.

The ratio of inventory to current assets shows a fluctuating trend during the period under study. It varied from 0.54 to 0.77, with an average of 0.70. It shows that more than 70 per cent of the current assets is in the form of inventory, except in the year 2008–09 when 54 per cent of the current assets was in the form of inventory.

**Table 1: Analysis of Working Capital of Sangam Dairy**

(Rs in lakhs)

| S. No. | Ratio | 2005–06 | 2006–07 | 2007–08 | 2008–09 | 2009–10 | 2010–11 | 2011–12 | Total | Average |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Current Assets | 3039.24 | 3141.45 | 2924.15 | 2930.55 | 2506.65 | 3745.57 | 5300.15 | 28008.28 | 3501.04 |
| 2. | Current Liabilities | 751.49 | 828.24 | 1005.35 | 1666.03 | 2293.05 | 1942.96 | 2115.81 | 11429.27 | 1428.66 |
| 3. | Net Working Capital | 2287.75 | 2313.21 | 1918.8 | 1264.53 | 1213.6 | 1802.61 | 3184.34 | 16579.02 | 2072.38 |
| 4. | Current Ratio | 4.04 | 3.79 | 2.91 | 1.76 | 1.53 | 1.93 | 2.51 | 22.61 | 2.83 |
| 5. | Quick Ratio | 1.09 | 0.86 | 0.81 | 0.81 | 0.40 | 0.55 | 0.65 | 6.48 | 0.81 |
| 6. | Inventory to Current Assets Ratio | 0.73 | 0.77 | 0.72 | 0.54 | 0.74 | 0.71 | 0.74 | 5.63 | 0.70 |
| 7. | Inventory Turnover Ratio | 5.27 | 5.91 | 7.01 | 10.43 | 10.37 | 9.63 | 9.42 | 58.04 | 8.29 |
| 8. | Working Capital Turnover Ratio | 5.90 | 5.92 | 8.12 | 15.00 | 17.52 | 13.93 | 9.66 | 76.05 | 10.86 |

*Source:* Compiled from the annual reports of Sangam Dairy.

The inventory turnover ratio of Sangam Dairy showed an increasing trend during the first four years under study and a decreasing trend during the last three years under study. It ranged between 5.27 and 10.43 with an average of 8.29.

The working capital ratio of Sangam Dairy showed an increasing trend during the first five years under study and a decreasing trend during the last two years under study. It ranged between 5.90 and 17.52, with an average of 10.86.

It is evident from the analysis of current ratio that the liquidity position of Sangam Dairy is satisfactory and from the point of view of Quick Ratio, the liquidity position of the dairy is not so satisfactory. Inventory to current assets ratio showed that more than 70 per cent of the current assets were in the form of inventory. The dairy has utilized the inventory and working capital in its business operations moderately.

### 3.1.1. *Trend values for the net working capital of Sangam Dairy*

The trend values for the net working capital of Sangam Dairy are calculated by the method of least squares and presented in Table 2 and graphically shown in Figure 1.

**Table 2: Computation of Net Working Capital of Sangam Dairy by the Method of Least Squares**

| Obs | X | Y | X | XY | $X^2$ | Trend |
|---|---|---|---|---|---|---|
| 1 | 1 | 2287.75 | -3 | -6863.25 | 9 | 1894.62 |
| 2 | 2 | 2313.21 | -2 | -4626.42 | 4 | 1929.02 |
| 3 | 3 | 1918.8 | -1 | -1918.8 | 1 | 1963.43 |
| 4 | 4 | 1264.53 | 0 | 0 | 0 | 1997.84 |
| 5 | 5 | 1213.6 | 1 | 1213.6 | 1 | 2032.24 |
| 6 | 6 | 1802.61 | 2 | 3605.22 | 4 | 2066.65 |
| 7 | 7 | 3184.34 | 3 | 9553.02 | 9 | 2101.05 |
| **Total** | | **13,984.84** | | 963.37 | 28 | **13984.84** |

**Source:** Table 1.

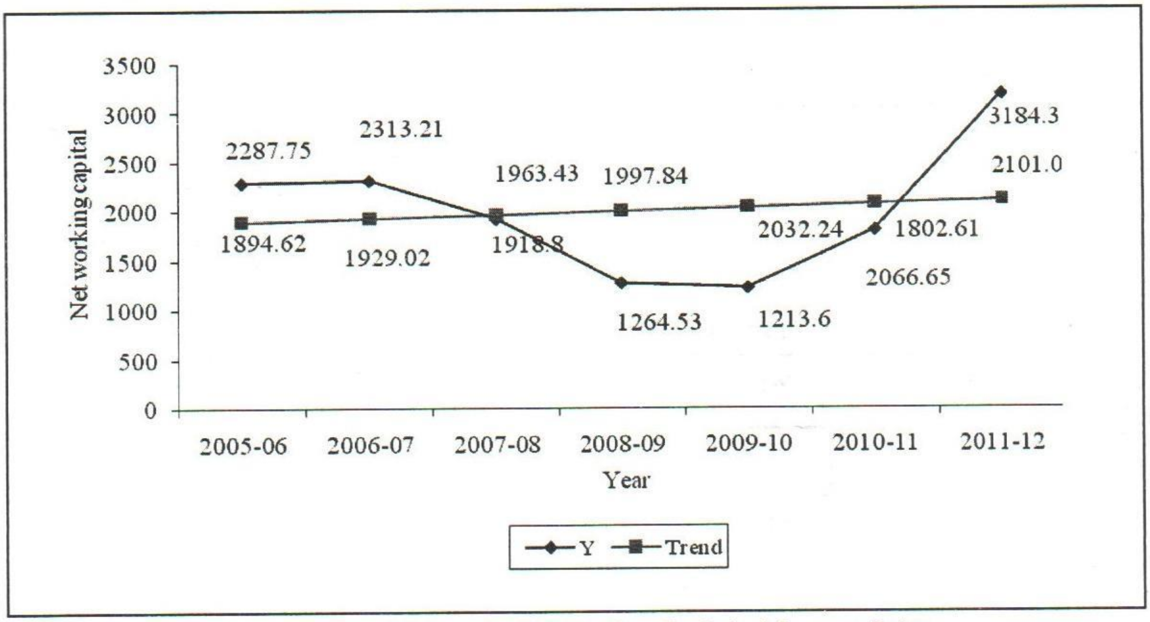


**Figure 1. Trend Values for Net Working Capital of Sangam Dairy**

The formula used to predict the working capital is given by the linear regression.

$y_t = a + bx$

Where $y_t$ = Working capital for the year 't'

$X$ = Time period and a, b are constants.

The method of least squares gives the following equations to get the value of 'a' and 'b'.

$$\Sigma y = na + b\Sigma xy$$

$$\Sigma xy = \Sigma x + b\Sigma x^2$$

when $\Sigma x = 0$

$$a = \frac{\Sigma y}{n} \text{ and } b = \frac{\Sigma xy}{\Sigma x^2}$$

For the Sangam Dairy, the estimates are

$a$ = 1997.83

$b$ = 34.41

The model is $y_t$ = 1997.83+34.41(x)

For the year 2017, we have $x = 8$. Substituting this value weight

$y_t$ = 1997.83+34.41(8)

= 2273.11 Lakh

**Result:** The Sangam Dairy's predicted net working capital for the year 2017 would be Rs 2273.08 lakh.

### *3.2. Heritage Foods (India) Limited*

The working capital of Heritage Foods (India) Limited has been analyzed by using select ratios. The details are presented in Table 3.

It is evident from Table 3 that the current assets of Heritage Foods (India) Ltd, which stood at Rs 7010 lakh in 2005–06 increased to Rs 16878 lakh in 2011–12. There is a continuous rising trend in the current assets, except in the year 2008–09.

The current liabilities of Heritage Foods (India) Ltd stood at Rs 3505 lakh in 2005–06 and increased to Rs 17559 lakh in 2011–12. There is a continuous rising trend in the current liabilities of Heritage Foods (India) Ltd. In the year 2011–12, the current liabilities were more than the current assets by Rs 681 lakh; this might be due to non-payment of the outstanding bills at the end of the year.

The net working capital of Heritage Foods (India) Ltd for the first three years of study increased, and for the remaining four years there was a decreasing trend and in the year 2011–12 it became negative.

The current ratio of Heritage Foods (India) Ltd ranged between 0.96 and 2.26 with an average of 1.63, which is below the normally accepted level of 2:1.

**Table 3: Analysis of Working Capital of Heritage Foods (India) Limited**

(Rs in lakhs)

| S. No. | Ratio | 2005–06 | 2006–07 | 2007–08 | 2008–09 | 2009–10 | 2010–11 | 2011–12 | Total | Average |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Current Assets | 7010 | 10265 | 13940 | 12630 | 14906 | 14436 | 16878 | 90065 | 12866.43 |
| 2. | Current Liabilities | 3505 | 4550 | 7635 | 8067 | 10261 | 10648 | 17559 | 62225 | 8889.29 |
| 3. | Net Working Capital | 3505 | 5715 | 6305 | 4563 | 4645 | 3788 | -681 | 27840 | 3977.14 |
| 4. | Current Ratio | 2.00 | 2.26 | 1.83 | 1.57 | 1.45 | 1.36 | 0.96 | 11.43 | 1.63 |
| 5. | Quick Ratio | 1.26 | 1.26 | 1.23 | 0.95 | 0.74 | 0.74 | 0.57 | 6.75 | 0.96 |
| 6. | Inventory to Current Assets Ratio | 0.37 | 0.44 | 0.33 | 0.39 | 0.49 | 0.46 | 0.41 | 2.89 | 0.41 |
| 7. | Inventory Turnover Ratio | 10.90 | 9.70 | 13.47 | 16.58 | 13.95 | 15.07 | 20.20 | 99.87 | 14.27 |
| 8. | Working Capital Turnover Ratio | 8.33 | 6.06 | 9.33 | 17.37 | 19.38 | 28.94 | -204.61 | -115.2 | -16.46 |

*Source:* Compiled from the annual reports of Heritage Foods (India) Ltd.

The quick ratio of Heritage Foods (India) Ltd ranged between 0.57 and 1.26 with an average of 0.96 which is below the standard norm of 1:1, except in the years 2005–06, 2006–07 and 2007–08. It shows that the liquidity position is not normal from the point of view of quick ratio.

The ratio of inventory of current assets is almost consistent ranging between 0.33 and 0.49 with an average of 0.41, which implies that almost 41 per cent of the current assets consist of inventories.

The inventory turnover ratio of Heritage Foods (India) Ltd showed a mixed trend and varied between 9.70 and 20.20 with an average of 14.27.

The working capital turnover ratio of Heritage Foods (India) Ltd has a wide variation ranging between 6.06 and 204.61 with an average of -16.46.

It is evident from the analysis of current and quick ratio that the liquidity position of the company is not satisfactory. Inventory to current assets ratio showed that 41 per cent of the current assets comprised inventory. The company has utilized the inventory and working capital in its business operations moderately.

### *3.2.1. Trend values for the net working capital of Heritage Foods (India) Limited*

The trend values for the net working capital of Heritage Foods (India) Ltd are calculated by the method of least squares and presented in Table 4 and graphically shown in Figure 2.

**Table 4: Computation of Net Working Capital of Heritage Foods (India) Limited by the Method of Least Squares**

| Obs | X | Y | X | XY | XY | Trend |
|---|---|---|---|---|---|---|
| 1 | 1 | 3505 | -3 | 9 | -10515 | 5913.44 |
| 2 | 2 | 5715 | -2 | 4 | -11430 | 5268.00 |
| 3 | 3 | 6305 | -1 | 1 | -6305 | 4622.58 |
| 4 | 4 | 4563 | 0 | 0 | 0 | 3977.15 |
| 5 | 5 | 4645 | 1 | 1 | 4645 | 3331.72 |
| 6 | 6 | 3788 | 2 | 4 | 7576 | 2686.15 |
| 7 | 7 | -681 | 3 | 9 | -2043 | 2040.86 |
| **Total** | | **27840** | | **28** | **-18072** | **27840** |

*Source:* Table 5.

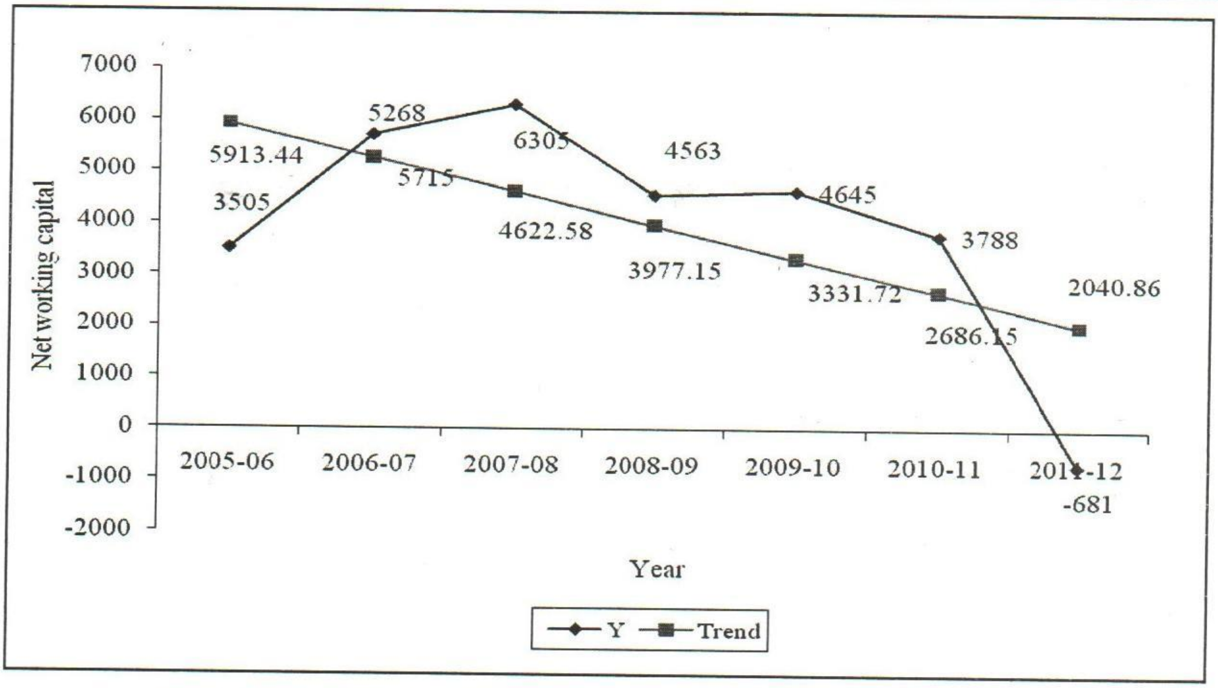


**Figure 2. Trend Values of Net Working Capital of Heritage Foods (India) Limited**

The formula used to predict the working capital is given by the linear regression.

$$y_t = a + bx$$

Where $y_t =$ working capital for the year 't'

$X$ = Time period and a, b are constants.

The method of least squares gives the following equations to get the value of 'a' and 'b'.

$$\Sigma Y = na + b\Sigma X$$

$$\Sigma XY = a\Sigma X + b\Sigma X^2$$

When $\Sigma x = 0$

$$a = \frac{\Sigma Y}{n} \text{ and } b = \frac{\Sigma XY}{\Sigma X^2}$$

For the company, the estimates are a = 3977.14
b = -645.43

The model is $Y_t$ = 3977.14 –645.43(X)

For the year 2017, we have X = 8, substituting this value weight

$Y_t$ = 3977.14 –645.43(8)

= -1186.3 lakh

**Result:** The Heritage Foods (India) Limited's predicted net working capital for the year 2017 would be Rs 1186.3 lakh.

### *3.3. Krishna Milk Union*

The working capital of Krishna Milk Union has been analyzed by using select ratios. Results of the analysis are presented in Table 5.

It is evident from Table 5 that the current assets of Krishna Milk Union which stood at Rs 2741.92 lakh in 2005–06 increased to Rs 5031.03 lakh in 2011–12. In the first three years, there was a rising trend in the current assets of Krishna Milk Union. The current assets were very low in the year 2008–09, due to decrease in stock.

The current liabilities of Krishna Milk Union had a mixed trend. The current liabilities of the milk union which stood at Rs 1583.86 lakh in 2005–06 increased to Rs 2827.96 lakh in 2011–12. The highest amount of liabilities amounting to Rs 3029.51 lakh was recorded in the year 2009–10.

The net working capital of Krishna Milk Union had a fluctuating trend during the period of study. Lowest net working capital was recorded in the year 2009–10 with Rs 193 lakh and it was maximum in the year 2011–12 with Rs 2203.07 lakh.

Table 5: Analysis of Working Capital of Krishna Milk Union

(Rs in lakhs)

| S. No. | Ratio | 2005–06 | 2006–07 | 2007–08 | 2008–09 | 2009–10 | 2010–11 | 2011–12 | Total | Average |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Current Assets | 2741.92 | 2856.27 | 3773.97 | 2668.41 | 3222.51 | 3346.18 | 5031.03 | 23640.29 | 3377.18 |
| 2. | Current Liabilities | 1583.86 | 1518.90 | 1696.39 | 2439.22 | 3029.51 | 2523.22 | 2827.96 | 15619.06 | 2231.29 |
| 3. | Net Working Capital | 1158.06 | 1337.37 | 2077.58 | 229.19 | 193 | 822.96 | 2203.07 | 8021.23 | 1145.89 |
| 4. | Current Ratio | 1.73 | 1.88 | 2.22 | 1.09 | 1.06 | 1.33 | 1.78 | 11.09 | 1.58 |
| 5. | Quick Ratio | 0.82 | 1.03 | 1.32 | 0.54 | 0.48 | 0.62 | 0.95 | 5.76 | 0.82 |
| 6. | Inventory to Current Assets Ratio | 0.53 | 0.45 | 0.41 | 0.51 | 0.55 | 0.53 | 0.46 | 3.44 | 0.49 |
| 7. | Inventory Turnover Ratio | 18.95 | 28.91 | 17.44 | 14.57 | 15.30 | 16.18 | 17.82 | 129.17 | 18.45 |
| 8. | Working Capital Turnover Ratio | 12.32 | 12.20 | 8.20 | 41.10 | 34.43 | 35.10 | 16.53 | 159.88 | 22.84 |

*Source:* Compiled from the annual reports of Krishna Milk Union.

The current ratio of Krishna Milk Union ranged between 1.06 and 2.22 with an average of 1.58, which was below the standard norm of 2:1. The solvency position of the milk union in terms of current ratio was below the standard norm of 2:1, except in the year 2007–08.

The quick ratio of Krishna Milk Union varied from 0.54 to 1.32 with an average of 0.82, which is below the standard norm of 1:1. It confirms that the liquidity position of the milk union in terms of quick ratio was not normal except in the years 2006–07 and 2007–08.

The ratio of inventory to current assets is almost consistent between 0.41 and 0.53 with an average of 0.49. This implies that on an average, 49 per cent of the current assets comprise inventory.

The inventory turnover ratio showed a mixed trend during the study period ranging from 14.57 to 28.91 with an average of 18.45. The working capital turnover of Krishna Milk Union showed wide fluctuations during the study period, ranging from 8.20 in 2007–08 to 41.10 in 2008–09 with an average of 22.84.

