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Unfolding Industrial Output: A Study of India's Formal Manufacturing Sector

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ABSTRACT

Investigation of economic development and growth has been at the forefront of economic research (Denison 1962; Barro' 1996). The idea of focusing on the industrial sector to drive economic growth has been a global phenomenon. The process of economic growth has been supplemented with several structural changes that an economy goes through. The mainstream literature predicts that the opening up of the economy increases the exports of commodities based on the economy's comparative advantage. One of the principal questions that the paper attempts is to examine whether the openness of the Indian economy resulted in the expansion of the share of export-oriented industries and the reduction of import-competing industries' share in manufacturing output. The analysis uses rich granular-level data on the Indian formal manufacturing sector. Furthermore, the analysis of structural changes requires looking not only at the growth rate over a particular period but also at the cumulative increase in growth of the sector according to different activities which may be labour or capital-intensive. The paper using cluster-based analysis decomposes manufacturing growth into labour and capital-intensive activities and brings out important aspects on how the manufacturing output is been produced. The pattern of capital intensity of Indian manufacturing firms shows that firms have systematically witnessed an increase in capital intensity. Factors such as incentives in the form of subsidies, and reduction in tariffs on capital goods made access easier to adopt advanced technology. Also in today's globalised world, the pressure on domestic firms to remain competitive both in the external and domestic markets created grounds for adopting the latest (more capital-intensive) techniques.

Keywords

capital intensity; cluster analysis; export orientation; gross value added; import competing

JEL Codes: L16; L52; O14

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INTRODUCTION

Since a long, investigation of country's economic development and growth has been at the forefront of economic research (Denison, 2012; Barro & Sala-i-Martin, 1992). The process of economic development has been characterised by several structural changes the economy goes through. Kuznets and Murphys' (1966) work on a country's long-term economic development pattern concluded that an essential element of modern economic growth relates to the rising share of the manufacturing sector in Gross Domestic Product (GDP). Empirical studies conducted on economic growth in the past century re-emphasised that manufacturing sector was considered as the engine of economic growth for a long period (Cornwall & Cornwall, 2002; Thirlwall, 2006). The rationale behind this thought was the fact that productivity in manufacturing is usually higher than in other sectors such as agriculture or services. Hence, any increment in the growth of manufacturing sector provides a boost to the average productivity of an economy. The Indian manufacturing sector, since independence, has also been considered as a dynamic sector in county's development, whether in terms of economy's structural transformation or creation of a skilled workforce.

One of the oldest debates in economic literature focuses on the link between the liberalisation of the economy and industrial performance. On one hand, the proponents of liberal trade regimes argue that there is a positive impact of economic reforms on the performance, efficiency, and output of the manufacturing sector. A common inference that can be derived from the literature surveyed is that a country's pattern of specialisation and industrialisation is influenced to a great extent by the degree of openness of the economy (Lloyd & MacLaren, 2000; Weiss, 2002; Jayanthakumaran, 2002; Srinivas, 2014; Tejani, 2016). Various authors have concluded that industrial output is greatly influenced by the economy's trade policies, export promotion, trade opening, import protection and business climate (Ghose, 2000; Kniivilä, 2007). Studies conclude that trade reforms have contributed to tremendous export growth in the East Asian manufacturing sector (Fischer & Rotemberg, 1994; Shafaeddin, 2005, 2012). This export growth, in turn, was supported by rapid growth in the industrial supply capacity and up-gradation of the industrial base (Shafaeddin, 2005, 2006). On the other hand, there is research that indicates that openness of the economy leads to greater import penetration in the economy and hence depresses the share of import-competing industries in total output (Bakht et al., 2002; Ghose, 2000, 2016; Sen, 2008; Yunus & Yamagata, 2014). Further, research argue that trade openness and globalisation can impact the economy and result in relocation of resources in different ways. Early research based on the argument of easy mobility of capital resource over labour conclude that globalisation and trade tend to favour capital over labour (Rodrik, 1997).

The Indian economy over the years has undergone significant changes in planning strategies since independence. Soon after independence, India adopted a mixed economy strategy, with a principal focus on self-reliance. The trade policies were framed to focus on the adoption of import substitution and export pessimism as the underlying trade strategy. External trade liberalization, which was seen as a shift away from strategies based on the import substitution, was initiated from the mid-1980s but a key impetus was established with the introduction of the "New Economic Reforms". With the Indian policy commitment to support industrial development, the 'Make-in-India' initiative introduced in 2014 and start-up India programme aims to provide new boost to manufacturing sector and brand India as a major manufacturing hub in the global market. These initiatives under the scheme have further strengthen India's growing integration with the Asian international production networks across manufacturing sectors (Aggarwal & Chakraborty, 2022).

In terms of structural transformation over time, India represents as one of the best illustrations which has seen a rapid expanding service sector along with a stagnant manufacturing sector (Djidonou & Foster-McGregor, 2022). Assessing structural change requires estimating the relative growth different sectors. Clark (1940) and Kuznets (1955) argued that structural shifts in the output in an economy will always accompany a sustained and rapid growth of per capita output (Mazumdar, 2008; McMillan & Rodrik, 2011). The recent industrial economics literature mentions that structural transformation can be seen in terms transition of an economy from lower productivity activities to higher productivity modern activities (McMillan & Rodrik, 2011; Lin, 2011; Szirmai, 2013; Naudé et al., 2015). Such structural change could happen, not necessarily in terms of the shift from one sector to another, but within the broadly defined sectors, for instance, within the manufacturing or services sectors. Therefore, understanding heterogeneity among different industries at a more detailed level provides insights on structural change. India being labour abundant economy, it was expected that with new economic reforms and with removal (at least in part) of existing distortions in factor and capital markets, production structure would tend more towards labour-intensive sectors, and hence would result in expansion in labour-intensity across the board in Indian manufacturing sector (Das & Sengupta, 2015). With growing globalisation and integration the question that confront us today is the following: Does the comparative advantage theory still holds in the case of India and what has been the pattern of factor intensity in case of Indian manufacturing a sector.

This study thus examines whether the opening up of the Indian economy resulted in an improvement of output share contributed by export-oriented industries. The theory of comparative advantage postulates that the opening up of the economy has a positive effect on abundant factor-intensive industries[1] (in this case, labour). This suggests that the openness of the economy will increase the demand for a good in which country has an advantage and hence the supply capacity and derived demand for abundant (Ghose 2000; Goldar 2002; 2009) factors should increase (Milner & Wright, 1998; Greenaway et al., 1998; Lall, 1999; Goldar, 2009). However, a key assumption in the model pertains to the use of similar technology across economies. New trade theory, which accommodates economies of scale and technological differences, formulates that trade openness might result in multiple equilibria which will decide whether openness has a positive impact on the good using the abundant factor or not (Grossman & Helpman, 1990). Nevertheless, the literature recognises that the H-O model provides important insights into the issues related to the specialisation of goods traded. In the case of India being a developing and labour-abundant country, it is anticipated that labour-intensive industries will contribute more to value addition (Ghose, 2000, 2005; Goldar, 2002; Bhattacharjea, 2006; Hasan et al., 2007; Kapoor, 2018, 2020). This study, therefore, analyses the relative importance of labour-intensive and capital-intensive industries in terms of value addition. Using the conceptual framework for clustering of groups, the study examines the changes in the formal manufacturing sector based on factor intensity.

