The decline in the aggregate productivity growth of Indian Manufacturing: Evidence from plant-level panel dataset*

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Abstract

Aggregate labour and multifactor productivity growth declined sharply in the Indian organised manufacturing from 2008-2009 onwards. To investigate the sources of this decline, the paper decomposes aggregate productivity growth into the microcomponents of growth that occurs directly from within the plants, from reallocation of inputs across continuing plants and from the net entry of the plants using plant-level panel data. This decomposition uses the methodology of Jorgenson and his collaborators under the assumption of non-neoclassical features of the plant level economic environment. The paper employs quantile regression under panel data and find the presence of increasing returns to scale and a positive effect of capacity utilisation on value-added. The results from the decomposition suggests the decline in productivity growth due to an increase in excess capacity and the movement of capital and labour from more productive to less productive plants. These decline in productivity growth are mostly driven by the export oriented industries.

Keywords: Manufacturing, Productivity, Trade

JEL Codes: L60, E23, F10

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1 Introduction

The Indian organised manufacturing experienced high growth rates of output between 2003-04 and 2008-09 with an annual average of around 15 percent. This high growth was an outcome of large private investment and exports after the integration with the global economy. However, this positive phase came to a halt with the onset of the global financial crisis in 2007-08. The financial recession in the US had a negative impact on the Indian manufacturing with the decline in foreign demand, the outflow of foreign institutional investments, the volatility of the exchange rate and so on. The export growth plummeted drastically, and it never gained momentum after that due to one or the other crisis in the global economy. The export-oriented industries that were adversely affected due to global slowdown are automobile, leather, electronics, diamond jewellery, garments, textiles and handicrafts, machinery industry [1].These industries experienced cut in production and workers layoff with the slowdown in demand from the world's two largest consumer markets-the US and Europe. The growth in demand from the domestic economy also stagnated due to the rise in unemployment. Under such circumstances, the Indian government announced certain initiatives in the form of stimulus packages like; increase in public spending, easy accessible credit and reduction in excise duty. These efforts increased consumer demand and led to the revival of sectors like automobile and housing. However, this revival of the growth in domestic demand was not long-lived, and India's domestic private investors started to be skeptic by 2011-12 following a slowdown in both domestic and foreign demand and accumulation of unutilized capacities. The export sector was again adversely affected following the global crisis of 2011-12. There was slowdown in business confidence and capacity utilisation due to the uncertainty from the global as well as the domestic market. All these resulted in the decline of output, employment and productivity growth (both total and multifactor productivity) in the Indian organised manufacturing from

[1] In this paper we only look at the organised manufacturing due to the availability of year-wise data to analyse productivity growth. We focus on the organised sector also because it produces nearly 80 percent of the value-added or output in Indian manufacturing. The organised manufacturing is also characterised by relatively high wages than unorganised manufacturing. So a decline in productivity growth (labour) will have serious implication on real wages. The effects of the global recession may be similar in unorganised manufacturing or infact more intense.

2009-10 onwards. This slowdown cannot be attributed to only one factor even though this paper advocates the decline in productivity growth mainly from the exporters. The lacklustre performance of the Indian manufacturing from 2009-10 is the result of an amalgamation of several factors like high-interest rates, lack of foreign and domestic demand, high energy and oil prices, unavailability/extraordinary high price of raw materials, competition from foreign markets and the volatility of foreign exchange.

This paper focuses on the slowdown in productivity growth post-2008-09 and analyses the sources as well as the primary drivers of such sharp decline [2]. To understand the slowdown in productivity growth, we decompose aggregate productivity growth into the growth that is directly occurring within individual plants (within-plant effect), the growth that is taking place due to reallocation of inputs between continuing plants (between-plant effect) and the growth from the dynamics of plant entry and exit (net-entry effect). The proposed decomposition method in this study further delves deeper where the within-plant effect for multifactor productivity growth is decomposed into the effect from technological progress, scale economies and capacity utilization at individual plants. The within-plant effect of aggregate labour productivity growth is decomposed into all the above sub-components plus the effect from capital deepening. The reallocation effect or the between-plant component of multifactor productivity growth comprises the effect of reallocation of labour and capital[3] across plants on aggregate multifactor productivity growth. The between-plant effect of aggregate labour productivity growth is decomposed into the effect of reallocation of inputs across plants on aggregate multifactor productivity growth plus the effect of reallocation on aggregate capital deepening. The net-entry effect captures the change in productivity growth (both labour and multifactor) occurring due to the entry of plants in the industry and exit of plants from the industry. All these components contribute to the growth in productivity. What are the important factors that help in explaining the decline in aggregate productivity growth in Indian organised manufacturing from

[2]The coefficient of α_2 is significantly positive at 95 percent confidence level if we regress(OLS) $y = \alpha_0 + \alpha_1 D_1 + \alpha_2 D_1 Year + \epsilon$ where y is labour productivity, D_1 is a dummy variable with 1 for years previous to 2009-10 and zero otherwise

[3]and of intermediate inputs if output is considered rather than value added.

2009-10 onwards? Who are the primary drivers of this decline in productivity growth? The decomposition method mentioned above will help in answering the first question whereas a detailed study of the economic environment following the decline in productivity aids in answering the second question. This paper is an exploration to these two broad questions.

The decomposition method used in this paper is an extension of the work of Jorgenson and his collaborators (Jorgenson, 1966; Jorgenson et al., 2008). The beauty of this methodology is that it helps in a deeper decomposition of the within and between plant components that helps in a detailed understanding of the mechanism of productivity growth. This paper decomposes both aggregate labour and multifactor productivity growth using the approach of Jorgenson and his collaborators under certain assumption of non-neoclassical features of the plant level economic environment like monopolistic competition and increasing returns to scale[4]. We find it important to decompose both labour and multifactor productivity as both have its distinct uses. Labour productivity provides an idea of how efficiently labour is used in the production process. A positive growth in labour productivity will cause a positive growth in real wages of workers and vice-versa. Thus analysing the components of the decline in labour productivity growth is important from the perspective of the welfare of workers. A more inclusive measurement of productivity is multi-factor productivity which is the weighted average of both labour and capital productivity. Multi-factor productivity captures all the unmeasured factors in the productivity growth including disembodied technical progress and thus is important to analyse. In our study, the labour productivity growth is decomposed into multifactor productivity growth and input-deepening. Thus the changes in the economy that influence either the multifactor productivity growth or the input deepening will affect the labour productivity growth.