It is evident from the analysis of current and quick ratio that the liquidity position of the union is not satisfactory. The ratio of inventory to current assets showed that 49 per cent of the current assets is of inventory. The Krishna Milk Union has utilized the inventory moderately and it used the working capital in a better way in its business operations.

### *3.3.1. Trend values for the net working capital of Krishna Milk Union*

The trend values for the net working capital of Krishna Milk union are calculated by the method of least squares and are presented in Table 6 and graphically shown in the Figure 3.

The formula used to predict the working capital is given by the linear regression.

$$y_t = a + bx$$

Where $y_t =$ working capital for the year 't'

$X$ = Time period and a, b are constants.

The method of least squares gives the following equations to get the value of 'a' and 'b'.

$$\Sigma Y = na + b\Sigma X$$

$$\Sigma XY = a\Sigma X + b\Sigma X^2$$

When $\Sigma x = 0$

$$a = \frac{\Sigma Y}{n} \text{ and } b = \frac{\Sigma XY}{\Sigma X^2}$$

For the Krishna Milk Union, the estimates are a = 1145.89
b = -7.915

The model is $Y_t$ = 1145.89 + 7.915(X)

For the year 2017, we have x=8, sustituting this value weight

$Y_t$ = 1145.89 –7.915(8)
= -1209.21 lakh

**Table 6: Computation of Net Working Capital of Krishna Milk Union by the Method of Least Squares**

| Obs | X | Y | $X^2$ | XY | XY | Trend |
|---|---|---|---|---|---|---|
| 1 | 1 | 1158.06 | -3 | 9 | -3474.18 | 1122.15 |
| 2 | 2 | 1137.37 | -2 | 4 | -2674.74 | 1130.06 |
| 3 | 3 | 2077.58 | -1 | 1 | -2077.58 | 1137.98 |
| 4 | 4 | 229.19 | 0 | 0 | 0 | 1145.89 |
| 5 | 5 | 193 | 1 | 1 | 193.00 | 1153.81 |
| 6 | 6 | 822.96 | 2 | 4 | 1645.92 | 1161.72 |
| 7 | 7 | 2203.07 | 3 | 9 | 6609.21 | 1169.62 |
| **Total** | | **8021.23** | | **28** | **221.63** | **8021.23** |

*Source:* Table 5.

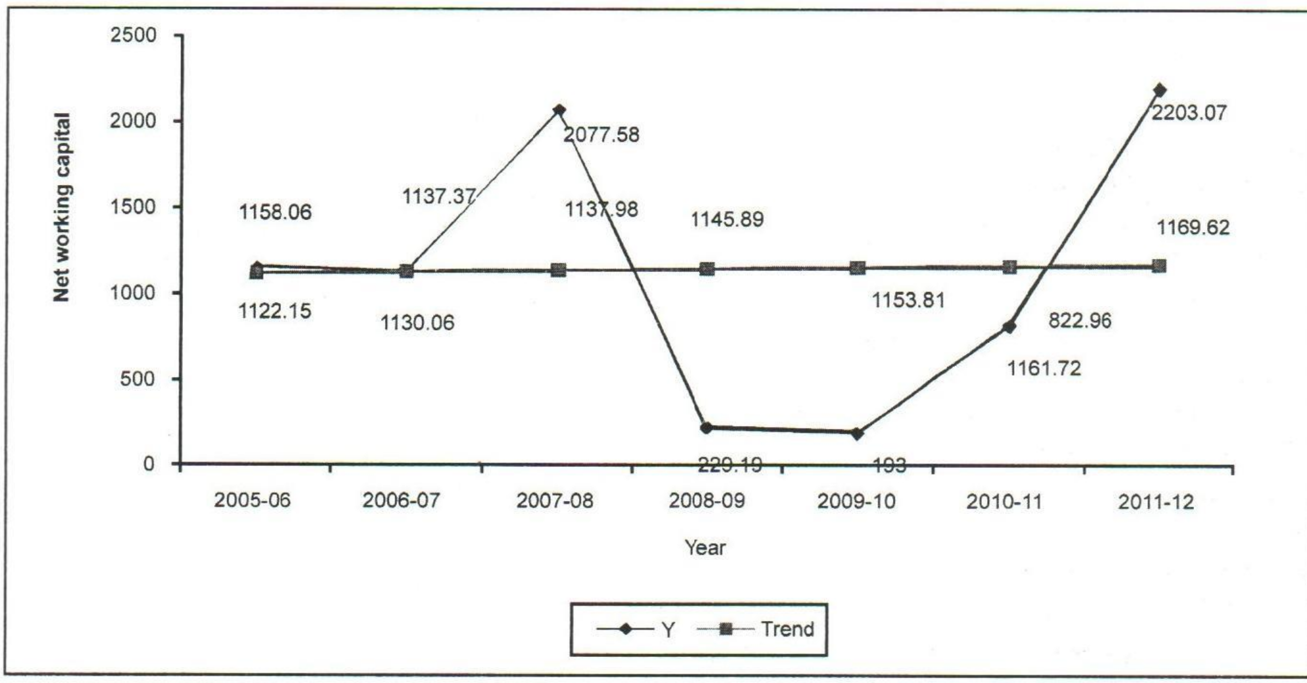


**Figure 3. Trend Values for Net Working Capital of Krishna Milk Union**

**Result:** The predicted net working capital of Krishna Milk Union for the year 2017 would be Rs 1209.21 lakh.

### *3.4. Tirumala Milk Products Private Limited*

The working capital of Tirumala Milk Products Private Limited has been analyzed by using select ratios. Results of the analysis are presented in Table 7. It is very clear from Table 7 that the current assets of Tirumala Milk Products Private Limited which stood at Rs 3377.96 lakh in 2005–06, increased to Rs 19,205.39 lakh in 2011–12. There had been an increasing trend in the current assets of the company. There was a sudden jump in the current assets from Rs 5,973.16 lakh in 2008–09 to Rs 12,224.89 lakh in 2009–10.

The current liabilities of the company which stood at Rs 686.49 lakh in 2005–06, increased to Rs 13,975.54 lakh in 2011–12. The current liabilities of the company showed an increasing trend during the study period. There was a sudden increase in the current liabilities from Rs 3,903.30 lakh in 2010–11 to Rs 13,975.54 lakh in 2011–12.

**Table 7: Analysis of Working Capital of Tirumala Milk Products Private Limited**

(Rs in lakhs)

| S. No. | Ratio | 2005–06 | 2006–07 | 2007–08 | 2008–09 | 2009–10 | 2010–11 | 2011–12 | Total | Average |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Current Assets | 3377.96 | 4819.52 | 4992.32 | 5973.16 | 12224.89 | 15078.82 | 19205.39 | 65672.06 | 9381.72 |
| 2. | Current Liabilities | 686.49 | 1737.35 | 2054.62 | 2194.43 | 2942.04 | 3903.30 | 13975.54 | 27493.77 | 3927.68 |
| 3. | Net Working Capital | 2691.47 | 3082.17 | 2937.70 | 3778.73 | 9282.82 | 11175.52 | 5229.85 | 27718.59 | 3959.80 |
| 4. | Current Ratio | 4.92 | 2.77 | 2.43 | 2.72 | 4.16 | 3.86 | 1.37 | 22.23 | 3.18 |
| 5. | Quick Ratio | 3.45 | 1.28 | 1.11 | 1.31 | 2.01 | 2.02 | 0.65 | 11.83 | 1.69 |
| 6. | Inventory to Current Assets Ratio | 0.30 | 0.54 | 0.54 | 0.52 | 0.52 | 0.48 | 0.53 | 3.43 | 0.49 |
| 7. | Inventory Turnover Ratio | 20.51 | 15.51 | 13.62 | 15.42 | 12.28 | 11.78 | 12.90 | 102.02 | 14.57 |
| 8. | Working Capital Turnover Ratio | 13.81 | 9.26 | 12.72 | 12.46 | 6.31 | 7.47 | 22.47 | 84.50 | 12.07 |

*Source:* Compiled from the annual reports of Tirumala Milk Products Private Limited.

The net working capital of Tirumala Milk Products Private Limited showed a mixed trend during the study period. Net working capital stood at Rs 2691.47 lakh in 2005–06 and increased to a maximum of Rs 11,175.52 lakh in 2010–11.

The current ratio of Tirumala Milk Products Private Limited varied between 1.37 and 4.92 during the study period with an average of 3.18. The solvency position of the company in terms of current ratio is much satisfactory, which is above the standard norm of 2:1, except in the year 2011–12.

The quick ratio of Tirumala Milk Products Private Limited varied from 0.65 to 3.45 with an average of 1.69, during the study period. The liquidity position of the company is much satisfactory from the point of view of quick ratio as it is above the standard norm of 1:1, except in the year 2011–12.

The ratio of inventory to current assets was ranging between 0.30 and 0.54 with an average of 0.49, which implies that 49 per cent of the current assets were in the form of inventory.

The inventory turnover ratio of Tirumala Milk Products Private Limited showed a mixed trend ranging from 11.78 to 20.51, with an average of 14.57. The working capital turnover ratio of the company had a fluctuating trend varying from 6.31 to 22.47, with an average of 12.07. There were wide fluctuations in the net working capital of the company.

It is evident from the analysis of current and quick ratio that the liquidity position of the company is satisfactory. The ratio of inventory to current assets made it clear that 49 per cent of the current assets is of inventory. The Tirumala Milk Products Private Limited has used its inventory and working capital in its business operations moderately.

### *3.4.1. Trend values for the net working capital of Tirumala Milk Products Private Limited*

The trend values for the net working capital of Tirumala Milk Products Private Limited is calculated by the method of least squares and presented in Table 8 and graphically shown in Figure 4.

The formula used to predict the working capital is given by the linear regression.

$$y_t = a + bx$$

Where $y_t$ = working capital for the year 't'

$X$ = Time period and a, b are constants.

The method of least squares gives the following equations to get the value of 'a' and 'b'.

$$\Sigma Y = na + b\Sigma X$$

$$\Sigma XY = a\Sigma X + b\Sigma X^2$$

Table 8: Computation of Net Working Capital of Tirumala Milk Products Private Limited by the Method of Least Squares

| Obs | X | Y | X² | XY | XY | Trend |
|---|---|---|---|---|---|---|
| 1 | 1 | 2691.47 | -3 | 9 | -8074.41 | 2224.01 |
| 2 | 2 | 3082.17 | -2 | 4 | -6164.34 | 3300.68 |
| 3 | 3 | 2937.70 | -1 | 1 | -2937.70 | 4377.36 |
| 4 | 4 | 3778.73 | 0 | 0 | 0 | 5454.04 |
| 5 | 5 | 9282.85 | 1 | 1 | 9282.85 | 6530.72 |
| 6 | 6 | 11175.52 | 2 | 4 | 22351.04 | 7607.40 |
| 7 | 7 | 5229.85 | 3 | 9 | 15689.55 | 8684.08 |
| Total | | 38178.29 | | 28 | 30146.99 | 38178.29 |

*Source:* Table 7.

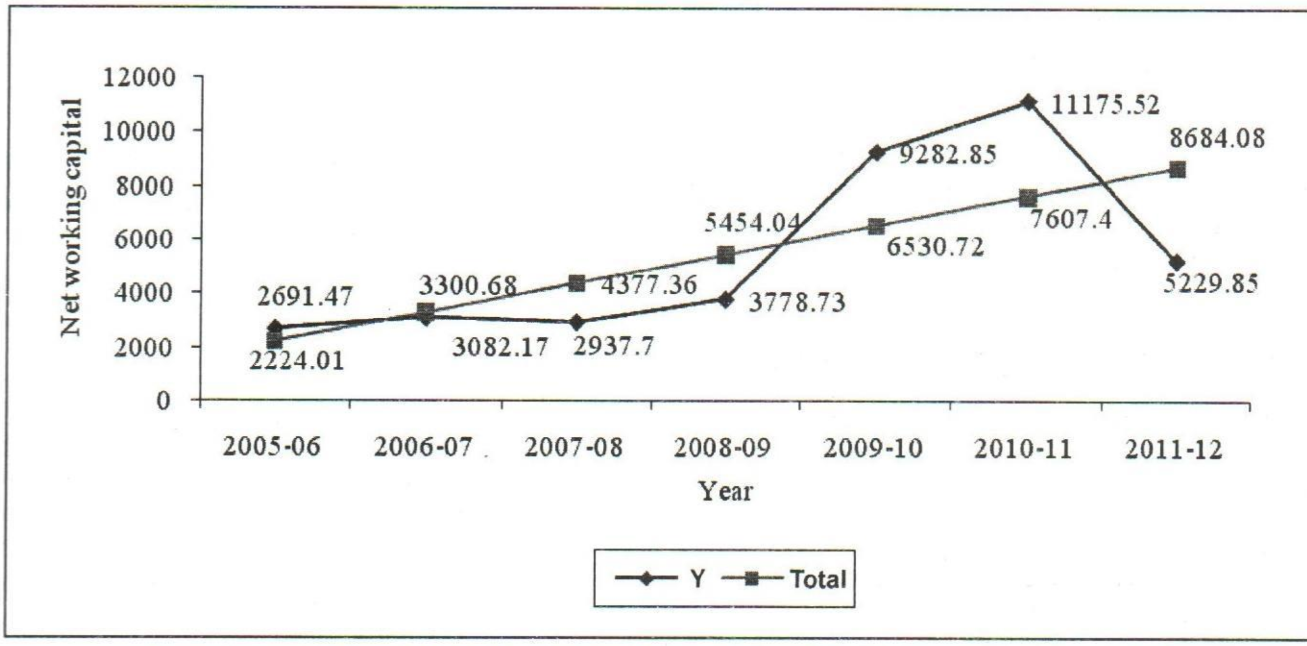


**Figure 4. Trend Values for the Net Working Capital of Tirumala Milk Products Private Limited.**

When $\Sigma X = 0$

$$a = \frac{\Sigma Y}{n} \text{ and } b = \frac{\Sigma XY}{\Sigma X^2}$$

For the Tirumala Milk Products Private Limited, the estimates are $a =$ 5454.04

$b =$ 1076.678

The model is $y_t$ = 5454.04 + 1076.678(X)

For the year 2017, we have X= 8, substituting this value weight

$Y_t$ = 5454.04 + 1076.678(8)

= 14067.47 lakh

**Result:** The predicted net working capital of Triumala Milk Products Private Limited, for the year 2017 would be Rs 14067.47 lakh.

### *3.5. Vijaya Dairy*

The working capital of Vijaya Dairy has been analyzed by using select ratios. Results of the analysis are presented in Table 9.

Table 9: Analysis of Working Capital of Vijaya Dairy

(Rs in lakhs)

| S. No. | Ratio | 2005–06 | 2006–07 | 2007–08 | 2008–09 | 2009–10 | 2010–11 | 2011–12 | Total | Average |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Current Assets | 6977.80 | 7726.96 | 13494.35 | 15715.80 | 12240.73 | 15615.87 | 18015.27 | 89786.78 | 12826.68 |
| 2. | Current Liabilities | 4043.70 | 3345.34 | 4062.43 | 4669.41 | 5658.29 | 6484.96 | 5327.61 | 33591.74 | 4798.82 |
| 3. | Net Working Capital | 2943.1 | 4381.62 | 9431.92 | 11046.39 | 6582.44 | 9130.91 | 12687.66 | 56195.04 | 8027.86 |
| 4. | Current Ratio | 1.73 | 2.31 | 3.32 | 3.37 | 2.16 | 2.41 | 3.38 | 18.68 | 2.67 |
| 5. | Quick Ratio | 1.43 | 2.01 | 2.93 | 2.91 | 1.74 | 1.94 | 2.52 | 15.48 | 2.21 |
| 6. | Inventory to Current Assets Ratio | 0.17 | 0.13 | 0.12 | 0.13 | 0.20 | 0.19 | 0.25 | 1.19 | 0.17 |
| 7. | Inventory Turnover Ratio | 14.57 | 23.02 | 27.74 | 31.77 | 20.48 | 17.05 | 17.61 | 152.24 | 21.75 |
| 8. | Working Capital Turnover Ratio | 7.08 | 5.30 | 3.01 | 3.41 | 5.49 | 4.45 | 3.89 | 32.63 | 4.66 |

*Source:* Compiled from the annual reports of Vijaya Dairy.

It is evident from Table 9 that the current assets of Vijaya Dairy stood at Rs 6977.80 lakh in 2005–06, and it increased to Rs 18015.27 lakh in 2011–12. There was an increasing trend in the current assets of Vijaya Dairy except in the year 2009–10.

The current liabilities of Vijaya Dairy which stood at Rs 4043.70 lakh in 2005–06, increased to Rs 5327.61 lakh in 2011–12. There was a fluctuating trend in the current liabilities of the dairy.

The net working capital of Vijaya Dairy showed an increasing trend except in the year 2009–10. The net working capital of the dairy, which stood at Rs 2934.1 lakh in 2005–06 increased to Rs 12687.66 lakh in 2011–12.

The current ratio of Vijaya Dairy varied between 1.73 and 3.38 with an average of 2.67, which is above the standard norm of 2.1. The solvency position of Vijaya Dairy, in terms of current ratio, was very much satisfactory except in the year 2005–06, which was 1.73 in that year.

The quick ratio of Vijaya Dairy ranged from 1.43 to 2.93 with an average of 2.21 which is far above the required standard norm of 1:1. The liquidity position of the dairy is good in terms of quick ratio.

Inventory to current assets ratio of Vijaya Dairy ranged between 0.12 and 0.25 with an average of 0.17 which implies that the inventory component in the current assets was only to the extent of 17 per cent.

The inventory turnover ratio of Vijaya Dairy ranged between 14.57 and 31.77 with an average of 21.75. It showed a mixed trend during the study period.

The working capital turnover ratio of Vijaya Dairy had a fluctuating trend during the study period ranging between 3.01 and 7.08 with an average of 4.66.

It is evident from the analysis of current ratio and quick ratio that the liquidity position of the dairy is good. The ratio of inventory to current assets made it clear that only 17 per cent of the current assets are composed of inventory. The Vijaya Dairy has used the inventory in a better way and the working capital moderately in its business operations.

#### *3.5.1. Trend values for the net working capital of Vijaya Dairy*

The trend values for the net working capital of Vijaya Dairy are calculated by the method of least squares and presented in Table 10 and graphically shown in Figure 5.

The formula used to (predict) estimate the net working capital is given by linear regression.

$$Y_t = a + bx$$

Where $Y_t$ = working capital for the year 't'

$X$ = Time period and a, b are constants.

**Table 10: Computation of Net Working Capital of Vijaya Dairy by the Method of Least Squares**

| Obs | X | Y | X² | XY | XY | Trend |
|---|---|---|---|---|---|---|
| 1 | 1 | 2934.10 | -3 | 9 | -8802.3 | 4180.39 |
| 2 | 2 | 4381.62 | -2 | 4 | -8763.24 | 5462.88 |
| 3 | 3 | 9434.92 | -1 | 1 | -9431.92 | 6745.37 |
| 4 | 4 | 11046.39 | 0 | 0 | 0 | 8027.86 |
| 5 | 5 | 6582.44 | 1 | 1 | 6582.44 | 9310.35 |
| 6 | 6 | 9130.91 | 2 | 4 | 18261.82 | 10592.85 |
| 7 | 7 | 12687.66 | 3 | 9 | 38062.98 | 11875.34 |
| **Total** | | **56195.04** | | 28 | 35909.78 | **56195.04** |

*Source:* Table 9.