DATA DESCRIPTION

The study focuses on the Indian formal manufacturing sector and hence the primary data is collected from Annual Survey of Industries (ASI) sourced from the Ministry of Statistics. The survey includes all manufacturing firms which employ more than 10 workers using power and firms with more than 20 workers not using power. Also, firms that employ greater than 100 workers (categorized as "census firms") are surveyed each year, on the other hand, smaller firms are randomly sampled every year. Literature notes that "the ASI firm-level data is fairly of high quality and covers a much larger subset of Indian producers than other comparable datasets such as Prowess" (Martin et al., 2017; Orr, 2019). The time period considered for the analysis is from 1990 to 2015-16. Additionally, during the considered period for the study, the survey classifies industries using three industrial different classifications. To ensure data compa-

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[1] This theory is popularly known as Heckscher Ohlin theory - "H-O model"

rability industries are classified as per the classification of National Industrial Classification 1998 (NIC 1998). The rationale behind the choice of industrial classification is as follows: the difference between the classification of industries according to NIC 1998 and 2004 is minuscule; however, for NIC 2008 the ASI reports do not provide any information on what proportion of the 4-digit industry in 2008 contributes to some other industry (as classified in NIC 1998). For instance, according to NIC-2008, 1311 (spinning textile) is mapped as 1711(p) + 1713(p) but no further information on the disaggregation of these codes or the proportion is provided by the ASI. The study constructs a mapping for industries according to NIC 2008 and NIC 1998 based on the assumption related to the importance of value-added of that industry in total value-added.

In addition, it may be noted that the survey provides data for different industries based on the current price. Appropriate price deflators are used to convert the nominal values into real values. In order to do so, all the monetary values given in the study have been adjusted for 1993-94 prices by deflating the variables using the price index (WPI) at a specific industrial level group.[2] The data on WPI at the sectoral level is provided by the Office of the Economic Advisor. Thus, the study constructs a one-to-one mapping of NIC classification and WPI for each industry according to economic activity. Also, information on trade and tariff data at the 6-digit level is accessed from World Integrated Trade Solutions (WITS), WTO-TAO, Commodity Trade Statistics Database (COMTRADE). In order to make the trade data comparable, industry and trade data are harmonized using one to one correspondence of International Standard Industrial Classification (ISIC) codes and NIC. Also, the trade data is converted using US dollar INR exchange rates published by RBI.

RESULTS AND DISCUSSION

The analysis of structural changes requires looking not only at the rate of growth over a particular period, but also at the cumulative increase in growth of the sector according to different activities which may be labour or capital-intensive (Nübler, 2014). Decomposing manufacturing growth into labour and capital-intensive activities brings out important aspects of how the aggregate manufacturing output is been produced. The questions are rather of significant importance for a country like India which is characterised as a labour surplus economy. Indian policymakers in the past

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[2] The choice of 1993-94 as base year for prices was a matter of convenience as it is one of the middle years on which the earlier series of national accounts were based. NIC 1998 was the base year for industrial grouping. Note that for industries where WPI product groups were not comparable with NIC industry groups, weighted average of manufacturing group was used for that particular industry.

and also in the present have undertaken reforms focusing on strengthening labour-intensive industries. For instance, apart from sector specific reforms, the Government in the Foreign Trade Policy 2015-20 increased the export incentives by 2 per cent for labour-intensive and MSME sectors. The recent policy District as Export Hubs (DEH) scheme focuses to convert each district into a manufacturing and export Hub by identifying products with export potential in the district.[3] However, with the growth in exports and output from a policy perspective, it is critical to assess whether the output produced by the manufacturing sector is dominated by labour-intensive or capital-intensive activities.

Labour abundant economies, particularly major Asian countries like Japan, Taiwan, Korea, and China, adopted economic trajectories focusing on export-oriented policies. The extent to which industrial policies such as subsidies or tariffs have supported the late industrialisation success stories like South Korea, Taiwan or more recently China have been well debated (Amsden, 2001; Cherif & Hasanov, 2019; Lane, 2021).The success stories of these economies indicate the possibility of leveraging the integration of a labour surplus economy into the world economy to accelerate industrialisation. Structural transformation in these economies led to pulling out surplus labour from agriculture to manufacturing, with the strong momentum in growth driven by labour-intensive industries in the early stages of expansion. With global production fragmentation, these economies have not only experienced steady expansion but have moved up in the global supply chains with the increased technological sophistication of their manufactured goods.

The mainstream literature predicts that the opening up of the economy increases the exports of commodities based on the economy's comparative advantage. Traditional trade theory within the Heckscher–Ohlin–Samuelson (H-O-S) framework posits a well-defined correlation of factor intensities of commodities, factor endowment of a country and the specialisation of production/trade flows. According to the theory, an economy's production and exports would be relatively more for a product that uses abundant factors more intensively than the other factor. Accordingly, the model predicts that developing countries which are characterised by an abundant labour supply than developed countries should specialise in the production of goods which are labour intensive, in which they have a comparative advantage. Seminal work by Schott (2003, 2004) and Hummel & Klenoew (2005) supports the old trade theory of

[3] Ministry of commerce report on District as Export Hubs, https://commerce.gov.in/wp-content/uploads/2021/03/Devolping-Districts-as-Export-Hubs.pdf

trade specialisation and provide evidence related to product specialisation (Heckscher-Ohlin model). Research predicts that economies with high wages produce and export high-quality commodities compared with low wages economies even at a granular product category.[4] Recent research examine the change in product and labour market conditions as openness results in redistribution of resources. Maiti (2019) concludes that openness in case of India, explain a part of the sharp decline in the labour share of Indian formal industries from around 30 per cent in 1980 to less than 10 per cent in 2014. Using semi-parametric approach, empirical evidence shows there is a decline in labour bargaining power, along with a rise in mark-up which explain the gradual decline in labour share.

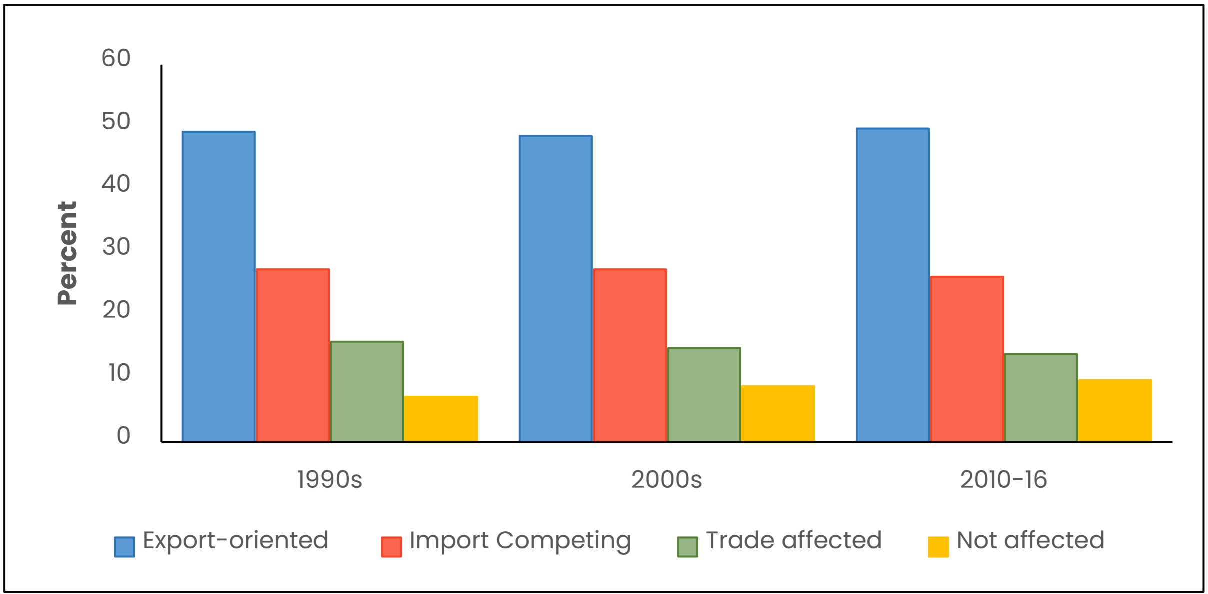
In the case of economies abundant in capital and skill tend to have better productivity and charge higher prices for their products. Schott (2004) provides evidence that a country's factor endowment plays a crucial role in the determination of the product variety mix. It is expected that with trade openness there will be an expansion in the country's exports, and hence the contribution by export-oriented industries in the manufacturing sector would surge. On the flip side, opening up the economy leads to greater import penetration in the economy and hence depresses the share of import-competing industries in total output (Ghose, 2000; Sen, 2008; Yunus & Yamagata, 2014). This impact is generally quoted in the literature as the scale effect. In this context, the study classifies industries into four categories – export competing, import-competing, trade affected, and industries not affected, by using the ratio of net exports to value-added for each industry which is deflated using WPI.[5] The industries with positive ratios throughout are considered export-oriented, industries with negative ratios are taken as import-competing industries, trade-affected industries are those that were import-competing and over the years have come under the category of export-oriented (or vice versa) and the remaining industries are labelled as not affected.