The literature on the sources of productivity growth in the Indian economy consists of some rigorous work. Harrison et al. (2011) find a significant role of market share

[4]Recent papers like Basu and Fernald (2002); Petrin and Levinsohn (2012) have followed similar methodologies.

reallocations across firms in increasing aggregate total factor productivity growth of the Indian organised manufacturing after the initiation of Indian trade reforms of 1991. The views of Bollard et al. (2013) are slightly different where they find high importance of within-plant effect in raising total factor productivity growth of large (greater than 200 workers) formal Indian manufacturing rather than reallocation across plants in India following reforms. Sivadasan (2009) find an increase in total factor productivity growth in Indian organised manufacturing following tariff and FDI liberalization in India. This increase in productivity is driven mostly by within the plants rather than by reallocation. The work by McMillan and Rodrik (2011) find the effect of globalisation on labour productivity to be positive in some Asian countries like India and China due to movement of labour from low productive to high productive sectors whereas for Africa and Latin American countries, the structural change is growth reducing due to the movement of labour in the wrong direction (from high productive to low productive sectors). However, all these studies are different in terms of methodology, level of data aggregation and the objectives. Our paper is unique in various features; it is an attempt to study the factors of recent downturn in organised manufacturing in India, uses the relatively unused plant-level panel data, employs the recent estimation technique of quantile regression in panel data Powell (2016), decomposes aggregate productivity growth using the methodology of Jorgenson and his collaborators (Jorgenson, 1966; Jorgenson et al., 2008) in a non-neoclassical framework, and analyse the nexus between productivity growth and export orientation. A similar study to ours using plant-level panel data is by Aggarwal et al. (2011) where they analyse the effects of entry and exit of plants on the productivity of 22 industries from 2000-01 to 2005-06. They use three different decomposition techniques (Griliches and Regev (1995); Foster et al. (2001); Melitz and Polanec (2009)) and find positive contribution of entry of new plants on aggregate labour productivity growth. On the basis of the level of technology, they concluded the presence of entry effects and within effects in low tech industries, entry effects and reallocation effects in medium tech industries and all the three effects for high tech industries. Our study differs from this in many aspects: firstly, the time span for our study is more prolonged and recent that helps in analysing the decline in productivity growth from 2008-09 onwards; secondly, unlike Aggarwal et al. (2011) our study goes deeper into within and between components and look at both labour and multifactor productivity. Our study also analyse the relation between productivity growth and export orientation.

2 Methodology

A large number of empirical studies on plant level or firm level productivity behaviour have already been conducted worldwide. Most of this literature has decomposed aggregate productivity growth into the effect of reallocation across plants/firms and the effect of productivity growth from within the plants/firms (Griliches and Regev, 1995; Foster et al., 2001; Bartelsman et al., 2005; Baldwin and Gu, 2006; Aggarwal et al., 2011). They, however, do not mention the causes of variations in labour or multifactor productivity at the plant level that arise from factors such as investment, technological up-gradation, scale economies and variable input utilization. Therefore previous studies focused only on whether changes in productivity growth were internal to the plants or were caused by reallocation of inputs arising from dynamic competitive forces.

This paper finds the within and between plant component of productivity growth as well as the sources of such internal changes in the plant and the changes arising from the reallocation of inputs. The methodologies of Jorgenson and his collaborators (Jorgenson, 1966; Jorgenson et al., 2008) are adopted in this paper in order to have a more detail and deeper understanding of the sources of changes in productivity growth. Jorgenson and his collaborators developed the framework of productivity decomposition under the assumption of perfect competition and constant returns to scale. This methodology was further extended to include imperfect competition and increasing returns to scale (Hall, 1988, 1989; Basu and Fernald, 2002; Petrin and Levinsohn, 2012; Baldwin et al., 2013).

According to the methodologies of Jorgenson and his collaborators, two different approaches were developed to estimate aggregate productivity growth. The more traditional approach is the production possibility frontier approach or the top-down approach which is used to calculate productivity growth when aggregate industry-level data is available. In the case of availability of plant or firm-level data, the direct aggregation across micro-producers or the bottom-up approach is considered. The sources of within and between plant components of productivity growth can be calculated only with the later approach.

The decomposition in this paper uses value-added at both plant and aggregate level instead of gross output. The aggregate value-added of an industry is the sum of value-added of individual plants. However, value-added requires separability assumption. As the value added is the residual of gross output and intermediate input, the existence of value-added function assumes that the production function is separable between the various factors of production and the intermediate inputs. It might be argued that gross output capture more of the production process due to the inclusion of intermediate inputs in the production function. However, using gross output might cause the problem of double counting resulting from the transaction of intermediate inputs among plants within the same industry. This might happen in the case of reorganisation of production when there occurs an increased use of intermediate inputs. This increase in the use of intermediate inputs will lead to increase in productivity even when the amount of output available for use outside industry has not increased due to reorganisation. Apart from the above-mentioned difficulties, usage of either gross output or value-added method produce similar trends in labour or multifactor productivity. The next two sections will provide a brief description of the two different approaches of productivity decomposition.