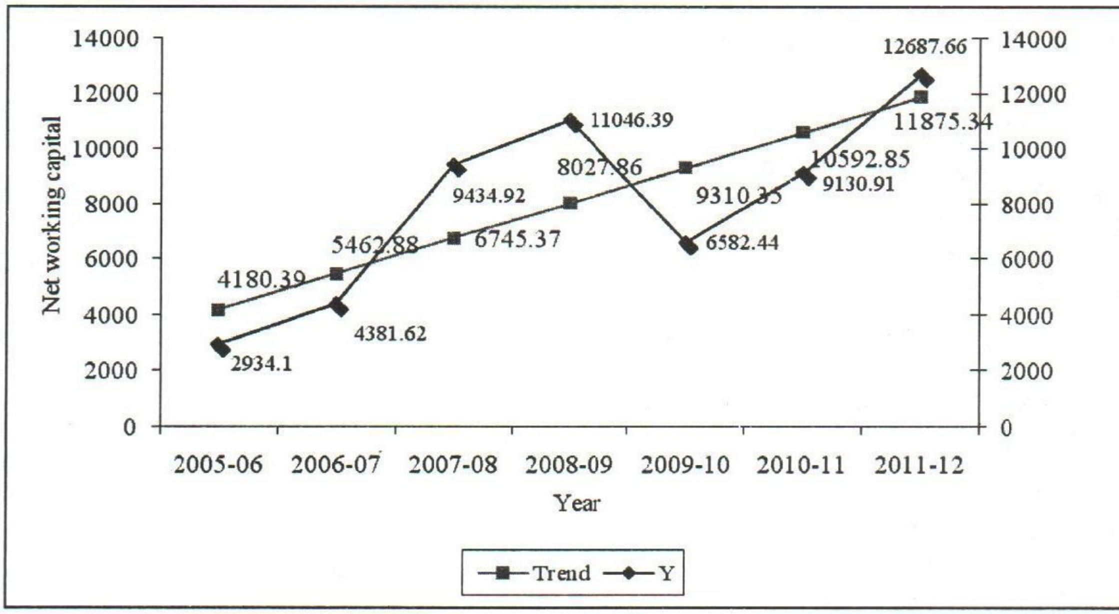


**Figure 5. Trend Values for the Net Working Capital of Vijaya Dairy**

The method of least squares gives the following equations to get the value of 'a' and 'b'.

$$\Sigma Y = na + b\Sigma X$$
$$\Sigma XY = a\Sigma X + b\Sigma X^2$$

When $\Sigma X = 0$

$$a = \frac{\Sigma Y}{n} \text{ and } b = \frac{\Sigma XY}{\Sigma X^2}$$

For Vijaya Dairy, the estimates are a = 8027.86

b = 1282.49

The model is $y_t$ = 8027.86 + 1282.49 (X)

For the year 2017, we have X = 8, substituting this value weight

$Y_t$ = 8027.86 + 1282.49 (8) = Rs 18287.80 lakh

**Result:** The estimated net working capital of Vijaya Dairy for the year 2017 would be Rs 18287.80 lakh.

### *3.6. Nandi Milk Products Private Limited*

The working capital of Nandi Milk Products Private Limited has been analyzed by using select ratios. Results of the

Table 11: Analysis of Working Capital of Nandi Milk Products Private Limited

(Rs in lakhs)

| S. No. | Ratio | 2005–06 | 2006–07 | 2007–08 | 2008–09 | 2009–10 | 2010–11 | 2011–12 | Total | Average |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Current Assets | 134.08 | 99.52 | 115.41 | 106.55 | 123.77 | 195.88 | 358.81 | 977.98 | 139.71 |
| 2. | Current Liabilities | 80.84 | 49.85 | 43.53 | 68.69 | 186.87 | 193.42 | 280.79 | 903.99 | 129.14 |
| 3. | Net Working Capital | 53.24 | 49.67 | 71.88 | 37.86 | -63.1 | 2.46 | 78.02 | 73.99 | 10.57 |
| 4. | Current Ratio | 1.66 | 2.00 | 2.65 | 1.55 | 0.66 | 1.01 | 1.27 | 10.25 | 1.46 |
| 5. | Quick Ratio | 1.54 | 1.78 | 2.20 | 1.10 | 0.40 | 0.72 | 0.44 | 8.18 | 1.17 |
| 6. | Inventory to Current Assets Ratio | 0.07 | 0.11 | 0.17 | 0.29 | 0.40 | 0.29 | 0.39 | 1.72 | 0.25 |
| 7. | Inventory Turnover Ratio | 122.22 | 62.48 | 42.07 | 40.53 | 62.02 | 66.68 | 40.49 | 436.49 | 62.36 |
| 8. | Working Capital Turnover Ratio | 15.76 | 12.75 | 9.25 | 27.42 | 20.02 | 71.85 | 42.88 | 114.17 | 16.31 |

*Source:* Complied from the annual reports of Nandi Dairy.

analysis are presented in Table 11. Table 11 shows that the current assets of Nandi Milk Products Private Limited stood at Rs 134.08 lakh in 2005–06 and increased to Rs 358.81 lakh in 2011–12. The current assets of the Nandi Dairy reflect a fluctuating trend.

The current liabilities of Nandi Milk Products Private Limited stood at Rs 80.84 lakh in 2005–06 and it increased to Rs 280.79 lakh in 2011–12. There was a fluctuating trend in the current liabilities of the company. In the year 2009–10, the current liabilities were more than the current assets of the dairy.

The net working capital of Nandi Milk Products Private Limited had a wide range of fluctuations throughout the study period. Particularly in the years 2009–10, the net working capital of the dairy was negative. The net working capital in the year 2005–06 was Rs 53.24 lakh, whereas the net working capital in the year 2011–12 was Rs 78.02 lakh.

The current ratio of Nandi Milk Products Private Limited ranged between 0.66 and 2.65 with an average of 1.46 which was below the standard norm of 2:1. The solvency position of the Nandi dairy, in terms of current ratio, was not satisfactory and it was alarming, especially in the years 2009–10 when it was not even 1:1.

The quick ratio of Nandi Milk Products Private Limited varied between 0.40 and 2.20 with an average of 1.17, which was above the standard norm of 1:1. The overall solvency in terms of quick ratio was satisfactory, but it was very low in the years 2009–10 to 2011–12.

The ratio of inventory to current assets of Nandi Milk Products Private Limited varied from 0.07 to 0.40 with an average of 0.25. It implies that only 25 per cent of the current assets were in the form of inventory. There was a wide fluctuation in the inventory to current assets ratio of Nandi Dairy.

The inventory turnover ratio of Nandi Milk Products Private Limited ranged from 40.49 to 122.22 with an average of 62.36.

The working capital turnover of the dairy varied from 9.25 to 71.85, with an average of 28.56. It shows that there was a wide fluctuation in the working capital turnover ratio.

It is evident from the analysis of current ratio and quick ratio that the liquidity position is not satisfactory. The ratio of inventory to current assets made it clear that 25 per cent of the current assets comprised inventory. Nandi Dairy has used the inventory and working capital in a better way in its business operations.

### *3.6.1. Trend values for the net working capital of Nandi Milk Products Private Limited*

The trend values for the net working capital of Nandi Dairy is calculated by the method of least squares and are presented in Table 12 and graphically shown in Figure 6.

**Table 12: Computation of Net Working Capital of Nandi Milk Products Private Limited by the Method of Least Squares**

| Obs | X | Y | $X^2$ | XY | XY | Trend |
|---|---|---|---|---|---|---|
| 1 | 1 | 53.24 | -3 | 9 | -159.72 | 49.37 |
| 2 | 2 | 49.67 | -2 | 4 | -99.34 | 43.87 |
| 3 | 3 | 71.88 | -1 | 1 | -71.88 | 38.36 |
| 4 | 4 | 37.86 | 0 | 0 | 0 | 32.86 |
| 5 | 5 | -63.10 | 1 | 1 | -63.10 | 27.36 |
| 6 | 6 | 2.46 | 2 | 4 | 5.92 | 21.86 |
| 7 | 7 | 78.02 | 3 | 9 | 234.06 | 16.35 |
| Total | | 230.03 | | 28 | | 230.03 |

*Source:* Table 11.

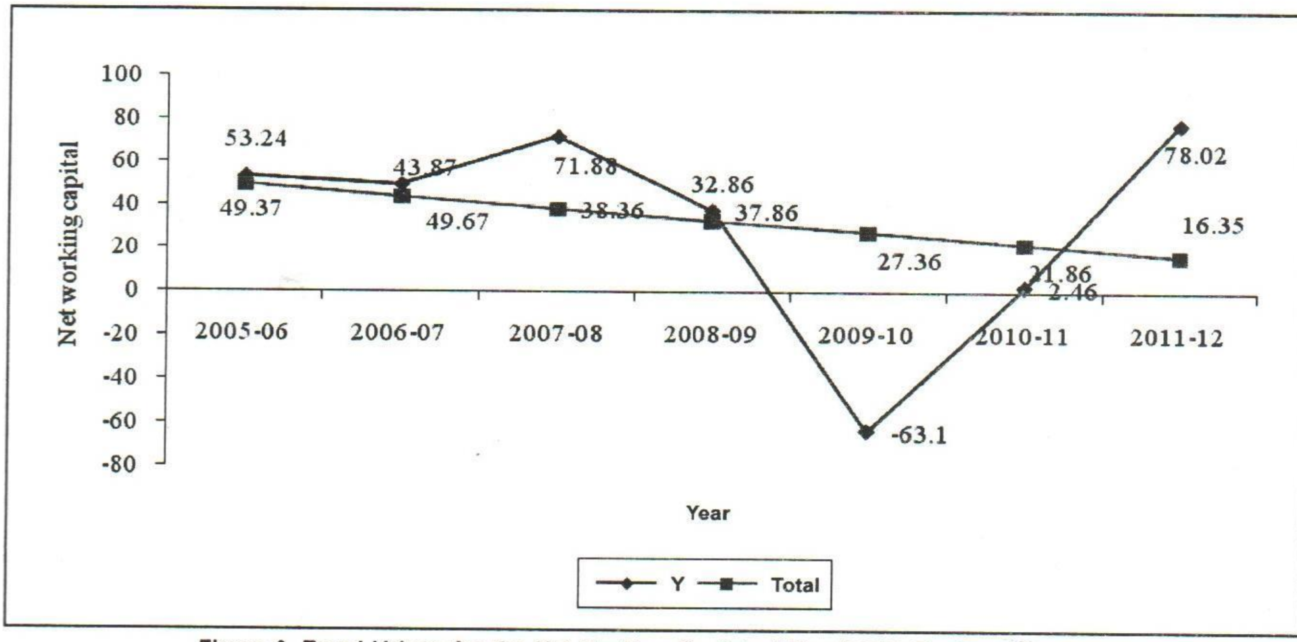


**Figure 6. Trend Values for the Net Working Capital of Nandi Milk Products Pvt. Ltd.**

The formula used to (predict) estimate the net working capital is given by linear regression.

$$Y_t = a + bx$$

Where $Y_t =$ working capital for the year 't'

$X$ = Time period and a, b are constants.

The method of least squares gives the following equations to get the value of 'a' and 'b'.

$$\Sigma Y = na + b\Sigma X$$

$$\Sigma XY = a\Sigma X + b\Sigma X^2$$

When $\Sigma X = 0$

$$a = \frac{\Sigma Y}{n} \text{ and } b = \frac{\Sigma XY}{\Sigma X^2}$$

For Nandi Milk Products Private Limited, the estimates are a = 32.86

b = -5.50

The model is $y_t = 32.86 - 5.50\,(X)$

For the year 2017, we have X = 8, substituting this value weight

$$Y_t = 32.86 - 5.50\ (8) \qquad = -11.16 \text{ lakh}$$

**Result:** The net working capital of Nandi Milk Products Private Limited for the year 2017 may be Rs -11.16 lakh.

### *3.7. Mulukanoor Women's Cooperative Dairy*

The working capital of Mulukanoor Women's Cooperative Dairy has been analyzed by using select ratios. Results of the analysis are presented in Table 13.

In the Mulukanoor Women's Cooperative Dairy, the current assets had an increasing trend except in the years 2007–08 and 2008–09. In the year 2005–06, the current assets were Rs 249.57 lakh which rose to Rs 613.18 lakh in the year 2011–12. The dairy maintained an average of Rs 376.43 lakh current assets during the study period.

The current liabilities of the Mulukanoor Women's Cooperative Dairy had a mixed trend during the study period. In 2005–06, the current liabilities of the dairy stood at Rs 179.52 lakh and gradually increased to Rs 247.32 lakh in 2011–12.

**Table 13: Analysis of Working Capital of Mulukanoor Women's Cooperative Dairy**

**(Rs in lakhs)**

| S. No. | Ratio | 2005–06 | 2006–07 | 2007–08 | 2008–09 | 2009–10 | 2010–11 | 2011–12 | Total | Average |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Current Assets | 249.57 | 301.40 | 295.56 | 300.30 | 409.66 | 465.31 | 613.18 | 2634.98 | 376.43 |
| 2. | Current Liabilities | 179.52 | 143.70 | 100.55 | 167.18 | 241.08 | 218.89 | 247.32 | 1298.24 | 185.46 |
| 3. | Net Working Capital | 70.05 | 157.7 | 195.01 | 133.12 | 168.58 | 246.42 | 365.86 | 1336.74 | 190.96 |
| 4. | Current Ratio | 1.39 | 2.10 | 2.94 | 1.80 | 1.70 | 2.13 | 2.48 | 14.54 | 2.08 |
| 5. | Quick Ratio | 0.68 | 0.53 | 1.66 | 0.94 | 0.94 | 1.29 | 1.22 | 7.26 | 1.04 |
| 6. | Inventory to Current Assets Ratio | 0.51 | 0.75 | 0.44 | 0.48 | 0.45 | 0.39 | 0.51 | 3.53 | 0.50 |
| 7. | Inventory Turnover Ratio | 11.34 | 14.06 | 16.06 | 27.23 | 28.02 | 30.14 | 25.92 | 152.77 | 21.82 |
| 8. | Working Capital Turnover Ratio | 22.89 | 15.82 | 14.66 | 28.06 | 27.37 | 22.12 | 17.48 | 148.4 | 21.2 |

*Source:* Complied from the annual reports of Mulukanoor Women's Cooperative Dairy.

The net working capital of the dairy stood at Rs 70.05 lakh in 2005–06 and rose to Rs 365.86 lakh in 2011–12. The average net working capital during the study period was Rs 190.96 lakh.

The current ratio of Mulukanoor Women's Cooperative Dairy varied between 1.39 and 2.94 with an average of 2.08, which is above the acceptable standard norm of 2:1. The solvency of the dairy with respect to current ratio is satisfactory.

The quick ratio of the Mulukanoor Women's Cooperative Dairy ranged from 0.53 to 1.66 with an average of 1.04, which is just above the acceptable standard norm of 1:1. The liquidity of the dairy with regard to the quick ratio is satisfactory except for the years 2005–06 and 2006–07.

The inventory to current assets ratio of the dairy ranged between 0.39 and 0.75 with an average of 0.50 which implies that 50 per cent of the current assets was inventory component on an average, during the study period.

The inventory turnover ratio kept increasing continuously throughout the study period, except in the year 2011–12. The ratio has been ranging between 11.34 and 30.14 with an average of 21.82.

The working capital turnover ratio is almost consistent, ranging from 14.66 to 28.06, with an average of 21.2.

It is evident from the analysis of current and quick ratios that the liquidity position is satisfactory during the study period. The ratio of inventory to current assets makes it clear that 50 per cent of the current assets comprises inventory. The Mulukanoor Women's Cooperative dairy used its inventory and working capital in a better manner.

### 3.7.1. Trend values for the net working capital of Mulukanoor Women's Cooperative Dairy

The trend values for the net working capital of Mulukanoor Women's Cooperative Dairy are calculated by the method of least squares and presented in Table 14 and graphically shown in Figure 7.

The formula used to estimate the net working capital is given by linear regression.

$$Y_t = a + bx$$

Where $Y_t =$ working capital for the year 't'

$X$ = Time period and a, b are constants.

The method of least squares gives the following equations to get the value of 'a' and 'b'.

$$\Sigma Y = na + b\Sigma X$$

$$\Sigma XY = a\Sigma X + b\Sigma X^2$$

**Table 14: Computation of Net Working Capital of Mulkanoor Women's Cooperative Dairy by the Method of Least Squares**

| Obs | X | Y | X² | XY | XY | Trend |
|---|---|---|---|---|---|---|
| 1 | 1 | 70.05 | -3 | 9 | -210.15 | 79.70 |
| 2 | 2 | 157.70 | -2 | 4 | -315.40 | 116.79 |
| 3 | 3 | 195.01 | -1 | 1 | -195.01 | 153.88 |
| 4 | 4 | 133.12 | 0 | 0 | 0 | 190.96 |
| 5 | 5 | 168.58 | 1 | 1 | 168.58 | 228.05 |
| 6 | 6 | 246.42 | 2 | 4 | 492.84 | 265.14 |
| 7 | 7 | 365.86 | 3 | 9 | 1097.58 | 302.22 |
| **Total** | | **1336.74** | | 28 | 1038.44 | **1136.74** |

*Source:* Table 13.