[4] Schott (2003) provides evidence that the high wage economies are abundant with endowments to add more features or improve quality compared to a low wage economy.

[5] The methodology adopted in the study to classify industries is in line with the research by Goldar (2002) and Ghose (2000).

Figure 1

Share in real gross value-added for different categories of industry



Source: Calculation using data provided by ASI data

Figure 1 reveals that the contribution by export-oriented sectors in aggregate value-added has slightly increased. However, in line with the literature, there was a small drop in the share of import-competing industries with greater import penetration in the economy (Ghose, 2000; Sen, 2008; Yunus & Yamagata, 2014). The share of these industries declined marginally from about 27.5 per cent in the initial years of reforms to 26.2 per cent in 2010/16. The share of trade-affected industries (those that were import-competing and over the years became export-oriented, or vice versa) showed average shares of gross value-added of around 15 per cent. Interestingly, the movement of trade-affected industries shows that the direction of industries is around the same for import-competing and export-oriented industries. Industries such as dairy (152) and auto components (343) eventually turned export-oriented, even as their share in total value-added increased (Annexure Table A.1). However, on the other side beverages (155), domestic appliances (293), watches and clocks' (333) share in value addition increased marginally or declined over the period. These industries have shifted to import-competing from export-oriented, due to growing consumption demand in India.

However, the performance of export-oriented industries at a disaggregated level after the 1990s was mixed. Industries such as food products (154), spinning, weaving and finishing of textiles (171), tanning and dressing of leather, manufacture of luggage, handbags, saddlery and harness (191) showed declines in their shares of gross value-added. Others export-oriented industries registered improvement in their shares, such as other textiles (172), knitted and crocheted fabrics and articles (173), wearing apparel, except fur apparel (181), manufacture of other chemical products (242), rubber product (251), plastic products (252), other fabricated metal products (289), transport equipment n.e.c. (359).

The share of gross value-added in import-competing industries fell over time both at aggregate and disaggregated levels. Some industries that witnessed sharp declines in their contribution to value-added include paper (210), publishing (221) basic chemicals (241), electric motors, generators and Transformers (311), television and radio transmitters etc. (322), railway etc. (352), aircraft and spacecraft (353). There was a decline in bank credit in industries such as paper, chemical, and metal products during 2002 compared to 1991 (RBI, 2003). In the case of the chemical industry, there has been a huge decline in production as a result of large imports from other economies such as China during 2007-12 (Government of India 2012). A similar trend was observed in the case of television and radio (322); aircraft spacecraft (353) (Chaudhuri, 2013). However, there were a few industries such as electricity distribution and control apparatus (312), insulated wire and cable (313), other electrical equipment n.e.c. (319), electronic valves and tubes and other electronic components (321), which registered (relatively small) increases in the share of values added. One of the possible reasons for the increase could relate to an increase in demand by the automobile industry and telecom infrastructure as the electric machinery industry supply some intermediate products to these sectors.

The data described above show that the contribution by export-oriented sectors has increased during the recent period, and they include some non-traditional labour-intensive sectors. On these lines, a key question arises about the performance of labour-intensive and capital-intensive industries in the Indian formal manufacturing sector. According to Krueger (1997) in a labour surplus economy, labour will shift away from a less productive sector, say agriculture, to a more productive sector, manufacturing. In this process, during the initial phase of economic growth, there will be a huge expansion of labour-intensive industries. One of the key expectations from Indian economic reforms was not just improving efficiency but also increasing labour intensity. A question that arises is whether the trade openness led to changes in output in favour of labour-intensive industries.

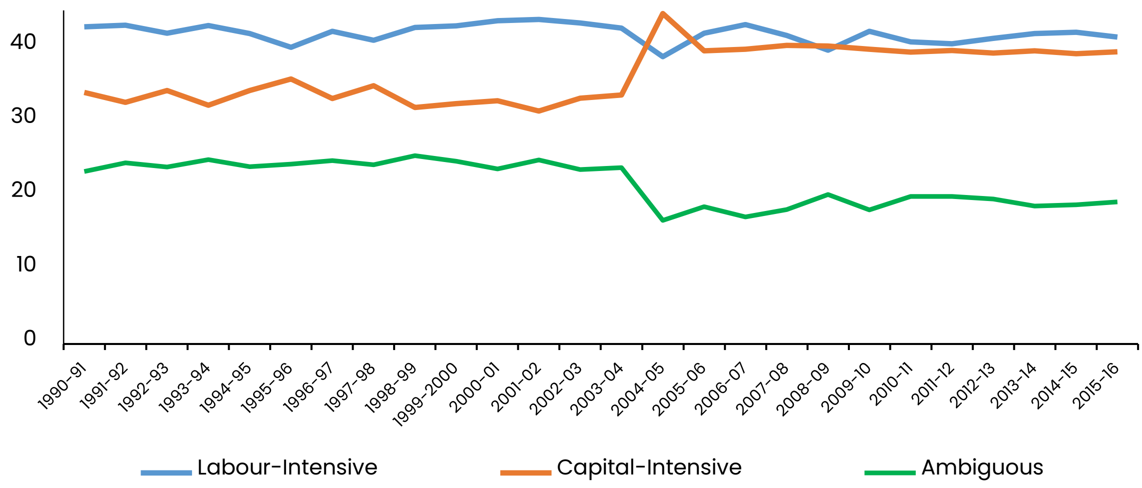
In order to examine this question, the industries are classified based on the capital intensity of an industry which is defined in terms of the ratio of real fixed capital (K) to total persons engaged (L).[6] Capital intensity is calculated at three-digit (NIC 1998)

[6] Fixed capital reported by ASI is the depreciated value of fixed assets owned by the factory on the closing day of the accounting year. These values are deflated by the Wholesale Price Index for machinery and equip-

level for each year from 1990-91 to 2015-16. A particular industry is categorised as labour-intensive in the case where capital intensity is lower than the trimmed means[7] for the manufacturing sector throughout the period and industries above the trimmed mean for each year are labelled as capital-intensive.[8] The remaining industries are classified as ambiguous.[9]

Figure 2

Share in gross value-added (%)



Source: Calculation using data provided by ASI data

On this basis, out of 56 three-digit (NIC-1998) industries, 23 labour-intensive industries were identified, 16 capital-intensive industries and the remaining 17 industries were labelled as ambiguous. **Figure 2** shows that over a quarter-century the labour-intensive industries' contribution to the aggregate gross value-added has remained constant at around 42 per cent. However, in the case of these labour-intensive industries the growth momentum registered a decline in the recent period, which is reflected in the contraction of their share in gross value-added to as low as 38.8 per cent

ment. On the other hand, ASI defines "total persons engaged as workers (both directly employed and employed through contractors), employees other than workers (supervisory, managerial and other employees) and unpaid family members/proprietors etc."