2.1 Production Possibility Frontier Approach

Production possibility frontier approach require certain assumptions. These assumptions are: the prices of inputs (capital and labour) are similar across all plants, plants have different production function that define the association between value-added and labour and capital inputs, prices of output differs across plants due to the presence of different production function. Under all these mentioned assumptions, aggregate value added (V) is a function of aggregate capital (K), aggregate labour (L) and technology (proxied by time variable,T):

$$V = F(K, L, T) \tag{1}$$

Aggregate labour productivity is the difference between growth in aggregate value added and growth in aggregate labour input.

$$\Delta lnP = \Delta lnV - \Delta lnL \tag{2}$$

The aggregate value added is Tornqvist aggregation of plant value-added. Change in aggregate value added is defined as:

$$\Delta lnV = \sum_i \bar{w_i} \Delta lnV_i \tag{3}$$

Δ is the change between time $t-1$ and t and $\bar{w_i}$ is the average share of plant i in aggregate nominal value-added between $t-1$ and t.

Aggregate labour productivity growth can be decomposed into the effect from within the plants and from between-plants reallocation. The within-plant measures the contribution of growth occurring within individual plants while assuming their shares of output to be fixed. The between-plant effect captures the change in productivity growth due to reallocation of labour input. The between-plant reallocation effect is greater than zero when labour reallocates from less productive to more productive plants. The decomposition of aggregate growth in labour productivity is expressed as:

$$\Delta lnP = \Delta lnV - \Delta lnL = \sum_i \bar{w_i} \Delta lnP_i + [\sum_i \bar{w_i} \Delta lnL_i - \Delta lnL] \tag{4}$$

where $\Delta lnP_i = \Delta lnV_i - \Delta lnL_i$ is the plant i labour productivity growth. The labour productivity growth of plant i is the difference between value-added growth ΔlnV_i and labour input growth ΔlnL_i. The first term in Equation 4 is the within-plant effect while the second term is the between-plant effect.

The decomposition in the previous studies (Griliches and Regev, 1995; Foster et al., 2001; Bartelsman et al., 2005; Baldwin and Gu, 2006) differs from Equation 4. In the studies mentioned above, aggregate labour productivity is expressed as the weighted sum of plant labour productivity where employment shares s_i are used as weights:

$$P = \sum_i s_i P_i \tag{5}$$

The within and between plant effect is derived by first differencing Equation 5. This is expressed as $\Delta P = \sum_i \bar{s_i} \Delta P_i + \sum_i \Delta s_i \bar{P_i}$ where the average values over two periods are expressed as bar. However, this decomposition is valid under the assumption of identical output price across all the plants. Thus in the case of different output price across plants, the decomposition used in these previous studies only provides an approximation.

Under the assumption of competitive product and factor markets and constant returns to scale, growth in aggregate multifactor productivity is the difference between aggregate labour productivity and the effect of capital deepening:

$$v_T = \Delta lnP - \bar{\alpha_K} \Delta ln(K/L) \tag{6}$$

where v_T is multifactor productivity growth and $\bar{\alpha_K}$ is the average share of capital cost in nominal value added over periods of $t-1$ and t.

2.2 Direct Aggregation Across Micro-producers

Jorgenson et al. (1987, 2005) developed the method of estimating aggregate labour or multifactor productivity by directly aggregating across plants. In this approach, the assumptions of the production possibility frontier approach are not required and so the prices of capital and labour inputs vary across plants. This paper further extends the approach to consider non-neoclassical features. The two non-neoclassical features considered in this paper are: plants have increasing returns to scale production function and the product market is characterised by monopolistic competition.

Production function of plant i is defined as:

$$V_i = F^i(e_{Ki}K_i, e_{Li}L_i, T_i) \tag{7}$$

where V_i is the output , K_i and L_i are the capital and labour inputs and T_i is the technology index of plant i. e_{Ki} and e_{Li} are the unobserved utilization of capital and labour of plant i. The production function of Equation 7 is characterised by increasing returns to scale γ_i.

Growth in output is the weighted sum of growth of inputs, weighted sum of growth in input utilization and multifactor productivity growth (Hall, 1989; Basu and Fernald, 2002). The output growth is expressed as:

$$\Delta lnV_i = \mu_i \Delta lnX_i + \alpha_i \Delta lne_i + \upsilon_{T,i} \tag{8}$$

ΔlnX_i is the weighted sum of the growth of inputs where the weights are the share of input costs in nominal output. Δlne_i is the weighted sum of changes in input utilization.

$$\Delta lnX_i = \bar{\alpha_{Ki}} \Delta lnK_i + \bar{\alpha_{Li}} \Delta lnL_i \tag{9}$$

$$\Delta lne_i = \bar{\alpha_{Ki}} \Delta lne_{Ki} + \bar{\alpha_{Li}} \Delta lne_{Li} \tag{10}$$

The weights in the calculation of change in inputs and input utilization are $\bar{\alpha_{Ki}}$ and $\bar{\alpha_{Li}}$. These weights are the capital and labour cost in nominal output. In the presence of economic profits, the sum of these input costs in nominal output will be less than one. $\upsilon_{T,i}$ is the growth in multifactor productivity. μ_i is the mark-up over marginal cost. The mark-up is equal to returns to scale when economic profit is zero under monopolistic competition[5]. α_i is the effect of changes in capacity utilization on the growth of output.

Deducting labour input growth from Equation 8 provides the decomposition of the

[5] $\mu_i = P_i/MC_i = (AC_i/MC_i) * (P_i/AC_i) = \gamma_i/(1 - s_{\pi i})$ where $s_{\pi i}$ is the ratio of economic profits to nominal output. In monopolistic competition, $s_{\pi i}$ is zero and so the mark-up is equal to returns to scale. Also the sum of input cost share in nominal output is unity.

labour productivity growth of plant i:

$$\Delta lnP_i = (\mu_i - 1)\Delta lnX_i + \bar{\alpha_{Ki}}\Delta ln(K_i/L_i) + \alpha_i \Delta lne_i + v_{T,i} \tag{11}$$

