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Abstract:

A comparative analysis of total factor productivity (TFP) growth in the formal and informal segments of Indian manufacturing industries is undertaken, along with an analysis of differences in the level of TFP between the two segments of these industries. The period covered for the analysis of TFP growth is 1980-81 (1980) to 2011-12 (2011), which is broken into three-sub-periods, 1980-1993, 1994-2002 and 2003-2011. The period covered for the analysis of TFP level differences is 2003-04 to 2011-12. From the analysis of TFP growth trends, it is found that the average growth rate in TFP in the informal manufacturing sector during 1980-2011 was significantly lower than that in the formal manufacturing sector (0.6% per annum as against 4.4% per annum, based on value added function framework). Both formal and informal manufacturing experienced a fall in the rate of TFP growth during 1994-2002 as compared to 1980-1993, and then achieved a marked acceleration in TFP growth during 2003-11. The acceleration in TFP growth in aggregate formal manufacturing in India in the period since 2003 is contributed mainly by improved TFP growth performance of Coke and refined petroleum products industry with additional contributions made by Food, beverages and tobacco products, Chemicals and chemical products, and Textiles and leather products. In the case of informal manufacturing, the acceleration in TFP growth after 2003 is mainly traceable to the improved TFP growth performance of Textiles and leather products industry with additional contributions made by Wood and wood products, Food, beverages and tobacco products, and Chemicals and chemical products. The comparison of the level of TFP between the formal and informal segments of Indian manufacturing industries for the period 2003-2011 brings out that it is substantially lower in informal manufacturing than formal manufacturing.

Key words: Total Factor Productivity, Indian Manufacturing, Formal and Informal Segments

JEL Code: D24, L60

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1. Introduction

Over the last three decades, 1980s, 1990s and 2000s, the share of manufacturing in GDP (at current prices) in India has stagnated at around 15 to 16 percent, whereas the share of services (construction excluded) has increased by more than 15 percentage points, from about 40 percent in 1980-81 to about 55 percent in 2011-12.[1] Similarly, in this period, the share of manufacturing in aggregate employment has stagnated at around 10 to 11 percent, whereas the share of services in aggregate employment has increased from about 17 percent in 1980-81 to about 29 percent in 2011-12.[2]

The relatively mediocre growth performance of the manufacturing sector as compared to the services sector in India has emerged as a matter of concern. There has been growing recognition in the policy making circles and academia that India needs an accelerated growth in manufacturing in the next few decades, so that India's economic growth is led by manufacturing rather than services.[3] It is believed that India's demographic dividend is likely to give a boost to the pace of economic growth in India, and it is accepted at the same time that for taking full advantage of the demographic dividend, an accelerated growth of the manufacturing sector is essential (Goldar, 2015b).[4]

The National Manufacturing Policy, which was formulated in 2011, has set a goal of raising the share of manufacturing in GDP from 15-16 percent in 2011 to about 25 percent by 2022, reflecting the aforementioned view of policy makers pertaining to the need for attaining an accelerated manufacturing sector growth. It is needless to say that for fulfilling the goal of the National Manufacturing policy, a major hike is required in the growth rate of manufacturing output, and arguably this is hard to achieve without a significant increase in the growth rate in total factor productivity (TFP) in manufacturing (Goldar, 2015b).

The informal sector of Indian manufacturing which accounts for about 70-80 percent of manufacturing employment in India may prove to be a major drag in India's efforts to accelerate the growth of manufacturing output and productivity. Available literature dealing with

[1] Measured at constant (2004-05) prices, the share of manufacturing in aggregate GDP was in the range of 14 to 16 percent during 1980-81 to 2011-12, while the share of services in GDP increased from 38 percent in 1980-81 to 59 percent in 2011-12.

[2] The shares of manufacturing and services in GDP and employment reported here are based on India-KLEMS database, version 2016.

[3] The importance of a manufacturing-led growth has been underscored in Ghose (2016). He has drawn attention to the growing imbalance between domestic absorption and domestic production caused by a services-led growth and has argued that this imbalance has led to growth deceleration. Accordingly, he has given emphasis to the need for a rapid growth in manufacturing.