[7] Trimmed mean has been taken as a measure to calculate the average K/L ratio of manufacturing sector in a particular year which is not sensitive to the presence of extreme values of outliers on either side of the data and hence is robust measure against the outliers in contrast to the simple average which is highly sensitive to outliers.

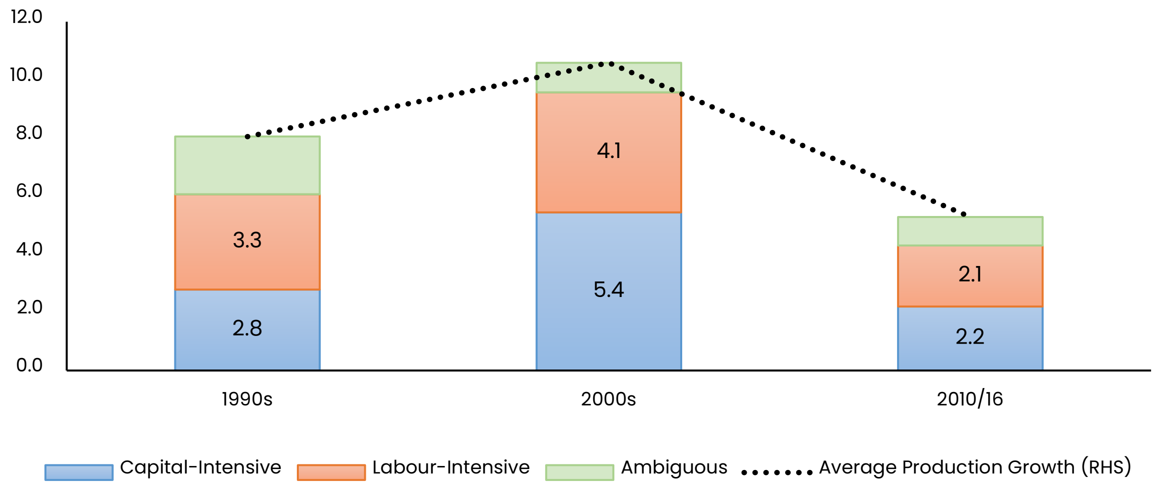
[8] On comparison of capital intensity ratio one can clearly identify a given industry as less or more capital intensive. However, the challenging task is to categorise these groups into capital and labour intensive sectors. One needs to set a threshold of capital to labour ratio which invariably requires some degree of arbitrariness.

[9] Ambiguous category contains those industries which are above mean in a particular year and then below the mean in the next year or vice-versa

during the mid-2000s. Interestingly, there was a surge in the share of capital-intensive industries in manufacturing sector production particularly in the last decade, reaching as high as the level of labour-intensive industries (**Figure 2**). Capital-intensive contributed 34 per cent of the manufacturing sector's gross value-added during 1990-91, whereas this contribution reached nearly 40 per cent during 2015-16. The greater role of capital-intensive industries is also evident in their average relative contribution to the overall average growth of the manufacturing sector.

Figure 3

Relative contribution to GVA growth



Source: Calculation using data provided by ASI data. Values in percentage points

The influence on growth is evident in **Figure 3** wherein the contribution by capital-intensive industries increased in comparison with other industries in the 2000s. The formal manufacturing sector grew at a rate of 8.1 per cent during the 1990s, out of which the labour-intensive sectors contributed 3.3 per cent of the growth. However, in the 2000s, the growth in the manufacturing sector value-added was majorly driven by capital-intensive industries and the labour-intensive industries' relative contribution increased to just 4.1 per cent (**Figure 3**). Thus, capital-intensive sectors became crucial for India's formal manufacturing sector, particularly during the 2000s. This is contrary to the finding one would forecast in the case of India being a large labour-abundant developing country. In this context, one may examine how the capital intensity of different sectors changed over time. There can be alternative ways of setting an empirical benchmark for conceptualising the changes in capital intensity of industries. The study categorises industries using K-mean clustering algorithm[10] for an arbitrary grouping, using capital intensity as the underlying parameter. The key intuition behind the methodology is that the distribution of capital usage across industries is different, so the clustering algorithm will group industries which are similar in terms of the parameter. One can interpret the cluster methodology as a method to identify how many industries use capital-intensive technology and whether there has been an increase in the usage of capital over time. Nevertheless, it may be noted that this does not necessarily differentiate industries using similar capital-intensive technologies. The study extends the k clustering based on industry data on average capital intensity (K/L) that has been used during the 1990s and 2000s.

The first preliminary step to use K-mean clustering is to identify the number of clusters in which these industries can be partitioned. Alternatively, this means that the clustering algorithm requires input on the number of clusters (k) before the initialization of the algorithm K-means. To get the range of possible groups and to determine the optimum number of clusters, the study uses "elbow plot" which provides preliminary information on the number of clusters at which algorithm stability is achieved. The objective is to identify the number of partition groups where each industry is assigned to a particular single cluster and each cluster is attached to at least one industry. In particular, the optimal partition plots aim to minimize the sum of squared errors (SSE) between the capital/labour ratio and the mean of the ratio for each industry group.

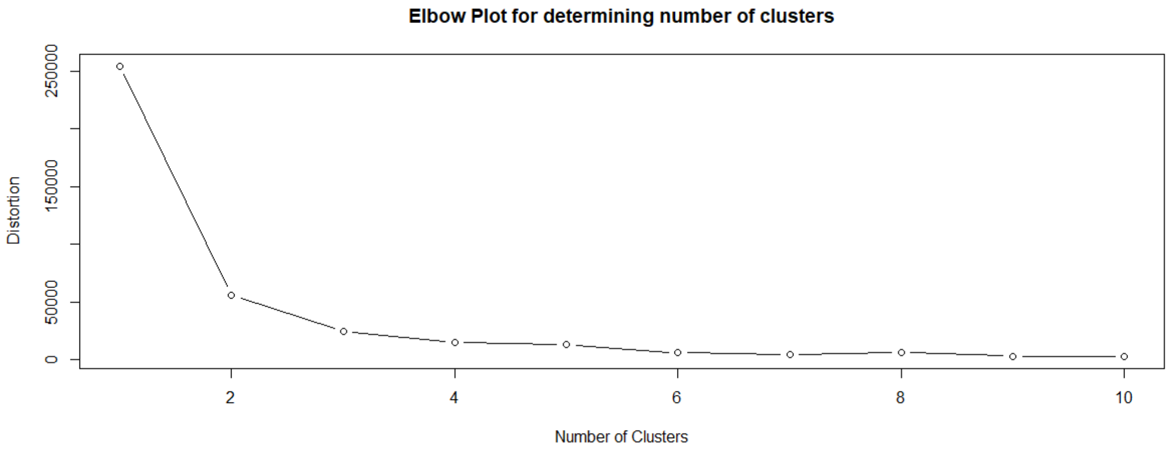
The purpose is to recover the total number of clusters within the manufacturing sector. The elbow plot methodology works by identifying different k-means clustering on the provided capital intensity database for a range of values of k (in the figure from 1 to 10), and for each value of k calculate the sum of squared errors (SSE). Importantly, it may be noted that here k represents the number of clusters. **Figure 4** depicts the curve representing the within-cluster sum of square error i.e. SSE for each respective number of clusters (k). The goal of the methodology is to distribute industries in such a way that the SSE is minimized. The cluster analysis is based on certain underlying assumptions. The first assumption is that the partitioned firm's capital intensity is closest to the average capital intensity for its cluster. Secondly, the optimal number of clusters depends not only on SSE being minuscule but also the cluster

[10] K-means clustering is one of most widely used unsupervised machine learning algorithm which divides a given dataset into k clusters. Where k represents the pre-defined number of distinct non-overlapping clusters. To the extent possible, the resultant intra-cluster data points are similar while clusters are different.

number should be small. Based on these assumptions, it is considered that an appropriate number of clusters in the plot is given at a point where the plot bends (it looks like an "elbow"). This elbow represents that increasing the number of cluster beyond this point would make a little difference. In **Figure 4**, after k=3 the SSE seems to stabilize and move towards zero hence the study will divide industries into 3 clusters. One of the key benefits of this cluster analysis relates to the fact that the method a priori does not require the number of specific clusters present within the sector, rather the methodology itself recovers and provides the optimal number of clusters after detecting the dispersion of capital intensity across industries.