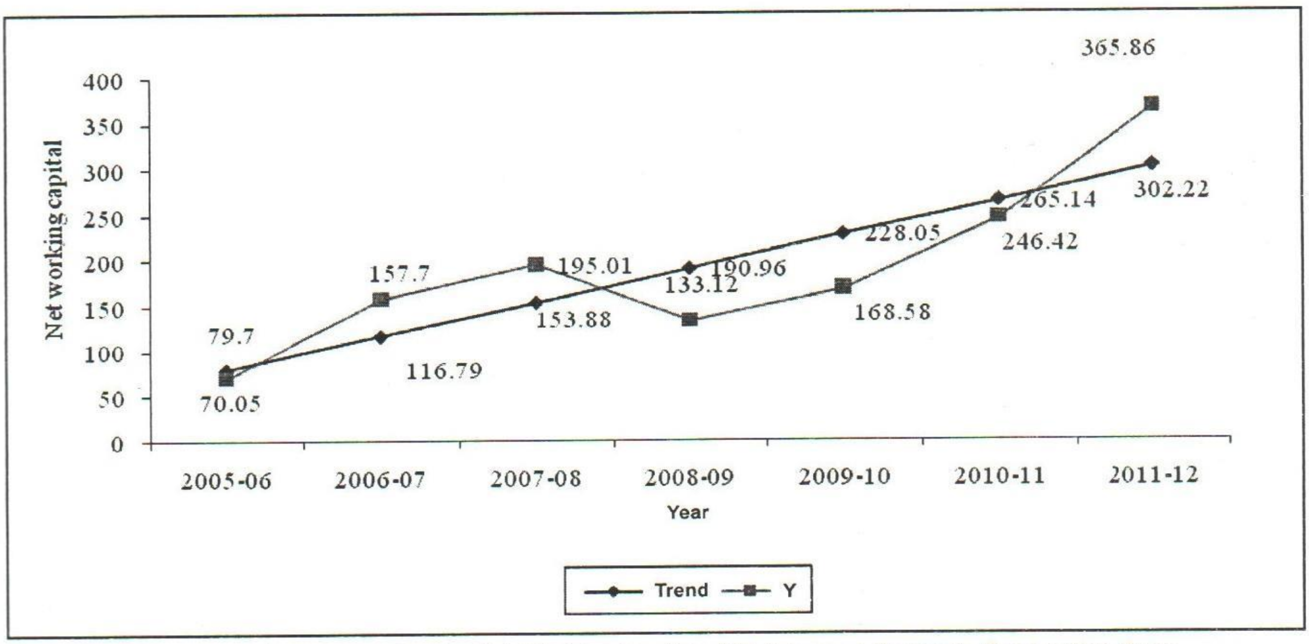


**Figure 7. Trend Values for the Net Working Capital of Mulukanoor Women's Cooperative Dairy**

When $\Sigma X = 0$

$$a = \frac{\Sigma Y}{n} \text{ and } b = \frac{\Sigma XY}{\Sigma X^2}$$

For Mulukanoor Women's Cooperative Dairy, the estimates are

a = 190.96

b = 37.09

The model is $y_t = 190.96 + 37.09\,(X)$

For the year 2017, we have X = 8, substituting this value weight

$Y_t = 190.96 + 37.09\,(8) =$ Rs 487.66 lakh

**Result:** The net working capital of Mulukanoor Women's Cooperative Dairy for the year 2017 would be Rs 487.66 lakh.

**4. Comparison of Net Working Capital of Select Dairy Units**

In order to compare the working capital of dairy units, the net working capital of each dairy unit has been presented in Table 15.

It is inferred from Table 15 that the average net working capital during the study period is high for Vijaya Dairy followed by Heritage Foods (India) Ltd and Tirumala Milk Products Pvt. Ltd in the second and third places with Rs 8027.86, Rs 3977.14 and Rs 3959.80 lakhs respectively. The lowest net working capital during the study period is for Nandi Milk Products Private Limited, followed by Mulukanoor Women's Cooperative Dairy and Krishna Milk Union with Rs 10.57, Rs 190.96 and Rs 11454.89 lakh respectively, and in the middle is Sangam Dairy with a net working capital of Rs 2072.38 lakh.

**Table 15: Comparison of Net Working Capital of the Select Dairy Units**

(Rs in lakhs)

| S. No. | Dairy Unit | 2005–06 | 2006–07 | 2007–08 | 2008–09 | 2009–10 | 2010–11 | 2011–12 | Total | Average |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Sangam Dairy | 2287.75 | 2313.21 | 1918.8 | 1264.53 | 1213.6 | 1802.61 | 3184.34 | 16579.02 | 2072.38 |
| 2. | Heritage Foods (India) Limited | 3505 | 5715 | 6305 | 4563 | 4645 | 3788 | -681 | 27840 | 3977.14 |
| 3. | Krishna Milk Union | 1158.06 | 1337.37 | 2077.58 | 229.19 | 193 | 822.96 | 2203.07 | 8021.23 | 1145.89 |
| 4. | Tirumala Milk Products Pvt. Ltd | 2691.47 | 3082.17 | 2937.70 | 3778.73 | 9282.85 | 11175.52 | 5229.85 | 27718.59 | 3959.80 |
| 5. | Vijaya Dairy | 2934.1 | 4381.62 | 9431.92 | 11046.39 | 6582.44 | 9130.91 | 12687.66 | 56195.04 | 8027.86 |
| 6. | Nandi Milk Products Pvt. Ltd | 53.24 | 49.67 | 71.88 | 37.86 | -63.1 | 2.46 | -78.02 | 73.99 | 10.57 |
| 7. | Mulukanoor Women's Cooperative Dairy | 70.05 | 157.70 | 195.01 | 133.12 | 168.58 | 246.42 | 365.86 | 1336.74 | 190.96 |

*Source:* Tables 1, 3, 5, 7, 9, 11 and 13.

**5. Comparison of the Averages of the Working Capital Ratios**

In order to analyze the working capital utilization by the select dairy units, the average current ratio, quick ratio, inventory turnover ratio, inventory to current assets ratio and working capital turnover ratio for each of the dairy units have been presented in Table 16.

The average current ratio of Heritage Foods India Limited, Krishna Milk Union and Nandi Milk Products is below the standard norm, i.e., 1.63:1, 1.58:1 and 1.46:1 respectively. In the case of Sangam Dairy, Tirumala Milk Products, Vijaya Dairy and Mulukanoor Women's Co-operative Dairy, the average current ratio is above the standard norm, i.e., 2.83:1, 3.18:1, 2.67:1 and 2.08:1 respectively.

Regarding the average quick ratio, for the three dairy units viz., Sangam, Heritage and Krishna it is below the standard norm (1:1), and in the remaining four dairy units

**Table 16: Comparison of Working Capital Performance of the Select Dairy Units**

| Dairy Unit | Current Ratio | Liquid Ratio | Inventory to Current Assets Ratio | Inventory Turnover Ratio | Working Capital Turnover Ratio |
|---|---|---|---|---|---|
| Sangam | 2.83 | 0.81 | 0.70 | 8.29 | 10.86 |
| Heritage | 1.63 | 0.96 | 0.41 | 14.27 | 16.46 |
| Krishna | 1.58 | 0.82 | 0.49 | 18.45 | 22.84 |
| Tirumala | 3.18 | 1.69 | 0.49 | 14.57 | 12.07 |
| Vijaya | 2.67 | 2.21 | 0.17 | 21.75 | 4.66 |
| Nandi | 1.46 | 1.17 | 0.25 | 62.36 | 16.31 |
| Mulukanoor | 2.08 | 1.04 | 0.50 | 21.82 | 21.20 |

*Source:* Tables 1, 3, 5, 7, 9, 11 and 13.

Tirumala, Vijaya, Nandi and Mulukanoor Women's Co-operative Dairy it is above the standard norm.

The average of the inventory to current assets ratio is not up to the mark and it is below 0.5 for Heritage, Krishna Union, Tirumala, Vijaya and Nandi, and more than 0.5 in the case of Sangam Dairy and Mulukanoor Women's Co-operative Dairy.

The average of the inventory turnover ratio is more than the standard norm in all the dairy units during the period under study. The highest ratio (62.36) is obtained in Nandi Milk products and the lowest ratio (8.29) noticed in the case of Sangam Dairy.

The average of the working capital turnover ratio is more than eight times in the case of Sangam, Heritage, Krishna, Tirumala, Nandi and Mulukanoor dairy units and confirms their excellent performance. In the case of Vijaya dairy, the average working capital turnover ratio is less than five, which indicates poor performance.

## 6. Impact of Working Capital Performance on Profitability

This section presents an analysis of the effect of the working capital performance on profitability. The study includes the analysis of current ratio, quick ratio, inventory turnover ratio, inventory to current assets ratio and working capital turnover ratio. Profitability is measured in terms of the ratio of net earnings on sales. To study the intensity of the linear relationship between the working capital ratios and profitability, co-efficient of correlation has been computed. The results are given in Table 17.

Table 17 shows that for Sangam Dairy, the current ratio has a high degree of positive correlation with profitability and the correlation co-efficient is significant at 5 per cent level. Inventory to current assets ratio has a high degree of negative correlation with profitability and its co-efficient is significant at 5 per cent level. All other working capital ratios have shown insignificant correlation with profitability.

In the case of Heritage Dairy, inventory to current assets ratio has a high degree of correlation with profitability and the co-efficient of inventory turnover ratio is found to be significant at 5 per cent level. All other working capital ratios have shown insignificant correlation with profitability.

In the case of Krishna Dairy, inventory turnover ratio has shown negatively high degree of correlation and significant at 1 per cent level with profitability.

For Tirumala Dairy, all ratios have shown positive and insignificant relation with profitability except working capital turnover ratio.

In the case of Vijaya Dairy, all the ratios have shown negative and insignificant relation with profitability, except inventory turnover ratio which has shown high degree of positive correlation with profitability and is significant at 5 per cent level.

In the case of Nandi Dairy, both current ratio and quick ratio have a moderate degree of positive correlation with profitability, whereas inventory turnover ratio correlates negatively and moderately with profitability.

**Table 17: Co-efficient of Correlation between Working Capital Ratios and Profitability**

| Dairy Unit | Current Ratio | Liquid Ratio | Inventory to Current Assets Ratio | Inventory Turnover Ratio | Working Capital Turnover Ratio |
|---|---|---|---|---|---|
| Sangam | 0.7345 (2.67)* | 0.3461 (0.06) | -0.6534 (-2.92)* | 0.2278 (0.61) | 0.5062 (1.26) |
| Heritage | 0.3607 (1.09) | 0.5234 (1.42) | -0.8215 (-1.23) | -0.4211 (-2.65)* | -0.5236 (-0.19) |
| Krishna | -0.1362 (-1.21) | -0.5326 (-1.72) | 0.4972 (0.67) | -0.6742 (-3.42)* | -0.1322 (-0.71) |
| Tirumala | 0.4214 (0.72) | 0.6507 (0.12) | 0.3267 (0.66) | 0.2212 (0.82) | -0.3306 (-0.43) |
| Vijaya | -0.2206 (-0.77) | -0.6032 (-0.62) | -0.3224 (-1.07) | 0.6235 (2.94)* | -0.3207 (-0.45) |
| Nandi | 0.6026 (1.07) | 0.6315 (0.78) | 0.4435 (0.67) | -0.5074 (-0.72) | 0.4075 (0.88) |
| Mulukanoor | -0.6234 (-0.85) | -0.6823 (-0.33) | -0.4752 (-2.92) | -0.2565 (-0.76) | -0.4865 (-0.67) |

*Note:* Figures in parenthesis are t-values.

* Significant at 5 per cent level.

All the working capital ratios have indicated negative and insignificant relationship with profitability in Mulukanoor Women's Co-operative Dairy.

## 7. Explaining Variations in Profitability

To study the nature and extent of variations in profitability, all the five ratios viz., current ratio, quick ratio, inventory to current ratio, inventory turnover ratio and working capital turnover ratio have been considered. However, to avoid the problem of multi-colinearity in the estimation of regression coefficients, the variables namely quick ratio, inventory to current assets ratio and inventory turnover ratio have been excluded on the basis of zero-order correlation co-efficient. Linear multiple regression has been computed by using the following formula:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2$$

$X_1$ = Current Ratio,

$X_2$ = Working capital turnover ratio

Y = Net profit,

$\beta_0$ = Intercept,

$\beta_1$ & $\beta_0$ = Regression co-efficients

The regression estimates of working capital on profitability are shown in Table 18.

It can be observed from Table 18 that the linear regression model was adequate only for the dairy units 2, 5 and 7. This could be due to many reasons like small volume of data in each unit, low correlation co-efficient between NPR and regression, etc. In the case of those units where regression is found to be significant, it is possible to estimate the NPR with given ratios, current ratio and working capital turnover ratio.

A further analysis has been carried out using stepwise regression in order to know relatively important variables that determine NPR. This is done by stepwise regression (with the help of SPSS) for each unit. No explanatory variable was found suitable for the units 1, 3, 4 and 6. For the remaining units, the following regression models have been obtained.

**Unit No. 2**

NPR = 4.12 – 0.078(WTO), $R^2 = 0.7164$, F = 14.64, P = 0.05

For the unit WTO alone accounts for 71.64 per cent of variation in NPR. The ratio CR is excluded from the model by the stepwise regression.

**Table 18: Regression Estimates of Working Capital on Profitability**

| Dairy Unit | $\beta_0$ | $\beta_1$ | $B_2$ | $R^2$ | F-value |
|---|---|---|---|---|---|
| Sangam | -127.34 (1.03) | 0.45 (0.46) | 0.36 (1.64) | 0.96 | 23.77 |
| Heritage | -1061.32 (0.15) | 32.64 (0.66) | 76.22 (0.73) | 0.99 | 342.84* |
| Krishna | -59.65 (0.42) | 8.64 (0.86) | 18.07 (1.67) | 0.95 | 10.66 |
| Tirumala | -1267.07 (4.07) | 1.15 (3.11) | 0.45 (2.06) | 0.96 | 32.61 |
| Vijaya | -268.49 (4.14) | 2.07 (2.65) | 1.65 (0.98) | 0.99 | 218.37* |
| Nandi | -66.08 (0.96) | 15.64 (10.23) | 10.07 (11.75) | 0.88 | 14.08 |
| Mulukanoor | -1540.33 (0.98) | 12.05 (1.07) | 8.26 (1.33) | 0.99 | 156.02* |

*Note:* Figures in parenthesis are t-values.

* Significant at 5 per cent level.

*Source:* Tables 1, 3, 5, 7, 9, 11 and 13

### Unit No. 5

NPR = 5.05 - 0.143(WTO), $R^2 = 0.6867$, F = 19.07, P = 0.03

For the unit WTO alone accounts for 68.67 per cent of variation in NPR. The ratio CR is excluded from the model by the stepwise procedure.

### Unit No. 7

NPR = 3.84 -0.116(WTO), $R^2 = 0.6452$, F = 16.07, P = 0.02

For the unit WTO alone accounts for 64.52 per cent of variation in NPR. The ratio CR is excluded from the model by the stepwise regression.

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*You need a stubborn belief in an idea in order to see it realised.*

*– James Dyson*

# Relationship between Industrial Expenditure and Industrial Growth Rate: The Case of India

KOTI REDDY TAMMA

*The study aims at testing the relationship between industrial expenditure and industrial growth rate for the period 1950–51 to 2013–14. The study applies Johansen Co-integration and Vector Error Correction Model to test the long-term relationship between industrial expenditure and industrial growth rate. The National Accounts Statistics (NAS) was used for the data on private investment for the analysis of this study.*

*The study reveals that during the post-reform period, the rate of capital formation had decreased in the public sector and increased in the private sector. The study concludes that there is a long-term association between industrial expenditure and industrial growth rate, implying that the industrial expenditure contributes significantly to the industrial growth rate. The author suggests that in order to expand the scope of long-term finance for industrial sector, securities market needs to be developed and strengthened.*

*Koti Reddy Tamma, Professor in Economics, IBS Hyderabad (A constituent of the ICFAI Foundation for Higher Education), India.*

## 1. Introduction

In the post-Independence period, India started to develop different types of industries during the five-year plans process. The index of industrial production (Base 1980–81=100) had increased from 18.3 in 1950–51 to 65.3 in 1970–71. Some basic and heavy industries were developed in the country during those 20 years. Moreover, with the expansion of public sector enterprises, joint-sector enterprises and private sector enterprises in the later period, various types of industries developed in the country. The number of public sector enterprises had increased from a mere five in 1951 to 290 CPSEs that existed under the administrative control of various ministries/departments as on 31 March 2014 (Economic Survey 2015–16).

The public sector enterprises in India are engaged in producing goods like coal, steel, light and heavy engineering goods, power, petroleum, minerals and metals, fertilizers, chemicals and pharmaceuticals, textiles, transportation equipments and consumer goods. Since Independence, industrial sector has achieved a significant achievement in diversifying its productive capacities. In respect of almost all consumer goods, both durable and non-durable, the stage of self-sufficiency has already been attained.

A substantial increase in the production of capital goods has also been achieved. The country has also achieved an impressive industrial productive capacity in respect of mining and metallurgical industries, capital goods industries (even producing highly sophisticated equipments necessary for the production of steel, chemical, fertilizer, software, refinery products, etc.), chemical and petro-chemical industries, medium and heavy engineering industries, fertilizer and paper industry, power and transportation industry, construction industry, etc.

The post-reform period (up to the end of 2001–02) was marked by considerable fluctuations and thus showed a total lack of consistency in the industrial growth performance. Slowdown in investment, exposure to external competition, sluggish growth in exports, the infrastructural constraints, anomalies in tariff structure, contraction in consumer demand and difficulties in obtaining funds for expansion were the causes for unsatisfactory industrial performance during the post-reform period.

The aim of this study is to empirically analyze the relationship between industrial expenditures and industrial growth rate, which is argued by endogenous economic growth theories, on the basis of Indian economy. In the study, Johansen Co-integration and Vector Error Correction Model are used to test the long-term relationship between industrial expenditure and industrial growth rate of India between 1950–51 and 2014–15. In the literature review section of this study, the researches and findings about the impacts of industrial sector expenditures on industrial growth will be scrutinized, and then the results will be presented and evaluated in the empirical findings section, which will offer information about the data set and methodology deployed in the empirical part of this study. Finally, the paper ends with policy implications and conclusion.

Table 1 provides information about secondary sector contribution to Gross Domestic Product (GDP) since 1950–51. Secondary sector contribution to Net Domestic Product (NDP) accounted for 16.3 per cent in 1950–51. Since then, its contribution to India's NDP increased to 24.2 per cent in 2011–12 and 31.37 per cent by 2014–15 (CVA at constant price). The contribution of mining and quarrying to NDP was 1.1 per cent in 1950–51 and its share in NDP rose to 1.7 per cent in 2011–12 and 2.88 per cent by 2014–15 (GVA at constant price). Manufacturing is the predominant activity in the secondary sector. It is clear from Table 1 that for the national income estimation, manufacturing industry is divided into two parts viz., registered and unregistered.

**Table 1: Secondary Sector Contribution to GDP**

| | At 1980–81 price | | | | At 1999–2000 prices | At 2004–05 price | | GVA at 2011–12 price | |
|---|---|---|---|---|---|---|---|---|---|
| **Industry** | **1950–51** | **1970–71** | **1980–81** | **1990–91** | **1999–2000** | **2010–11** | **2011–12** | **2013–14** | **2014–15** |
| Secondary Sector | **16.3** | **22.3** | **24.2** | **28.0** | **22.7** | **24.7** | **24.2** | **31.68** | **31.37** |
| 1. Mining & Quarrying | 1.1 | 1.2 | 1.3 | 1.4 | 2.1 | 1.9 | 1.7 | 3.01 | 2.88 |
| 2. Manufacturing | 11.4 | 15.3 | 16.9 | 20.7 | 12.9 | 13.4 | 13.2 | 18.08 | 18.08 |
| (a) Registered | 5.3 | 8.3 | 9.1 | 12.4 | 8.1 | 8.5 | 8.4 | | |
| (b) Unregistered | 6.1 | 7.0 | 7.8 | 8.3 | 4.8 | 4.9 | 4.7 | | |
| 3. Electricity, gas and water supply | 0.3 | 0.7 | 0.8 | 1.1 | 1.5 | 1.1 | 1.0 | 2.31 | 2.33 |
| 4. Construction | 3.5 | 5.1 | 5.2 | 4.8 | 6.2 | 8.3 | 8.3 | 8.28 | 8.09 |

Registered manufacturing sector contribution to NDP steadily rose from 5.3 per cent in 1950–51 to 12.4 per cent in 1990–91. However, during the 1990s, the share of the organized industrial sector declined to 8.4 per cent in 2011–12.The unorganized manufacturing sector accounted for 6.1 per cent to NDP in 1950–51 and 4.7 per cent in 2011–12. Electricity, gas and water supply accounted for 0.3 per cent in NDP in 1950–51 and it has expanded rather slowly. This sector accounted for 1.0 per cent of the country's NDP in 2011–12 and increased to 2.33 per cent by 2014–15 (GVA at constant price). With the expansion of the infrastructure sector, construction activity has increased significantly. As a result, its contribution to NDP rose from 3.5 per cent in 1950–51 to 8.3 per cent in 2011–12 and 8.09 per cent by 2014–15 (GVA at constant price).