[4] There is an emerging view that the much-talked-about phenomenon of 'youth bulge' and 'demographic dividend' has not materialized in India. Ghose (2016) observes that in the 1980s and 1990s and the period after 1999, the share of youth of working-age labour force had been falling. A similar view has been expressed by Mundle (2017). He observes that the falling labour force participation rate has demolished the myth of so-called 'demographic dividend'.

productivity comparison between formal and informal manufacturing in India indicates that the level of TFP of informal manufacturing is substantially lower than that of formal manufacturing (discussed further later in the literature review section of the paper). Also, while India's formal manufacturing sector has made some improvement in its level of TFP over the last three decades, there are indications that there has probably been very little increase in TFP in informal manufacturing in India. Rather, some studies have reported a significant negative growth rate in TFP in informal manufacturing during the period 1978-79 to 2005-06.[5]

In the above context, this paper makes an attempt to analyze differences in the level of TFP and growth rate of TFP between formal and informal manufacturing sectors in India. The analysis is undertaken for 13 major industries (or industry groups) which together constitute manufacturing (for the list, see Table 1 in Section 3). The period of the analysis is 1980-81 (fiscal year, from April 1980 to March 1981) to 2011-12. First, a comparison of rates of TFP growth in the formal and informal segments of each industry during the period 1980-81 (1981) to 2011-12 (2011), and three selected sub-period (1980-81 to 1993-94, 1994-95 to 2002-03, and 2003-04 to 2011-12) within this period is undertaken (also, a comparison is made between aggregate formal manufacturing and aggregate informal manufacturing in regard to TFP growth based on Domar aggregation). Then, the difference in the level of productivity between the formal and informal segments of each industry in the period 2003-04 to 2011-12 is analyzed. This is followed up by a more detailed analysis of productivity level difference between formal and informal manufacturing, which is undertaken for 25 industries for the year 2010-11 (list provided later in Section 5.2).

The rest of the paper is organized as follows. The next section, i.e. Section 2, reviews briefly the literature on the informal sector of Indian economy with a particular focus on the role of informal manufacturing in India and productivity of informal manufacturing enterprises. Section 3 briefly describes the data sources, construction of variables and methodology adopted for this study. Section 4 is devoted to an analysis of TFP growth rates in the formal and informal segments of 13 major manufacturing industries (which together constitute India's manufacturing sector). The growth rates in TFP achieved by the formal segment of the manufacturing industries are compared with the growth rate in TFP achieved by the informal segment of the manufacturing industries. In addition, TFP growth rate estimates have been made for formal manufacturing at the aggregate level and similarly for informal manufacturing at the aggregate level. Trends in TFP growth in aggregate formal manufacturing sector and aggregate informal manufacturing sector are analyzed and contrasted. Contributions made by different industries to aggregate level TFP growth for formal and informal segments of the manufacturing sector are estimated and studied. Section 5 is devoted to an analysis of productivity level differentials between formal and informal segments of manufacturing industries. This is divided into two sub-sections. Section 5.1 presents an analysis of productivity level differences between formal and informal segments of

[5] See Unni et al. (2001) and Kathuria et al. (2014). For a review of studies on TFP growth in India's unorganized manufacturing, see Goldar (2014).

the previously mentioned 13 major manufacturing industries for the period 2003-04 to 2011-12. Section 5.2 presents such an analysis for the year 2010-11 for a larger number of industries (25 industries) with the informal segment of various manufacturing industries being further split into own account enterprises (relatively small within the informal sector, these are household enterprises with no hired workers) and establishments (enterprises not registered as 'factory' and have at least one hired worker). Finally, the main findings of the study are summarized and some concluding remarks are made in Section 6.

2. Formal-Informal Divide in Indian Manufacturing: A Review

In the context of development and growth story of any developing country, including India, the informal sector plays a very significant role. This section provides a comprehensive overview of the formal and informal segments in India and discusses its role in the manufacturing sector.[6] We begin by providing a detailed analysis of the formal-informal divide in the Indian context. This is followed up by an overview of this divide in the manufacturing sector in India. We discuss some of the important issues that pertain to the informal segment of the manufacturing sector and conclude the section by indicating briefly the results pertaining to the relative efficiency of the two segments of manufacturing in question obtained in previous studies.