The sources of growth in plant labour productivity from Equation 11 are scale economies, capital deepening, variable input utilisation and technological progress. Aggregate labour productivity is the agrregation of plant labour productivity using Equation 4. Substitution of aggregate labour productivity in Equation 6 provides the decomposition of aggregate multifactor productivity growth. The decomposition equation of aggregate labour and multifactor productivity growth are:

$$\begin{aligned}\Delta lnP = \sum_i \bar{w}_i(\mu_i - 1)\Delta lnX_i + \sum_i \bar{w}_i \alpha_i \Delta lne_i + \sum_i \bar{w}_i v_{T,i} + \sum_i \bar{w}_i \bar{\alpha_{Ki}} \Delta ln(K_i/L_i) \\ + \bar{\alpha_K}[\sum_i \bar{w_{Ki}} \Delta lnK_i - \Delta lnK] + \bar{\alpha_L}[\sum_i \bar{w_{Li}} \Delta lnL_i - \Delta lnL] \\ + \bar{\alpha_K}[\Delta ln(K/L) - \sum_i \bar{w_{Ki}} \Delta ln(K_i/L_i)]\end{aligned} \tag{12}$$

$$\begin{aligned}v_T = \sum_i \bar{w}_i(\mu_i - 1)\Delta lnX_i + \sum_i \bar{w}_i \alpha_i \Delta lne_i + \sum_i \bar{w}_i v_{T,i} \\ + \bar{\alpha_K}[\sum_i \bar{w_{Ki}} \Delta lnK_i - \Delta lnK] + \bar{\alpha_L}[\sum_i \bar{w_{Li}} \Delta lnL_i - \Delta lnL]\end{aligned} \tag{13}$$

Where $\bar{w_{Ki}}$ is the average share of plant i in capital cost over two periods. Similarly, $\bar{w_{Li}}$ is the average share of plant i in the labour cost over two periods.

Both aggregate labour productivity growth and multifactor productivity growth are decomposed into within-plant growth and the growth occurring due to reallocation of capital and labour in Equations 12 and 13. The first row of Equation 12 measures the direct contribution of growth in labour productivity occurring at the plants due to scale economies, capacity utilisation, multifactor productivity growth and capital deepening. The second and third row of Equation 12 captures the productivity growth occurring due to reallocation of capital and labour which is the sum of the effect of reallocation on multifactor productivity growth and the effect of reallocation on capital deepening. The effect of reallocation on multifactor productivity growth is presented in the second row whereas the third row of Equation 12 captures the effect of reallocation on capital deepening. The decomposition of aggregate multifactor productivity growth (Equation 13) is similar to labour productivity decomposition. The first row of Equation 13 captures the contribution to multifactor productivity growth from within the plants which consist of scale economies, variable input utilisation and technical progress. The last row of Equation 13 measures the effect of reallocation of capital and labour on aggregate multifactor productivity growth. In both labour and multifactor productivity growth, the contribution to reallocation of labour and capital is positive when inputs shift towards plants with higher input price or with higher marginal product.

Aggregate capital deepening effect can be decomposed into the effect of capital deepening directly within the plants and the effect of reallocation on aggregate capital deepening:

$$\bar{\alpha_K} \Delta ln(K/L) = \sum_i \bar{w_i} \bar{\alpha_{Ki}} \Delta ln(K_i/L_i) + \bar{\alpha_K}[\Delta ln(K/L) - \sum_i \bar{w_{Ki}} \Delta ln(K_i/L_i)] \quad (14)$$

Aggregate productivity also changes due to dynamic entry and exit of plants in industry. The decomposition of aggregate productivity growth thus should be extended to capture the effect of entrants and exits. However, the growth rate of inputs, outputs and productivity cannot be observed over a period for both entrants and exits. This is because of the inability to observe the inputs and outputs of an entering plant at the start of the period and for an existing plant at the end of the period. Following Baldwin et al. (1998), the effect of entry and exit on productivity growth is estimated by assuming a hypothetical plant whose inputs and outputs at the start of the period is set equal to those of exiters and whose inputs and outputs at the end of the period is set identical to those of the entrants. The contribution of this hypothetical plant to the within-plant component can be approximated as the contribution of entry and exit. The effect of entry and exit on productivity growth is the difference between the average productivity of the entry cohort at the end of the period and of the exit cohort at the start of the period multiplied by the average shares in aggregate value added. This effect is positive when the average productivity of entrants is greater than that of the exits. This decomposition approach of Jorgenson and his collaborators helps to delve deeper into the between and within components and thus provides a richer understanding.

3 Data

The paper decomposes the productivity growth rates of the Indian organised manufacturing to analyse the sources of the decline from 2008-09. The decomposition uses plant-level longitudinal data of Annual Survey of Industries (ASI) where the plants can be traced over time. ASI provides information on various plant characteristics. ASI schedule is divided into two parts. The first part contains data on ownership, region, fixed assets, working capital and loan, employment and labour cost, various expenses, outputs and inputs and so on. The second part contains information mostly on the labour aspect like man-days worked, absenteeism and labour turnover. Unique plant identifiers are present that help in tracing plants from one year to the next. ASI does not provide information for the plants that have less than ten workers[6] which might be a potential source of bias in our results. The industrial units are divided into sample and census sector although the sampling strategy has been modified over time[7]. ASI data, therefore, consists of a panel of establishments from the census sector and randomly chosen establishments, which varies year to year, from the sample sector. We found that some establishments in the sample sector are selected repeatedly for multiple years[8]. Therefore, we are able to create a panel (unbalanced) of establishments

[6] 10 workers with power or 20 workers without power.

[7] In general, establishments with more than 100 workers, filing joint returns in ASI survey and all the establishments of some states like Manipur, Meghalaya, Nagaland, Tripura, Andaman and Nicobar Island are surveyed every year and hence called census sector. The rest of the establishments are randomly surveyed, and therefore these are called sample sector.

[8] We exclude the establishments that have only one observation throughout the period.

using the ASI data from 2004 to 2015. The total number of plants used in this analysis are 114972. Table **??** shows the number of observations that are used in the analysis. We use suitable multipliers for the sample sector provided by ASI during estimation.

