LUND UNIVERSITY
School of Economics and Management

Masters in Economic Growth, Population and Development

Sources of TFP Growth in Indian Manufacturing Sector: A Frontier Approach

by

Nisha Gurulingappa Koppa

Email: ni4201ko-s@student.lu.se

Abstract: Traditionally, Total Factor Productivity (TFP) growth, interpreted as growth due to technological advancement, is considered as the main source of long-term economic growth as other factors of input i.e. labor and capital are subjected to diminishing returns. However, conventional methods of measuring TFP did not distinguish between technological change and efficiency change. Recent developments in the TFP growth analysis acknowledges these shortcomings and have extended estimation techniques to separate these components. With a focus on Indian manufacturing sector, this study decomposes TFP growth into Technical Progress (TP) and Technical Efficiency change (TEC). The main objective of the study is to understand which component contributes to the overall productivity growth during the period 1980-2011. Specifically, 15 organized manufacturing sectors are considered for the analysis. The study further analyzes if the economic reforms adopted in 1991 had an impact on the productivity growth. The study adopts an advanced parametric estimation method specified by stochastic production frontier for the decomposition analysis. The results indicate that TP contributed positively to the growth of TFP, while TEC contributed negatively for the entire time period of study. The results also show a negative trend in TFP growth across the aggregate manufacturing sector for the entire period of study.

Key Words: Total Factor Productivity growth, Technical Progress, Technical Efficiency Change, Stochastic Production Frontier

EKHS21
Master’s Thesis (15 credits ECTS)
29 May 2019
Supervisor: Seán Kenny
Examiner: Håkan Lobell
Word Count: 10914

Acknowledgements

Firstly, I would like to thank my supervisor Seán for his amazing support, constructive feedback and enriching ideas. His encouraging and kind words helped me to achieve what I thought was impossible in just 2 months. Thank you for helping me realize my ideas in the best possible way.

Then I would like to thank Juliane. Firstly for befriending me and enabling me to find my footing in this faraway place. Secondly, introducing me to the mix of cultures that you represent. And finally, for constantly helping and accompanying me in the dungeons of the Alpha-building and encouraging me to keep going and finishing this thesis. I would also like to thank my special friend, Amit Sinha; whose constant support helped me get where I am today.

Finally, thank-you to my beautiful parents for their innumerable sacrifices and constant support which enabled me to pursue my dreams and follow my beliefs. Thank-you for believing in me and helping me stay strong.

Table of Contents

List of Figures

List of Tables

1. Introduction

1.1. Objective of the Study

Economic growth can be attributed to either growth of inputs or growth due to productivity change. Unlike the input-driven growth or capital accumulation which is subjected to diminishing returns, productivity driven growth is crucial for the long-term growth of an economy (Young, 1992; Krugman, 1994; Easterly and Levine, 2001). In his seminal work, Solow (1957) found that 80% of per capita income growth in United States could not be accounted by the differences in physical and human capital. This unexplained ‘residual’, which later came to be known as Total Factor Productivity (TFP) was then interpreted as growth due to technological advance, improvement in knowledge or efficient use of factors of production. However, there was no clear distinction between these concepts and therefore, for a long time since its conception, the exact interpretation of what TFP reflected was highly debated. Several methods like Solow’s growth accounting framework, index method and so on, were developed to obtain more accurate TFP growth estimates for the economy as a whole and at various levels of disaggregation. This was because, in the traditional growth accounting framework, the various components of the TFP could not be separated. In the last two decades, the productivity growth measurement literature has extended from a simple growth accounting framework to more refined decomposition analysis methods to estimate the sources of TFP growth.

In this context, this study investigates the sources of TFP growth in the aggregate manufacturing sectors of India. The trajectory of India’s manufacturing growth, has been a subject of intense debate, especially since 1991 when it adopted liberalization policies. One of the expected outcome of these economic reforms was to increase the productivity and efficiency of the manufacturing firms so that they can become competitive in both domestic and international markets. While the policies were able to stimulate aggregate growth of the Indian Economy, the productivity growth of manufacturing sector still remained low. From the point of view of a developing country, it is important to understand what affects the productivity[1] growth so as to frame better policies and devote resources that enhances the growth.

Hence, the main objective of this study is to provide yet another insight into the productivity slowdown in Indian manufacturing sectors for the period from 1980-2011 using newly established data from India KLEMS. Specifically, this paper tries to understand, *which source, Technological progress (TP) or technical efficiency change (TEC) accounts for a greater part of TFP growth in the 15 organized manufacturing sectors*[2] *of India from 1980 to 2010*. To obtain the estimates of TP and TEC components, Stochastic Frontier model is used. For the purpose of analysis, the periods are split into 3 decades i.e. pre-reform 1980-1990, post-reform 1991-2000 and 2001-2011.

1.2. Structure of the Thesis

The remainder of the thesis is structured as following: section 2 presents the background on two aspects of the study: first, why the manufacturing sector of an economy is important for the overall growth of the economy and second, on India's growth patterns in manufacturing sector. Section 3 presents the review of literature on two aspects of the study: first, the concept and development of TFP and its decomposition analysis and second, a review of previous studies on the productivity analysis in Indian manufacturing sector. Section 4 presents the theoretical framework and empirical specification, along with a discussion on data. Section 5 presents the results along with its discussion. Section 6 ends with an overall summary, policy implications and limitations

[1] In this paper, the term productivity growth is used interchangeably to refer TFP growth.

[2] The term sector denotes a part of the economy in which a large number of companies can be categorized, while an industry refers to a specific business sphere.

2. Background

2.1. Importance of Manufacturing sector.

During the 18th century, Great Britain became the first country to experience a systematic development in its manufacturing sector due to major technological developments, in mining, textiles and steam power (Crafts, 2004; Crafts, 2014). Consequently, these developments led to a dramatic rise in Britain's productivity and output. By the nineteenth century, these advances soon led United States and other European countries like Belgium, Switzerland and France to replicate this success and develop their own manufacturing sectors during the 19th century (Andreoni, 2013). The process was further expanded as the latecomers; Germany, Russia and Japan joined the industrializing nations, while the developing countries (both colonies and non-colonies) remained oriented towards the production of primary goods (Gerschenkron, 1962; Maddison, 2007). As noted by Gerschenkron (1962), the latecomers benefitted greatly due to their "advantages of backwardness", in other words, poorer countries have an advantage as they can replicate the production methods and technologies of the developed countries. After the World War II, East Asian economies began to enter the 'catch-up phase' as these countries had access to the technological know-how and therefore experienced rapid rates of growth (Wade, 1990; Amsden, 2001). Common to all these countries successful growth experience was the role played by industrialization.

Now, for an emerging economy which aspires to grow at a sustained high GDP growth rate, lessons offered by the historical patterns of growth becomes very important. While the initial conditions and growth drivers can be diverse for each country, the combined experience of a large set of countries for a long period shows common trends as mentioned above. Therefore, it was a long held view amongst the economists that manufacturing is the engine of growth of an economy (Kaldor, 1966,1967; Rodrik, 2009). Furthermore, Kuznets (1966, pp 64) pointed that the rapid growth in industrial productivity has been an essential element of economic development and structural transformation of the developed countries. This is also the basis of Lewis model and structuralist growth models (Lewis, 1957;. According to these models, the countries that begin their development process with most of the labor force in low productive agriculture sector, the development of manufacturing is then, generally associated with an increase in average productivity

(Andreoni, et al, 2013). It is also, generally accepted that the productivity gains achieved in manufacturing sector, significantly contribute to the productivity growth in other industries[3] of the economy and, thus pushing the overall growth of an economy (Dougherty, 2009). This is because industrial sector, unlike agriculture or services, is also characterized by a strong forward and backward linkages. Backward and forward linkages of sectors was formulated by Hirschman (1958), to show how each sector in the economy exerts a push and pull force on the rest of economy. For instance, the high tech industries such as chemicals and motor vehicles, make significant contributions to manufacturing-related services employment like business services (Szirmai, 2015). Essentially, the manufacturing sector is a the major channel through which a developing economy absorbs knowledge and industrial science from abroad (Jones and Olken 2005). Consequently, the diffusion and spill-over effects of the technological advances generated in manufacturing sector to other sectors occurs via the linkage system and therefore creating opportunities for the overall growth of the economy (Szirmai, 2015).

In a much recent study, Rodrik (2012) finds an unconditional convergence of productivity in manufacturing sector i.e. manufacturing sectors of countries that are away from the technological frontier tend to experience a rapid productivity growth. In this view, developing countries should show a rapid productivity growth in manufacturing sectors. However, many of the developing countries are already experiencing 'premature de-industrialization' (Rodrik, 2016). There is a debate as to whether the conventional path of development i.e. via manufacturing should be followed. The importance of manufacturing as an engine of growth has come under scrutiny, given the example of India's growth since the 1990's which is driven primarily by the services sector (Dasgupta and Singh, 2005). After India liberalized and adopted economic reforms it has been successful in stimulating rapid economic growth, however, it is a widely known fact that India's phenomenal growth is mostly driven by its services sector. The growth of aggregate manufacturing sector has remained consistently stagnant for years.

However, since the industrial revolution, no country has been able to achieve and sustain a high standard of living without making significant developments in their manufacturing sector, except the oil rich countries(Acharya, 2007; Chang, 2016). And

[3] This refers to the industries in agriculture and services

given the importance of the sector in terms playing a catalytic role via technological diffusion and generation of employment, manufacturing is important for the growth of the economy.

2.2. India's Growth: Patterns and Trends in Manufacturing

After India gained its independence in the year 1947, under the leadership of Jawaharlal Nehru, it embarked on a path of planned economic development and consequently opted for a mixed economy as a middle road between the Soviet-influenced socialist and free-market ideology. Over the period of next three decades, the economy had become over controlled and rigid, due to which entrepreneurship was heavily constrained (Mohan, 2006). And therefore, for the first three decades till the 70's, the nation continued along at a steady low-growth rate of around 3.5 % per annum (Basu, 2017). Table 1 demonstrates the decadal growth rate of GDP. This disappointing growth during the first three decades came to be known as the "Hindu" rate of growth (Rodrik and Subramanian, 2004). Critics pointed that this low growth rate was due to the barriers instituted by the country which often led to inefficiencies and hampered the growth of business environment. The beginning of 1980's showed a big break as the growth rate breached 5 % mark for the first time since independence. This was due to reform of some of the policies towards a pro-business outlook (Rodrik and Subramaniam, 2004).

Table 1.1. India's decadal GDP growth rate

Year	Annual GDP Growth rate
1951-61	3.91
1961-71	3.68
1971-81	3.68
1981-91	5.38
1991-2001	5.71
2001-11	7.68

Note: the growth rate of Gross domestic product is measured at factor cost with 2004-05 as constant prices. Source: Economic survey 2017-18, Government of India

In the specific context of the industrial sector, like many other countries, India also followed an economic strategy with a strong bias in favor of the public sector, strict government controls over private sector investment and opted for Import Substitution Industrialization (ISI) (Ray, 2015). Basically, to promote the domestic production, controls were imposed on imports, or getting FDI etc. Specifically, industrial licensing; where, every investor needs to obtain license before establishing an industrial plant or adding a product line to an existing plant or expanding it or even changing the location, and labor laws were thought to constitute a major problem that hindered industrialization before the reforms in 1991 were initiated. All these restrictive policies, made the firms uncompetitive compared to the international markets. The 90's represent a paradigm shift in India's economic structure, when the balance of payment crisis forced the country to experiment with policy shifts and reforms which ultimately led to a shift in its overall performance. These reforms included discontinuation of industrial licensing system import liberalization, reduction of import tariffs, removal of quantitative restrictions on international trade, reduction of barriers to allow foreign direct investment, allowing private initiative in public sector, reforms in banking and financial sector (Mohan, 2006). The rationale behind these particular reforms were to deliberately shift towards an open economy which would improve the efficiency and productivity of the industries.

Despite introducing these reforms, the growth of Indian economy during the 1991-2000 period remained lower than 6%, while during the 80's the growth had risen by 2% even though the reforms weren't adopted. Several studies have attributed the reasons for this poor growth to the low contribution of manufacturing sector and its lagging productivity (Virmani, 2005).