Figure 4

Elbow plot-cluster

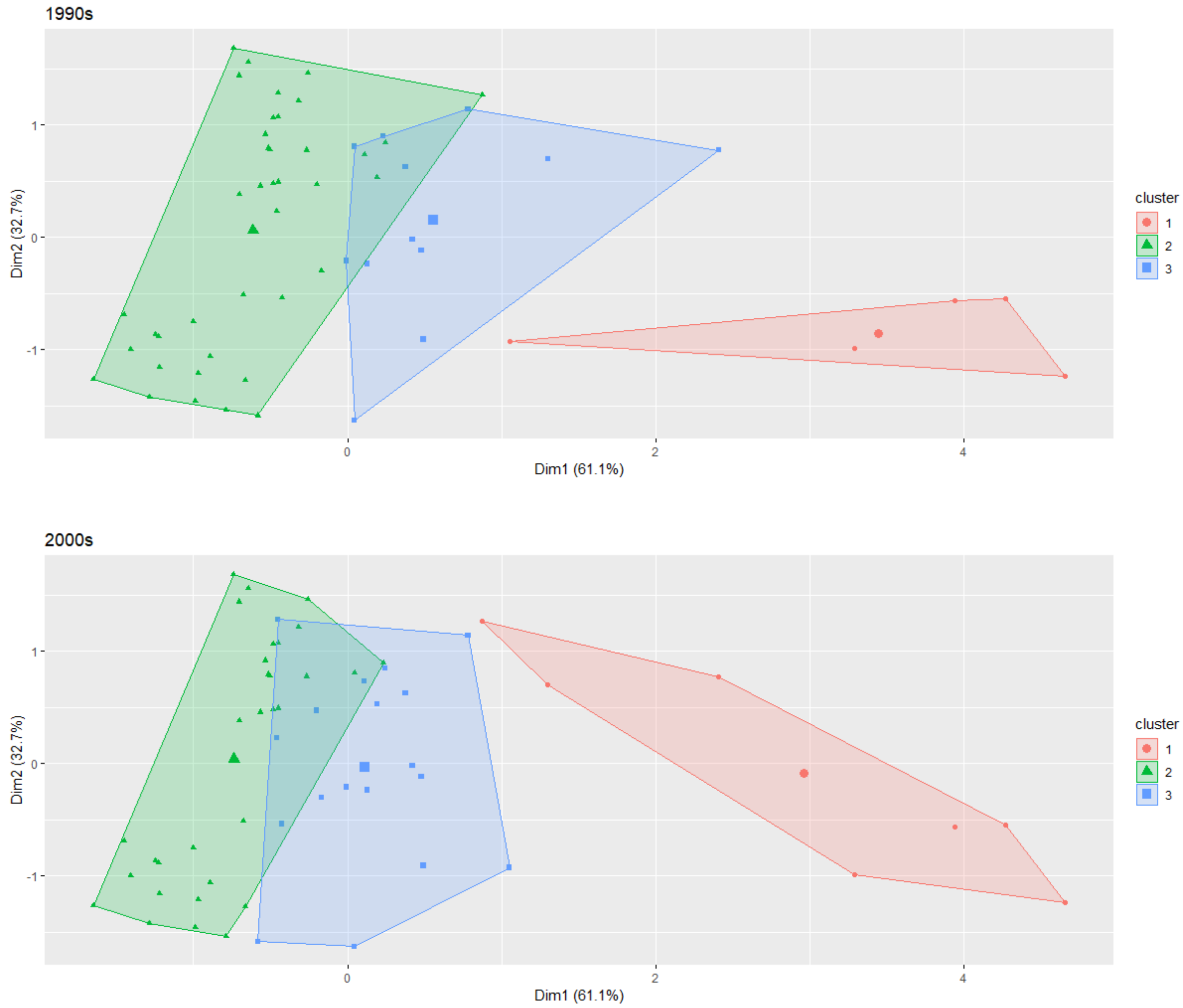


Source: Calculations on R using data provided by ASI.

After determining the optimal number of clusters within the manufacturing sector, the study partition the group of industries and recover the clusters, each of which consists of industries where the mean capital intensity is similar. Figure 5 provides information on the K mean plot which recovers 3 clusters in such a way that there is some gap in the placement of distribution between industries in one cluster compared to industries in some different cluster based on capital intensity. The intuition behind K means is to group industries which are similar within a cluster and ensure that the clusters are distinct such that the partitioning does not allow a single industry to be in multiple clusters.

Figure 5

Industries clusters based on capital intensity



Source: K-mean clustering based on ASI Data

Table 1

Summary of results

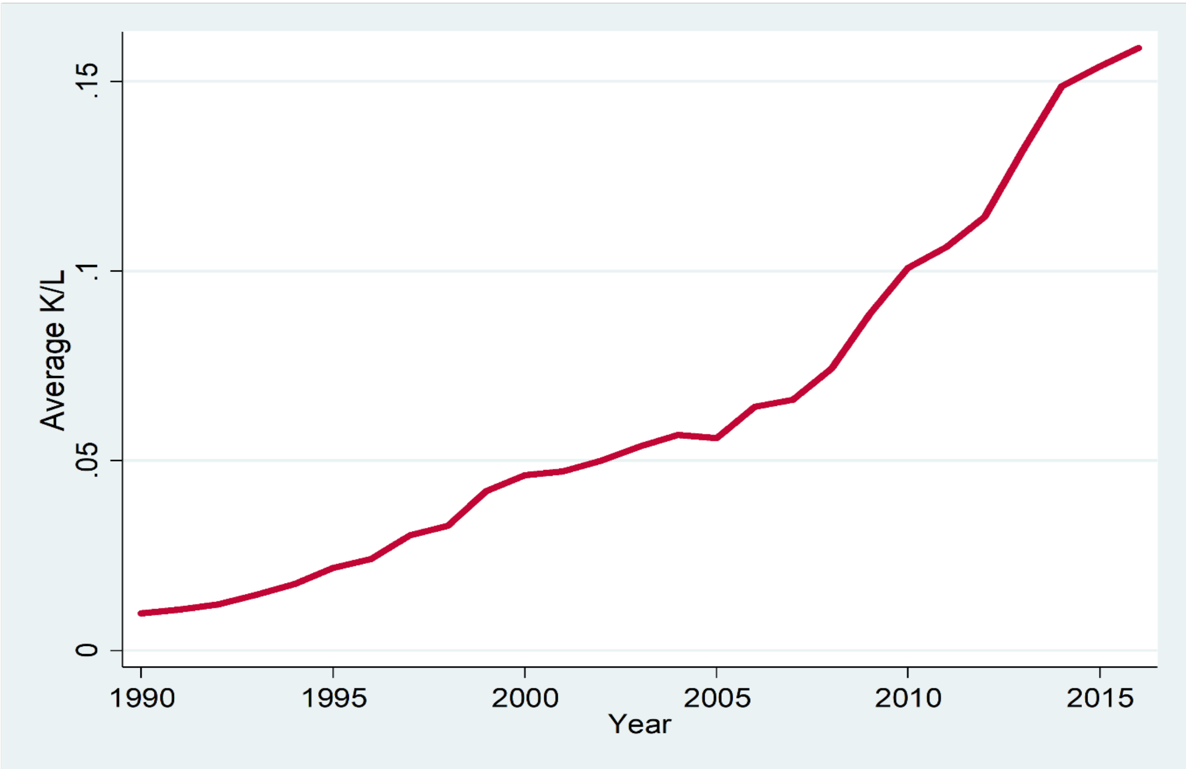
Cluster (K)	K means (1990s)	Number of In-dustries	K means (2000s)	Number of In-dustries	K means (2000)/K means (1990s)
Cluster 1	0.09	5	0.29	7	221.76
Cluster 2	0.01	39	0.045	31	243.29
Cluster 3	0.03	12	0.10	18	175.76