Table 1: Year-wise number of observations in both sample and census surveys

Year	Census	Sample	Total
2003-2004	5998	18090	24088
2004-2005	7257	11715	18972
2005-2006	11508	11365	22873
2006-2007	12323	8648	20971
2007-2008	12553	6847	19400
2008-2009	9350	9162	18512
2009-2010	9860	11148	21008
2010-2011	10760	11411	22171
2011-2012	11663	11154	22817
2012-2013	21163	5517	26680
2013-2014	23965	6590	30555
2014-2015	14700	15477	30177

Source: ASI rounds(2004-2015)

The variables of our interest include gross value added (GVA), labour input, capital input and utilisation of capital. GVA is calculated as outputs minus inputs. According to the ASI framework, output is defined as the ex-factory value of quantity manufactured including subsidy received and various other receipts like the value of own construction, rent collected from fixed assets, value of electricity generated and sold, value of own construction and so on. Inputs are calculated as the sum of total expenses, total inputs required in the production process and the purchase value of all the total imported inputs directly consumed. Total expenses include rent paid for plant and machinery and fixed assets, insurance charges, expenses incurred on raw materials and other components for own construction, operating expenses, expenses on repair and maintenance and the expense on work done by others on materials supplied by the industrial undertaking. Fixed capital is measured as the average of the net book value of fixed capital at the beginning and at the end of the fiscal year. Using of book value can be a source of measurement problems. However, as it is not possible to acquire data on capital consumption in the production process, the researcher has to settle for the book value of the total capital and machinery used in the production process. The information on the average number of persons worked provided by the ASI is considered as an estimate of employment size in a given plant. This employment size is considered as labour input in our analysis. The average number of persons worked is the ratio of total man-days to the number of working days. Employment information used in this paper are for the total employees which include both male and female directly employed workers, contractual workers, supervisory and managerial staff and all other members including unpaid family members.

As direct measures of capacity utilization are not observable, it is mostly defined by statistical agencies as the ratio of actual to potential output. However, this measure is not suitable to adjust multifactor productivity growth for changes in capacity utilization. The ratio of capital used in production to capital available in production is a better measure of capacity utilization for our purpose. This is mainly the ratio of expost to exante returns to capital. This measure (non-parametric) was introduced by Berndt and Fuss (1986) which was further modified by Gu et al. (2013). However, difficulty arises in estimating the exante return to capital as it is not observed. Assuming a constant exante rate of return to capital, the ratio of expost capital income to capital stock can be used as an approximate measure of capacity utilization that is suitable for adjusting multifator productivity growth for changes in capacity utilization. In this paper, capital income is calculated residually as the difference between the gross value added and the labour cost. Labour cost is the sum of wages/salaries paid to the employees, bonus, contribution to provident and other funds and the contribution to workmen and staff welfare expenses. This is termed as total emoluments of the employees.

All the variables are deflated using suitable deflators and converted to 2005 constant rupees. GVA is deflated by the suitable wholesale price index (WPI) by groups using 2005 as the base year. Matching of the detailed categories of WPI with the 2-digit industry classification was not possible due to data limitations. However, a close and mindful comparison of the groups was undertaken to choose appropriate price deflators. Fixed capital is deflated using WPI for machinery and equipment. Consumer price index (CPI) of rural labourers and industrial workers are used as a deflator for total emoluments of the employees. Thus the labour cost is deflated with respect to rural and urban areas. We consider only the positive values for GVA, capital, and capacity utilization. Graph A1 depict the log values of the variables discussed above that are required for the analysis.

ASI doesnot provide data on export orientation for plants before 2008-2009. To find the link between productivity and export orientation, we match the plant level ASI dataset with the industry level dataset of UN Comtrade. UN Comtrade dataset provides information on the export value of the manufacturing industries at the NIC two digit industry level. The classification in the UN Comtrade database is on the basis of NIC 1998 (ISIC revision 3), whereas ASI database are according to NIC 2004 and NIC 2008. To facilitate the analysis, we use concordance table to match NIC 2004, NIC 2008 and NIC 1998 codes and put both the dataset according to NIC 1998 classification. We then match the industry level measures of the trade database with the plant level ASI dataset on the basis of the identified industry of the plants.

4 Empirical Results

4.1 Empirical estimation of production function

Decomposition of aggregate productivity growth requires estimates of scale economies and the effect of capacity utilization on value-added. The estimating equation is Equation 8 in the level form:

$$lnV_{it} = \alpha_K lnK_{it} + \alpha_L lnL_{it} + u_i + \alpha lne_{it} + \epsilon_{it} \tag{15}$$

The estimate of returns to scale is the sum of output elasticities $\hat{\alpha_K}$ and $\hat{\alpha_L}$. $\hat{\alpha}$ is the estimate of the effect of capacity utilization on value added. e_{it} is the random disturbance term capturing the stochastic variations in value-added of the ith plant, measurement errors or missing variables. u_i is the unobserved plant effect.

The presence of heterogeneity across plants poses a problem in estimating Equation 15 . The inclusion of the exogeneous variables like capital, labour, capacity utilization and industry and year fixed effects take care of heterogeneity to some extent. However, various other factors like quality characteristics of the plants, managers ability and other skills can cause heterogeneity that is not directly observed. This unobserved heterogeneity may cause the outcome variable and consequently to the error term to be independent but heterogeneously distributed across plants. This phenomenon of errors being non-i.i.d violates one of the assumptions of classical linear regression. Under such condition of residuals being non-Gaussian, the application of quantile regression (QR) is appropriate. While the classical linear regression finds out the change in the conditional mean of response variable associated with the change in the independent variable, QR analyses the change in conditional quantiles. In contrast to OLS regression, QR does not assume the relation between dependent and independent variable to be same at all levels and thus permit the regression slope to vary according to the quantiles. It also does not require a particular parametric distribution or a constant variance of the dependent variable. The primary advantage of using QR is that it is robust to outliers and non-normal errors. The distribution of value added and inputs are likely to vary from normal distribution as it posseses heavier tails and can mostly be described by laplace distribution. QR is also invariant to monotonic transformations.