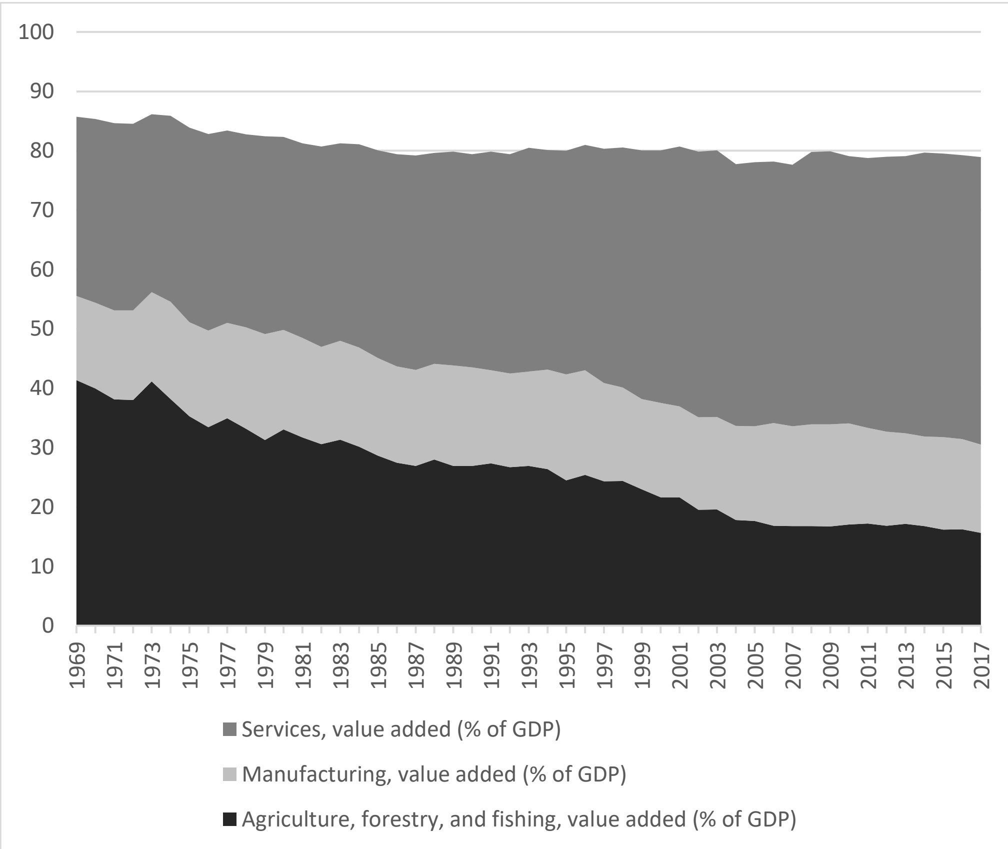
2.2.1. Pattern of Sectoral growth

In many developing countries, promoting manufacturing sector and exports has been a key growth strategy, especially in labor abundant countries. In this context, India's growth experience appears puzzling, as most of the growth momentum has not been based on manufacturing but on the services sector. The growth and contribution of each aggregate sector for the period 1969 to 2017 are presented in figure 1.1.

Now, looking at the past six decades, the gross value added (GVA) share of agriculture and related activities in the country appears to have declined sharply: from approximately 40% during the year 1969 to less than 20% in 2017. And the services sector contribution increased significantly. It is evident from the figure that the diversification of GVA occurred largely from agriculture to services. This is in contrast to China and other East Asian countries which saw the traditional pattern of development i.e. via agriculture to manufacturing (Thomas, 2013). It can be seen that even before the reforms were adopted, manufacturing sector's contribution to the economy was low. The opening up of the economy was able to boost the growth of services sector while manufacturing still remained low. Thomas (2017) in his estimation notes that the combined share of services and construction in India's aggregate GDP was 62% during 2008, while the manufacturing share was only 15%.

India's growth set precedent to the importance of service sector as an engine of growth. Another caveat of this pattern of growth is that the service sector created jobs only for skilled workers. Since the industrial sector's growth wasn't fast enough, it was unable to absorb workers from agriculture sector which has led to a structural retrogression. A large proportion of population, approximately 50 % of the population is still employed in the agriculture sector (Thomas, 2013). It was believed that with opening up of the markets, manufacturing sector will become competitive and experience an increase in its growth, however, this has clearly not been the case.

Figure 1.1 Sectoral composition of Gross value added as % of GDP , 1969 to 2017



Source: Own elaboration using data from World bank Indicators

2.2.2 Sources of growth in manufacturing sector

It can be seen from the above analysis that manufacturing sector has been growing slower than services sector and contributing less to the overall output of the economy. The process of growth and the causes in developing countries are still not entirely clear. However, a general notion prevails in academia that capital accumulation contributes the most to the overall growth as countries lack capital to start with and their adaptation to newer techniques is rather slow (Kiran and Kaur, 2008). This is because it is understood that the poor countries suffer from a paucity of capital and their adaptation to new techniques is rather slow. Now, in terms of sources of growth, table 3 provides growth rate of output measured in Gross value added at constant prices of 2004-05, capital (K), Labor (L) expressed as number of people employed, and productivity measurements for pre and post reform period.

Table 1.2: Sources of Growth in manufacturing sector (average growth rate)

Period	**Output**	**Labor**	**Capital**	**Capital productivity**	**Labor Productivity**	**Total Factor Productivity**
1980-81 to 1990-91	6.67	0.23	4.34	2.23	6.43	1.53
1991-92 to 2002-03	4.38	-0.81	4.63	-0.23	5.24	0.44

Source: Kiran and Kaur, 2006

From table 3, it is evident that production has been particularly capital-intensive in both pre- and post-reform period. The growth rate of labor becomes negative during the post reform phase indicating the non-absorption capacity as a result of low growth. A sharp decline in labor productivity growth rate can also be seen in the post reform phase. Capital productivity growth rate declined however, compared to labor productivity the decline was low.

From table 3, it can be seen that TFP growth was higher in the pre-reform phase and declined after the adoption of reforms. The decline in TFP has also been documented by several other studies like Goldar (2000), Trivedi et al. (2000) and Balakrishnan et al (2000). Virmani (2005) notes that due to the adoption of reform, the old form of production capacities became obsolete leading to a slowdown in structural transformation. It follows that faster growth of TFP in the manufacturing sector is needed to raise its competitiveness, GDP growth and convergence with the world technology frontier.

In sum, this background emphasizes the importance of the productivity growth in manufacturing sector for the overall growth of the economy. To set the context, it further presents India's unconventional growth pattern in terms of its GDP growth, sectoral contribution and specifically the sources of growth in manufacturing sector.

3. Literature Review and Theoretical Approach

3.1. Productivity: Concept and Measurement

The idea of TFP growth can be traced back to the earliest works of Abramovitz (1956), Solow (1957) and Griliches & Jorgenson (1966). Abramovitz (1956), analyzed the role of technical change in economic growth for the US labor market for the period 1900-1950. He found that almost two-thirds of the increase in labor productivity was unexplained by the increase in availability of capital per worker (Abramovitz, 1956). This 'residual' was subsequently termed as the 'coefficient of ignorance' by Abramovitz, as it measured everything and anything that was not explained by factors of production Furthermore, Solow (1960) developed a framework of growth accounting and quantified this residual which came to be known as Solow's residual/TFP/multifactor productivity. This framework was used extensively in the earlier days to identify and analyze the sources of growth at various level of aggregation. Solow's growth accounting framework can be understood as following:

Firstly, a Cobb-Douglas production function is assumed which defines the relationship between potential output and input. A crucial aspect of this framework is the assumption of constant returns to scale which indicates that an increase in the number of inputs leads to an equivalent increase in the output. Equation (1) below, defines the functional form of the Cobb-Douglas production function. The Cobb-Douglas function is a particular form of function used in economics to represent the relationship between inputs and outputs.

$$Y_t = A_t {K_t}^{\alpha} {L_t}^{1-\alpha} \qquad (1)$$

Here, Y is the output, K is capital, L is labor and A is the constant which measures the residual/TFP, while α and 1-α denote the elasticities of output with respect to capital and labor respectively and t denotes the year. Taking the growth rates of equation (1) gives us:

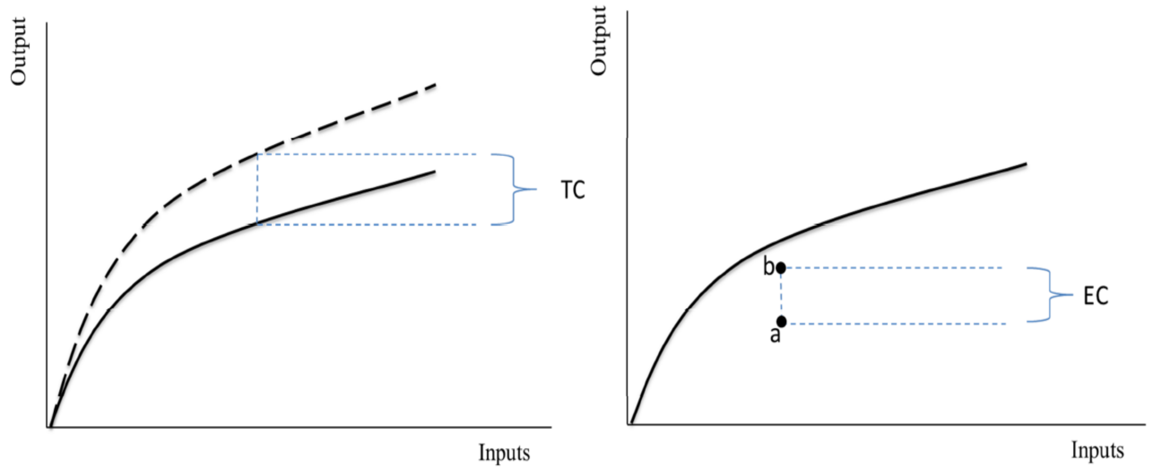
$$\frac{\Delta Y}{y_t} = \frac{\Delta A}{A_t} + \frac{\alpha \Delta K}{K_t} + \frac{(1-\alpha)\Delta L}{L_t} \qquad (2)$$

Equation (2) provides the basic growth accounting framework, where $\frac{\alpha \Delta K}{K_t}$ captures the growth of capital over time occurring due to an increase in investment. The term $\frac{(1-\alpha)\Delta L}{L_t}$, captures the contribution of Labor supply to the growth of output over time which can occur due to increase in population growth, increases in participation rates etc. Finally, the most important outcome of this process was quantifying $\frac{\Delta A}{A_t}$ which is the residual term or Total factor Productivity that grows over time.

Solow (1960) argued that this residual accounted for the overall productivity that occurred due to technological advances. However, Griliches (1996) noted that the TFP captured not only technical change but also other factors that lead to a shift in the production function. And with more research, TFP came to be used interchangeably, to refer technological change, technical progress, embodied technical change, which refers to technical change as a result of efficient use of new and better types of capital and also captures the effects of learning by doing, managerial efficiency etc., and disembodied technical change; however, the definition, measurement and interpretation of TFP has been a subject of investigation since its conception with no clear conclusion (Mahadevan, 2013). Additionally, there was no clear distinction or method to deduce what affected TFP or how it could be improved given its importance in the growth of an economy. In other words, while TFP was recognized as an important aspect, it was unclear what actually determined TFP.

One of the main drawback of measuring TFP using Solow’s growth accounting method was that it assumed that all production units are “efficient” i.e. all the combination of inputs produced maximum output. This implied that no separate adjustments for technical improvements that was embodied in labor or capital stock could be considered (Danquah et al, 2014). With further research, it was understood that TFP was composed of two components; Technical change (TC) and Efficiency change (EC). The differences between technological change and efficiency change can be understood in a simple graphical illustration (refer fig 1.2). It can be seen from the figure 1.2 that TC component measures the shift of the production function over time, while efficiency change component measures the movement of the production unit towards the optimal combination, represented by the production function, with given input. Across the world, efficiency improvement is often regarded as the most important goal behind many social and economic policies. For example, liberalization policies that opened markets to competition and removal of trade barriers are all motivated by the potential for efficiency improvement (Kumbhakar, 2015; pp19). Furthermore, Weil (2005) argues that, efficiency change may contribute as much if not more than technological change to the growth of an economy. Thus, technical change and efficiency change are understood as the sources of TFP growth. As Solow's accounting framework was unable to account for this distinction, several new methods were developed over the years.

Figure 1.2 Technological change and efficiency change



Note: The graph on the left depicts a shift in production frontier representing technological changes due to the adoption of new technology; a country with the same level of efficiency produces an additional level of output by adopting the new technology. The graph on right depicts the movement towards the frontier due to efficient use of inputs; a country produces an additional level of output given the same technology level.
Source: Kloks and Puharts, 2015.

The literature on TFP decomposition analysis can be classified into four groups: parametric estimation, non-parametric indices, exact index numbers and nonparametric methods using linear programming (Kumbhakar, 2000). The parametric or econometric estimation of TFP growth has two approaches based on the assumption of the existence of production function. They are, Frontier and non-frontier approaches (Mahadevan, 2013). The major distinction between these two approaches lies in the definition of the word 'frontier'. Frontier refers to the bounding function i.e. the best attainable positions given the inputs or the prices (Mahadevan, 2013). A 'production frontier' then, traces the set of maximum obtainable output for a given set of inputs and technology. In case of a cost frontier, it traces the minimum attainable cost given input prices and output. The TFP growth as obtained from frontier approach consists of two components- outward shifts of production function due to technological progress or vice versa and technical efficiency related to the movements towards the production frontier (as illustrated in the fig). While, the non-frontier approach considers technical progress as a measure of TFP growth.

Two specific methods; Stochastic Frontier Analysis (SFA), a parametric method and Data Envelopment Analysis (DEA), a non-parametric method, use the frontier approach to decompose TFP as technical change and efficiency change. Both the models assume that all the measurement units (industries, in this case) have a common production possibility frontier. Fare et al (1994), used the DEA method to determine the sources of TFP, which laid the foundation work to estimate and understand the role of efficiency component in the current TFP literature. However, a major shortcoming of DEA is its deterministic nature i.e. it introduces inefficiency and assumes that any deviations from the frontier must be explained only by the efficiency. In other words, the deviations from the frontier could not be explained by anything else like external shocks, luck or unexpected disturbances outside the control of the producer (Cooper, Seiford and Zhu, 2004). This problem was overcome by Stochastic Frontier Analysis (SFA) which also introduced a random shock element. The SFA builds on the microeconomic concept of production function which represents the maximum output attainable given a certain quantity of inputs Another advantage of SFA is that it follows a parametric estimation methodology by specifying the functional form of the production function and also allows for statistical tests which can give reliable evidence over DEA.