Source: K-mean clustering based on ASI Data

Table 1 reports the summary statistics of k mean clustering. As the clustering is based on capital intensity, a higher k means value reflects that the cluster industries have higher capital to labour ratio and a lower value means that the cluster has a higher usage of labour compared to capital. Interestingly the k- mean results postulate that in terms of numbers of industries during the 1990s and 2000s most of these were grouped in the 2nd cluster and then in 3rd cluster. A piece of important evidence provided in **Figure 5** and **Table 1** is that for each cluster, the average mean capital-labour ratio has significantly increased in all three clusters. This means that the average capital intensity of the Indian formal manufacturing sector has gone up in the 2000s compared to the 1990s. Not only were the means higher in the 2000s compared to the 1990s, but also there was a shift of industries between clusters. For example, about 6 industries in cluster 2 shifted to cluster 3 and 2 industries moved to cluster 1 as a consequence of high usage of capital input over labour. **Figure 6** depicts that the capital intensity for the overall organized manufacturing sector has increased over a quarter of a century (1990-91 till 2015-16). This contrasts with the clustering-based approach on capital-labour usage, which confirms the finding that the average capital intensity of production has risen not only for capital-intensive industries but also for labour-intensive industries.

Figure 6

Average Capital Intensity in Manufacturing Sector



Source: Calculation using data provided by ASI data. Here 1990 depicts 1990-91, 1995 as 1995-96 and so on.

In the case of India, a recent study finds that the Indian manufacturing sector utilizes greater capital-intensive techniques during the production process in comparison with economies at a similar developmental level and alike factor endowments (Hasan et al., 2007). Studies point out that with greater import penetration, the elasticity of substitution of labour with respect to all other inputs also increases. So, in other words, a trade might lead to a relative change in the labour requirements to produce a given output, which is known as the “substitution effect” (Rodrik, 1997; Feenstra, 2007). One obvious explanation behind the greater utilisation of capital-intensive techniques is that the process of globalisation generates greater external competition, which creates pressure on domestic firms to adopt the latest techniques in production in order to remain competitive to cater to both external and internal demand. The composition of both domestic and external demand shifts towards commodities which require higher usage of capital-intensive technologies hence creating incentives for firms to shift away from labour to capital-intensive techniques and creates a ‘demonstration effect’ (Chandrasekhar & Ghosh, 2007; Patnaik, 2009). During the post-reform period, several incentives were also provided to industries in the form of a sharp reduction of tariffs (Annexure Figure A.1) of capital goods, interest subsidy, and cheap electricity by the Government, which increased access to and affordability of capital-intensive techniques. The above analysis provides evidence that manufacturing firms are shifting towards more capital usage relative to labour. Empirical evidence based on both the input intensity and trade-based classification together implies that value-added by capital-intensive manufacturing has grown faster than remaining industries in aggregate.

CONCLUSION

Since the economic reforms of the 1990s, important changes have taken place in the Indian formal manufacturing sector. This paper documents changes by examining the export and import-competing industries' growth over time. A comparison of the post-reform output growth performance of export-oriented and import-competing industries reveals that the real value-added in the post-reform period was higher in the export-oriented industries than in the import-competing ones, which is in line with the literature. At a disaggregated level, there was a mixed experience, as a few export-oriented industries registered considerable increases in their share, while some registered declines in their share of manufacturing value-added. On the other hand, the share in manufacturing value-added of import-competing industries decreased considerably in most of the sub-sectors.

Economic Reforms were expected to not just provide productivity gains but also to benefit labour-intensive sectors. India being a labour-abundant country, it was expected that opening up of economy would lead to a higher contribution in output by labour-intensive sectors relatively. Therefore, the paper examined changes in industrial structure in terms of the growth of labour- and capital-intensive industries. It was found that the importance of capital-intensive industries in terms of contribution to value-added has become stronger. Further, the pattern of the capital intensity of the manufacturing sector using cluster analysis on granular level data shows that the relative usage of capital to labour rose not just in capital-intensive sectors but sharply increased for other industries too. The important question pertaining to output growth towards more capital-intensive products away from traditional labour-intensive sectors is, whether this growth is sustainable in the long term for a labour-abundant economy like India. This finding provides a starting point for future research question to examine long-run relationship of factor prices, productivity and output in case of Indian manufacturing sector.

With China occupying less space in labour-intensive sectors now, India has opportunity to expand its exports particularly in labour intensive sectors. Policy makers in order to accelerate exports and production of labour-intensive sector exports, are formalising new labour laws both at national and sub-national level. With evolving dynamic comparative advantage, there should be systematic efforts to improve the skill of the labour force with the aim to work with complex and advance technology.

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ANNEXURE

Construction of Capital Stock Series for India

The measurement of capital stock in the literature of growth accounting is one of the most crucial and controversial variables. There has been persistent dispute among economists on the nature of capital and the appropriate method of its measurement (Hulten, 1991). There is an important difference related to capital and labour as input where the former is a produced and durable input for production. It is necessary to differentiate between the value of using or renting capital in any given year and the value of owning the capital asset if a capital good is durable because it is productive for two or more time periods. Durability means that a capital good is productive for two or more time periods (Hulten, 1991; Harper, 1999). There has been vast literature related to capital input estimates for growth accounting (Miller, 1989; Feenstra et al., 1992; Barro, 1999; Aghion & Howitt, 2007; Hsieh & Klenow, 2010) in particular on the Indian economy (Abbas & Mujahid-Mukhtar, 2000; Viswanath et al., 2009; Goldberg et al., 2010; Nin-Pratt et al., 2010; Das, 2016).

Studies have most widely used the 'Perpetual Inventory Method' (PIM) for measurement of capital stock. This particular method provides information on capital estimates by utilising the information on investments flows (Balakrishnan et al., 2000; Mueller, 2008; Berlemann & Wesselhöft, 2014). However, it may be noted that there is variation in the approach for measurement of capital input that uses capital stock using perpetual inventory in many respects. Some differences include choice over utilising gross versus net capital stock, the benchmark year considered for initial capital stock calculation, land treatment recognised as a capital good, assumptions for depreciation and difference in estimating investment price deflators. Further studies differ even in the way they define investment and capital. While on one hand studies have recognised fixed capital in terms of book value, other hand studies have also utilised the information related to working capital or overall productive capital or gross fixed capital at replacement cost.