### 1.1. IIP-based Industrial Performance since Independence

The annual compound growth rate of industrial production during the first three five-year plan periods (1951–66) was accelerated, i.e., from 5.7 per cent during the first plan to 7.2 per cent in the second plan and then to 9 per cent in the third plan. Capital goods industries had registered an annual average compound growth rate from 9.8 per cent during the first plan to 19.6 per cent during the third plan. The annual growth rate of basic industries had also increased from 4.7 per cent in the first plan to 12.1 per cent in the second plan and it stood at 10.4 per cent during the third plan. Thus, a strong industrial base was laid in India during the period 1951–66.

The annual compound growth rate in industrial production sharply declined from 9 per cent during the third plan to only 4.1 per cent during the period 1965–76. During the period of sixth five-year plan (1980–85), the average annual growth rate of industrial production got accelerated to 7 per cent. It again increased to 8.5 per cent during 1985–89. In 1990–91, the annual rate of industrial growth was registered at 8.5 per cent. This shows that the rate of growth during the entire 1980s varied between 7 to 8.6 per cent as compared to only 4.1 per cent during 1965–76 showing a perceptible industrial recovery. During 1991–92, the country had a bitter experience of negative growth rate to the extent of -0.10 per cent as compared to that of 8.5 per cent in 1990–91.

This is a clear case of sharp industrial retrogression in the country. But after that in 1995–96, the country experienced an industrial upturn as the estimated annual growth rate during this period stood at 11.7 per cent (CMIE, 1996). During 1996–97, the industrial sector of the country recorded a moderate growth over the previous year. The overall industrial production during 1996–97 registered an increase of 12.1 per cent supported by a growth rate of 8.6 per cent in manufacturing, 3.9 per cent in electricity and a mere 0.7 per cent in mining.

After experiencing an industrial slowdown during 2000–01 and 2001–02, the industrial sector started to show signs of recovery gradually. According to estimates of the Index of Industrial Production released by the Central Statistical Organisation (CSO), industrial output recorded a growth rate of 5.7 per cent during 2002–03 as compared to that of 2.7 per cent recorded during 2001–02. In 2006–07, industrial output recorded a growth rate of 11.6 per cent, supported by a growth rate of 12.5 per cent in manufacturing, 7.2 per cent in electricity and 5.4 per cent in mining and quarrying. Again in 2010–11, the industrial output recorded a growth rate of 8.2 per cent.

However, the last year of the eleventh five-year plan (2011–12) registered a steep fall in the industrial growth rate to just 2.9 per cent. Hardening of interest rates, slowdown in consumption expenditure, moderation in demand both domestic and external, global economic uncertainty and subdued business confidence were the factors responsible for low industrial growth in 2011–12. The first year of the twelfth five-year plan (2012–13) also witnessed further slowdown in the industrial sector with the rate of industrial growth in that year being only 1.0 per cent. The main reason for this was the sharp decline in the investment activity. In 2013–14, industrial output recorded a growth rate of 0.4 per cent only.

### 1.2. Methodology

The study applied Johansen Co-integration and Vector Error Correction Model to test the long-term relationship between industrial expenditure and industrial growth rate. Initially, industrial expenditure and industrial growth rate of the sample period were converted into logarithmic values. Then the study tested the stationarity and also the order of integration of both the series using Augmented Dickey Fuller (ADF) test. Johansen's Co-integration (1991, 1992) test was applied to confirm the presence of co-integration between both the variables. When the co-integration between both the variables was confirmed, vector error correction model was estimated as follows:

$$\Delta L(IE)_t = a_1 + \gamma_1 \varepsilon_{t-1} + \sum_{k=1}^{n} \beta_{ie,\, t-k} \Delta L(IE)_{t-k} + \sum_{k=1}^{n} \delta_{ie,\, t-k} \Delta L(IG)_{t-k} + \in_{ie,\, t} \quad \ldots \quad (1)$$

$$\Delta L(IG)_t = a_2 + \gamma_1 \varepsilon_{t-2} + \sum_{k=1}^{n} \beta_{ig,\, t-k} \Delta L(IG)_{t-k} + \sum_{k=1}^{n} \delta_{ig,\, t-k} \Delta L(IE)_{t-k} + \in_{ig,\, t} \quad \ldots \quad (2)$$

$\varepsilon_{t-1}$, $\varepsilon_{t-2}$ are equilibrium error terms;

$\Delta\ L(IE)_{t-k}$ and $\Delta\ L(IG)_{t-k}$ are differences in industrial expenditure and industrial growth at lag k;

$\varepsilon_{ig,\ t-k}$ and $\varepsilon_{ig,\ t-k}$ are equilibrium error terms;

and $\gamma_1$ and $\gamma_2$ are coefficients of equilibrium errors which indicate the speed of adjustment.

In the equations (1) and (2), error terms ($\varepsilon_{t-1}$) and ($\varepsilon_{t-2}$) imply equilibrium error terms, which measure how dependent variable in the equation adjusts to the previous period's deviation from long-run equilibrium. Coefficients of error terms, i.e.,$\gamma_2$ and $\gamma_2$ imply the speed of adjustment coefficients in industrial expenditure and industrial growth respectively. If at least one coefficient of error terms is negative and statistically significant, it implies the long-term association between both the variables. The coefficients of lagged differences imply the short-run effects of previous period's change in the price of current period's deviation. As per Enders (1995), results are same irrespective of whether industrial expenditure or industrial growth is used as dependent variable.

### *1.3. Review of Literature*

Jagannath Mallick (2009) examined the trends and patterns of private investment in India. The author argued that the rate of capital formation had increased in the private sector and decreased in the public sector after economic reforms. Further, the industrial sector had been ranked one in terms of its contribution to the growth of private investment, followed by the service and agricultural sectors in India in the short term as well as long term. The study finds that the growth of private investment in the service sector was considerably higher in the post-reform period than in the pre-reform period.

Fölster and Henrekson (2001) have examined the effects of government expenditure and taxation in rich countries by using econometric panel study for the period 1970–95. The study reveals that there was a robust negative relationship between government expenditure and growth in rich countries. It has been suggested that there is a need to address more econometric problems to establish a robust relationship between government size and economic growth.

Mani (2014) has examined the industrial investments in Kerala, trends, constraints and future prospects. The author opines that land, labour, environmental consciousness of civil society and the role of the bureaucracy are the factors dampening the flow of investments. It has been suggested to establish land bank and setting up of industrial parks under public–private partnership to promote industrialization in Kerala.

According to Nagraj (1989), growth rates in value added for 1959–60 to 1965–66 came out to be 7.6 per cent per annum, 5.5 per cent per annum for the period 1966–67 to 1979–80 and 10.4 per cent per annum for the period 1980–81 to 1986–87. The study reveals that the industrial growth in the period 1980–81 to 1986–87 was higher than the growth rate in the period 1966–67 to 1979–80 in all industry groups, except textiles, wood and furniture and basic metals.

There are some studies that focus on the effects of liberalization on efficiency. Driffield and Kambhampati (2003) used stochastic frontier approach and Ray (2004) used data envelopment analysis to arrive at efficiency. The efficiencies thus calculated for Indian or US manufacturing are ranked.

Vepa (1988) examined the association between the growth of small industries and growth of resources. The study reveals that small industries have strong linkage with the total development of raw material and human resources. If these natural resources are not exploited properly, the industrial development cannot be accelerated, which will adversely affect the economic growth.

The study highlights that the small sector should be developed from the grassroot levels, as proper development of small units facilitates optimum use of raw material, infrastructural facilities and human resources, thereby contributing to the growth of large and medium units in a big way.

## 2. Relationship between Public Expenditure and Growth Rate

The study also attempts to investigate the relationship between public expenditure and growth rate using Johansen Co-integration and Granger causality test based on Vector Auto Regression (VAR) model. Initially, log transformation of public expenditure (L(PE)) and growth rate (L(GR)) is done which is subsequently tested for stationarity using ADF. There is an evidence of non-stationarity in both the variables at level but stationarity when converted into their first differences (Table 2.), indicating that both the variables are integrated of order (1). To confirm the co-integrating relationship between public expenditure and growth rate, Johansen Co-integration test is also applied. However, null hypothesis of 'no co-integration' could not be rejected, at 5 per cent level of significance, implying that there is no long-run association between public expenditure and growth rate (Table 3). However, from the results of Granger Causality Wald test, there is an evidence of short-run causality running from public expenditure to growth rate and vice versa (Table 4). The model is subject to testing the robustness using LM test for serial correlation and Jarque-Bera (JB) test for normality. There is no evidence of serial correlation and non-normality in the residuals of the model, implying that it is a good fit (Table 5).

Thus, the study concludes that there is long-term association between industrial expenditure and industrial growth rate, implying that industrial expenditure contributes significantly to the industrial growth rate.

**Table 2: Industrial Expenditure and Industrial Growth Rate**

| Augmented Dickey Fuller Unit Root Test Results | | |
|---|---|---|
| | Test Statistics | P Value |
| L(IE) | -2.437 | 0.1314 |
| DL(IE) | -3.119 | 0.0252 |
| L(IG) | -5.616 | 0.000* |
| DL(IG) | -4.839 | 0.000* |

Null Hypothesis: Given series are not stationary; Alternative Hypothesis: Given series are stationary.

L(IE) and L(IG) are log values of Industrial Expenditure Series and Industrial Growth Series

DL(IE) and DL(IG) are first differences of Logged Industrial Expenditure Series and Logged Industrial Growth Series

Critical value at 1% level of significance is -3.750 and 5% level of significance is -3.000 *Indicates significance at 5% level

**Table 3: Johansen Co-integration Test Result**

| Maximum Rank | Trace Statistics | Critical Value |
|---|---|---|
| 0 | 22.7916* | 15.41 |
| 1 | 2.2817 | 3.76 |
| | | |
| 0 | 20.5099* | 14.07 |
| 1 | 2.2817 | 3.76 |

Null Hypothesis: There is no co-integration between Industrial Expenditure and Industrial Growth Rate

Indicates significance at 5% level.

Null hypothesis of no co-integration has been rejected at 5% level indicating that there is a long-run relationship between Industrial Expenditure and Industrial Growth Rate

**Table 4: Vector Error Correction Model Test Results**

| | Industrial Expenditure Leads to Industrial Growth | Industrial Growth Leads to Industrial Expenditure |
|---|---|---|
| Constant | -0.2325237 | 0.4148157 |
| | (-2.08, 0.038) | (2.79 0.005) |
| Equilibrium Error Term | -2.146932 | 0.2023567 |
| | (-6.28, 0.000)* | (2.65, 0.008) |
| L(Ind Gro) (-1) | 0.2205327 | 0.5679891 |
| | (1.24, 0.214) | (2.41, 0.016)* |
| L(Ind Exp) (-1) | 0.5990856 | 0.2947356 |
| | (4.47, 0.000)* | (1.66, 0.098) |

**Table 5: Residual Diagnostics**

| Langrange Multiplier Test for Autocorrelation | | | | |
|---|---|---|---|---|
| | Industrial Expenditure Leads to Industrial Growth | | Industrial Growth Leads to Industrial Expenditure | |
| | Chi² | P-Value | Chi² | P-Value |
| 1 | 1.4821 | 0.8298 | 1.4821 | 0.8298 |
| 2 | 3.735 | 0.4431 | 3.735 | 0.4431 |

Null Hypothesis: No autocorrelation at lag order in the residuals of the model.

Null Hypothesis has been accepted at 5% level of significance indicating that there is no auto correlation in the residuals of the model

| Jarque Bera Test of Normality | | | | |
|---|---|---|---|---|
| | Industrial Expenditure Leads to Industrial Growth | | Industrial Growth Leads to Industrial Expenditure | |
| | Chi² | P-Value | | |
| L (IE) (-1) | 0.325 | 0.85003 | 0.696 | 0.70593 |
| L (IG) (-1) | 0.173 | 0.91691 | 1.098 | 0.57754 |
| All | 0.498 | 0.97365 | 1.794 | 0.7735 |

Null Hypothesis: Normality in the residuals of the model.

Null Hypothesis has been accepted at 5% level of significance indicating that residuals of the model are normally distributed

## 3. Results and Analysis

Table 2 exhibits the results of Augmented Dickey Fuller test of log values of industrial expenditure (L(IE)) and industrial growth rate (L(IG)) and first differences of the same. Null hypothesis of unit root cannot be rejected at 5 per cent level for L(IE) and L(IG), implying that both the variables are non-stationary at level. However, there is an evidence of first differences of both the variables to be stationary, implying that both industrial expenditure and industry growth rate are integrated of order (1). The study applies Johansen's co-integration test also to confirm the presence of co-integration between industrial expenditure and industry growth rate. Table 3 summarizes the results of Johansen's co-integration test. Null hypothesis of 'no co-integration between industrial expenditure and industry growth rate' has been rejected at 5 per cent level, as Trace Statistic value is more than critical value of 15.41. It indicates that there is at least one co-integration vector between industrial expenditure and industrial growth rate. As there is an evidence of co-integration between both the variables, the study applies Vector Error Correction Model (VECM) to investigate the long-term relationship. The results of VECM are shown in Table 4. When industrial growth rate is taken as a dependent variable, there is an evidence of long-term relationship between industrial expenditure and industrial growth rate. It is evident from the statistically significant negative coefficient of error correction term, when industrial growth rate is taken as a dependent variable. It implies that causality is running from industrial expenditure to industrial growth rate. Thus, there is an evidence of industrial expenditure having impact on industrial growth rate. The robustness of the model is tested by observing the normality and serial correlation in the residuals of the model. The results of Langrage Multiplier test (LM test) for autocorrelation suggest that 'null hypothesis of no serial correlation' has been accepted at 5 per cent level of significance. There is also no evidence of non-normality in residuals as observed from the results of Jarque-Bera test of normality, indicating that the model is a good fit (Table 5).

## 4. Conclusion

The volume and sources of industrial finance in India are considered as inadequate and unsatisfactory considering the needs of the industrial sector. For the smooth operation and faster expansion of industries, the requirements of their finance are not adequately met by the existing sources of industrial finance in India. The extent of capital market, which is a source of long-term finance including equity and debt, is quite small. The interest rate structure for different types of loans like short-term, medium-term and long-term are more or less unsatisfactory. Industrial finance usually suffers from lack of adequate capital formation. There are inherent difficulties of mobilizing the quantum of incremental rural incomes which could have been utilized for financing rural industries. During the post-reform period, the rate of capital formation had decreased in the public sector and increased in the private sector. In order to improve the system of industrial finance, the domestic sources of finance need to be strengthened and expanded. Sources of finance should be diversified by setting up new institutions and expanding the existing system. Moreover, to expand the scope of long-term finance, securities market needs to be developed and strengthened.

The results of VECM indicate that when industrial growth rate is taken as a dependent variable, there is an evidence of long-term relationship between industrial expenditure and industrial growth rate. It is evident from the statistically significant negative coefficient of error correction term, when industrial growth rate is taken as a dependent variable. It implies that causality is running from industrial expenditure to industrial growth rate. Thus, there is an evidence of industrial expenditure having impact on the industrial growth rate. The study concludes that there is a long-term association between industrial expenditure and industrial growth rate, implying that industrial expenditure contributes significantly to industrial growth rate. Development of long-term financial institutions, mutual fund industry, etc., and establishing proper monitoring framework can strengthen the industrial sector. Inflow of foreign direct investment is more important than the entry of portfolio investment. Foreign capital should also facilitate entry of advanced technology and improve business practices.

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*Lean manufacturing is at the core of our strategy to support our growth. You have to take waste out of everything. We only want to do things that our customers are willing to pay for.*

*– David Buck*

Feature

# Six Sigma Marketing and Productivity Improvement

**K. MURALIDHARAN AND NEHA RAVAL**

*Six Sigma is considered to be one of the most powerful quality improvement programmes applied successfully to most of the organizational areas. Productivity of sales and marketing processes has always remained a vital component of Six Sigma quality implementation. In order to justify this, sales and marketing processes should work efficiently to generate high return of investment. Six Sigma Marketing is defined as a fact-based data-driven disciplined approach to grow market share by providing targeted product/markets with superior value. This article studies a structured approach to productivity improvement by integrating two concepts like Six Sigma and Marketing. The DMAIC philosophy associated with Six Sigma Marketing is presented in detail. The importance of supply chain in Six Sigma Marketing is emphasized.*

*K. Muralidharan, Department of Statistics, Faculty of Science, The Maharajah Sayajirao University of Baroda, Gujarat, India.*

*Neha Raval, Department of Statistics, Faculty of Science, The Maharajah Sayajirao University of Baroda, Gujarat, India.*

## 1. Introduction

Six Sigma is a structured, project-oriented, data-driven approach and methodology for eliminating defects in a process—from manufacturing to transactional and from product to service. It is a management philosophy attempting to improve effectiveness and efficiency. It is uniquely driven by close understanding of customer requirements and reinventing business processes (Coronado and Antony, 2002; Eckes, 2000; Harry and Schroeder, 2000; Henderson and Evans, 2000; Dinesh Kumar, 2008; Pande et al., 2003; Schroeder, 2008; Snee, 1999). The 'science' of Six Sigma resides in its reliance on two things: measurement of activities and results, and secondly, a rigorous approach to problem solving. It is a disciplined methodology of *defining*, *measuring*, *analyzing*, *improving* and *controlling* the quality in each of the company's products, processes and transactions with the ultimate goal of virtually eliminating all defects.

The five steps of DMAIC are as follows:

- *Define*–the problem;
- *Measure*–the current process or product performance;
- *Analyze*–the current performance to isolate the problem;
- *Improve*–the problem by selecting a solution;
- *Control*–the improved process or product performance to ensure that the targets are met.

Technically speaking, Six Sigma is described as a data-driven approach to reduce defects in a process or cut costs in a process or product, as measured by 'six standard deviations' between the mean and the nearest specification limits. From a statistics perspective, how well a desired outcome (or target) has been reached can be described by its average or mean ($\mu$), which is nothing but the sum of all data points divided by the number of data points. The standard deviation ($\sigma$) describes how much variation actually exists within a data set, which is calculated as the square root of the variation from the mean.

According to Muralidharan (2015), 'A Six Sigma initiative is a customer focused problem-solving approach with reactive and proactive improvements of a process leading to sustainable business practices. The sustainable business practices include innovation, improvement, productivity, competition, environmental compliance, customer satisfaction, and growth of the organization'. This definition entails organization to undergo structured problem-solving approach through proper data collection and deliver the expected customer satisfaction. The growth of the organization may be valued in terms of its financial gain, marketing strategies, stakeholder confidence, employee retention, productivity and resource utilization, etc.