A vast number of studies have employed SFA for decomposition analysis of TFP growth. Representative studies are Nishimizu and Page (1982), Kumbhakar (1990), Fecher and Perelman (1992), which are also amongst the earliest studies that further developed and nuanced the models and methodologies for decomposition analysis. Using a flexible stochastic translog production function, studies by Kumbhakar and Lovell (2000), Kim and Han (2001) and Sharma et al (2007) decompose TFP growth into four components namely, technological progress, changes in technical efficiency, changes in allocative efficiency and scale effect. However, the estimation of allocative efficiency is often difficult due to unavailability of data. Therefore, reviewing the various methodologies, this study intends to use SFA to decompose TFP growth into TP and TEC.

3.2. Previous Studies

The literature on decomposition analysis of productivity growth is quite extensive and diverse. Various empirical studies on the topic have used a range of dimensions such as modelling, estimation, identification of determinants that affect inefficiency, channels, effects and policy implications at different levels of aggregation i.e. firms, sectors and industries. The following section presents a review on the productivity analysis in manufacturing sector in India.

At an aggregate level, there are several studies which have estimated the productivity growth in the Indian manufacturing sector from 1960's onwards. Goldar (1986) estimated the TFP indices for aggregate manufacturing sector for two sub-period's 1951-1965 and 1959-1979. The average annual rate of growth of productivity for these period varied between 1.31%, 1.29 and 1.06% per annum. Goldar's study concluded that technological progress had contributed to output growth marginally and growth in TFP for the period 1951-1979 was slow. In another study for the same period i.e. 1960-79, Ahluwalia (1991) found a decline in the total factor productivity at the rate of 0.3 % per annum.

As India started to adopt slight liberalization policies which focused on promoting entrepreneurship from the 1980's, a seemingly increasing trend in TFP growth was observed. Using the data from Annual Survey of Industry (ASI), the study found a steady increase in the growth of TFP at 3.4 per cent per annum for the first half of 1980's. Ahluwalia (1991) attributed this turnaround in productivity growth in the 1980's to the adoption of some of the reforms. In another study, Kiran (1998) estimates that changes in the growth of productivity in Indian manufacturing sector during 1973-74 to 1992-93 was higher than the period after the complete liberalization. Similar to Ahluwali (1991), they find an increase in the productivity for the time period.

Since the adoption of reforms, most of the studies have focused on analyzing the impact liberalization policies had on the growth of productivity and efficiency in the manufacturing sector. Some of the notable studies have followed non-parametric methods to quantify productivity trends and to analyze them in the context of liberalization. The study by Sivadasan (2003) examines the effect of delicensing, liberalizing FDI and tariff reductions on both firm level and aggregate-level productivity in manufacturing sector. The study covers the period from 1986 to 1994 and shows that the delicensing and other micro-reforms had a significant positive impact on the productivity level in the aggregate productivity growth after FDI liberalization. Empirical studies by Goldar (2000) and Chand and Sen (2002), suggest that trade reforms promoted TFP during the 1990's in manufacturing sector. According to these studies, the high growth rate was due to the continued structural reforms including trade liberalization which subsequently lead to efficiency gains. In a similar vein, Krishna and Mitra (1998) and Das (1998) find a positive impact of liberalization policies on the TFP growth of industrial sector. However, there is no clear consensus with regards to the positive impact liberalization policies had on TFP growth. Studies by Das (2001, 2003), Kumari (2001) and Shrivastava (2001) argue that the TFP growth in manufacturing sector only worsened during the 1990's as the industrial sector was not ready for the competition that liberalization brought. Especially, there appears to be little evidence of any positive impact on productivity growth during the 90's (Hulten and Srinivasan, 1999). In a similar vein, Misra (2006) explored the impact of economic reforms on industrial structure and productivity using the ASI data which covered both two-digit and three-digit industries. The results showed a very low performance of Indian manufacturing sector due to the adoption of the policies that increased the competition.

At an aggregate level, Mitra (1999), estimated technical efficiency change in manufacturing industries across Indian States using the frontier production framework and observed a decreasing trend in the technical efficiency measures. In a similar vein, using the data from Annual Survey of Industries (ASI), Madheswaran, Liao and Rath (2007) examined the sources of TFP growth of the manufacturing industries with Stochastic Production Frontier during 1979-80 to 1997-98. The analysis focused specifically on identifying the trend of Technical Progress (TP) and Technical Efficiency Change (TEC). The empirical result suggests that the TFP growth in a large number of manufacturing industries improved during 1997–1998 as compared to 1980–1981. They find that the TFP growth was mainly driven by technical progress and not by efficiency changes in the industries. At the firm-level, Parameshwaran (2002) analyses the sources of TFP growth for four major industry groups for the period of 1990-1997. He finds a decreasing trend in the efficiency levels in all four industry groups, and also shows that the reform measures did not particularly favor the improvement of technical efficiency in the Indian manufacturing sector. At the firm level, Tripathi (2006) employs both SFA and DEA methods to examine the efficiency gap between foreign and domestic firms in eleven manufacturing industries of India during 1990-2000. Some of the studies, have also focused on state specific analysis of TFP growth determinants, particularly in the manufacturing sector. The study by Roy et al (2017), employed frontier model to decompose TFP growth for the manufacturing industries to identify the source of growth in manufacturing industries in the state of West Bengal for a period from 1991-92 to 2010-11.

They find that the TFP growth in almost all the industries after the reforms was due to technical progress compared to efficiency measures.

In the view of background and literature review, this study contributes to the existing literature first, by extending the period of study to identify the trends of the sources of productivity growth specifically as a composition of Technical progress (TP) and technical efficiency change (TEC) in India's manufacturing sector. Precisely, the period studied in this paper is from 1980-2011 for 15 organized manufacturing sectors. None of the previous studies have analyzed sources of TFP growth for long periods. Secondly, this will be the first study which employs India KLEMS data to analyze TFP determinants in manufacturing sector using Stochastic frontier analysis. Along with getting an insight into which component of TFP accounts more in the manufacturing sector, this research also contributes to the debate on whether TFP increased after the adoption of reforms or not.

4. Methodology

Stochastic frontier analysis (SFA) was formalized by Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977) for productivity and efficiency studies. Over the years, the methodology for TFP decomposition using Stochastic Frontier Analysis (SFA) has undergone tremendous variation, reformation and extension for better analysis. Coelli (1996) also developed a software program called 'frontier' specifically to conduct decomposition analysis. However, for this study STATA software was used.

The estimation of technical efficiency using econometric models is highly dependent on the type of data i.e. panel data or cross-sectional. The first is time-invariant, where technical efficiency is allowed to vary across the industries but remains constant through time for each industry. And the second is time-varying model in which the technical efficiency is allowed to vary across industries and through time for each industry. For the purpose of this study, the time-varying specification will be used as given the availability of panel data set and also the competitive environment due to which the efficiency changes are affected. Following the previous studies by Kumbhakar and Lovell (2000); Mahadevan (2000); Kim and Han (2001); Sharma et al. (2007); Rath and Madheswaran (2004), to decompose TFP for industrial sectors, the main econometric model adopted in this study, is the time-varying stochastic frontier model developed by Battese and Coelli (1992). The theoretical framework for the TFP decomposition for this study is taken from Kumbhakar and Lovell (2000).

The following sub-section describes the theoretical framework of TFP decomposition using Stochastic production frontier which is followed by its empirical specification to estimate the parameters, and a discussion of data.

4.1. Theoretical Framework

In its generic form, the stochastic frontier production function is defined by:

$$y_{it} = f\,(x_{it},\ t,\ \beta\,)\ exp(v_{it}\text{-}u_{it}) \tag{3}$$

where i=1,……I indexes of firms or industries; t = 1,…T indexes the observations overtime. Also, *exp* in the above equation denotes exponential. Furthermore, the variables and parameters are described as following:

y_{it} denotes output level of industry i at time t;

x_{it} represents a vector of inputs of industry i at time t;

β is vector of unknown parameters to be estimated;

v_{it} is a symmetric random error term which is independently and identically distributed as $N(0, \sigma_v^2)$. This captures the random variation in output level due to external shocks;

u_{it} they are non-negative random variables associated with technical inefficiency of production which are assumed to be independently distributed. It should be noted that u_{it}, gives the inefficiency scores and to get the estimates of technical efficiency change, the exponential of $-u_{it}$ ($\exp(-u_{it})$) is taken. As the level of technical efficiency is the ratio of observed output to potential output as given by the frontier, it is captured by the component exp(-u) .

Now, taking natural logarithm and differentiating the equation (3) with respect to time gives the growth rate of output at time t for industry i as:

$$Y_{it} = \frac{dlnf(x_{it},\beta)}{dt} + \sum_j \varepsilon_j\, \dot{x}_j - \frac{du_{it}}{dt} + \frac{dv_{it}}{dt} \tag{4}$$

Here, $\varepsilon_j = \frac{\partial lnf(.)}{\partial lnx_j}$ represents the elasticity of output with respect to *j*th input. A dot over x indicates its rate of change. And the term, $\frac{dlnf(x_{it},\beta)}{dt}$ is interpreted as technical progress (TP) or technical change (TC). From equation (4), it can be seen that the overall productivity change is affected by TP, changes in the input use and also by a change in technical efficiency ($-du_{it}/dt$), which can be positive (or negative) indicating an improvement (or deterioration) over time.

Now, to determine the effects of technical progress and changes in efficiency on TFP growth, the traditional definition for TFP, which is the result of output growth that cannot be explained by input growth, is used.

$$T\dot{F}P = \dot{y_{it}} - \sum_j s_j \dot{x}_j \quad (5)$$

Here, s_j denotes the share of input *j* in production costs.

By substituting Eq. (4) in Eq. (5), the equation (5) can be rewritten as:

$$T\dot{F}P = T\dot{P} - \frac{du}{dt} + (RS-1)\sum_j \lambda_j \dot{x}_j + \sum_j(\lambda_j - s_j)\dot{x}_j \quad (6)$$

Here, RS = $\sum_j \varepsilon_j$ which denotes Returns to Scale and $\lambda_j = \varepsilon_j/RS$. Depending on whether $RS > 1$, $RS < 1$ or $RS = 1$, positive scale effects, negative effects or non-scale effects, respectively, will exist.

The Eq. (5) shows that TFP growth can be decomposed into four components, namely, Technical progress (TP), changes in technical efficiency, changes in the scale component and changes in the allocative efficiency (CAE = $\sum_j(\lambda_j - s_j)\dot{x}_j$). The rate of change in technical efficiency (TE) illustrates the rate at which a firm/industry moves towards or away from the production function. The rate of technical change/progress (TP), indicates if the production function shifts upward, downward or remains unchanged. The scale effects (SE) measures returns to scale characterizing the production function. Under the assumption of constant returns to scale, which is common in neo-classical growth models, ε_j would be zero and then equation 4 will be:

$$T\dot{F}P = T\dot{P} + T\dot{E} + C\dot{A}E \quad (7)$$

For the purpose of this study and due to unavailability of data on prices of factor inputs, TFP is decomposed into the first two components from eq. (7) i.e. Technical progress (TP) and changes in technical efficiency (TEC).

4.2. Econometric Specification

To decompose TFP series and separate the technological progress from efficiency change component, a transcendental logarithmic (also referred to as translog) production function is used. The translog production function was originally developed by Christensen, Jorgenson and Lau (1971), which came to be used widely for decomposition analysis. The translog production function is used over Cobb-Douglas function, especially for the study of TFP decomposition is favored as it allows for nonconstant return to scale i.e. it doesn't require any restrictive assumptions on the elasticity and substitution like Cobb-Douglas production function does (Kumbhakar, 2000). Also, the suitability of translog production function is checked using hypothesis tests indicating the use of translog function, which are discussed latter in the results section.

The translog specification of the production function using two inputs i.e. Capital and labor is represented by the following equation (5) :

$$lnf(x_{it}, t, \beta) = \beta_0 + \beta_1 lnK_{it} + \beta_2 lnL_{it} + \beta_3 T + \frac{1}{2}\beta_4(\ln K_{it})^2 + \frac{1}{2}\beta_5(\ln L_{it})^2 + \beta_6 lnK_{it} lnL_{it} + \beta_7 T\, lnK_{it} + \beta_8 T\, lnL_{it} + \frac{1}{2}\beta_9 T^2 + v_{it} - u_{it} \quad (5)$$

Where, L denotes the labor input, K denote the capital input and T is the time trend which captures technological progress. As noted earlier, the term $exp(v_{it})$ or random error term, captures the measurement errors and the exogenous shocks. It is assumed to be independent and identically distributed with zero mean and constant variance. The inefficiency parameter $\exp(u_{it})$ represents the production loss due to industry specific technical inefficiency level. Previous studies show that, the distribution of this term varies from exponential, truncated-normal and half-normal distributions (Pires and Garcia, 2012). In this analysis, following previous studies, the $u_{it}$is assumed to have truncated normal distribution. The estimation of parameter is done following the method of maximum likelihood estimation technique. The purpose of MLE is to find the maximum of the specified translog function i.e. the parameters which are most likely to have produced the observed data.