We conduct a normality test for linear panel data models to check the presence of non-normal errors as lack of Gaussianity effect the reliability of simple estimation and testing procedures. As errors in linear panel data models consists of both individual-specific(u_i) as well as the remainder component (e_{it}), problem arises in identifying as to which component causes the departures from normality. Galvao et al. (2013) solves this by developing a battery of tests to identify non-normality in standard error components panel models through a new command xtsktest which can be visualized as an extention of the Jarque Bera test. Table 2 presents the results of the test for normality in linear panel data model using standarised statistics. The table shows the observed coefficients for symmetry and kurtosis in both the error terms as well as the joint test for normality in both the component of error(lower portion). The model depict that both the components of error are assymmetric and has excess kurtosis and results in the rejection of the null hypothesis of normality. These findings suggest the necessity to use a more advanced econometric technique to analyse such distributional characteristics.

Table 2: Normality test in linear panel data model using standarized statistics(xtsktest)

	Observed Coef.	Bootstrap Std. Err.	z	$P > \|z\|$	Normal-based [95% Conf. Interval]
Skewness_e	2.26	0.07	29.67	0	[2.11, 2.40]
Kurtosis_e	40.68	1.60	25.37	0	[37.54, 43.82]
Skewness_u	1.97	0.07	28.06	0	[1.83, 2.11]
Kurtosis_u	14.50	1.52	9.5	0	[11.51, 17.50]
Joint test for	Normality on	e:	chi2(2)=	1523.84	$Prob > chi2 = 0.00$
Joint test for	Normality on	u:	chi2(2)=	877.33	$Prob > chi2 = 0.00$

Note: Calculation uses 100 bootstrap replications. The coefficients in the table are standarised

Table 3: Estimates of Returns to scale and effect of capacity utilization

	Method 1	Method 2	Method 3	Method 4
Coefficient of Capital	.7684 ***	.7684***	.7684***	.7685***
Standard Error	.0005	.0005	.0000	.0000
Coefficient of Labour	.2826***	.2826***	.2827***	.2825***
Standard Error	.0008	.0007	.0000	.0000
Capacity Utilization	.7478***	.7478***	.7478***	.7483***
Standard Error	.0008	.0008	.0000	.0000

Note: Method1 - quantile regression with bootstrapped standard error, Method2 - quantile regression with robust and clustered standard errors(qreg2), Method3 - quantile regression for panel data(qregpd), Method4 - quantile regression for panel data(qregpd) with instrumental variables. Time and industry fixed effects are included. This table presents results of 50th percentile. ***p<0.01

This paper uses QR to estimate Equation 15. We estimate equation 15 using all the plants that have more than one observation over the period 2004-2015. We include time and industry fixed effects in the estimating equation. Table 3 presents the estimates of returns to scale and effect of capacity utilization using four different methods of quantile regression. In method 1, we run QR with bootstrapped standard error(50 bootstrap replications) (Koenker, 2005). The Machado-Santos Silva (2000) test for heteroskedasticity rejects the null hypothesis of constant variance of errors in our sample data with $p < 0.01$. As the consistence of method 1 could be a question, so in the second method we estimate median regression using heteroskedastic robust standard errors (Machado and Silva, 2000). The estimates of method 2 are similar to that of method 1 and thus they are robust to heteroskedasticity. In method 3, we estimate the coefficients by fitting robust QR for panel data which was developed by Powell (2016). This estimate addresses an important problem arising from the inclusion of individual fixed effects that alters the interpretation of the estimated coefficient on the treatment variable. This method uses a Markov Chain Monte Carlo method to estimate generalised QR. Lastly, as endogeneity of the explanatory variables could be an issue due to simultaneity in the production process, in method 4 we estimate QR for panel data using one year lagged explanatory variables as instruments. Using all the four different methods help us to verify the robustness of the findings. In all the four methods, the estimates of the coefficients are approximately similar. We use the coefficient of method 3 to calculate the productivity decomposition. In all the methods, the estimated coefficient of the cost-weighted input variable is close to 1.05, and it rejects the null hypothesis of constant returns to scale at $p < 0.01$. The Indian organised manufacturing thus experiences increasing returns to scale. The estimated effect of capacity utilization is positive (0.74). This means that an increase in capacity utilization by 1 percent will increase the value-added by 0.74 percent. Thus the decline in capacity utilization from 2007-08 onwards led to falling in value-added and hence productivity growth.

5 Productivity Decomposition Results

This section presents the estimates of the components of growth of aggregate labour and multifactor productivity rate. Table 4 provides the decomposition of aggregate labour productivity growth using production possibility frontier approach. Aggregate labour productivity growth is decomposed into the effect from aggregate capital deepening and the effect from aggregate multifactor productivity growth. As can be seen from Table 4, aggregate labour productivity growth declined from 7 percent per year between 2004-05 to 2008-09 to negative 2 percent per year between 2009-10 to 2014-15. This decline in productivity growth is driven by the decline in multifactor productivity growth by 17 percent. The contribution of aggregate capital deepening to aggregate labour productivity growth is positive[9]. However, this positive effect is small in magnitude to replace the negative effect of multifactor productivity growth.

Table 4: Aggregate labour productivity decomposition by production possibility frontier approach

	2004-05 to 2008-09	2009-10 to 2014-15	Change
Aggregate capital deepening	0.01	0.10	0.09
Aggregate MFP growth	0.06	-0.12	-0.17
Aggregate LP growth	0.07	-0.02	-0.09

Note: All the above numbers are average annual rates. Source:Authors‘ calculation from ASI plant level panel data (2003-2004 to 2014-2015).