The present study utilises the PIM for construction of capital stock and follows the methodology used in previous studies (Trivedi, 1970, 1975; Ahluwalia, 1992; Balakrishnan et al., 2000; Banga & Goldar, 2007) except that the concept of depreciation rate which has been taken from the study of Erumban & Das (2016). The perpetual inventory method allows for an estimate to be made of the stock of fixed assets that are currently in existence and in the hands of producers. These estimates are generally based on making a guess as to what percentage of the fixed assets that were installed as a result of gross fixed capital formation carried out in prior years have survived to the current time period (European Communities, et al., 2009). For our analysis the study generates time-series data points on capital stock at current prices using the following equation:

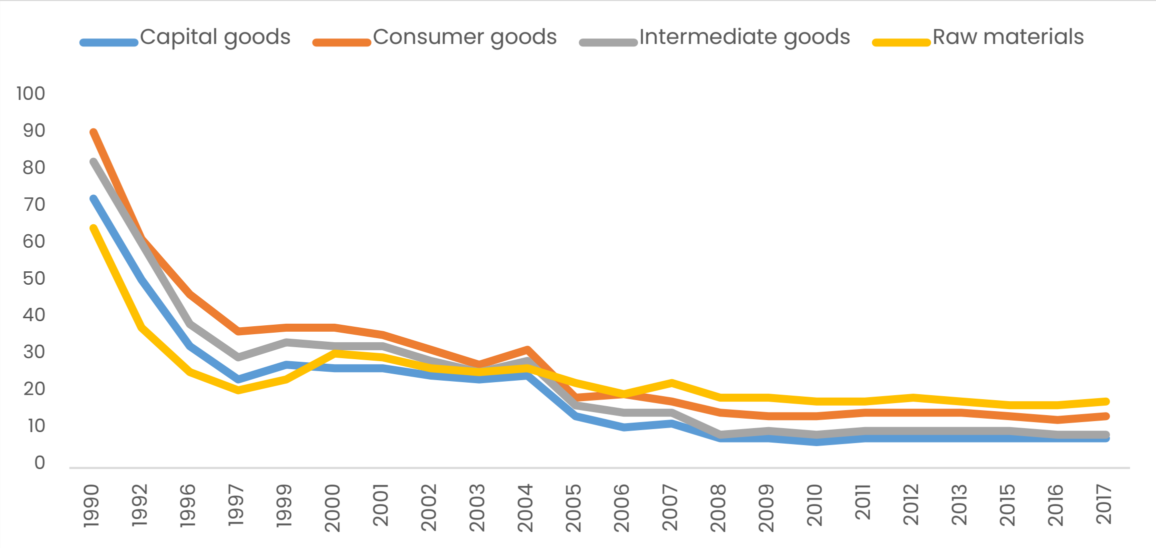
$$Kt = It + (1- \delta)\, Kt\text{-}1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

The above equation shows that for estimation capital stock for a benchmark year and investment values of different years are required. In equation 1, I refer to the gross fixed capital formation which represents annual investment flows. K is the stock of capital at current prices. δ represents the depreciation rate. Subscript t has been used to denote time.

According to ASI fixed capital includes land, including leased land, buildings, plant and machinery, furniture and fittings, transport equipment, water system and roadways, and other fixed assets utilized for the benefit of factory staff, such as hospitals, schools, etc. (International Labour Organization, 2014). Data on fixed capital stock available in ASI is the historical data on book value and are unreliable as it does not reflect the replacement cost. The study uses the data on the capital stock of registered manufacturing sector at replacement cost provided by 'National Accounts Statistics' (NAS) which serve as benchmark capital stock. This capital stock is distributed in the proportion of each three-digit industry share in the total fixed capital. It may be noted that in the estimation of benchmark capital a proportionality is assumed. But in this process, one would involve in some assumption or the other (Trivedi et al., 2011). Time series data points on investment (It) has been estimated using ASI's gross fixed capital (GFC) series. In order to estimate the capital stock appropriate depreciation rate for the capital stock is required. In the case of ASI, data depreciation is available at book value which as mentioned earlier poses concerns with respect to its reliability in case of measurement of capital stock for India's formal manufacturing sector. The specific methodology used for capital approximation is sensitive with respect to true depreciation estimation. The available approximation for depreciation is based on either tax accounting concepts or are related to some rule of thumb. Various authors perceive that the true economic depreciation approximation as a complex process and hence estimates based on gross capital stock are preferred (Hashim & Dadi, 1973; Banerji, 1975; Goldar, 1986). However, under some assumptions, few studies formulate their estimates based on information related to net capital stock through the PIM based on available estimates on depreciation. Kumar et al. (1987) and Choudhury (1988) utilise depreciation at book value based on the assumption that the depreciation rate is in the range of 5 per cent annually (Goldar, 2002; Banga & Goldar, 2007). The present study follows Erumban & Das (2016) for estimates on the depreciation rate. Their chapter calculates depreciation rate using detailed information on NAS for the assumed life of various assets. The implicit aggregate depreciation rate for various sectors has been derived as the weighted depreciation rate of individual assets. Thus, our study uses the estimated depreciation rate of the manufacturing sector at 5.8 per cent. After deriving the nominal capital stock, the study converts these into real by adjusting the nominal by investment deflator. The Investment deflator is generated using the series of Gross Capital Formation at current and constant prices published by CSO, the constant prices are shifted to 1998-99 the base for other deflators.

Figure A.1

Simple Tariff according to COMESA classification



Source: COMESA classification prepared by CWS, and WITS

Table A.1

Share in real gross value-added 3 digit industry grouping (in percentage)

Industry Group		1990s	2000s	2010-16
151	Production, Processing and Preservation of Meat, Fish, Fruit Vegetables, Oils and Fats	1.7	1.3	1.3
152	Dairy Products	0.8	0.8	0.8
153	Grain Mill Products, Starches and Starch Products, and Prepared Animal Feeds	1.3	1.3	1.7
154	Other Food Products	4.7	3.1	2.8
155	Beverages	1.1	1.4	1.3
160	Tobacco Products	1.6	1.3	0.8
171	Spinning, Weaving and Finishing of Textiles	9.9	7.6	6.7
172	Other Textiles	0.5	1.2	1.5
173	Knitted and Crocheted Fabrics and Articles	0.5	0.9	0.9
181	Wearing Apparel, Except Fur Apparel	2	2.5	2.4
182	Dressing and Dyeing of Fur; Articles of Fur	0	0	0
191	Tanning and Dressing of Leather, Luggage, Handbags, Saddlery and Harness	0.4	0.3	0.3
192	Footwear	0.6	0.6	0.6
201	Saw Milling and Planning of Wood	0.1	0	0
202	Products of Wood, Cork, Straw and Plaiting Materials	0.3	0.2	0.2
210	Paper and Paper Product	2	1.6	1.4
221	Publishing	1.2	0.6	0.2
222	Printing and Service Activities Related to Printing	0.5	0.5	0.7
223	Reproduction of Recorded Media	0	0	0
241	Basic Chemicals	9	6.9	5.2
242	Other Chemical Products	8.9	9.3	11.6