The production function, as described in the previous section, consists of three key variables which can be estimated from the parameters obtained using the translog specification (eq. (6)).

$$TP_{it} = \frac{\partial lnf(x_{it},t,\beta)}{\partial t} = \beta_3 + \beta_9 T + \beta_7 lnK_{it} + \beta_8 lnL_{it} \quad (6)$$

Essentially, the objective is to obtain the estimates of the parameter vector $\beta's$, which describe the structure of the production function and also to obtain the estimates of u_{it} which can then be used to get the estimates of TEC for each sector. If the values of all the $\beta's$ is equal to zero, the production function reduces to Cobb-Douglass function. The model is estimated by maximum-likelihood (ML) estimation. For the purpose of this study, technical efficiency component is taken as time-variant, following Battese and Coelli (1992):

$$u_{it} = \exp[-\eta(t-T)]\,.\,u_i \qquad u_{it} \geq 0, i = 1 \ldots \ldots, N,\ t \in \tau(i) \quad (9)$$

Here, u_i are the independent random variables and η is an unknown parameter, which represents the rates of changes in the technical inefficiency. It is expected that, u_{it} decreases, remains constant or increases as 't' increases depending on whether η>0, η=0 or η<0, respectively. The case in which η is positive implies that on average, industry improved their level of technical efficiency over time. As it follows, if η is negative, it implies that the industry's efficiency worsens over time.

The models are also tested to check if the inefficiencies are not simply due to random errors, the variance parameter γ for all models is calculated. $\gamma = \sigma_u^2/(\sigma_u^2 + \sigma_v^2)$. The closer the value of γ to one, the greater part of the deviations of industry from the frontier is attributed to the inefficiency. And if the value of γ is closer to zero, then all deviations from the frontier are due to random errors and statistical noise (Ghosh and Mastromarco, 2013).

4.3. Data

For the purpose of this study, the latest version of India KLEMS dataset is used. This dataset is taken from the World KLEMS database. This dataset provides data at industrial sectors to examine the productivity performance of individual industries and their contribution to aggregate growth. It provides annual panel data from the year 1980 to 2011 for 27 disaggregated industrial sectors belonging to agriculture, manufacturing and services. For comparability across the sectors, the data is deflated and converted to constant prices taking 2004-05 as the base year. Specifically, this database provides industry-level series on output, number of people employed, composition of labor, aggregate capital stock and estimated values of TFP and labor productivity. To fulfil the gap in availability of consistent dataset on productivity measurements across the industrial sectors in India, the KLEMS database for India was established by Indian Council for Research on International Economics (ICRIER) with the support of Reserve Bank of India. As this study focuses on manufacturing sector, the data for 15 manufacturing industries is used.

The dependent variable is the output measured by Gross Value Added (GVA) at constant prices of 2004-05. Gross value added is defined as the value of output minus the value of its intermediary inputs. Although many studies use Gross domestic output (GDP) as the output variable in TFP decomposition analysis, however, with GDP there is a possibility of double counting (Madheswaran, 2006). Also, it is widely accepted that GVA provides better measure of economic activity as, GDP can also record a sharp increase just on the account of increased tax collections and not due to an increase in output. Therefore, to avoid double counting, the gross value added at constant price (Indian rupees) is used as the measure of output. For factor input variables, the total number of workers is proxied for labor input. Ideally, total number of labor hours is considered a better measurement for labor input, however, at an aggregate level this data is not available. The physical capital input is proxied by aggregate capital stock (in Indian rupees) which is also taken from the same database. Similar to the gross value added, capital stock is measured at constant prices with 2004-05 as the base year. This allows the variables to be comparable. Table A1 in the appendix provides the descriptive statistics of the data for input and output variables. The total number of observations for this study is 480. Studies by Badri et al (2004), Kloks and Puharts (2015), Ray et al (2017) and several other use data with observations less than 500.

5. Analysis of Results

5.1. Estimates of Frontier Production Function

In this section, the maximum likelihood estimates of frontier production function in the transcendental logarithmic specification for the period 1980-81 to 2010-2011 are discussed. The results of estimates are presented in table 1.3. The estimated model I is equivalent to that of Ordinary Least Square estimations. Model I shows that the estimates of average production function wherein, μ, γ and η are restricted to be zero, which indicates that the model does not control for technical inefficiency effects in the production function. In other words, the OLS production function fits the translog function through the center of the data, assuming all industries are efficient. Model II represents a time-invariant panel model, in which there is no change in the technical inefficiency levels across time periods in the industries. The frontier input coefficients in model II are insignificant except a few. Model III, is the time-varying model, which takes into consideration the existence of technical inefficiency and is the preferred model for this analysis. The frontier input coefficients for model III, shows that all variables except interaction term $\ln(\text{labor})^2$ are significant at 1 % level. Therefore, the model III is preferred.

The positive sign on ln(K) or β_1, in the model III, implies that capital had a positive effect on the output growth. The marginal product of labor i.e. β_2 is negative, indicating that the labor did not have a significant impact of the growth of output. This result is intuitive given that after the reforms, especially the reductions in tariff rates, lead the firms to use more capital than labor in the formation of new production capacity. The second order term of capital i.e. β_4, is negative which indicates that the capital stock will eventually diminish the output level. Similarly, the positive sign of second order term i.e. β_5, of labor indicates the increasing rate of change on labor contribution. The coefficient of time*ln(K), β_7, is positive and that of time * ln(L) is negative; this indicates that marginal product of capital has been increasing over the time while that of labor has been decreasing. The decreasing marginal product of labor can be attributed or understood as occurring due to the technological advances that required more capital then labor and therefore leading to a fall in the output attributed to labor. The coefficient on time, which is also a proxy for technical progress, is positive which indicates that time has contributed towards output growth. The second-order term on time, β_9, is small and negative which implies that the technical progress has been decreasing very slowly.

Furthermore, the variance parameter γ was calculated to see if the inefficiencies were not simply the random errors. The value of γ in the models vary from 0.98 to 0.68. As noted earlier, the closer the value of γ to one, the greater part of the deviations from frontier is attributed to inefficiencies and not statistical noise. The hypothesis that γ=0 is rejected for both the models, which implies that the realized output differs from the potential output significantly and the differences are due to the industry specific technical inefficiency effects and not due to any random errors or shocks like luck, weather, strikes etc.

Table 1.3: Estimates of Stochastic Frontier Production Function using Maximum Likelihood Method (1980-81 to 2010-11)

VARIABLES	**Intercept**	**(I) OLS**	**(II) MLE**	**(III) MLE**
Ln(Capital)	β_1	0.675	0.461	3.467***
		(0.482)	(0.571)	(0.571)
Ln(Labor)	β_2	-0.238	0.142	-0.868***
		(0.227)	(0.291)	(0.302)
Time	β_3	-0.140***	-0.0851*	0.311***
		(0.0538)	(0.0466)	(0.0497)
Ln $(Capital)^2$	β_4	0.0861**	-0.107*	-0.416***
		(0.0347)	(0.0628)	(0.0627)
$Ln(Labor)^2$	β_5	0.367***	-0.115***	0.0276
		(0.0218)	(0.0313)	(0.0264)
Ln(Labor)* Ln(Capital)	β_6	-0.198***	0.107***	0.112***
		(0.0314)	(0.0309)	(0.0291)
Time* Ln (Capital)	β_7	0.0164***	0.0218***	0.0434***
		(0.00373)	(0.00431)	(0.00470)
Time* ln (Labor)	β_8	0.00193	-0.0143***	-0.0164***
		(0.00345)	(0.00290)	(0.00279)
Time* Time	β_9	-0.00232***	-0.00181***	-0.00293***
		(0.000661)	(0.000414)	(0.000449)
Observations		480	480	480
No. of Industries		15	15	15
Gamma (γ)		0	0.9882	0.6845
Mu		0	1.4912	.6709413
Log likelihood function		0.838	71.2974	85.0812

Note: The dependent variable, output, is Gross Value added at constant prices. MLE stands for maximum likelihood estimation. Standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Additionally, test results for model specification are presented in the appendix Table A2. The likelihood test in table A2, is conducted to see if the null hypothesis that translog stochastic frontier production function can be reduced to a Cobb-Douglas production function. The test statistic as specified by null hypothesis, $H_0: \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = 0$ has a likelihood ratio value of 78.70 which indicates rejection of the null hypothesis at 1% significance level. This implies that translog production function is adequate for conducting this analysis.

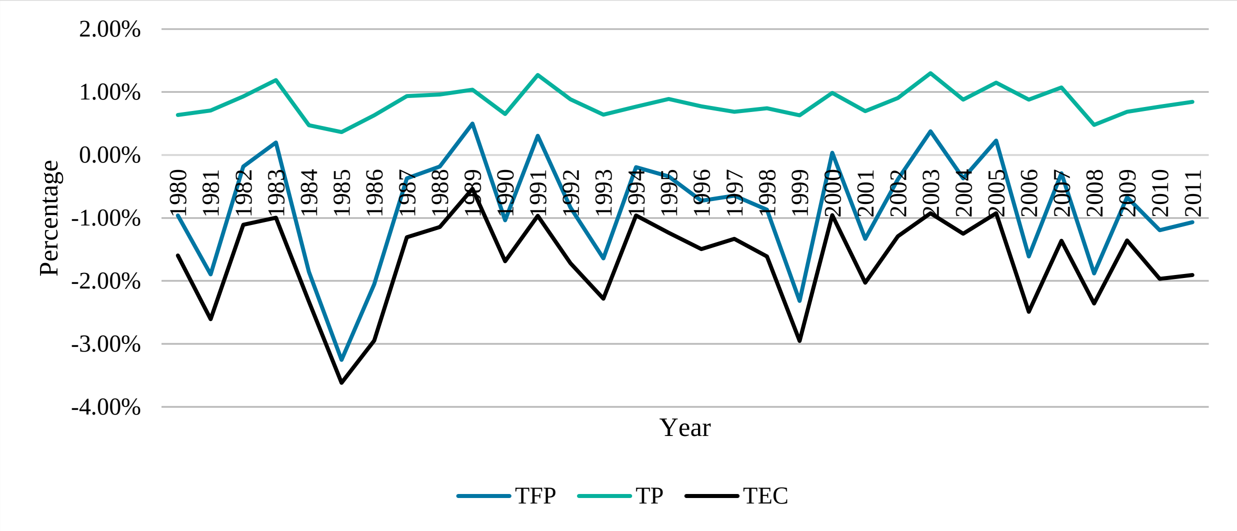
5.2. TFP, TP and TEC across aggregate manufacturing sector

Here, the estimation of TP, TEC and TFP as derived using the estimated parameters are discussed. Specifically, the values of TP are derived using equation (4). And the estimations of TFP is derived as a sum of TP and TEC. The summary statistics of the Total Factor Productivity and its components; TP and TEC are provided in the appendix (table A3). It shows that the mean value of TFP is negative. As TFP is the sum of TEC and TP, it is evident that TFP is driven primarily by the negative TEC as opposed to TP.

For a better insight into the pattern, the fig 1.3 below, plots the average estimates of TFP, TP and TEC across all the industries from 1980-2011. *The most interesting finding of this study is the negative growth rate of TFP across the aggregate manufacturing sector for most parts during the past 3 decades*. This decline in TFP is primarily driven by the low level of efficiency changes. It should be noted that the average growth rate of TFP for the entire period i.e. from 1980-2011 across the aggregate manufacturing sector was -0.80%. The period-wise average growth rate of TFP is as follows: -1.01% growth rate during 1980-1990, -0.72% growth during 1991-2000 and finally, for the period 2001-2011 it was -0.68%. This result is comparable to the recent estimates done using KLEMS data, with a different methodology, which showed a negative growth trend of -1.12% for the same period i.e. 1980-2014 (Goldar, 2014).

The graph (fig 1.3) shows the trends of TFP which closely follow TEC for all the period. TP has remained consistently stable and positive with minor declines during the mid-80's. It can also be observed from the graph that TP TFP and TEC all fall during the year 1991, which marks the adoption of economic reforms. TP's decline during 1991 is very small and negligible as compared to TEC. Furthermore, the TFP remained negative for the entire decade from 1991, increasing only at the end of decade. It can also be seen that during the 2008 recession, there was a decline in TFP. Again the major source of this decline was the low level of efficiency. This is a major cause of concern for the long term economic growth of India. Broadberry and Wallis (2017) in their analysis show that a country needs to end TFP growth reversals so as to transition to a modern economy. As these estimations show, the TFP in manufacturing sector in India has been subject to constant fluctuations, which reveals its below par performance in the Indian economy. Considering the important role manufacturing plays in the economic structure of the country, these results indicate the importance of policy reforms to increase the efficiency.

Figure 1.3 : Average TFP, TP and TEC across aggregate manufacturing sector, 1980-2011



Note: Calculations based on own estimations using KLEMS data

5.2.1. Technical Progress

The technical progress (TP) component denotes the shift of production frontier due to technological advance, or gains in knowledge. Table 1.4, below, presents the average decadal growth of technical change for the 15 manufacturing industries. It is evident that several industries registered either an increase in TP during the post-reform period or had no growth. This is also same for the period 2001-2011. Especially, Other non-metallic sector saw a significant increase in TP during this time period.

Table B1 and B2 in the appendix, present the estimated technical progress of all manufacturing sector for two period 1980-1990 and 1991-2000 respectively. In the pre-reform period i.e. 1980-1990 there were slight policy changes towards a more pro-business outlook. Several industries during the first period registered a high and positive TP for example, basic metals and fabricated metal products, chemicals and chemical products, electricity gas and water supply. However, by the end of the first period, most of the industry's TP had declined.