Table 5 and Table 6 demonstrates the sources of decline in both labour and multifactor productivity growth. Both the productivity growth rates are decomposed into the within-plant effect, the between-plant effect and the effect of net-entry. These three components are further decomposed to provide a deeper understanding of the within and between components of productivity growth in the Indian organised manufacturing.

The results from Table 5 and Table 6 convey that both the within-plant component and between-plant component are equally important in the overall productivity growth. The within-plant component is a significant contributor to labour productiv-

[9]Table A1 provides the decomposition of aggregate capital deepening

ity growth before 2009 whereas the reallocation effect is an important determinant in multifactor productivity growth after 2009. Infact, due to various changes in the economic environment post-2008-09 like the global recession along with the slowdown of demand (both domestic and foreign), the exchange rate fluctuation, increase in unutilized capacities and so on, the Indian organised manufacturing sector was facing some adjustment challenges that increased the impact of reallocation.

Table 5: Decomposition of aggregate labour productivity

	2004-2005 to 2014-2015	2004-2005 to 2008-2009	2009-2010 to 2014-2015	Change
Within plant effect	0.04	0.06	0.02	-0.04
Scale economies	0.00	0.00	0.00	0.00
Capacity utilization	0.02	0.04	0.01	-0.03
Technology change	0.00	0.00	0.00	0.00
Capital deepening	0.01	0.01	0.01	0.00
Between plant effect	-0.02	0.01	-0.04	-0.05
Reallocation of capital on MFP	-0.05	0.01	-0.11	-0.12
Reallocation of Labour on MFP	-0.01	0.00	-0.02	-0.02
Effect of reallocation on capital deepening	0.05	0.00	0.09	0.09
Net Entry	-0.10	-0.12	-0.07	0.05
Aggregate labour productivity growth	0.02	0.07	-0.02	-0.09

Note: All the above numbers are average annual rates. Source:Authors‘ calculation from ASI plant-level panel data (2003-2004 to 2014-2015).

Labour productivity growth declined from 7 percent per annum to negative 2 percent per annum from 2009-10 onwards. This decline is both from within the plants and from reallocation of inputs across continuing plants. The decline in capacity utilization is a significant factor in the decline of within-plant effect. Due to the slowdown of demand and various other economic changes, the businessmen lost confidence in the Indian market post-2009-10 that resulted in under-utilization of capacity. There was no contribution from scale economies, capital deepening and technical progress to the decline in within-plant effect.

The impact of the reallocation effect from continuing plants increased after 2008-09 due to various adjustments in the economy. This reallocation contributed negatively to labour productivity growth following the global crisis. The effect of reallocation of capital was positive before 2009 whereas it declined to a negative 11 percent between 2008-09 to 2014-15. The reallocation of labour to multifactor productivity also contributed to the decline. However, the reallocation of inputs on capital deepening raised the growth rate of labour productivity post-2008-09.

The net entry effect contributed positively to aggregate labour productivity growth rates. Thus the decomposition analysis suggests that the decline in the labour productivity growth from 2008-09 onwards is driven mostly by the negative effect of reallocation of inputs on aggregate multifactor productivity growth and a significant increase in under-utilization of production capacities. As explained previously, given the downturn in the economic environment post-2008-09, there occurred significant adjustments in inputs, outputs and the overall production process. This reallocation did not help in increasing the productivity growth of the Indian organised manufacturing. Both labour and capital shifted to plants that have lower marginal product and input price. Moreover, the gloomy business sentiments following the downturn in the Indian manufacturing as well as the non-instantaneous adjustment of production inputs caused excess capacity and low productivity estimates. Even though the effect of reallocation on capital deepening positively impacted labour productivity, but the magnitude was not so large to offset the effect of declining multifactor productivity growth due to reallocation of inputs and under-utilization of capacity.

Table 6: Decomposition of aggregate multifactor productivity growth

	2004-2005 to 2014-2015	2004-2005 to 2008-2009	2009-2010 to 2014-2015	Change
Within plant effect	0.03	0.04	0.01	-0.03
Scale economies	0.00	0.00	0.00	0.00
Capacity utilization	0.02	0.04	0.01	-0.03
Technology change	0.00	0.00	0.00	0.00
Between plant effect	-0.07	0.01	-0.13	-0.14
Reallocation of capital on MFP	-0.05	0.01	-0.11	-0.12
Reallocation of Labour on MFP	-0.01	0.00	-0.02	-0.02
Net Entry	-0.10	-0.12	-0.07	0.05
Aggregate MFP growth	-0.04	0.06	-0.12	-0.17

Note: All the above numbers are average annual rates. Source:Authors‘ calculation from ASI plant level panel data (2003-2004 to 2014-2015).

6 Nexus between export orientation and the decline in the growth of aggregate productivity

The decomposition of the aggregate productivity growth suggests the decline in capacity utilization and the reallocation of capital and labour on aggregate multifactor productivity growth as the primary causes for the decline in productivity growth. This section relates these components to the prevailing economic environment to identify the plants that drives the decline in aggregate productivity growth. A detailed analysis of the plants according to their trade oriention suggests that transformation in the trading environment is a crucial factor behind this decline in productivity growth. To corroborate this understanding, Table 7 presents the direct contribution of the plants to aggregate labour productivity growth according to their trade orientation.

Analysing the relationship between export orientation and productivity performance is difficult as ASI doesnot provide the export orientation of the plants for the whole study period. So we adopted the next best alternative where we merged the export values (according to the 2-digit industry level provided by UN Comtrade data) with the ASI plant level information. To analyse the change in productivity for the exporters and non-exporters, we divide the industries into quartiles according to the export value of 2004. The plants in the third and the forth quartiles are assumed to be export oriented whereas the plants in the first and second quartile are assumed to serve the domestic markets. It is observed that the productivity growth of the export oriented plants declined more than the non-export oriented plants. We categorise the export orientation based on 2004 as it is a normal year in terms of the macro-economic indicators and hence can be assumed that the industries having relatively high export values are export oriented. Moreover, as 2004 is the start of our study period, it will help in analysing the trading dynamics over all the years as well as the effect of global downturn on India's exports.