Industry Group		1990s	2000s	2010-16
243	Man-Made Fibers	1.6	0.4	0.4
251	Rubber Products	1.9	1.8	2.2
252	Plastic Products	1.5	2.4	3.5
261	Glass and Glass Products	0.5	0.5	0.4
269	Non-Metallic Mineral Products N.E.C.	4.7	5.9	5.1
271	Basic Iron and Steel	10	10.4	6.5
272	Basic Precious and Non-Ferrous Metals	2.3	2.4	2.1
273	Casting of Metals	1	0.8	1
281	Structural Metal Products, Tanks, Reservoirs and Steam Generators	1.4	1.4	1.5
289	Other Fabricated Metal Products; Metal Working Service Activities	1.4	1.5	1.6
291	General Purpose Machinery	3.2	4.2	5.2
292	Special Purpose Machinery	3.6	3.3	4.2
293	Domestic Appliances, N.E.C.	0.5	0.5	0.9
300	Office, Accounting and Computing Machinery	0.6	0.6	0.4
311	Electric Motors, Generators and Transformers	2.3	2.2	1.7
312	Electricity Distribution and Control Apparatus	0.9	1.4	1.7
313	Insulated Wire and Cable	1.2	0.9	1.2
314	Accumulators, Primary Cells and Primary Batteries	0.4	0.6	0.7
315	Electric Lamps and Lighting Equipment	0.3	0.3	0.4
319	Other Electrical Equipment N.E.C.	0.2	0.4	0.6
321	Electronic Valves and Tubes and Other Electronic Components	0.5	1.1	0.9
322	Television and Radio Transmitters and Apparatus for Line Telephony and Line Telegraphy	1.1	0.9	0.7
323	Television and Radio Receivers, Sound or Video Recording or Reproducing Apparatus, and Associated Goods	1.1	1	1
331	Medical Appliances and Instruments and Appliances for Measuring, Checking, Testing, Navigating and Other Purposes Except Optical Instruments	0.6	0.8	0.6
332	Optical Instruments and Photographic Equipment	0.1	0.1	0
333	Watches and Clocks	0.2	0.2	0.2
341	Motor Vehicles	4.4	3.8	4.2
342	Bodies (Coach Work) for Motor Vehicles; Trailers and Semi-Trailers	0.2	0.2	0.4
343	Parts and Accessories for Motor Vehicles and Their Engines	0.6	3.5	5.1
351	Building and Repair of Ships & Boats	0.2	0.4	0.3
352	Railway and Tramway Locomotives and Rolling Stock	1.1	0.3	0.3
353	Aircraft and Spacecraft	0.3	0.1	0.1
359	Transport Equipment N.E.C.	1.7	2.7	2.9
361	Furniture	0.2	0.3	0.3
369	Manufacturing N.E.C.	1	1.3	1.4
Grand Total		100	100	100

Notes: Red indicates the lower share, yellow indicates the moderate share and green indicates the higher share of the industry during the period 1990-16. The table provides a decadal share of industries at 3-digit.

Table A.2

Average Effective tariff rates: 1990- 2017 (in percentage)

NIC	Industry Name	1990	1992	1997	1999	2001	2004	2005
15	Food Products and Beverages	88.4	47.9	31.8	34.5	44.8	40.7	40.9
16	Tobacco Products	100.0	65.0	40.0	40.0	35.0	30.0	30.0
17	Textiles	94.4	62.4	38.5	38.7	30.3	27.6	15.6
18	Wearing Apparel; Dressing and Dyeing of Fur	100.0	63.6	39.2	39.3	34.4	29.6	14.9
19	Tanning and Dressing of Leather	87.5	63.4	28.2	35.2	31.9	28.2	15.2
20	Sawmilling and Planing of Wood	64.1	58.0	29.6	33.3	32.1	28.2	14.6
21	Pulp, Chapter and Chapterboard	90.3	58.2	24.3	32.5	30.8	26.6	13.7
22	Printing	64.7	29.3	26.1	26.7	23.9	21.5	11.3
24	Other Chemical Products N.E.C.	78.6	61.9	29.5	34.0	32.8	28.6	15.4
25	Rubber and Plastics Products	91.2	64.3	34.3	37.3	34.7	29.8	14.9
26	Other Non-Metallic Mineral Products	87.1	63.6	38.4	38.5	34.1	29.4	15.0
27	Basic Metals	79.9	62.6	28.4	33.3	32.9	31.2	17.2
28	Fabricated Metal Products, Except Machinery and Equipment	77.0	60.9	29.7	32.3	34.0	28.4	15.0
29	Machinery and Equipment N.E.C.	75.6	49.1	23.0	27.3	26.8	25.9	14.9
30	Office, Accounting and Computing Machinery	118.7	57.7	33.7	28.8	21.5	20.3	4.9
31	Other Electrical Equipment N.E.C.	77.2	52.4	30.7	32.7	30.2	27.4	14.6
32	Television and Radio Transmitters and Apparatus for Line Telephony and Line Telegraph	95.5	65.0	30.1	28.2	22.8	21.1	8.6
33	Medical, Precision and Optical Instruments, Watches and Clocks	73.0	57.6	28.6	30.8	27.5	25.6	13.9
34	Motor Vehicles, Trailers and Semi-Trailers	76.7	62.7	37.5	39.4	46.5	42.3	28.9
35	Other Transport Equipment	50.9	45.5	27.6	34.1	34.7	31.9	20.3
36	Manufacturing of Furniture, Manufacturing N.E.C.	100.5	58.0	35.0	35.8	33.8	29.4	15.0

Source: WITS- TRAINS and WTO -Tariff analysis online (TAO)

Table A.2 (Cont.)

Average Effective tariff rates: 1990- 2017 (in percentage)

NIC	Industry Name	2007	2009	2011	2013	2015	2016	2017
15	Food Products and Beverages	40.8	34.3	34.3	38.6	38.2	35.6	35.6
16	Tobacco Products	30.0	35.0	35.1	35.1	35.1	36.0	36.0
17	Textiles	12.8	10.1	9.9	10.0	9.9	10.2	10.0
18	Wearing Apparel; Dressing and Dyeing of Fur	12.5	9.8	9.5	9.7	9.7	9.8	9.7
19	Tanning and Dressing of Leather	12.8	10.0	10.0	10.0	10.0	10.0	10.3
20	Sawmilling and Planing of Wood	12.2	9.8	9.7	9.8	9.7	9.8	9.9
21	Pulp, Chapter and Chapterboard	11.4	9.3	9.2	9.2	9.2	9.2	9.2
22	Printing	9.6	7.6	6.1	6.2	5.8	7.5	7.5
24	Other Chemical Products N.E.C.	12.9	8.4	8.1	8.2	8.1	8.1	8.1
25	Rubber and Plastics Products	12.4	9.9	9.9	9.9	9.9	9.8	9.9
26	Other Non-Metallic Mineral Products	12.5	9.5	9.4	9.4	9.4	9.5	9.4
27	Basic Metals	15.8	6.0	6.0	6.3	7.2	8.2	8.1
28	Fabricated Metal Products, Except Machinery	12.5	9.8	9.8	9.8	9.8	9.9	9.9

NIC	Industry Name	2007	2009	2011	2013	2015	2016	2017
	and Equipment							
29	Machinery and Equipment N.E.C.	12.4	8.2	7.7	7.6	7.6	7.9	7.7
30	Office, Accounting and Computing Machinery	4.6	2.2	1.9	1.9	1.9	3.0	2.0
31	Other Electrical Equipment N.E.C.	12.3	8.6	8.2	8.2	8.2	9.1	8.7
32	Television and Radio Transmitters and Apparatus for Line Telephony and Line Telegraph	6.9	5.4	5.5	5.4	5.4	5.4	5.4
33	Medical, Precision and Optical Instruments, Watches and Clocks	11.8	8.5	8.2	8.2	8.2	8.0	8.0
34	Motor Vehicles, Trailers and Semi-Trailers	27.1	24.7	24.0	24.3	18.6	24.3	32.4
35	Other Transport Equipment	18.3	15.6	15.4	17.4	17.4	16.0	17.1
36	Manufacturing of Furniture, Manufacturing N.E.C.	12.5	9.7	9.3	9.6	9.8	10.2	10.4

Source: WITS- TRAINS and WTO -Tariff analysis online (TAO)

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