The period 1991-2000 is when the Indian economy fully embraced the liberalization policies. Policy reform included allowing FDI, reduction in import tariffs etc. From table B3 (refer appendix), it can be seen that several industries saw a slight fall in the growth rate of technical progress (TP) initially. For several sectors like coke, refined petroleum products and nuclear fuel, manufacturing in recycling, rubber and plastic products and wood and products of wood sectors all show a negative trend during all the decades. Especially the wood and products of wood sector has the lowest TP growth. Electricity, gas and water supply, on the other hand saw a seemingly steady increase in TP during this period. Ray (2014), finds that an increase in capital and foreign ownership explain the increase in TP for this sector. The increase in textile industry is explained by the import reductions that led to an increase in the import of raw materials (Ray, 2014). TP trend for the period 2001-2011, shows a steady increase in most sectors except the coke, refined petroleum products and nuclear fuel, manufacturing in recycling, rubber and plastic products and wood and products of wood sectors.

The new industrial policies and economic reforms which allowed FDI and tariff reductions that led to import of new technologies can be seen as the probable reason for this increase in technological progress across some of the manufacturing sectors. These results are similar to the earlier analysis using SFA for manufacturing sector, which concluded that productivity growth in manufacturing sector was driven by Technical progress and that there was a positive trend in most sectors (Srivastava, 2000; Badri et al, 2008).

Table 1.4 : Average decadal growth of Technical progress

	TP	**TP**	**TP**
Industry	**1980-1990**	**1991-2000**	**2001-2011**
Basic Metals and Fabricated Metal Products	2.70%	2.81%	2.67%
Chemicals and Chemical Products	2.32%	2.25%	2.31%
Coke, Refined Petroleum Products and Nuclear fuel	-0.48%	-0.49%	-0.58%
Construction	0.91%	1.53%	1.12%
Electrical and Optical Equipment	0.34%	0.25%	0.40%
Electricity, Gas and Water Supply	3.92%	3.93%	3.90%
Food Products, Beverages and Tobacco	2.16%	2.22%	2.20%
Machinery	0.01%	0.12%	-0.11%
Manufacturing, ; recycling	-0.87%	-0.69%	-0.79%
Other Non-Metallic Mineral Products	1.07%	-0.10%	1.08%
Pulp, Paper, Paper products, Printing and Publishing	1.24%	1.24%	1.27%
Rubber and Plastic Products	-0.71%	-1.16%	-0.41%
Textiles, Textile Products, Leather and Footwear	1.96%	2.05%	2.17%
Transport Equipment	0.36%	0.69%	0.26%
Wood and Products of wood	-2.21%	-2.21%	-2.31%

Source: Own calculations estimated using the SFA on KLEMS data.

5.2.2. Technical Efficiency Changes

Table 1.5 summarizes the average decadal growth in technical efficiency changes across the manufacturing sectors in India. From the table it is evident that unlike TP, TEC shows a consistent negative trend in all of the sectors. This clearly indicates the lack of resource utilization in these sectors. There are several factors that can lead to an inefficient utilization. These are discussed in the following section. Again these findings are similar the earlier findings which indicate a negative TEC in both pre-reform and post-reform period.

Table 1.5 Average decadal growth of Technical Efficiency Change

Industry	TEC 1980-1990	TEC 1991-2000	TEC 2001-2011
Basic Metals and Fabricated Metal Products	-1.62%	-1.52%	-1.84%
Chemicals and Chemical Products	-2.13%	-1.83%	-1.05%
Coke, Refined Petroleum Products and Nuclear fuel	-1.93%	-1.36%	-1.67%
Construction	-2.04%	-0.89%	-1.99%
Electrical and Optical Equipment	-1.29%	-1.56%	-2.14%
Electricity, Gas and Water Supply	-1.83%	-1.80%	-1.37%
Food Products, Beverages and Tobacco	-2.17%	-1.46%	-1.34%
Machinery	-1.28%	-1.71%	-2.01%
Manufacturing, ; recycling	-1.21%	-1.87%	-1.93%
Other Non-Metallic Mineral Products	-1.57%	-2.52%	-0.99%
Pulp, Paper, Paper products, Printing and Publishing	-2.33%	-1.39%	-1.24%
Rubber and Plastic Products	-1.75%	-2.13%	-1.16%
Textiles, Textile Products, Leather and Footwear	-1.92%	-1.29%	-1.75%
Transport Equipment	-1.57%	-1.04%	-2.33%
Wood and Products of wood	-2.48%	-0.89%	-1.55%

Source: Own calculations estimated using the SFA method on KLEMS data.

The table B4, B5 and B6 in the appendix gives the time-variant industry specific predictors of technical efficiency change based on the equation (9). Overall, the results show that there are negative trends in technical efficiency in all periods. In the pre-reform period, 1980-1990, several sectors like Chemicals and chemical products, Electricity, Gas and Water Supply, Manufacturing in recycling, Rubber and plastic products all saw a substantial decline, especially after 1985. After the adoption of reforms, the technical efficiency, initially remained same, and started to decline from the year 1995. Technical efficiency fell drastically for rubber and plastic product sector during this period. Overall, the technical efficiency change does not appear to have grown significantly across the industries, leading to the conclusion that it has been dragging the TFP growth down in all the sectors. These estimates of technical efficiency change are directly related to the technical know-how, and socio-economic characteristic of the workers (Madheswaran et al, 2004).

5.2.3. Total factor Productivity growth

The average decadal growth rate of TFP across the manufacturing sectors are summarized in table 4. As noted earlier, TFP is derived as a sum of TP and TEC . From table 1.6, it is evident that TFP growth in most industrial sectors declined during the second decade, 1991-2000. Only the textiles, textile products, leather and footwear registered a gradual positive increase in TFP after the adoption of reforms. The negative contribution of TFP can be seen in 2001-2011 too for several industries like machinery, coke, refined petroleum products and nuclear fuel, manufacturing and pulp, paper, paper products etc. Overall, a decline in the industrial sector is visible, which indicates that the contribution of productivity is shrinking. This has also been documented by Goldar (2004), Srivastava (2001) and Trivedi et al (2011). To sustain a high growth rate, the manufacturing sector needs to increase its productivity growth.

Table 1.6: Average decadal growth of Total factor Productivity

Industry	**TFP 1980-1990**	**TFP 1991-2000**	**TFP 2001-2011**
Basic Metals and Fabricated Metal Products	1.28%	1.29%	0.83%
Chemicals and Chemical Products	0.12%	0.42%	1.26%
Coke, Refined Petroleum Products and Nuclear fuel	-3.04%	-1.85%	-2.26%
Construction	-0.79%	0.64%	-0.87%
Electrical and Optical Equipment	-0.90%	-1.31%	-1.74%
Electricity, Gas and Water Supply	2.06%	2.12%	2.53%
Food Products, Beverages and Tobacco	-0.09%	0.77%	0.87%
Machinery	-1.08%	-1.59%	-2.12%
Manufacturing, ; recycling	-1.63%	-2.56%	-2.73%
Other Non-Metallic Mineral Products	-0.91%	-2.62%	0.10%
Pulp, Paper, Paper products, Printing and Publishing	-1.22%	-0.15%	0.03%
Rubber and Plastic Products	-2.71%	-3.29%	-1.57%
Textiles, Textile Products, Leather and Footwear	-0.03%	0.76%	0.43%
Transport Equipment	-1.09%	-0.35%	-2.07%
Wood and Products of wood	-5.07%	-3.10%	-3.86%

Source: Own calculations estimated using the SFA on KLEMS data.

5.3. Discussion of Results

The frontier equation estimated for the entire period from 1980-2011 showed that the contribution of capital to output growth as measured in terms of Gross value added at constant prices (2004-05) has been positive, while that of labor is negative to the output growth (refer table 1.3) for the entire period from 1980-2011. Using the parameters estimated, the study further estimated TFP and its components as TP and TEC. The intended effect of industrial reforms seems to have only impacted the TP aspect of TFP as only TP shows a positive growth rate and also a rather small drop during the 1991 as compared to TEC. These results are in line with earlier findings which study the TFP growth for manufacturing sector.

These findings compared with earlier studies indicate that the overall post-reform period i.e. 1991-2000, saw a slowdown in productivity growth confirming earlier findings for the same (Goldar, 2004; Goldar and Kumari, 2003). Also, with respect to SFA analysis, these findings are similar to the analysis by Madheswaran et al. (2004) and Rath et al (200, who conclude that technical progress showed positive trends while efficiency change did not for the post reform period. There are several factors' that might have contributed to the positive trend in TP. Factors like FDI, technological advances, increased Research and development (RD) intensity and import of technologies are some of the factors that have been found to have positively contributed in TP across various sectors (Ray 2014). It should be noted that the results for each industrial sector is heterogenous i.e. the estimates show trends different for different sector. As the data availability was an issue, the factors that affect TP varies with each sector. While TP has been largely positive, it is still quite low compared to other emerging economies (Mahadevan, 2000).

Several other studies have documented the factors that contribute to the negative growth of efficiency change in the productivity growth of manufacturing sector at various levels of aggregation within manufacturing sector in India. It should be noted that while TEC is largely affecting the growth of TFP, it is not a sufficient cause to explain a decline in TFP. Due to unavailability of data at sectoral level, this study could not control for the factors that affect the level of TEC. As TEC refers to the ability to use the combination of factors in the most efficient way, major factors that affect TEC are due to the labor. Madheswaran et al (2006), notes that as TEC is also directly related to the technical know-how and socio economic characteristics of the industrial workers. Socio-economic characteristics of a worker includes the skill level, education etc. Therefore a variation in these attributes of labor can have an impact on the TEC and therefore on TFP. In India, except heavy industries, other industries are basically producing output using labor- intensive techniques (Rath et al, 2004). Therefore, most of the workers are unskilled and have limited knowledge of using the new technology. Similarly, other socio economic variables like the age of the workers, non-firm income of the worker, health conditions, poverty and other bureaucratic constraint can also be relevant for the negative TEC's.

On another note, these findings also relates to Rodrik's (2009) hypothesis on unconditional convergence of productivity in manufacturing sector, which states that the manufacturing sectors that are further away from the technological frontier tends to experience more rapid productivity growth, irrespective of the quality of domestic policies, institutions or geography of the country. Clearly, India's manufacturing productivity growth does not lends support to this hypothesis. Its manufacturing sector is still far from the technological frontier as it can be seen from its consistent negative trends in TFP. This constant low growth of manufacturing sector also has an impact on the entire growth of the economy and this needs to be corrected.

6. Conclusion

6.1 Summary

Over the past three decades, India has sustained a rapid growth of GDP which has led to an increase in living standards and reduction in poverty. Unlike the traditional structural development path i.e. via industrialization, India directly skipped to services sector, which accounts for more than half of its aggregate GDP. A slow development of its manufacturing sector after the independence is attributed to its rigid policies protecting the producers from competition. However, even after the removal of these barriers, manufacturing sector has been subjected to a low contribution to the overall growth of the economy. . Therefore, much of the debate for this slow development of manufacturing sector has centered around the adoption of economic reforms during the 90's. Several studies have attempted to identify the causes and sources of low growth in the sector. In this line of thought, this study attempted to look at the productivity growth pattern in India's organized manufacturing sector. The main research objective of this study was to identify and analyze which component of TFP growth i.e. Technical progress (TP) and Technical Efficiency Change (TEC) , contributed to the overall productivity growth in India's 15 manufacturing sectors for the period 1980-2011. To overcome the problems of traditional growth accounting framework, and to identify and separate TP and TEC, stochastic production frontier was used. The stochastic frontier production function developed by Battese and Coelli (1992), which allows for the time varying technical efficiency estimation was used to derive the parameters and then estimate TP and TEC.

The results showed that, with regards to the main source of TFP growth for the aggregate manufacturing sector, it was TP which contributed positively while TEC contributed negatively for the entire period of study (1980-2011). The average growth trends showed that TP was either increasing or constant. TEC however, showed a completely negative trend across the sector, which also pulled the overall TFP down for the entire period. The estimation for 15 individual sectors showed a positive trend in TP and a negative trend in TEC. However, there are variations in the trends observed for each sector and therefore, only general observations can be made. Overall TFP growth fell during the post reform period i.e. 1990-2000, for almost all the sectors. This low growth was driven by a negative technical efficiency change. Along with decomposing and analyzing which source of TFP contributed to the growth, another central aspect of the analysis was to analyze if economic reforms had an effect on the productivity. It also appears that the expected impact of reforms had a small yet significant impact on increasing TP from 90's onwards. Specifically, FDI, import reduction and increasing R&D spending had a positive impact on the technological progress for some industries (Ray, 2014). However, the lack of improvement in TEC might also indicate the unpreparedness of the firms for more competition during the time of adoption of reforms.

Overall, the findings indicate a low growth of TFP across the manufacturing sector. As noted in the beginning of the study, while capital accumulation is important for the growth of the economy, it is subjected to decreasing returns. Therefore, increasing productivity growth can play a key role in its long-term growth.

6.2. Implications

Pulling together the findings and the analysis of the study, a number of implications for India's manufacturing growth can be drawn. To generate gains in aggregate TFP, reforms should be directed towards making it easier to expand domestic production. And given an increasing competition the industries and firms have to become more conscious of their survival and competitiveness. An improvement in TFP growth is intended to trigger the better utilization of inputs along with an improvement in technological progress. As the efficient use of inputs is largely dependent on the inputs, it follows that workers should be given better training to develop their skills and expertise to use the existing technology more effectively within the firms and industry. The management aspect is also crucial when new technologies are adopted. As technological progress relies on the management capability of the organization in utilizing the factors to their full potential. Enhancement of technical progress largely comes from R&D activities, FDI and therefore, efforts should be made to increase R&D activities in the manufacturing sector. The major policy implication is that the firms within the sectors that registered low TFP growth need to become competitive and this requires a general environment of entrepreneurship and ease of business doing.