Table 7 focus on the direct contribution of the plants based on trade orientation and do not decompose the reallocation effect among incumbents as it demand strong assumptions of the reallocation process (Baldwin et al., 1998; Reinsdorf, 2015). The plants catering to the demand of the domestic market contributes substantially to the overall productivity growth. Productivity growth declined for both types of plants from 2009-10 onwards. The decline in productivity growth for the export oriented plants are more than for the plants serving the domestic market. The within plant

Table 7: Direct contribution of the plants serving the domestic and foreign markets of India to aggregate labour productivity growth

	Plants serving the export market in 2003-2004			
	2004-2005 to 2014-2015	2004-2005 to 2008-2009	2009-2010 to 2014-2015	Change
Within plant effect	-0.02	0.07	-0.09	-0.16
Scale economies	0.00	0.00	-0.01	-0.02
Capacity utilization	0.00	0.04	-0.03	-0.07
Technology change	0.00	0.00	-0.01	-0.02
Capital deepening	-0.01	0.02	-0.04	-0.06
	Plants serving the domestic market in 2003-2004			
	2004-2005 to 2014-2015	2004-2005 to 2008-2009	2009-2010 to 2014-2015	Change
Within plant effect	0.07	0.08	0.06	-0.02
Scale economies	0.00	0.00	0.01	0.01
Capacity utilization	0.03	0.07	-0.01	-0.08
Technology change	0.00	0.00	0.00	0.00
Capital deepening	0.03	0.00	0.06	0.06

Note: All the above numbers are average annual rates. Source:Authors‘ calculation from ASI plant level panel data (2003-2004 to 2014-2015) and UN Comtrade data.

effect fell from 7 percent points between 2004-2005 and 2008-2009 to negative 9 percent between 2009-2010 and 2014-2015. It declined by 16 percent points whereas the decline in productivity growth for the plants serving the domestic market is marginal. The decline in capacity utilization is a primary determinant in the decline in productivity growth for both types of plants. Thus it can be concluded that the decline in productivity growth is driven by exporters and as a result of the decline in capacity utilization. Capital deepening within the export oriented plants also contributed to the decline in productivity growth.

7 Conclusion

Indian economy underwent structural changes from 2008-09 onwards as a result of multiple factors like global recession, slowdown of demand (domestic and foreign), exchange rate fluctuations, the outflow of foreign institutional investments, excess capacities and so on. This paper analyses the drivers as well as the causes of the slowdown in productivity growth following the changes in an economic environment using the decomposition methodology of Jorgenson and his collaborators. The decline in productivity growth from 2009 onwards was primarily due to increase in excess capacities and movement of inputs in wrong direction. The structural changes post

2009 led to the build-up of excess capacities due to lack of both foreign and domestic demand and non-instanteneous adjustments of production inputs. The changes in the economic environment also aggravated reallocation of inputs between the plants. This movement of both labour and capital was from high productive to low productive plants that increased the decline in multifactor productivity growth. All these decline in productivity growth was primarily driven by the export oriented industries following a slowdown in the global demand which subsequently affected the domestic demand with an increase in unemployment.

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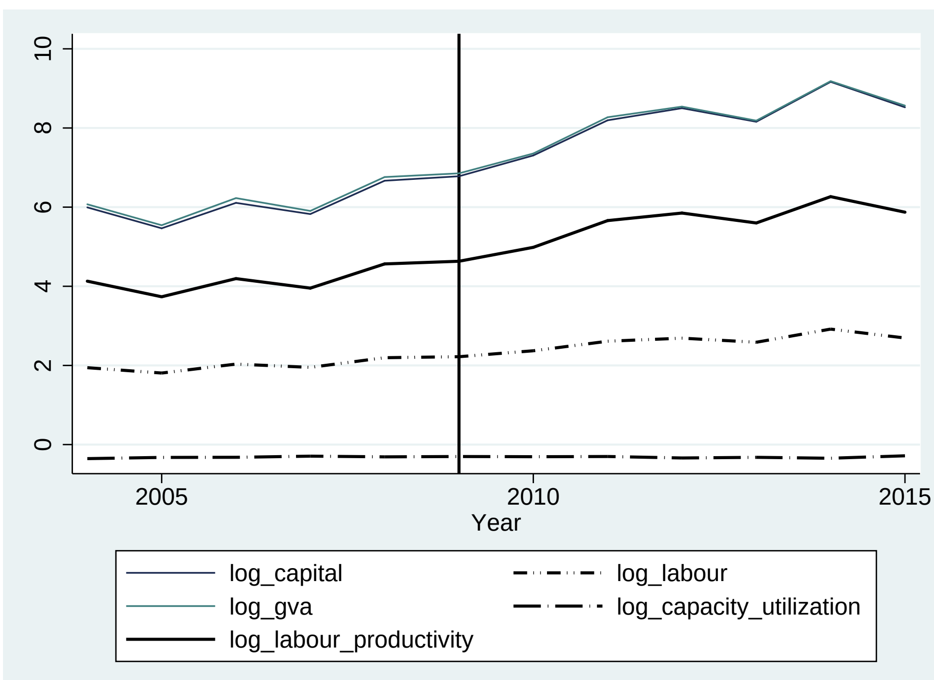
Appendices

Table A1: Decomposition of aggregate capital deepening effect

	2004-05 to 2008-09	2009-10 to 2014-15	Change
Effect of capital deepening within plants	0.01	0.01	0.00
Effect of reallocation on capital deepening	0.00	0.09	0.09
Effect of aggregate capital deepening	0.01	0.10	0.09

Note: All the above numbers are average annual rates. Source:Authors' calculation from ASI plant level panel data (2003-2004 to 2014-2015).

Figure A1: Log values of some variables by year (numbers in lakh)



Source-Calculations from Annual Survey of Industries panel data(2003-2004 to 2014-2015)