A relatively simple approach to speed up the process and productivity improvement is Lean Six Sigma (LSS). LSS (sometimes referred to lean or lean manufacturing) is a process improvement programme that combines two ideas: *Lean*–a collection of techniques for reducing the time needed to provide products or services, and Six *Sigma*–a collection of techniques for improving the quality by combining the two. Lean Six Sigma is a proven business management strategy that helps organizations operate more efficiently.

In Lean Six Sigma, the emphasis is on reducing costs by eliminating product and process waste (Shuker, 2000). It also focuses on eliminating non-value added activities such as producing defective product, excess inventory charges due to work-in-process and finished goods inventory, excess internal and external transportation of product, excessive inspection, and idle time of equipment or workers due to poor balance of work steps in a sequential process. The goal of lean manufacturing has long been one of the goals of industrial engineering (Gryna et al., 2007; Muir, 2006).

According to many business analysts and quality improvement experts, Lean Six Sigma is the most popular business performance methodology in the history of corporate development of quality of products and services, substantially contributing to increased customer satisfaction. The operating philosophy of Lean is to eliminate waste through continuous improvement. This is achieved through:

- defining value from the client's perspective;
- identify the value stream;
- only make what the client pulls;
- keep the flow moving continuously; and
- always improve the process.

The process improvement, with its definitions and measures of value, can help management put a process or parts of a process in place that will keep everyone honest when it comes to adding value for customers. Promoting more sophisticated Lean manufacturing is another value adding phase of marketing activity. The Lean manufacturing has become widely accepted in supply-chain management, as it identifies customer value and maps the value stream and also helps to pursue perfection by continually reducing errors, mistakes and waste. Another relatively new concept of Six Sigma is the Six Sigma Marketing which integrates marketing concepts into Six Sigma methodology, which is discussed in section 2 below.

This article emphasizes the importance of Six Sigma Marketing, relatively an upcoming topic and explores the marketing essentials needed to improve the quality of service, product and growth of the organization. The article is addressed to management professionals, Six Sigma consultants and quality professionals responsible for the Six Sigma marketing processes and sales. In various sections below, we discuss the science of marketing through the DMAIC philosophy of Six Sigma methodology.

## 2. Six Sigma Marketing

As seen from the growth of Six Sigma in various organizational activities, its implications are diversified to many outside organizational activities as well. This includes marketing and sales of the organization in terms of its sigma level and performance. Six Sigma Marketing is the bridge between marketing or sales professionals and quality improvement professionals (Redenbach, 2009; Webb, 2006). This enables the professionals to explore the voice of customer (VOC) and voice of business (VOB) to build quality in the respective processes. Six Sigma professionals and sales and marketing professionals have similar objectives in mind—finding the path of least resistance and sticking to what works best. The difference is that sales and marketing often rely on intuition and judgement, while Six Sigma relies strictly on scientific analysis of data.

Six Sigma Marketing (SSM) is defined as a fact-based data-driven disciplined approach to growing market share by providing targeted product/markets with superior value (Creveling et al., 2006; Harry and Schroeder, 2000; Pestorius, 2006). SSM for marketing and sales are relatively new approaches to enable and sustain growth. Some of the other specific objectives of SSM are:

- Influencing customers in such a way that it would motivate them to opt for the offered products or services.
- Six Sigma seeks to remove the randomness from marketing and make it systematic and predictable.
- A process that can allow an organization to concentrate its limited resources on the greatest opportunities to increase sales and achieve a sustainable competitive advantage.
- Activities making sure that organizations are continuing to meet the needs of their customers and are getting appropriate value in return.

SSM enables companies to improve the marketing's strategic, tactical and operational processes as a way to enhance the top line to drive revenue. By applying Six Sigma to marketing, organizations can identify leading indicators of growth and become proactive about performance improvement (Muralidharan, 2015).

However, organizations need SSM as:

- Marketing and sales professionals and quality professionals both focus on the value of the customer, thereby uniting a common platform for quality and productivity improvement.
- Quality professionals help their company to do more of what adds value for customers, thereby committing to the quality function deployment.
- Marketing and sales professionals make customers aware of that value, guide them to purchase it, and then deliver as much of that value as possible to as many customers as possible.

The benefit of integrating Six Sigma into marketing processes includes better information (management by fact) to make better decisions. Using the more robust approach reduces the uncertainty inherent in marketing—a creative, dynamic discipline. A marketing methodology should also facilitate the customer–product–financial linkages. This requirement seeks a comprehensive scope of marketing's responsibilities from offering inception, through offering development, to the customer experience. This comprehensive scope encompasses a business's strategic, tactical and operational aspects (Creveling et al., 2006).

Further, Creveling et al. (2006) offer three unique methods of Six Sigma Marketing namely strategic, tactical and operational areas of business processes. According to them, the natural flow of marketing work starts with strategic renewal of the offering portfolios, to the tactical work of commercializing new offerings, and finally to the operational work of managing the product and services lines in the post-launch sales, support and service environment. Marketing's role in each of these three business areas can be defined by the work it performs in each. This work can be characterized by a process unique to each. These three processes define how marketing's work links the strategic, tactical and operational areas in a closed-loop fashion.

The method to guide marketing strategic work is called IDEA (Identify, Define, Evaluate and Activate). The approach for tactical work is called UAPL (Understand, Analyze, Plan and Launch) and the method to direct marketing's operational work is called LMAD (Launch, Manage, Adapt and Discontinue). The methods just described are product/service specific and are useful for commercialization of the projects. Each of these processes features distinct phases in which sets of tasks are completed. Each task can be enabled by one or more tools, methods or best practices that give high confidence that the marketing team will develop the right data to meet the task requirements for each phase of work. Marketing processes and their deliverables must be designed for efficiency, stability and most importantly, measureable results and hence the importance of Six Sigma. Therefore, the phases discussed in IDEA, UAPL and LMAD processes ensure measurable results that fulfill any company's requirements.

### 3. DMAIC Philosophy of SSM

Like in any Six Sigma project, we often calculate the performance evaluation through initial sigma level or capability analysis and set goals accordingly for each process, for further improvement. A balanced scorecard is then prepared to visualize and monitor the improvement and manage the resources to market and sales. A scorecard must track the right information to be useful to a data-driven marketing leader. Taking the time to determine the critical marketing risk accrual requirements defines the appropriate information to design into and track in a scorecard. The requirements may vary based on the tools, tasks and deliverables. Through a scorecard a marketing professional can address the issues like brand equity, customer equity/loyalty, target markets and return on investment (ROI), etc. Below, we discuss the phase tools and deliverables for a better marketing process.

### 3.1. Define

This phase involves the defining and clarifying customer requirements (both internal and external). Those requirements then get translated and parsed into supplier (or technical) specifications. Here, each specification becomes a deliverable and gets assigned to the person accountable for producing the deliverable. The necessary activities to complete that deliverable get defined; the appropriate support tools are identified. Finally, all these steps are summarized in a project plan according to the agreed-on methodology, and it moves to marketing professionals for their comments and approvals.

Marketing creates predictable streams of revenue growth by enabling the organization to profitably identify and secure new customers, and to keep and grow the value of these customers. Key ingredient in this step is for marketing to establish goals and deliverables designed to achieve these outcomes. To fully realize these outcomes, the various marketing functions will need to be integrated to create a comprehensive and integrated workflow process. This integrated workflow process will then need to be mapped. Once these elements are completed, new metrics that tie marketing to the business outcomes must be defined and standardized across the marketing organization, for the purpose of providing insight into performance and facilitating strategic decisions.

### 3.2. Measure

A reliable data is essential for marketing, through which performance can be measured and improvements can be made. The first step in measuring and improving performance is to determine what data exists, where that data is, what data is needed and how to obtain the data. Customer purchase activity, marketing programme results and conversion rates, actual costs for programmes and people, lead quality data and lead cost, win/loss ratios defections that occur in the buying process, etc., are the core details that help professionals to make decisions. The more it is quantified, the better the decision would be.

Investments contribute to the company's ability to achieve its goals and generate profitable revenue. The marketing metrics are contingent upon knowing the business outcomes. It is imperative that the business outcomes be clarified and specified before the marketing metrics are established. Business outcomes may be related to the specific number of customers to be acquired and at what cost, the specific rate of customer acquisition, the specific lifetime value of a customer, customer loyalty, and specifically how quickly customers adopt new products. By knowing the business outcomes, marketing professionals know what objectives they need to achieve and within what parameters. Marketing can now establish the metrics, the performance targets and processes, and measure its performance. Tying marketing metrics to business outcomes forces marketing to transform from a transactional function to a strategic contributor.

Three of the significant marketing quality parameters that need special attention are: critical-to-quality (CTQ), critical-to-cost (CTC) and critical-to-process (CTP). A Six Sigma strategy guarantees to incorporate the customer requirements through these critical parameters and enable the metric for quality assessment performance evaluation. The process measurements also facilitate better planning, organizing, evaluating and controlling the business processes, both qualitatively and quantitatively. With the available measurements, the SSM professionals should establish a baseline performance, which may be the stepping stone for further improvement and progress.

### 3.3. Analyze

The SSM professionals must frequently use seven quality tools (Histogram, Pareto chart, Gantt-Chart, Cause and effect diagram, Failure mode effect analysis, Affinity diagram and Control chart) to have an up-to-date assessment of their marketing processes. Even a normality plot or Box-plot technique for quantitative measurement is a powerful tool for assessing whether the process is under statistical control or not. Performance improvement results from deriving insight through the analysis of the data helps the professionals to validate gaps in requirements versus current metrics with vital causes. Analyzing the data and understanding what it means, facilitates the marketing people to determine the degree of impact it is going to have on the organization, and redesign processes that will improve performance. Further, analysis helps to:

- Prioritize root causes and identify the most contributing one.
- Establish a proper process model in terms of deterministic or probability model.
- Suggest possible relationships and associations between control variables.
- Identify the most contributing input/output variables through statistical analysis.
- Test the significance of various input/output variables.
- Conduct a revised root cause analysis to identify the vital causes.
- Judge the current performance with the customer requirements.

Application of statistical methods and adoption of tools and techniques will enable and empower managers/ administrators for better utilization of resources, enhanced productivity and quality control in manufacturing, automobiles or services sector equally. Besides engineering knowledge and management skills, the analysis skill is also necessary for any Six Sigma Marketing project (Muralidharan, 2015). Knowledge of statistical methods alone does not work many a times. One should also have the supporting tools to substantiate the causes and effects, which is fulfilled through some of the effective management tools: brainstorming, process mapping, failure modes and effect analysis, etc. Analysis leads right into the improve step.

### *3.4. Improve*

The main purpose of applying Six Sigma to marketing is to determine how to improve productivity, performance and processes. Data analysis should result in valuable insights that generate possibilities for improvement. These possibilities for improvement can include enhancements in tools, systems, processes and skills. Even though change is disruptive, developing new ways to approach the market enables the marketing organization to play a more strategic role. Hence, the improve phase involves developing solutions targeted at confirmed causes. The objective also extends to verify that the confirmed causes are statistically and practically significant and to optimize the process or product/service with the improvements.

From a micro level, the SSM professionals are capable for suggesting an improvement implementation plan, develop potential improvements or solutions for root causes, develop evaluation criteria, and prioritize solution options for each root cause identified through the improve phase. Further it facilitates to:

- Examine solutions with a short-term and long-term approach.
- Weigh the costs and benefits of 'quick-hit' versus more difficult solution options.
- Select and implement the improved process and metric.
- Measure results and conduct a designed experiment as per the marketing requirements.
- Validate solutions for improvement using statistical analysis.
- Evaluate whether improvements meet targets.
- Evaluate for marketing risk.

It is often found that marketing data involves lot of error variations (noise variation). Hence improving such data by removing the presence of noise variation is a challenge for any improvement. Marketing professionals should work on stabilizing the noise variation using the available statistical techniques. Even professionals can use simulation techniques to create marketing models to understand the characteristics of a process.

The improve check sheets finally lead to the following:

- Prepare a list of innovative ideas for potential solutions.
- Use the narrowing and screening techniques to further develop and quality potential solutions.
- Create a solution statement for at least two possible proposed improvements.
- Make a final choice of solution based on the success criteria.
- Verify the present solution with the anticipated one.
- Develop a plan for piloting and testing the solution, including an action plan, results' assessment, schedule, etc.

- Consider potential problems and unintended consequences of the solution and develop preventive and contingent actions to address them.

### *3.5. Control*

Marketing prides itself on its creativity, viability and feasibility. But, the time has come for marketing to document its processes and best practices and to apply these consistently in order to optimize marketing opportunities. The phases discussed so far, enabled us to identify a viable model and help us to quantify the nature of the relationship between the important variables of the process output. The statistical process-control technique can now be employed with considerable effectiveness for monitoring and surveillance of the process.

Applying Six Sigma to marketing will increase marketing's ability to deliver on:

- Market requirements as per customer's perception.
- Improve the efficiency and effectiveness of the marketing planning process.
- Successfully manage marketing operations.
- Provide transparency into marketing processes.
- Improve the collaboration between marketing and other groups within the business.

We use control chart (both variable and attribute) to track performance over time, evaluate progress after process changes/improvements and focus attention on detecting and monitoring process variation over time. The use of statistical process control also ascertains the repeatability and reproducibility of metrics in an operational environment. It facilitates communications plan of the improvements and operational changes to the customers and stakeholders, prepare implementation and risk management plan, consolidate cost–benefit and change management plan, and establish tracking procedures in an operational environment. Besides setting up control plans for tolerances, controls, measures and standard operating procedures, it also validates in-control process and benefits for process capability, measurement system analysis (MSA) and Gage R&R and documentation.

## 4. Relevance of Supply Chain Metrics in Six Sigma Marketing

Supply chain measurements or metrics such as inventory turns, cycle time, defects per million opportunities (DPMO) and fill rate are used to track supply chain performance. Commonly used Supply Chain Management (SCM) metrics can help you to understand how your company is operating over a given period of time (Mentzer, 2001). SCM can cover many areas including procurement, production, distribution, warehousing, inventory, transportation, customer service like area of logistics. However, a good performance in one part of the supply chain is not sufficient (Pyzdek, 2000). It is important to focus on the key metrics in each area of the supply chain. Tracking the metrics allows one to view the performance over time and guides on how to optimize the supply chain. It allows management to identify problem areas. It also allows for comparison to other companies through industry benchmarking. The supply chain metrics improve the logistics operations in the following ways:

- The first step is to identify the metrics that you want to use. Do not use every metric available. Rather, focus on the vital measurements necessary to your business. These can be considered your key process input variables.
- Next, you need to understand the meaning of these metrics. It is not enough for management to simply view these measurements; they must also understand the meaning behind them.
- The next step is to learn the mechanics behind the measurements. What drives them positive and negative? Try to understand the various factors that influence your results.
- Using this information, identify weakness or areas of improvement in your current processes.
- Set goals based on these improvement areas. The goals should be aggressive, yet obtainable. Goals can be based on benchmarking against like companies or goals can be set to reflect a specific percentage improvement over past performance.
- Put corrective action in place to improve your processes. Make sure that these corrective actions do not negatively affect other areas. Also, check that all affected areas have a clear understanding of the changes.
- Monitor your results. Did your corrective actions yield your desired results? If so, what is your next area for improvement? If you did not get the desired results, what went wrong? Try to identify the root cause of your undesired results.

An effective SSM goes along with an effective SCM. To understand the pulse of the market and the customer behaviour pattern, these two should work in tandem with each other. All Six Sigma projects are generally marketed as per the sigma level of the process or project. It is not mandatory to use the sigma scale for this. Besides Sigma, DPMO and Yield, there are other valid ways to express and measure the performance of a process or product/service. One can also use methods like control charts and process capability indicators, for these purposes.

Some of the 'logistical' issues that surround Six Sigma marketing measures are:

- Establish guidelines for Six Sigma measures to be applied effectively across an organization—to ensure consistency.
- Six Sigma measures are not 'static'. As customer requirements change, Sigma performance will also change. It will be a good idea to continue calculating with the old requirement, simultaneously with the new requirement, at least for some time. This will make transition smoother and the project team will be judged fairly for their work.
- Set priorities on what can and should be measured. No one should expect accurate Sigma performance data for every part of a company in a short time.
- Sigma measures (or any other method of measures) by itself will not improve the performance. They are just report cards or milestones to show where the company is on its journey towards excellence. To bring about improvement, methods of analysis and tools are required to be used.

One may also see Muralidharan and Neha (2013) and Muralidharan (2015) for further details of SSM performance indicators and the importance of information technology in SSM.

## 5. Conclusions

To make marketing process meaningful, one must play with management by facts. Six Sigma Marketing is therefore strategic in identifying the problem, tactical in understanding the customer requirements and operational in implementing the strategy. Managing with Six Sigma may not be as exciting for some people as traditional management practices. Managing data, facts, measurement, analysis and experiments minimize the politics, power struggles, personality clashes and drama of organizational life. It works better, but mere improved performance does not appeal to some people. Others fear the transparency that data and facts bring to the table. Submitting to the rule of data demands maturity of mind, respect for reality, and dedication to standards (Muralidharan, 2015).

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*Manufacturing still has the greatest multiplier effect, in terms of job creation, of any sector of the economy.*

*– William Clay Ford, Jr*

Feature

# Knowledge, Attitude and Practices: Study on Energy Conservation among Energy Consumers in the State of Himachal Pradesh

ALOK KUMAR MITTAL, NIKHIL PANCHBHAI AND SUNIL KUMAR

*The government is developing and implementing many innovative programmes as a policy measure to promote energy efficiency and energy conservation in different sectors of Indian economy. These policy measures face challenges and issues in promoting and implementing their objectives. The policy programmes may be focused in right direction if the policy-makers are aware of the knowledge, attitude and practices prevalent among energy users. This paper aims to identify these three parameters in the state of Himachal Pradesh. We also review the energy saving consumption and energy saving potential in Himachal Pradesh. This paper aims to ignite interest among policy-makers, researchers, energy service companies, appliance manufacturers and other pertinent stakeholders. The learnings gained from this study will be useful for the policy-makers in designing and implementing effective energy policy measures.*

*Alok Kumar Mittal, Deputy Director, National Productivity Council, New Delhi, India.*

*Nikhil Panchbhai, Deputy Director, National Productivity Council, New Delhi, India.*

*Sunil Kumar, Director, National Productivity Council, New Delhi, India.*

## 1. Introduction

Energy is one of the vital ingredients for the economic growth and development of any region. Energy consumption is an indicator of economic growth of a country. Energy is scarce and expensive yet indispensible in order to improve the living standard of the vast population of a developing country like India.

Energy being scarce, its conservation has become a crucial necessity with the widening gap between its demand and availability. Energy saving is vital in this context for India through improving awareness and attitude of people across the use spectrum. The national and state governments are formulating the energy policy for different catogories of consumers in India. However, formulation of right policy depends upon existing 'knowledge', 'atttitude' and 'practices' (KAP) of various consumer categories in the area of energy conservation. It becomes imperative to study KAP of consumers to take a feedback to align energy conservation and efficiency strategies in the right direction.