6.3. Limitations and further research

The data used for the study is taken from World KLEMS database. To the best of my knowledge, this is the first study that uses the India KLEMS data for decomposition analysis using Stochastic frontier model. This dataset was prepared considering the international standard for an easy comparability, therefore the quality of data is assumed to be accurate and reliable. However, as the data is highly aggregated it might not be a correct representative of the industrial sectors and only estimated. Certain aspects like labor quality or education level of labor can be potentially biasing the results on technical efficiency component. However, due to lack of data on these aspects, the analysis could not control for them. Also, there are certain limitations present in the model that is used for analysis. First, while it is not uncommon to use stochastic frontier model for aggregate-level data, it is however considered to be an appropriate method for firm-level or micro level data. Given that this study uses aggregate level data, the results might still vary when looking at a particular industry or at a further micro-level i.e. firms etc. As for further research, firstly, the analysis can take into account the factors affecting inefficiency scores to give a broader and nuanced understanding of the long-run TFP growth. Secondly, there is scope in conducting these studies using different control variables at a firm-level or industry level. Admittedly, data availability would be a problem. Thirdly, future research can focus on the impact sectoral reallocation of labor has on the TFP growth.

References

Abramovitz M. (1975). Catching up, forging ahead, and falling behind. *Journal of Economic history*, 46(2):385–406.

Abramovitz, M., 1956. Resource and output trends in the United States since 1870. In *Resource and output trends in the United States since 1870* (pp. 1-23). NBER.

Ahluwalia, I.J. (1985) Industrial Growth in India – Stagnation Since the Mid-sixties. Delhi, India: Oxford University Press.

Ahluwalia, I.J. (1991) Productivity and Growth in Indian Manufacturing. New Delhi, India*: Oxford University Press.*

Aigner D., C. Lovell, and P. Schmidt (1977). Formulation and estimation of stochastic frontier models. *Journal of Econometrics*, 6(1):21–37.

Amsden, A.H., 2001. *The rise of" the rest": challenges to the west from late-industrializing economies*. Oxford University Press, USA.

Andreoni, A. and Gregory, M., 2013. Why and how does manufacturing still matter: old rationales, new realities. *Revue d'économie industrielle*, (144), pp.21-57.

Badri Narayan Rath & S.Madheswaran, 2004. "Productivity Growth of Indian Manufacturing Sector: Panel Estimation of Stochastic Production Frontier and Technical Inefficiency," *Econometric Society 2004 Far Eastern Meetings 528*, Econometric Society.

Balakrishnan, P., Pushapangdan, K. and Babu, M.S. (2000) 'Trade liberalization and productivity growth in manufacturing: evidence from firm-level panel data', Economic and Political Weekly, Vol. 35, October 7, pp.3679–3682.

Basu, K. and Maertens, A., 2007. The pattern and causes of economic growth in India. *Oxford Review of Economic Policy*, 23(2), pp.143-167.

Battese G. and T. Coelli (1992). Frontier production functions, technical efficiency and panel data: With application to paddy farmers in India. *Journal of Productivity Analysis*, 3:153–169.

Chand, S. and Sen, K. (2002) 'Trade liberalization and productivity growth: evidence from Indian manufacturing', Review of Development Economics, Vol. 6, pp.120–132.

Christensen, L.R., Jorgenson, D.W. and Lau, L.J., 1973. Transcendental logarithmic production frontiers. *The review of economics and statistics*, pp.28-45.

Coelli T.J. (1996). A guide to frontier version 4.1: A computer program for stochastic frontier production and cost function estimation. CEPA Working Papers, No. 7. Department of Econometrics, University of New England.

Cooper, W., Seiford, L., Zhu, J. (2004). Handbook On Data Envelopment Analysis. Massachusetts: Kluwer Academic Publishers.

Crafts, N., 2004. Steam as a general purpose technology: a growth accounting perspective. *The Economic Journal*, *114*(495), pp.338-351.

Crafts, N., 2014. *Industrialization: Why Britain Got There First*(No. 214). Competitive Advantage in the Global Economy (CAGE).

Danquah, M., Moral-Benito, E., & Ouattara, B. (2014). TFP growth and its determinants: a model averaging approach. Empirical Economics, 47(1), 227-251.

Das, D.K. (2001) Trade Liberalization and Industrial Productivity: An Assessment of Developing Country Experiences. Working Paper 77, April, ICRIER.

Dasgupta, S. and Singh, A., 2005. Will services be the new engine of Indian economic growth?. *Development and Change*, *36*(6), pp.1035-1057.

Dougherty, S., Herd, R. and Chalaux, T., 2010. What is holding back productivity growth in India?. *OECD Journal: Economic Studies*, *2009*(1), pp.1-22.

Easterly, W., & Levine, R. (2001). What have we learned from a decade of empirical research on growth? It's Not Factor Accumulation: Stylized Facts and Growth Models. *The World Bank economic review*, *15*(2), 177-219.

Fagerberg, J., Srholec, M. and Knell, M., 2007. The competitiveness of nations: Why some countries prosper while others fall behind. *World development*, *35*(10), pp.1595-1620.

Fare, R., Grosskopf, S., Norris, M., & Zhang, Z. (1994). Productivity growth, technical progress, and efficiency change in industrialized countries. *The American economic review*, 66-83.

Farrell M. (1957). The measurement of productivity efficiency. Journal of the Royal Statistical Society, Series A, 120(3):253–290.

Fecher, F. and Perelman, S., 1992. Productivity growth and technical efficiency in OECD industrial activities. *Industrial efficiency in six nations*, pp.459-488.

Ghosh, S., & Mastromarco, C. (2013). Cross-border Economic Activities, Human Capital and Efficiency: A Stochastic Frontier Analysis for OECD Countries. *World Economy*, 36(6), 761-785.

Goldar, B. (2000) 'Employment growth in organized manufacturing in India', *Economic and Political Weekly*, Vol. 35 (April 1–7), pp.1191–1195.

Goldar, B., 1986. Import substitution, industrial concentration and productivity growth in Indian manufacturing. *Oxford Bulletin of Economics and Statistics*, *48*(2), pp.143-164.

Griliches, Z. and Jorgenson, D.W., 1966. Sources of measured productivity change: Capital input. *The American Economic Review*, *56*(1/2), pp.50-61.

Hansen, G.D. and Prescott, E.C., 2002. Malthus to solow. *American economic review*, *92*(4), pp.1205-1217.

Hulten, C.R. and Srinivasan, S. (1999) 'Indian manufacturing industry: elephant or tiger? New Evidence on the Asian Miracle', NBER Working Paper No. 7441.

Jones, B.F. and Olken, B.A., 2005. Do leaders matter? National leadership and growth since World War II. *The Quarterly Journal of Economics*, *120*(3), pp.835-864.

Kaldor, N., 1966. Marginal productivity and the macro-economic theories of distribution: Comment on Samuelson and Modigliani. *The Review of Economic Studies*, *33*(4), pp.309-319.

Kaldor, N., 1967. Strategic factors in economic development.

Kalirajan K. P. M.B. Obwona and S.Zhao (1996). A decomposition of total factor productivity growth: The case of Chinese agricultural growth before and after reforms. American Journal of Agriculture Economics, 78 (May):331– 338.

Kim, S. and Han, G., 2001. A decomposition of total factor productivity growth in Korean manufacturing industries: A stochastic frontier approach. *Journal of Productivity Analysis*, *16*(3), pp.269-281.

Kiran, R. and Kaur, M., 2007. Is Liberalization associated with higher productivity? A case study of Punjab Manufacturing. *Vision*, *11*(4), pp.53-65.

Krishna, P. and Mitra, D. (1998) 'Trade liberalization, market discipline and productivity: new evidence from India', Journal of Development Economics, Vol. 56, pp.447–462.

Kumari, A. (2001) 'Productivity growth in Indian engineering industries during pre-reform and post-reform period an analysis at company level', Paper presented in the Proceedings of the Examining Ten Years of Economic Reforms in India', ANU, Canberra, Australia.

Kumbhakar S. (1990). Production frontier, panel data and time-varying technical inefficiency. *Journal of Econometrics*, 46:201–211.

Kumbhakar S. and C.A. Knox Lovell (2000). Stochastic Frontier Analysis. New York: Cambridge University Press.

Kumbhakar S., S. Ghosh, and J.T. McGukin (1991). A generalized production frontier approach for estimating determinants of inefficiency in U.S. dairy farms. *Journal of Business and Economic Statistics*, 9(3):279–286.

Kumbhakar, S.C. and Lovell, C.K., 2003. *Stochastic frontier analysis*. Cambridge university press.

Kumbhakar, S.C., Wang, H.J. and Horncastle, A.P., 2015. *A practitioner's guide to stochastic frontier analysis using Stata*. Cambridge University Press.

Kuznets, S. (1966) Modern Economic Growth, Rate, Structure and Spread. New Haven, CT: Yale University Press.

Mahadevan, R., 2000. How technically efficient are Singapore's manufacturing industries?. *Applied Economics*, *32*(15), pp.2007-2014.

Mahadevan, R., 2003. To measure or not to measure total factor productivity growth?. *Oxford Development Studies*, *31*(3), pp.365-378.

Meeusen, W. and van Den Broeck, J., 1977. Efficiency estimation from Cobb-Douglas production functions with composed error. *International economic review*, pp.435-444.

Mishra, S.K., 2006. Globalization and structural changes in the Indian industrial sector: an analysis of production functions. *Available at SSRN 952675*.

Nishimizu, M. and Page, J.M., 1982. Total factor productivity growth, technological progress and technical efficiency change: dimensions of productivity change in Yugoslavia, 1965-78. *The Economic Journal*, *92*(368), pp.920-936.

Pires, J.O. and Garcia, F., 2012. Productivity of nations: a stochastic frontier approach to TFP decomposition. *Economics Research International*, *2012*.

Puharts, A. and Kloks, P., 2015. Sources of TFP growth in the Baltic states: The frontier approach. *SSE Riga Student Res Pap*, *4*(169), pp.1-42.

Rao, J.M. (1996) 'Manufacturing productivity growth, method and measurement', Economic and Political Weekly, Vol. 31 (November 2), pp.2927–2936.

Rath, B.N. and Madheswaran, S. (2004) 'Productivity growth of Indian manufacturing sector: panel estimation of stochastic production frontier and technical inefficiency', Economic Society 2004 Far Eastern Meetings with No. 528.

Ray, S., 2014. What explains the productivity decline in manufacturing in the nineties in India? ICRIER working paper.

Rodrik, D. and Subramanian, A., 2004. *From" Hindu growth" to productivity surge: the mystery of the Indian growth transition* (No. w10376). National Bureau of Economic Research.

Rodrik, D., 2012. Unconditional convergence in manufacturing. *The Quarterly Journal of Economics*, *128*(1), pp.165-204.

Rodrik, D., 2016. Premature deindustrialization. *Journal of Economic Growth*, *21*(1), pp.1-33.

Roy, P.K., Das, P.S. and Pal, M.K., 2017. Decomposition of Total Factor Productivity Growth of the 2-Digit Manufacturing Industries in West Bengal: A Stochastic Frontier Approach. *Arthaniti-Journal of Economic Theory and Practice*, *16*(1-2), pp.101-124.

Sharma S.C., K. Sylwester, and H.Margono (2006). Decomposition of total factor productivity growth in U.S. states. *The Quarterly Review of Economics and Finance*, 47:215–241.

Sivadasan, J. (2003) Barriers to Entry and Productivity: Micro-Evidence from Indian Manufacturing Sector Reforms. Applied Economics Seminar at the University of Chicago, November.

Solow R.M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, 70(1):65–94. 49.

Solow R.M. (1957). Technical change and the aggregate production function. *The Review of Economics and Statistics*, 39:312–320.

Srivastava, V. (1996) Liberalization, Productivity and Competition: A Panel Study of Indian Manufacturing. Delhi, India: Oxford University Press.

Szirmai, A. and Verspagen, B., 2015. Manufacturing and economic growth in developing countries, 1950–2005. *Structural Change and Economic Dynamics*, *34*, pp.46-59.

Thomas, J.J., 2013. Explaining the 'jobless' growth in Indian manufacturing. *Journal of the Asia Pacific Economy*, *18*(4), pp.673-692.

Timmer, M.P. and De Vries, G.J., 2009. Structural change and growth accelerations in Asia and Latin America: a new sectoral data set. *Cliometrica*, *3*(2), pp.165-190.

Trivedi, P., Prakash, A. and Sinate, D. (2000) 'Productivity in major manufacturing industries in India: 1973–74 to 1997–98', Development Research Group Study No. 20, Department of Economic Analysis and Policy, Reserve Bank of India, Mumbai.

Virmani, Arvind. 2005. Policy Regimes, Growth and Poverty in India: Lessons of Government Failure and Entrepreneurial Success. ICRIER Working Paper no. 170.

Weil, D. N. (*2005*). Accounting for the Effect of Health on Economic Growth. NBER Working Papers, No. 11455.

Appendix A

Table A1. Descriptive statistics

Variable	Mean	Std. dev	Min	Max
Output	36253.2	48363	1422	415188
Capital stock	142774	169563	2896	1100000
Labor	4098	5995.07	46	49150

Table A2: Hypothesis Test for model Specification

Null Hypothesis	***Test statistics*** $\lambda = -2[L(H_0 - L(H_1)]$	***Critical value at 1% level***	***Decision***
Data can be explained by Cobb-Douglass production specification. H_0: $\beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = 0$	78.70	16.81	Reject H_0

Table A3: Summary statistics of TFP and its components

	Mean	Std. dev	Min	max
TFP	-0.00837	0.0311	-0.1190	0.04152
TP	0.00826	0.0176	-0.4158	0.04213
TEC	-0.01664	0.0205	-0.07748	-0.000612

Note: The tables provide the summary statistics of the TFP and its components which are TP and TEC. Source: own calculations

Appendix B[4]

Table B1: Technical progress across industries, 1980-1990

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	2.6%	3.0%	3.3%	2.9%	2.9%	3.7%	3.9%	2.2%	2.0%	3.1%	2.3%
2	2.4%	2.0%	2.0%	2.4%	1.9%	2.0%	2.1%	2.6%	2.6%	2.6%	2.0%
3	-3.3%	0.9%	-1.3%	0.8%	-1.9%	-1.0%	-1.5%	0.2%	-1.2%	-1.3%	-2.8%
4	0.8%	0.1%	0.5%	0.2%	0.1%	0.3%	0.1%	3.6%	3.1%	0.3%	0.5%
5	0.3%	0.5%	0.2%	1.2%	0.1%	0.7%	-0.3%	0.1%	1.0%	0.8%	-0.3%
6	4.0%	3.6%	4.1%	4.0%	4.0%	3.5%	3.7%	4.0%	3.9%	4.1%	4.0%
7	1.8%	1.8%	2.0%	1.6%	1.5%	2.1%	2.0%	3.0%	2.2%	2.9%	2.4%
8	0.4%	0.2%	-0.2%	0.3%	0.4%	-1.1%	1.4%	-0.5%	0.1%	0.3%	1.0%
9	0.6%	-0.6%	0.3%	0.6%	-1.1%	-1.6%	-1.0%	-0.6%	-1.1%	0.3%	-0.6%
10	0.6%	-1.4%	2.0%	-0.5%	1.3%	0.8%	0.0%	0.0%	1.8%	1.4%	1.1%
11	1.3%	1.3%	0.2%	1.3%	0.6%	0.9%	1.1%	1.4%	1.3%	1.5%	1.3%
12	-2.6%	0.4%	0.2%	0.3%	-1.3%	-3.5%	0.1%	-0.6%	-1.6%	-1.8%	0.0%
13	1.3%	1.3%	2.9%	3.0%	1.5%	1.9%	1.0%	1.4%	2.6%	2.2%	1.7%
14	1.8%	0.8%	0.6%	2.0%	-0.1%	-0.4%	-0.1%	-0.2%	-0.1%	1.0%	-0.1%
15	-2.4%	-3.2%	-2.8%	-2.2%	-2.8%	-2.8%	-3.0%	-2.5%	-2.3%	-1.9%	-2.7%

Note: 1-Basic metals and fabricated metal products, 2- chemicals and chemical products, 3- coke, refined petroleum products and nuclear fuel, 4 construction, 5- Electrical and optical equipment, 6- Electricity gas and water supply, 7- food products, beverages and tobacco, 8- machinery, 9 manufacturing; recycling, 10- Other Non-Metallic Mineral Products, 11- Pulp, Paper, Paper products, Printing and Publishing, 12-Rubber and Plastic Products, 13- Textiles, Textile Products, Leather and Footwear, 14- Transport Equipment and 15- Wood and Products of woods

Table B2 Technical progress across industries, 1991-2000

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	4.0%	3.6%	2.3%	2.8%	2.3%	2.1%	2.8%	3.0%	2.2%	2.9%
2	2.5%	2.4%	2.0%	2.0%	2.6%	2.2%	1.9%	2.0%	2.2%	2.7%
3	1.2%	1.1%	-2.4%	-1.6%	0.0%	-1.3%	-1.7%	0.8%	-1.7%	0.7%
4	3.2%	0.2%	3.5%	1.1%	1.0%	2.0%	1.5%	0.1%	2.3%	0.3%
5	0.0%	1.2%	0.0%	0.9%	-0.1%	0.6%	0.4%	-0.3%	0.0%	-0.3%
6	4.0%	3.4%	3.9%	4.2%	4.1%	4.1%	3.8%	3.9%	4.0%	4.0%
7	2.5%	1.6%	2.4%	2.4%	2.4%	2.5%	1.8%	2.3%	1.7%	2.8%
8	0.8%	-0.1%	1.0%	1.1%	-0.5%	0.6%	-0.3%	-1.0%	-0.7%	0.3%
9	-0.7%	-1.2%	-1.1%	-0.8%	-1.0%	-1.3%	-0.5%	-0.3%	0.2%	0.0%
10	0.4%	0.2%	-0.1%	-0.7%	-1.1%	0.2%	0.0%	-0.3%	-0.9%	1.2%
11	1.2%	1.4%	1.3%	1.5%	1.3%	1.1%	1.4%	1.4%	0.4%	1.4%
12	0.4%	-1.0%	-3.3%	-2.0%	0.2%	-1.9%	-1.2%	0.0%	0.2%	-3.0%
13	1.2%	1.4%	1.4%	2.0%	3.0%	2.5%	2.5%	2.5%	1.6%	2.3%
14	1.1%	0.8%	1.7%	0.1%	0.8%	0.8%	0.7%	-0.1%	-0.5%	1.6%
15	-2.8%	-1.6%	-2.8%	-1.5%	-1.7%	-2.6%	-2.8%	-2.8%	-1.5%	-2.0%

Note: 1-Basic metals and fabricated metal products, 2- chemicals and chemical products, 3- coke, refined petroleum products and nuclear fuel, 4 construction, 5- Electrical and optical equipment, 6- Electricity gas and water supply, 7- food products, beverages and tobacco, 8- machinery, 9 manufacturing; recycling, 10- Other Non-Metallic Mineral Products, 11- Pulp, Paper, Paper products, Printing and Publishing, 12-Rubber and Plastic Products, 13- Textiles, Textile Products, Leather and Footwear, 14- Transport Equipment and 15- Wood and Products of wood

[4] All the calculations in the following tables are based on own calculations using India KLEMS data

Table B3: Technical progress across industries, 2001-2011

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	2.3%	2.4%	3.0%	3.1%	2.7%	3.5%	2.8%	2.1%	2.8%	2.0%	2.7%
2	2.0%	2.3%	2.7%	2.5%	2.4%	2.0%	2.5%	2.6%	2.0%	2.6%	2.0%
3	-1.8%	-2.0%	1.1%	-1.4%	0.7%	0.7%	-1.1%	-4.2%	-0.2%	0.9%	0.8%
4	0.7%	2.8%	1.8%	0.3%	0.3%	0.1%	2.5%	0.0%	0.4%	0.1%	3.4%
5	-0.1%	0.7%	1.1%	0.6%	1.1%	-0.3%	-0.3%	0.7%	-0.2%	1.2%	-0.2%
6	4.0%	3.6%	3.9%	4.0%	4.1%	3.9%	4.0%	3.9%	3.9%	3.7%	3.9%
7	1.9%	2.2%	2.8%	1.6%	1.7%	2.7%	2.3%	2.0%	2.8%	1.9%	2.4%
8	-0.4%	-0.1%	-0.9%	1.3%	0.4%	-0.1%	-0.5%	-0.6%	0.0%	-0.8%	0.5%
9	-1.1%	-1.1%	0.4%	-1.0%	-0.5%	-1.3%	-0.1%	-0.7%	-1.0%	-1.0%	-1.3%
10	1.9%	0.1%	1.4%	1.5%	2.1%	1.0%	2.0%	-1.2%	1.6%	1.5%	0.0%
11	1.4%	1.4%	1.3%	1.3%	0.7%	1.3%	1.0%	1.4%	1.5%	1.5%	1.3%
12	0.1%	0.7%	0.5%	-0.9%	0.2%	0.2%	0.8%	0.1%	-2.3%	-1.9%	-2.2%
13	3.0%	2.4%	3.0%	2.5%	2.4%	1.1%	3.0%	2.7%	0.9%	1.4%	1.6%
14	-0.5%	0.8%	-0.4%	-0.1%	1.9%	1.3%	-0.1%	-0.1%	0.0%	0.5%	-0.3%
15	-2.9%	-2.8%	-2.1%	-2.1%	-2.8%	-2.8%	-2.7%	-1.7%	-1.8%	-1.9%	-1.8%

Note: 1-Basic metals and fabricated metal products, 2- chemicals and chemical products, 3- coke, refined petroleum products and nuclear fuel, 4 construction, 5- Electrical and optical equipment, 6- Electricity gas and water supply, 7- food products, beverages and tobacco, 8- machinery, 9 manufacturing; recycling, 10- Other Non-Metallic Mineral Products, 11- Pulp, Paper, Paper products, Printing and Publishing, 12-Rubber and Plastic Products, 13- Textiles, Textile Products, Leather and Footwear, 14- Transport Equipment and 15- Wood and Products of wood

Table B4. Technical Efficiency changes across industries, 1980-1990

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	-1.4%	-0.3%	-0.1%	-0.2%	-0.6%	-0.1%	-0.1%	-4.1%	-7.7%	-0.5%	-2.6%
2	-0.2%	-4.9%	-1.6%	-0.2%	-2.2%	-5.7%	-6.6%	-0.1%	-0.3%	-0.1%	-1.4%
3	-6.6%	-0.1%	-0.9%	-0.1%	-3.5%	-0.5%	-1.6%	-0.3%	-1.0%	-0.7%	-5.7%
4	-0.5%	-4.1%	-0.6%	-2.2%	-4.9%	-1.6%	-5.7%	-0.1%	-0.1%	-1.9%	-0.7%
5	-0.6%	-0.5%	-0.7%	-0.1%	-0.9%	-0.3%	-3.0%	-1.0%	-0.1%	-0.2%	-6.6%
6	-0.5%	-5.7%	-0.1%	-0.7%	-0.3%	-6.6%	-3.5%	-1.4%	-0.2%	-1.0%	-0.1%
7	-2.6%	-2.2%	-1.2%	-6.6%	-7.7%	-0.9%	-1.4%	-0.1%	-0.7%	-0.1%	-0.4%
8	-0.4%	-0.5%	-1.4%	-0.2%	-0.5%	-7.7%	-0.1%	-2.2%	-0.6%	-0.2%	-0.1%
9	-0.1%	-0.4%	-0.1%	-0.1%	-1.4%	-7.7%	-1.6%	-0.3%	-1.0%	-0.1%	-0.5%
10	-0.6%	-7.7%	-0.1%	-3.5%	-0.3%	-0.5%	-1.4%	-2.2%	-0.1%	-0.2%	-0.4%
11	-1.4%	-0.2%	-7.7%	-0.2%	-5.7%	-4.1%	-3.0%	-0.6%	-1.6%	-0.1%	-0.9%
12	-4.9%	-0.1%	-0.2%	-0.1%	-1.4%	-7.7%	-0.3%	-0.7%	-1.6%	-1.9%	-0.2%
13	-3.5%	-4.1%	-0.1%	-0.1%	-1.6%	-0.9%	-6.6%	-2.2%	-0.2%	-0.6%	-1.0%
14	-0.1%	-0.3%	-0.5%	-0.1%	-2.2%	-4.9%	-2.6%	-3.5%	-1.2%	-0.2%	-1.6%
15	-0.5%	-7.7%	-1.2%	-0.4%	-1.6%	-4.9%	-6.6%	-0.6%	-0.5%	-0.2%	-3.0%

Note: 1-Basic metals and fabricated metal products, 2- chemicals and chemical products, 3- coke, refined petroleum products and nuclear fuel, 4 construction, 5- Electrical and optical equipment, 6- Electricity gas and water supply, 7- food products, beverages and tobacco, 8- machinery, 9 manufacturing; recycling, 10- Other Non-Metallic Mineral Products, 11- Pulp, Paper, Paper products, Printing and Publishing, 12-Rubber and Plastic Products, 13- Textiles, Textile Products, Leather and Footwear, 14- Transport Equipment and 15- Wood and Products of wood.