Globally, several studies on KAP have been conducted in health industry to know KAP of people for better prevention and treatment of existing diseases (Kibret and Abera, 2012, Meena et al., 2013, Mpazi and Mnyika, 2005, Rizwan et al., 2015, Shah et al., 2011, Siow and Sani, 2011, Unusan, 2007). However, no such study has been found in case of energy management in India. As a part of its endeavour to create energy awareness in Himachal Pradesh and improve energy conservation scenario, Directorate of Energy, Himachal Pradesh sponsored a survey to identify KAP of consumers in the state.

## 2. Objectives

The objectives of this research study are:

- To collect and analyze baseline data reflecting level of awareness, attitude and practices of energy conservation aspects across the state.
- To bring in energy conservation and energy efficiency techniques to the centre-stage among key energy consumer categories and create an energy conservation mindset among them.
- To assess the impact of current programmes being run by the State Designated Agency (SDA) in Himachal Pradesh in the area of energy efficiency and energy conservation.
- To suggest key recommendations based on the findings of the present survey to SDA to align its energy policy framework in the right direction to achieve the set goals.
- To assist SDA in formulating a strategy for effective implementation of policy measures.

## 3. Research Methodology

The research study followed the standard 'Knowledge, Attitude and Practices' (KAP) methodology (Kaliyaperumal, 2004). KAP methodology is normally used to measure the level of awareness and adoption of knowledge across the respondents and its use or impact on their daily life on issues of vital importance such as health, energy, etc. The degree of KAP in turn measures the depth and spread of a particular type of information or knowledge, their attitude and the extent to which it is practiced in its application with respect to a particular category of respondent or community.

The three key notions, the KAP study measures are 'knowledge', 'attitude' and 'practice' among the participants. The knowledge possessed by a community refers to their understanding of any given topic, such as energy in the present case. Attitude pertains to their feelings towards this subject, as well as any preconceived ideas that they may have towards it. Practice refers to the ways in which they demonstrate their knowledge and attitude through their actions. Understanding the levels of these three notions will enable a more efficient process of awareness creation as it will allow the programme to be tailored more appropriately to the needs of the users.

The study was conducted for two categories of consumers, viz. industry and domestic consumers. A structured survey questionnaire was separately prepared for respondents of these two categories. Experts on the domain subject were consulted while preparing the questionnaire. Industrial consumers were divided in large, medium and small sub-segments. The household consumers were further segregated in rural and urban sub-categories. Table 1 lists the number of respondents

**Table 1: Distribution of Respondents among Different Categories in Survey Region**

| S. No. | Districts | Industry (Large & MSME) | Households (Rural) | Households (Urban) | Total |
|---|---|---|---|---|---|
| 1 | Solan | 85 | 10 | 5 | 100 |
| 2 | Sirmour | 35 | 10 | 5 | 50 |
| 3 | Una | 25 | 5 | 5 | 35 |
| 4 | Kangra | 10 | 5 | 5 | 20 |
| 5 | Shimla | 6 | 5 | 5 | 16 |
| 6 | Bilaspur | 10 | 10 | 5 | 25 |
| 7 | Hamirpur | 4 | 10 | 5 | 19 |
| 8 | Online data | 10 | 10 | 5 | 25 |
|  | Total | 185 | 65 | 40 | 290 |

*Source:* NPC (2013) "Energy conservation awareness survey using knowledge, attitude and practices (KAP) methodology for different categories of consumers in the state of Himachal Pradesh".

surveyed in each category in all the districts. While all the large industries were covered in the survey region, small and medium industries were picked randomly for the survey. The consumers from the other categories were also picked up randomly.

The present KAP study was conducted in the geographic region of seven districts of Solan, Shimla, Una, Kangra, Sirmour, Bilaspur and Hamirpur in Himachal Pradesh during October 2012–January 2013. These seven districts also consisted of industrial areas of Baddi, Nalagarh, Parwanoo and Solan. The domestic consumers were present all over the seven districts.

### 4. Results and Discussion

The responses were recorded using the specific questionnaire for each category of consumers. The results of survey on three notions of 'knowledge', 'attitude' and 'practices' are separately summarized and discussed below for each category.

### *4.1. Knowledge*

Oxford dictionary defines the word 'knowledge' as (i) facts, information and skills acquired through experience or education; (ii) the theoretical or practical understanding of a subject. The knowledge of respondents about energy efficiency and energy conservation issues also makes them adopt the energy efficient technologies and best practices in the area. The data collected in the survey is analyzed separately for each category in this section to bring out the awareness of the consumers on energy conservation issues.

#### *4.1.1. Industrial Consumers*

The survey attempted to gauge the general awareness of various schemes being run by many agencies on energy conservation apart from the general energy efficiency and energy conservation issues. It was astonishing to know that a few of the respondents in industry segment also expressed their unawareness about any of the schemes. As expected, the large industries were aware about most of the energy conservation programmes or schemes. It is assumed that since large industries have access to information and knowledge sources, they are aware about the energy conservation programmes and techniques. However, small and medium industries do lack in resources resulting in lack of specific awareness and information.

Table 2 lists the awareness levels of different industry segments towards the specific energy conservation initiatives or measures. About 18 per cent small and medium industry and 52 per cent of large industrial consumers were aware about the star rated

**Table 2: Analysis of Awareness Data among Industrial Category**

| S. No. | Energy Saving Initiative or Measure | %age of Aware Large Industries | %age of Aware Small and Medium Industries |
|---|---|---|---|
| 1 | Star rated products | 52 | 18 |
| 2 | Electricity Act 2003 | 52 | 30 |
| 3 | Energy saving companies | 64 | 11 |
| 4 | Energy Auditors and Energy Managers on payroll | 24 | 4 |
| 5 | Leakage of steam and condensate | 60 | 14 |
| 6 | Latest insulation materials and technology | 72 | 41 |
| 7 | Thermography camera applications to find hot spots | 56 | 6 |
| 8 | Improved power factor | 100 | 65 |
| 9 | Star rated energy equipment and motors | 64 | 29 |
| 10 | Variable Frequency Drive | 92 | 33 |

*Source:* NPC (2013) "Energy conservation awareness survey using knowledge, attitude and practices (KAP) methodology for different categories of consumers in the state of Himachal Pradesh".

industrial products. It is seen that 52 per cent of large industries were aware about the electricity act; whereas 30 per cent of small and medium industries were aware about it. BEE has initiated the energy efficiency interventions in selected 25 SME clusters to encourage the energy efficient technologies and operational practices in SME sectors in India. It is appealing to know that only 16 per cent of SME units were aware of these schemes, though the schemes were meant for SME clusters itself. It shows that extra efforts from SDA and BEE are required to publicize the BEE schemes among SME clusters.

It was found that only 25 per cent respondents were aware of the PAT scheme. It may be attributed to the low presence of designated consumers in HP. Designated consumers present in HP are mainly from the cement sector. The SME clusters in the surveyed region included mostly pharmaceutical and light engineering industries. The analysis of the data collected shows that awareness about the energy conservation programmes of BEE is low in HP.

Energy Service Company (ESCO) and Energy Auditors and Energy Managers are two major stakeholders in the success of energy conservation efforts of the government. The survey also attempted to identify the state of awareness of industrial respondents on ESCO and Energy Auditors and Managers. It was found that 64 per cent of large industries were aware of the concept of ESCO and were willing to implement energy conservation projects with the help of ESCOs. However, 89 per cent of small industries were not aware of the benefits of ESCO. It shows that though the government has been able to pave a path for ESCOs to strengthen energy conservation initiatives in large industries, more efforts are required to create awareness in small and medium industries. About 76 per cent of the large industries surveyed did not have energy auditors or energy managers on their payroll. As anticipated, about 96 per cent of the small industries did not have in-house energy auditors or energy managers on their payroll. The availability of in-house skills would improve the energy conservation initiatives of the industries.

The survey revealed that 84 per cent of large units could achieve a significant monetary savings during the last 2–3 years, however, the case was not as encouraging for small and medium units. Only 49 per cent small and medium industries accepted that thay had some significant monetary savings during the same period due to energy conservation measures. Low awareness among industries about the energy conservation measures discussed during survey may also mean limited scope of these energy conservation initiatives and measures in those industries.

To address the barrier of limited knowledge available to Small and Medium Enterprises (SMEs) sector, BEE has initiated the energy efficiency interventions in selected 25 SMEs clusters during the XI plan. BEE assessed the energy use and technology gap at the unit level for development of the cluster-specific energy efficiency manuals, preparation of Detailed Project Reports (DPRs) on energy efficient technologies and capacity building and knowledge enhancement of man-force involved in SMEs. This scheme would increase awareness of energy efficiency issues in SME clusters, however, the results are yet to be seen.

#### *4.1.2. Domestic Consumers (Rural and Urban Households)*

In Himachal Pradesh, the annual electricity sale to domestic sector is 1050 MU which accounts for 21 per cent of the total electricity sold. The domestic sector electricity consumption varies with respect to rural and urban segments and climatic seasonal variations. In the domestic sector, major use of electricity is towards lights, fans and domestic appliances. In this section, a brief inference of the knowledge/awareness on energy conservation across the two categories of the respondents viz. rural and urban households is illustrated.

Highlights of the inferences drawn from the survey are given in Table 3. It is found that as expected urban domestic consumers are more aware of the energy consumption and energy conservation issues in most of the quarters. However, it is interesting to know that the rural consumers also have good knowledge of related basic notions.

Campaigning in urban area through various media options has worked out positively in favour of creating awareness related to energy conservation and efficiency related issues. However, it is assumed that appearance of advertisement in local languages in local media will create more awareness among the masses.

### *4.2. Attitude on Energy Conservation*

Oxford dictionary defines the word 'attitude' as a settled way of thinking or feeling about something. The attitude of a respondent also expresses its willingness towards adoption of best practices in the area. This section assesses the attitude of the respondents of two consumer categories towards the energy management, energy conservation and efficiency issues.

**Table 3: Highlights of Analysis of Awareness Data for Domestic Consumers**

| S. No. | Description | Awareness Level | |
|---|---|---|---|
| | | Rural | Urban |
| 1 | Switching off power sources of electrical appliance saves electricity | 61 | 97 |
| 2 | FTLs have more advantages than bulbs | 56 | 90 |
| 3 | FTLs have longer life than bulbs | 24 | 35 |
| 4 | Advantages of electronic chokes | 10 | 28 |
| 5 | Benefits of CFL over bulbs | 47 | 92 |
| 6 | CFLs have longer life than bulbs | 27 | 65 |
| 7 | Savings by electronic regulators in ceiling fans | 32 | 65 |
| 8 | Longer life of LEDs as compared to bulbs/CFLs | 4 | 20 |
| 9 | Awareness on Bachat Lamp Yojna | 41 | 42 |
| 10 | Awareness on solar lamp scheme | 14 | 37 |
| 11 | Awareness on biogas scheme | 11 | 12 |
| 12 | Awareness on LED village campaign | 4 | 2.5 |
| 13 | Relation between global warming and energy conservation | 53 | 93 |

*Source:* NPC (2013) "Energy conservation awareness survey using knowledge, attitude and practices (KAP) methodology for different categories of consumers in the state of Himachal Pradesh".

### *4.2.1. Industrial Consumers*

It was found during analysis of data collected in the survey that large industries are ready for energy conservation measures. About 64 per cent of large industries are ready to implement energy conservation suggestion scheme. However, only 23 per cent of small and medium industries have a positive attitude towards implementing the energy conservation suggestion scheme. Energy conservation scheme is to invite suggestions from the employees to improve the energy performance of an organization. The suggestions from the employees ensure the participation of employees towards improvement of energy utilization in the organization. It has been seen that many large organizations including public sector undertakings such as NTPC, BHEL have implemented the energy conservation schemes. The large organizations also provide recognition or monetary incentive to the best suggestions or ideas collected through this scheme. During survey, it was found that 92 per cent of large industries are willing to give incentive to their employees for best ideas. However, only 23 per cent of small and medium industries are keen towards implementing the scheme and providing the employees with an incentive for best suggestions. While the large organizations keep their employees motivated to contribute in the scheme, the small and medium enterprises have not realized the potential of the suggestion scheme and are in a process of learning from the experience of large organizations.

When asked about the willingness of the industries to adopt expensive energy conservation measures; 100 per cent of large industries and 82 per cent of small and medium enterprises are ready to adopt and implement expensive energy conservation measures. The pilot projects implemented by large industries have demonstrated the benefits of energy efficiency and conservation measures. It gives the industries motivation to put even large-scale projects into operation to reap benefits of energy efficient technologies. Table 4 summarizes the highlights of analysis of attitude data of the industrial consumers collected during the survey.

During survey, it was found that 76 per cent of large industries were keen to conduct energy audits in their plants. In contrast, only 9 per cent of the small and medium enterprises were ready to get an energy audit done in their plants. The energy audits may be conducted by internal or external auditors. BEE as a part of capacity building programme has developed certified energy auditors, energy managers and accredited energy auditing agencies. The large industries have these auditors and managers on their payroll and they conduct energy audits in their own plants. The large plants also have sufficient resources to hire the services of external audit agencies, whereas MSME enterprises find it difficult to retain the energy auditors on their payroll and it is expensive to engage the external auditors resulting into a low frequency of energy audit exercises in MSME units.

Although 54 per cent of respondents from large industries were willing to get ISO-50001 certified, however none of the respondents from MSME sector was interested to get such certification. It also supports the assumption that larger industries are ready to spend resources for energy conservation initiatives. Almost all the industries irrespective of their size have an attitude of participation in energy conservation awards. This shows a tendency of energy conservation in industries through recognition in awards.

**Table 4: Highlights of Analysis of Attitude Data of Industrial Consumers**

| S. No. | Scheme/Parameter | %age of Large Industries with Positive Attitude | %age of Small and Medium Industries with Positive Attitude |
|---|---|---|---|
| 1 | Implementation of energy conservation suggestion scheme | 64 | 23 |
| 2 | Incentive on energy conservation suggestion | 92 | 22 |
| 3 | Willing to adopt expensive energy conservation measures | 100 | 82 |
| 4 | Conduct internal/external energy audits | 76 | 9 |
| 5 | Willing to get ISO 50001 certified | 54 | 0 |
| 6 | Participation in energy conservation awards | 92 | 97 |

*Source:* NPC (2013) "Energy conservation awareness survey using knowledge, attitude and practices (KAP) methodology for different categories of consumers in the state of Himachal Pradesh".

### *4.2.2. Domestic Consumers (Rural and Urban Households)*

The 'attitude' of the domestic consumers related to energy conservation and efficiency issues is explained in this sub-section. Table 5 briefly shows the attitude of the rural and urban domestic consumers. It is seen that urban consumers have a very high positive attitude towards energy conservation as compared to the rural households. Inspite of a strong attitude on importance of energy saving, it is seen that the consumers do not show an inclination to buy star rated appliances. It is assumed that significant

**Table 5: Highlights of Analysis of Attitude Data of Domestic Consumers**

| S. No. | Scheme/Parameter | %age of Rural Consumers with Positive Attitude | %age of Rural Consumers with Positive Attitude |
|---|---|---|---|
| 1 | Importance of energy saving | 58 | 97 |
| 2 | Switching off of electrical appliances when not in use | 58 | 97 |
| 3 | Insistence on buying star rated appliances | 10 | 17 |

*Source:* NPC (2013) "Energy conservation awareness survey using knowledge, attitude and practices (KAP) methodology for different categories of consumers in the state of Himachal Pradesh".

price difference between star and non-star rated appliances is a deterrent towards popularity of such star rated products in Indian market.

### 4.3. Practices

Oxford dictionary defines the word 'practice' as the actual application or use of an idea, belief, or method, as opposed to theories relating to it. It was attempted in the survey to identify the practices prevalent in the consumers of each category related to energy usage.

#### 4.3.1. Industrial Consumers

While the practice of training the workforce on energy management issues is more prevalent in large industries, it is awfully low in small and medium units. It states the fact that the large organizations have attitude and resources to train their personnel, however, concerted efforts need to be taken by the government to design and implement training programmes for smaller units on a collective basis. Table 6 shows the practices of energy conservation prevalent in industrial consumers.

**Table 6: Analysis of Data Collected for Practices Related to Energy Conservation Issues for Industrial Consumers**

| S. No. | Practice | %age of Practicing Large Industries | %age of Practicing Small and Medium Industries |
|---|---|---|---|
| 1 | Training of manpower on energy efficiency and conservation issues | 76 | 13 |
| 2 | Arresting or capturing steam and condensate leakages | 48 | 7 |
| 3 | Use of thermography camera to locate hot spots | 36 | 5 |
| 4 | Use of latest insulation material | 68 | 20 |
| 5 | Adoption of waste heat recovery | 48 | 10 |
| 6 | Use of boilers of suitable size | 48 | 17 |
| 7 | Use of variable frequency drives | 96 | 34 |
| 8 | Use of star rated motors/appliances | 48 | 15 |
| 9 | Generation of compressed air at different pressure | 80 | 47 |
| 10 | Conduct of any energy audit internally or externally in the plant | 44 | 9 |

*Source:* NPC (2013) "Energy conservation awareness survey using knowledge, attitude and practices (KAP) methodology for different categories of consumers in the state of Himachal Pradesh".

It also emphasizes on generating awareness about the benefits of energy conservation measures such as reduced cost of product and enhanced competitiveness among the smaller units. The awareness may be created by organizing focused seminars, conferences and training programmes in the area of energy conservation. Though BEE is running a separate scheme for the SME sector, it has been seen that more efforts are required in this direction to increase energy conservation practices in the SME sector. The increased awareness among the SMEs will result into a practice of training the personnel in SME.

It was found during the survey that steam and condensate leakages are arrested in 48 per cent of large industries and in only 7 per cent of SME units. It is found that the larger industries use thermography camera to locate hot spots as preventive maintenance tool upto a certain extent, however, this practice is almost non-existent in smaller and medium units. Low level of energy practices in certain areas in industrial sector is a result of poor knowledge in those areas.

The manufacturers of insulation material contact the energy managers of the plants and explain the benefit of reduced heat loss with use of good insulation material. As a result of which, 68 per cent of large units are using latest insulation material, however, the penetration of insulation material and technology is low in small enterprises. About 48 per cent of large units are recovering waste heat generated from various equipments such as furnaces. However, only 10 per cent of smaller units are successfully recovering the waste heat generated in the process.

About 48 per cent of large units and 17 per cent of smaller and medium units are producing steam in their plants with suitable size boilers. About 96 per cent of large industries and 34 per cent of smaller units use variable frequency drives to reduce their electricity consumption in motor-driven equipments. Star-rated appliances are more energy efficient. Nearly 48 per cent of large industries and 15 per cent of SMEs use star-rated motors and other star-rated appliances. If compressed air is produced at the pressures as per its use in the plant it results in less energy consumption in air compressions. It is found that 80 per cent large companies and 47 per cent of SMEs generate compressed air at different pressures. More than 90 per cent of SME units never got a formal energy audit conducted by external or internal energy auditors. It is in agreement of the unavailability of certified energy auditors and energy managers on payroll of smaller units, since more than 90 per cent of SME units did not have any energy auditors with them.

The data shows that practice of energy conservation measures in industries is low irrespective of their size. Generally, 50 per cent of large industries practise most of the energy conservation measures in the plants, however, it was found in the survey that only a few smaller and medium units implement the energy conservation measures in practice. Inspite of various schemes and policy measures of the government, the practice is found to be low among industries. This may be attributed to many reasons such as less priority of funds for energy conservation projects, unavailability of knowledge and skills and less awareness among the industrial consumers.

The government has come up with many innovative solutions to overcome the hurdle of funds. One of such programmes, Venture Capital Fund for Energy Efficiency (VCFEE), provides equity capital for energy efficiency projects. The fund provides equity support to specific energy efficiency projects, limited to a maximum of 15 per cent of total equity required, through Special Purpose Vehicles or Rs 2 crores, whichever is less, though the support is provided to only government buildings and municipalities. Earlier, commercial banks were less interested in financing energy efficiency projects because of the risk involved and low credibility. Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE) is a risk sharing mechanism to provide commercial banks with a partial coverage of risk involved in extending loans for energy efficiency projects. Initially the support was provided to only government buildings and municipalities, however, in the twelfth plan it has been extended to cover SMEs and industries too (BEE, 2016).

BEE has started National Certification Programme for Certified Energy Managers and Energy Auditors to make expertise available in country in the field of energy efficiency. It has also been noted that there are more than 20,000 certified energy managers and energy auditors in the country. These energy managers and energy auditors help industries to identify the opportunities available for them and evaluate the energy efficient technologies through cost benefit analysis. There are also more than 100 BEE accredited energy auditors and empanelled accredited energy auditor agencies in the country.

#### *4.3.2. Domestic Consumers (Rural and Urban Households)*

The practices of domestic consumers on energy conservation are discussed in this sub-section. Table 7 briefly lists energy conservation practices across rural and urban domestic consumer categories. There is a stark contrast regarding switching off light and other appliances from point of power source. Where 98 per cent urban consumers switch off the appliances from point of power, only 9 per cent rural consumers follow the same practice. This practice is also in contrast to the attitude shown by 58 per cent rural consumers for this practice.

About 65 per cent of both types of domestic consumers do not open the doors of refrigerators for a longer duration. While 67 per cent of urban consumers use CFLs in place of bulbs, only 33 per cent rural consumers follow the same practice. It could be due to the high cost of the CFLs as compared to bulbs. The number of domestic consumers using the solar water heaters is almost negligible.

It is also found during survey that 65 per cent urban consumers use electronic regulators for ceiling fans. However, only 28 per cent rural consumers use the electronic regulators. Electronic regulators and electronic chokes consume less energy during the operation as compared to conventional devices. Three mandatory star-rated products are available in market for domestic use. Fourth mandatory star rated product is for industrial use. Other star rated products are currently in voluntary stage. Although a good number of domestic consumers are aware of the star-rated appliances and show willingness to use them, the number of consumers actually using them is still not very high. The Indian consumers are price

**Table 7: Highlights of the Analysis of Practice Data of the Domestic Consumers**

| S. No. | Scheme/Parameter | %age of Practicing Rural Consumers | %age of Practicing Urban Consumers |
|---|---|---|---|
| 1 | Switching off of light and other appliances from point of power source | 9 | 98 |
| 2 | Not opening the refrigerators for long duration | 65 | 70 |
| 3 | Usage of CFLs in place of bulbs | 33 | 67 |
| 4 | Use of solar water heater | 3 | 5 |
| 5 | Use of electronic regulators in ceiling fans | 28 | 65 |
| 6 | Usage of a star rated electrical appliances | 63 | 75 |

*Source:* NPC (2013) "Energy conservation awareness survey using knowledge, attitude and practices (KAP) methodology for different categories of consumers in the state of Himachal Pradesh".

conscious consumers and star appliances are expensive as compared to non-star products. This may be one of the reasons that star-rated voluntary products are not much popular among domestic consumers.

## 5. Conclusion

The research study focused on the knowledge, attitude and practices of different categories of energy consumers in the area of energy efficiency and energy conservation aspects in state of Himachal Pradesh. The findings have brought out the subtle issues of insufficient knowledge among energy users, their attitude towards energy conservation and practices being followed in the area of energy conservation. The present section discusses some of the recommendations to be implemented to improve the knowledge, attitude and practices of the energy users in the state.

It is necessary to enhance the knowledge and awareness among energy users related to energy conservation schemes being run by various organizations such as BEE, Ministry of Micro, Small and Medium Enterprises (MSME), Ministry of New and Renewable Energy (MNRE) and state governments. Dissemination of information of energy conservation schemes through print and electronic media by repeated advertisements will be an important step towards generating awareness. Different means of communication such as e-mails, letters, flyers and leaflets from SDA directly addressed to the industries and organizations may be used for the purpose. SDA may also prepare an FAQ consisting of do's and don'ts on energy conservation measures in bilingual, latest technologies and products along with their benefits. These FAQs may also be circulated among users through different channels such as web, e-mails, local radio channels and cable TV.

SDA may form a panel of ESCOs and publish this list on its website to create awareness of ESCOs among industries. The list should be updated on a regular basis with the information of the projects completed or being executed by the ESCOs. Similarly, information in form of a list consisting of contact details of all the energy managers and energy auditors may be uploaded on SDA website. This will enable the management to access the certified energy managers and energy auditors for the expertise to identify the energy conservation opportunities in their organizations. SDA together with industry associations may organize demonstration workshops, exhibitions and fairs displaying the energy conservation products and technologies for all the stakeholders including, but not limited to, business promoters, industries, equipment manufacturers, service providers and end users. The communication established between SDA and end users will improve the knowledge, awareness, attitude and practices of energy users in the state.

SDA may start an energy conservation awards scheme on the similar lines of BEE's awards scheme. Large organizations and MSME enterprises may be given awards based on reduction of their specific energy consumption. Individual energy consumers may also be awarded according to their contribution in making the energy schemes popular among masses. Recognition of these awards may be made highly useful in terms of availing the bank loans for the organizations and promotion in career growth for individuals.

Tax incentives may be introduced for the energy efficient equipments and technologies. The introduced tax incentives would encourage the MSMEs for major investment to adopt the energy conservation measures. ISO 50001 (Energy Management Systems) implementation in MSMEs may also be subsidised motivating them to adopt best energy conservation practices. The monthly electricity bills may be used as a channel to advertise energy conservation tips for the energy users.

Although the energy users in the state of Himachal Pradesh are broadly conscious energy consumers, however, the present KAP survey specifically identified the knowledge, attitude and practices of different type of end users. The research study also outlined some initiatives required to be taken by SDA to improve the knowledge and attitude of the energy consumers in the state. These initiatives when taken into consideration by the policy makers while making the policy measures will steer the energy conservation programmes of the government in the right direction.

## Acknowledgement

As a part of its endeavour to create energy awareness in Himachal Pradesh and improve energy conservation scenario, Directorate of Energy, Government of Himachal Pradesh sponsored a survey to identify KAP of energy consumers in the state. The survey was conducted during the period October 2012–January 2013, and subsequently report was submitted to the Directorate of Energy, Government of Himachal Pradesh.

## Disclaimer

This research paper is based on the survey sponsored by Directorate of Energy, Government of Himachal Pradesh. The survey was conducted by National Productivity Council, New Delhi during the period October 2012–January 2013. Neither the Directorate of Energy, Government of Himachal Pradesh nor the National Productivity Council, New Delhi is responsible for any discrepancy in data.

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> *"Data is of course important in manufacturing, but I place the greatest emphasis on facts."*
>
> *– Taiichi Ohno*

# Changing Manufacturing Scenario: India *vis-à-vis* Select Countries

RAJESH SUND

## Introduction

Manufacturing's share in the global GDP has been stable for more than 50 years. As per the UNIDO Industrial Development Report 2016, the three largest manufacturing exporters in the Developing and Emerging Industrial Economies (DEIEs)—China, Mexico and India, accounted for 62.1 per cent of the total of the country group in 2013, up from 55.3 per cent in 2000, indicating a rapid growth of larger economies and an increasing gap with the smaller economies.

The growth of globalization over the period 2001–11 has indeed been a process of structural change, with different parts of the world specializing in different broad sectors. Manufacturing and market services play the leading role at a global level, but resources play a very important role in some parts of the world. Resource-based growth is important to Sub-Saharan Africa, India and Middle East and Northern Africa. The China–developed nations' economic relationship is very manufacturing-intensive in both directions.

The sectoral composition of world manufacturing value added (MVA), the dominant global manufacturing industries were food and beverages (12.0 per cent), chemicals and chemical products (11.7 per cent) and machinery and equipment (8.5 per cent). Between 2000 and 2013, eight manufacturing sectors registered an increase in their MVA share worldwide, from a combined 39.7 per cent to 46.6 per cent. Significant increase was recorded in the manufacture of radio, television and communication equipment; basic metals, chemicals and chemical products; and motor vehicles, trailers and semi-trailers. The increase in basic metals was driven mainly by the rapid growth in MVA of DEIEs, as well as country investments in infrastructure. A decline was observed in 14 manufacturing sectors, from a combined 60.3 per cent in 2000 to 53.4 per cent in 2013, including traditional industries such as textiles, wearing apparel, fur and wood

*Rajesh Sund, Deputy Director (Economic Services), National Productivity Council, New Delhi.*

products and paper and printing. Manufacture of fabricated metal products and machinery and equipment also witnessed a decline in their share in the manufacturing structure.

The dependence on developed-country markets is expected to weaken as some of these economies move towards more advanced manufactured exports. The three largest manufacturing exporters in the DEIE group—China, Mexico and India—accounted for 62.1 per cent of the total of the country group in 2013, up from 55.3 per cent in 2000, indicating a rapid growth of larger economies and an increasing gap with the smaller economies. About 58 per cent of the world's manufactured exports consist of medium- and high-tech products such as chemical machinery and equipment, communications equipment and motor vehicles. The high-tech sector reached its peak, 25 per cent in 2000, and fell to 20 per cent in 2013. This could be due to the high investment risk in the sector, which can hold markets back. While the export share of low- and medium-tech products fell during 2000–13, the share of resource-based goods increased from 17.8 per cent to 23.7 per cent. The increasing size of the middle class in industrialized and developing countries has generated higher demand for processed food.

Together, the five biggest manufacturing exporters within the DEIEs—China, Mexico, India, Thailand and Brazil—contributed almost 25 per cent of the global manufactured exports in 2013, up from 10.5 per cent in 2000. The share increased in Brazil and Mexico at the beginning of the century but they too have experienced a decline in the recent years. Among the five, only India managed to raise its level and share of manufacturing employment, from 35 million in 1991 to more than 56 million in 2014, largely explained by increased openness to trade and rising labour productivity. As can be seen from Table 1, manufactured exports per capita of India increased almost

**Table 1: Competitive Industrial Performance of Select Countries**

| S. No. | Country | Manufactured exports per capita (current $) | | Manufactured exports share in total exports (per cent) | | Impact of a country on world manufactures trade (per cent) | |
|---|---|---|---|---|---|---|---|
| | | 2008 | 2013 | 2008 | 2013 | 2008 | 2013 |
| 1 | Brazil | 691.7 | 766.8 | 67 | 63.4 | 0.01 | 1.21 |
| 2 | China | 1,020.40 | 1,540.50 | 95.8 | 96.6 | 0.12 | 16.83 |
| 3 | France | 8,371.40 | 7,724.40 | 88.1 | 87.6 | 0.05 | 3.92 |
| 4 | Germany | 15,427.80 | 15,504.20 | 87.7 | 87.9 | 0.11 | 10.11 |
| 5 | **India** | **132.90** | **223.30** | **85.8** | **83.1** | **0.01** | **2.20** |
| 6 | Indonesia | 353.90 | 438.80 | 60.5 | 60.1 | 0.01 | 0.86 |
| 7 | Japan | 5,675.60 | 5,163.50 | 92.5 | 91.8 | 0.06 | 5.18 |
| 8 | Malaysia | 5,148.30 | 6,201.90 | 70.7 | 80.7 | 0.01 | 1.45 |
| 9 | Philippines | 500.00 | 495.60 | 92.1 | 90.3 | 0.00 | 0.38 |
| 10 | Russian Federation | 1,228.10 | 1,532.10 | 37.7 | 41.5 | 0.02 | 1.73 |
| 11 | Singapore | 32,535.60 | 32,285.90 | 89.8 | 89.8 | 0.01 | 1.52 |
| 12 | South Africa | 1,016.90 | 1,208.90 | 69.1 | 67 | 0.00 | 0.50 |
| 13 | Sweden | 17,803.40 | 15,530.80 | 89.4 | 88.7 | 0.01 | 1.17 |
| 14 | Switzerland | 23,620.40 | 25,700.80 | 90.1 | 90.6 | 0.02 | 1.64 |
| 15 | Thailand | 2,253.10 | 2,998.60 | 84.8 | 88 | 0.01 | 1.58 |
| 16 | United Kingdom | 4,525.10 | 2,314.10 | 18.6 | 10.6 | 0.00 | 0.17 |
| 17 | United States | 6,051.80 | 2,844.50 | 77 | 76.3 | 0.03 | 1.42 |

*Source:* UNIDO, Industrial Development Report.

70 per cent from 2008 to 2013. Although India's impact on the world manufacture trade has shown substantial jump from negligible 0.01 per cent in 2008 to 2.20 per cent in 2013, however, it is not much when compared to China which has risen to 16.83 per cent from 0.12 per cent during the same period.

Among the top five, China's share in world MVA increased by almost 3.5 times over the period 1990–2014, compared to India's share which has risen only about 10 per cent (Table 2). China's manufacturing industry has been the largest sector in the country and accounted in 2015 for one-third of GDP, India's one-sixth. Although China and India improved their DEIE group share, the other three of the five faltered, particularly Brazil.

Cross-country comparisons of average annual growth rate of GDP, manufacturing GDP and manufacturing labour productivity for the 10 select Asian countries and the US are shown in Tables 4–6, for the period 2000–14. Asia enjoyed more vibrant growth than the US in all sectors, as shown in Table 5. It is notable that the US was more directly affected by the global financial crisis of 2008–09 than Asia. Japan was the slowest growing economy and Myanmar the fastest growing, India and China are the leader countries in Asia. Table 6 presents cross-country comparisons in labour productivity growth by industry for the period 2000–14. China and India have emerged as the driving force propelling Asia forward. The importance of manufacturing as a contributor to the overall labour productivity growth has been a major contributor in India in its recent development process.

**Table 2: Manufacturing Value Added Share of the Five Largest Countries**

| Countries | 1990 | 2000 | 2014 |
|---|---|---|---|
| China | 15.80% | 32.10% | 51.30% |
| India | 5.70% | 6.20% | 6.40% |
| Mexico | 10.90% | 10.20% | 5.00% |
| Brazil | 12.20% | 8.50% | 4.40% |
| Turkey | 5.20% | 4.80% | 3.60% |
| Other developing and emerging industrial economies | 50.20% | 38.20% | 29.30% |

*Source:* UNIDO, Industrial Development Report.

**Table 3: Manufacturing Value Added (% of GDP)**

| Countries | 1990 | 2000 | 2010 | 2015 |
|---|---|---|---|---|
| Brazil | .. | 15.27 | 14.97 | 11.40 |
| China | 32.30 | 31.78 | 31.54 | .. |
| France | 17.69 | 15.73 | 11.25 | 11.23 |
| Germany | .. | 22.98 | 22.19 | 22.81 |
| India | 16.16 | 15.31 | 17.47 | 16.24 |
| Indonesia | 22.27 | 27.75 | 22.04 | 20.84 |
| Japan | 25.93 | 20.45 | 18.94 | .. |
| Malaysia | 24.22 | 30.86 | 23.43 | 22.79 |
| Philippines | 24.83 | 24.47 | 21.44 | 20.06 |
| Singapore | 25.58 | 27.75 | 21.36 | 19.81 |
| South Africa | 23.64 | 19.17 | 14.38 | 13.22 |
| Sweden | 21.05 | 22.98 | 18.59 | 17.00 |
| Switzerland | 20.67 | 18.47 | 19.19 | 17.96 |
| Thailand | 27.20 | 28.59 | 31.09 | 26.92 |
| United Kingdom | 17.50 | 14.68 | 9.99 | 9.77 |
| United States | .. | 15.51 | 12.45 | .. |
| Russian Federation | .. | .. | 14.82 | 14.16 |
| World | .. | 19.17 | 16.71 | .. |

*Source:* World Development Indicators.

**Table 4: Average Annual Growth Rate of GDP at Constant Market Prices**

(%age)

| Countries | 2000–05 | 2005–10 | 2010–14 | 2000–14 |
|---|---|---|---|---|
| China | 9.4 | 10.7 | 7.8 | 9.6 |
| India | 6.5 | 7.8 | 5.7 | 6.2 |
| Thailand | 5.3 | 3.7 | 3 | 4.2 |
| Indonesia | 4.9 | 6.2 | 5.5 | 5.0 |
| Malaysia | 5.2 | 5.0 | 5.2 | 5.9 |
| Singapore | 4.8 | 6.5 | 4.4 | 5.9 |
| Korea | 4.6 | 4.0 | 3.0 | 5.1 |
| Philippines | 4.5 | 4.8 | 5.7 | 4.3 |
| Japan | 1.2 | 0.3 | 0.7 | 0.9 |
| Myanmar | 12.1 | 10.7 | 7.4 | 8.8 |
| US | 2.5 | 0.8 | 1.9 | 2.4 |

*Source:* APO Productivity Database.

**Table 5: Average Annual Growth Rate of Manufacturing GDP at Constant Market Prices**

(%age)

| Countries | 2000–14 |
|---|---|
| China | 10 (3.2) |
| India | 8.7 (1.3) |
| Thailand | 4.1 (1.2) |
| Indonesia | 4.6 (1.0) |
| Malaysia | 3.9 (1.0) |
| Singapore | 4.8 (1.2) |
| Korea | 5.6 (1.6) |
| Philippines | 4.6 (1.0) |
| Japan | 1.4 (0.3) |
| Myanmar | 16.8 (2.3) |
| US | 1.0 (0.2) |

*Source:* APO Productivity Database.

**Table 6: Average Annual Growth Rate of Manufacturing Labour Productivity**

(%age)

| Countries | 2000–14 |
|---|---|
| China | 7.6 (2.8) |
| India | 8.2 (1.2) |
| Thailand | 3.7 (0.9) |
| Indonesia | 2.1 (0.6) |
| Malaysia | 3.8 (1.0) |
| Singapore | 3.6 (0.9) |
| Korea | 5.7 (1.6) |
| Philippines | 3.5 (1.0) |
| Japan | 3.2 (0.6) |
| US | 4.0 (0.4) |

*Source:* APO Productivity Database.

*Source :*

•https://www.unido.org/fileadmin/user_media_upgrade/Resources/Publications/EBOOK_IDR2016_FULLREPORT.pdf

•http://databank.worldbank.org/data/download/site-content/wdi-2016-highlights-featuring-sdgs-booklet.pdf

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