Table B5. Technical Efficiency change across industries, 1991-2000

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	-0.1%	-0.1%	-3.0%	-0.7%	-1.9%	-4.9%	-0.2%	-0.4%	-3.5%	-0.3%
2	-0.5%	-0.2%	-3.0%	-1.2%	-0.4%	-0.7%	-3.5%	-0.9%	-7.7%	-0.1%
3	-0.1%	-0.1%	-4.9%	-1.9%	-0.4%	-1.2%	-2.2%	-0.1%	-2.6%	-0.2%
4	-0.1%	-2.6%	-0.1%	-0.3%	-0.4%	-0.2%	-0.3%	-3.5%	-0.2%	-1.2%
5	-1.2%	-0.1%	-1.6%	-0.2%	-1.9%	-0.3%	-0.5%	-3.5%	-1.4%	-4.9%
6	-1.6%	-7.7%	-2.6%	-0.1%	-1.2%	-0.9%	-3.0%	-0.2%	-0.5%	-0.1%
7	-0.2%	-5.7%	-0.2%	-0.3%	-0.2%	-0.2%	-3.0%	-0.5%	-4.1%	-0.1%
8	-0.1%	-0.9%	-0.1%	-0.1%	-3.0%	-0.2%	-1.6%	-6.6%	-4.1%	-0.3%
9	-0.6%	-4.1%	-3.5%	-0.7%	-2.2%	-6.6%	-0.2%	-0.2%	-0.1%	-0.2%
10	-0.7%	-1.0%	-2.6%	-4.1%	-5.7%	-0.9%	-1.9%	-3.0%	-4.9%	-0.3%
11	-2.2%	-0.1%	-1.0%	-0.1%	-0.3%	-2.6%	-0.4%	-0.5%	-6.6%	-0.1%
12	-0.1%	-1.0%	-6.6%	-3.0%	-0.4%	-2.6%	-1.2%	-0.2%	-0.5%	-5.7%
13	-4.9%	-1.9%	-2.6%	-0.7%	-0.1%	-0.2%	-0.3%	-0.4%	-1.2%	-0.5%
14	-0.2%	-0.2%	-0.1%	-0.7%	-0.2%	-0.3%	-0.5%	-1.4%	-6.6%	-0.1%
15	-1.9%	-0.1%	-2.2%	-0.1%	-0.1%	-0.7%	-0.9%	-2.6%	-0.1%	-0.2%

Note: 1-Basic metals and fabricated metal products, 2- chemicals and chemical products, 3- coke, refined petroleum products and nuclear fuel, 4 construction, 5- Electrical and optical equipment, 6- Electricity gas and water supply, 7- food products, beverages and tobacco, 8- machinery, 9 manufacturing; recycling, 10- Other Non-Metallic Mineral Products, 11- Pulp, Paper, Paper products, Printing and Publishing, 12-Rubber and Plastic Products, 13- Textiles, Textile Products, Leather and Footwear, 14- Transport Equipment and 15- Wood and Products of wood

Table B6. Technical efficiency changes across industries, 2001-2011

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	-2.2%	-1.6%	-0.5%	-0.2%	-1.0%	-0.1%	-0.9%	-5.7%	-0.2%	-6.6%	-1.2%
2	-2.6%	-0.6%	-0.1%	-0.1%	-0.2%	-4.1%	-0.3%	-0.1%	-1.0%	-0.5%	-1.9%
3	-3.0%	-4.1%	-0.1%	-1.4%	-0.2%	-0.2%	-0.6%	-7.7%	-0.5%	-0.2%	-0.3%
4	-0.5%	-0.1%	-0.2%	-1.4%	-1.0%	-6.6%	-0.2%	-7.7%	-0.9%	-3.0%	-0.1%
5	-2.2%	-0.2%	-0.1%	-0.4%	-0.1%	-5.7%	-4.1%	-0.2%	-2.6%	-0.1%	-7.7%
6	-0.4%	-4.9%	-0.3%	-1.9%	-0.1%	-2.2%	-0.6%	-0.2%	-0.1%	-4.1%	-0.2%
7	-1.6%	-0.6%	-0.1%	-4.9%	-3.5%	-0.1%	-0.5%	-1.0%	-0.1%	-1.9%	-0.3%
8	-1.9%	-1.0%	-5.7%	-0.1%	-0.3%	-1.2%	-2.6%	-3.5%	-0.7%	-4.9%	-0.2%
9	-1.2%	-2.6%	-0.1%	-3.0%	-0.3%	-4.9%	-0.2%	-0.5%	-0.9%	-1.9%	-5.7%
10	-0.1%	-1.2%	-0.2%	-0.2%	-0.1%	-0.5%	-0.1%	-6.6%	-0.1%	-0.2%	-1.6%
11	-0.7%	-0.5%	-0.3%	-1.9%	-4.9%	-1.2%	-3.5%	-0.2%	-0.1%	-0.1%	-0.2%
12	-0.3%	-0.1%	-0.1%	-0.9%	-0.2%	-0.5%	-0.1%	-0.6%	-4.1%	-2.2%	-3.5%
13	-0.1%	-0.3%	-0.1%	-0.2%	-0.5%	-5.7%	-0.1%	-0.2%	-7.7%	-3.0%	-1.4%
14	-7.7%	-0.4%	-5.7%	-1.9%	-0.1%	-0.1%	-3.0%	-0.9%	-1.0%	-0.6%	-4.1%
15	-5.7%	-1.0%	-0.3%	-0.3%	-1.4%	-4.1%	-3.5%	-0.1%	-0.2%	-0.2%	-0.1%

Note: 1-Basic metals and fabricated metal products, 2- chemicals and chemical products, 3- coke, refined petroleum products and nuclear fuel, 4 construction, 5- Electrical and optical equipment, 6- Electricity gas and water supply, 7- food products, beverages and tobacco, 8- machinery, 9 manufacturing; recycling, 10- Other Non-Metallic Mineral Products, 11- Pulp, Paper, Paper products, Printing and Publishing, 12-Rubber and Plastic Products, 13- Textiles, Textile Products, Leather and Footwear, 14- Transport Equipment and 15- Wood and Products of wood

Table B7: Total factor productivity across industries, 1980-1990

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	1.2%	2.6%	3.1%	2.7%	2.2%	3.7%	3.9%	-2.0%	-5.8%	2.7%	-0.3%
2	2.2%	-2.9%	0.3%	2.2%	-0.3%	-3.7%	-4.5%	2.6%	2.2%	2.5%	0.6%
3	-9.9%	0.7%	-2.1%	0.7%	-5.4%	-1.5%	-3.1%	-0.1%	-2.2%	-2.0%	-8.5%
4	0.4%	-4.0%	-0.1%	-2.0%	-4.7%	-1.3%	-1.6%	3.6%	3.0%	-1.6%	-0.2%
5	-0.3%	0.0%	-0.5%	1.1%	-0.7%	0.3%	-3.3%	-1.0%	0.8%	0.6%	-6.9%
6	3.5%	-2.1%	4.0%	3.3%	3.6%	-3.1%	0.2%	2.7%	3.7%	3.1%	3.9%
7	-0.8%	-0.4%	0.8%	-5.1%	-6.3%	1.2%	0.6%	2.9%	1.4%	2.8%	2.0%
8	0.0%	-0.3%	-1.6%	0.0%	-0.1%	-8.9%	1.3%	-2.8%	-0.5%	0.1%	0.9%
9	0.5%	-1.0%	0.2%	0.6%	-2.5%	-9.3%	-2.6%	-0.9%	-2.1%	0.2%	-1.1%
10	0.0%	-9.1%	2.0%	-4.1%	1.0%	0.3%	-1.3%	-2.2%	1.7%	1.1%	0.7%
11	-0.1%	1.1%	-7.5%	1.2%	-5.1%	-3.3%	-1.9%	0.7%	-0.3%	1.4%	0.5%
12	-7.5%	0.3%	0.0%	0.1%	-2.7%	-1.3%	-0.2%	-1.3%	-3.2%	-3.7%	-0.3%
13	-2.2%	-2.9%	2.8%	2.9%	-0.1%	1.0%	-5.7%	-0.9%	2.5%	1.5%	0.7%
14	1.7%	0.5%	0.0%	1.9%	-2.3%	-5.2%	-2.7%	-3.7%	-1.2%	0.8%	-1.7%
15	-3.0%	-10.9%	-4.0%	-2.6%	-4.4%	-7.7%	-9.6%	-3.1%	-2.7%	-2.0%	-5.8%

Note: 1-Basic metals and fabricated metal products, 2- chemicals and chemical products, 3- coke, refined petroleum products and nuclear fuel, 4 construction, 5- Electrical and optical equipment, 6- Electricity gas and water supply, 7- food products, beverages and tobacco, 8- machinery, 9 manufacturing; recycling, 10- Other Non-Metallic Mineral Products, 11- Pulp, Paper, Paper products, Printing and Publishing, 12-Rubber and Plastic Products, 13- Textiles, Textile Products, Leather and Footwear, 14- Transport Equipment and 15- Wood and Products of woods

Table B8: Total factor productivity across industries, 1991-2000

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	4.0%	3.5%	-0.8%	2.1%	0.4%	-2.7%	2.5%	2.6%	-1.3%	2.6%
2	2.0%	2.3%	-1.1%	0.8%	2.2%	1.4%	-1.6%	1.1%	-5.6%	2.6%
3	1.1%	1.0%	-7.3%	-3.5%	-0.4%	-2.5%	-3.9%	0.7%	-4.3%	0.5%
4	3.1%	-2.4%	3.4%	0.8%	0.6%	1.8%	1.2%	-3.4%	2.1%	-0.9%
5	-1.2%	1.1%	-1.7%	0.7%	-2.0%	0.3%	-0.1%	-3.8%	-1.4%	-5.1%
6	2.4%	-4.3%	1.3%	4.2%	2.9%	3.2%	0.8%	3.6%	3.5%	3.8%
7	2.3%	-4.1%	2.2%	2.1%	2.1%	2.4%	-1.3%	1.8%	-2.5%	2.7%
8	0.6%	-0.9%	0.9%	1.0%	-3.6%	0.5%	-1.9%	-7.7%	-4.8%	0.0%
9	-1.4%	-5.4%	-4.7%	-1.6%	-3.2%	-7.9%	-0.7%	-0.6%	0.0%	-0.2%
10	-0.3%	-0.8%	-2.7%	-4.9%	-6.7%	-0.6%	-1.9%	-3.3%	-5.7%	0.9%
11	-1.0%	1.4%	0.2%	1.4%	1.0%	-1.5%	1.0%	0.9%	-6.2%	1.3%
12	0.3%	-2.0%	-9.9%	-5.1%	-0.2%	-4.5%	-2.4%	-0.2%	-0.3%	-8.7%
13	-3.7%	-0.5%	-1.2%	1.3%	3.0%	2.2%	2.2%	2.1%	0.5%	1.8%
14	0.9%	0.5%	1.6%	-0.6%	0.6%	0.5%	0.2%	-1.5%	-7.1%	1.5%
15	-4.7%	-1.7%	-5.0%	-1.6%	-1.8%	-3.4%	-3.7%	-5.4%	-1.6%	-2.3%

Note: 1-Basic metals and fabricated metal products, 2- chemicals and chemical products, 3- coke, refined petroleum products and nuclear fuel, 4 construction, 5- Electrical and optical equipment, 6- Electricity gas and water supply, 7- food products, beverages and tobacco, 8- machinery, 9 manufacturing; recycling, 10- Other Non-Metallic Mineral Products, 11- Pulp, Paper, Paper products, Printing and Publishing, 12-Rubber and Plastic Products, 13- Textiles, Textile Products, Leather and Footwear, 14- Transport Equipment and 15- Wood and Products of woods

Table B9: Total factor productivity across industries, 2001-2011

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0.1%	0.8%	2.4%	2.9%	1.7%	3.3%	1.9%	-3.6%	2.6%	-4.6%	1.5%
2	-0.6%	1.7%	2.6%	2.4%	2.2%	-2.2%	2.2%	2.6%	1.0%	2.1%	0.1%
3	-4.8%	-6.2%	1.0%	-2.8%	0.5%	0.5%	-1.7%	-1.9%	-0.7%	0.7%	0.5%
4	0.2%	2.7%	1.5%	-1.1%	-0.7%	-6.6%	2.4%	-7.7%	-0.5%	-2.9%	3.3%
5	-2.3%	0.5%	1.0%	0.2%	1.0%	-5.9%	-4.4%	0.4%	-2.8%	1.2%	-8.0%
6	3.6%	-1.2%	3.6%	2.1%	4.0%	1.7%	3.4%	3.7%	3.8%	-0.5%	3.7%
7	0.3%	1.6%	2.7%	-3.2%	-1.8%	2.5%	1.7%	1.0%	2.7%	0.0%	2.1%
8	-2.3%	-1.1%	-6.6%	1.2%	0.0%	-1.3%	-3.1%	-4.1%	-0.7%	-5.7%	0.3%
9	-2.3%	-3.7%	0.3%	-4.1%	-0.9%	-6.2%	-0.3%	-1.2%	-1.9%	-2.9%	-7.0%
10	1.8%	-1.1%	1.2%	1.3%	2.0%	0.5%	1.9%	-7.8%	1.5%	1.4%	-1.6%
11	0.6%	0.8%	1.0%	-0.6%	-4.2%	0.1%	-2.6%	1.2%	1.4%	1.4%	1.1%
12	-0.2%	0.6%	0.5%	-1.8%	0.0%	-0.4%	0.8%	-0.5%	-6.5%	-4.1%	-5.7%
13	2.9%	2.2%	2.9%	2.3%	1.9%	-4.6%	2.9%	2.6%	-6.9%	-1.7%	0.2%
14	-8.2%	0.4%	-6.1%	-2.0%	1.8%	1.1%	-3.2%	-0.9%	-1.0%	-0.2%	-4.4%
15	-8.6%	-3.8%	-2.4%	-2.4%	-4.2%	-6.9%	-6.3%	-1.8%	-2.0%	-2.2%	-1.9%

Note: 1-Basic metals and fabricated metal products, 2- chemicals and chemical products, 3- coke, refined petroleum products and nuclear fuel, 4 construction, 5- Electrical and optical equipment, 6- Electricity gas and water supply, 7- food products, beverages and tobacco, 8- machinery, 9 manufacturing; recycling, 10- Other Non-Metallic Mineral Products, 11- Pulp, Paper, Paper products, Printing and Publishing, 12-Rubber and Plastic Products, 13- Textiles, Textile Products, Leather and Footwear, 14- Transport Equipment and 15- Wood and Products of wood