2.1 Informal-Formal Divide: Definition

The informal sector has been a major contributor to employment and income to the Indian economy for a sustained period of time. This, corroborated with the large size of the sector, has made the formal-informal divide a subject to a large body of literature (Schneider, 2002). Given the prominence of the discourse in the academic discourse, it may be expected that there would be a consistent definition pertaining to the informal sector. However, this has not been true – there have been wide variations in its definition both over time and across countries. One of the first definitions for the informal sector of the economy was proposed in Hart (1973). The basis for the difference between the sectors at this initial stage depended on whether the activity entailed wage or self-employment. Although the International Labour Organisation (ILO) later

[6] In this review of literature, the terms 'formal' and 'informal' are used somewhat loosely. This becomes necessary because a standard definition of formal sector enterprise and informal sector enterprise has not been adopted in the various studies undertaken on this subject. A further complication is created by the fact that there may be informal employment in a formal enterprise. Thus, the distinction between formal and informal employment in manufacturing is not the same as employment in formal manufacturing enterprises being distinguished from employment in informal manufacturing enterprises. It should be pointed out at the same time that for the empirical analysis presented in the paper, the focus is on the character of the enterprise rather than the nature of employment, and accordingly 'formal' is treated as synonymous with 'registered' or 'organized'. Informal segment therefore includes those enterprises which are not 'registered' and do not belong to the organized sector. The definition of registered or organized manufacturing sector adopted for the study (following the practice in *National Account Statistics*) is that it includes those industrial units which are registered as 'factories' under the Factories Act, 1948, and meet the criterion that they employ 10 or more workers with the aid of power or 20 or more workers without power. This is taken up again in Section 3.3.

on did develop a conceptual framework to define the term 'informal' sector, there has been no such uniform definition in the Indian context (Naik, 2009; Bairagya, 2010). One of the latest in the series of definitions for the informal sector is the one proposed by the National Commission for Enterprises in the Unorganised Sector (NCEUS henceforth) which goes as follows:

> *"The informal sector consists of all incorporated private enterprises owned by individuals or households engaged in the sale and production of goods and services operated on a proprietary or partnership basis and with less than ten total workers."*

The term "enterprises" in the above definition includes all workers in the agricultural sector except those in plantations. This is so because workers in the plantation sectors are protected under the Plantations Labour Act, 1951 (Naik, 2009). As is evident from the definition, the informal sector basically comprises of the plethora of small enterprises which is a common feature of Indian markets. They generally do not fall under the purview of most legislation that governs the formal sector (for example, legislations pertaining to the registration of the enterprises, and labour protection laws). The cornerstone of these legislations (e.g., the labour laws) has been the historical concept of "employment relationship" (ILO, 2003; Chen *et al,* 2004). The conundrum with the informal sector lies in the fact that this "employment relationship" is often not defined for this sector. As an example, the employment relationship may be disguised so as to avoid falling under the purview of laws. For instance, *bidi* traders in Ahmedabad claim that they sell tobacco and other related materials to *bidi* producers. They then buy the *bidis* from them, thereby avoiding any legal requirements to pay retirement benefits to the *bidi* producers (Chen, 2006).

The definition and basic features of informal sector, as it exists in India, naturally raises questions regarding the linkages it has with the formal sectors of the economy. The possible sources and sorts of linkages are varied, as brought out by the existing literature. Ranis and Stewart (1999), for instance, show that informal sector produces consumer goods aimed mainly at lower end customers. These goods often compete with goods of the formal sector. Another school of thought contends that the informal sector is integrated with the rest of the economy through complementary linkages (ILO, 1991). For instance, legalists advocate that high regulations that restricts the formal sector also raises inefficiency perpetuation of the informal sector. Crowell (2003) shows that small salt producers face high transport costs and thus remain less competitive than large firms. These small firms are not allowed to transport their salt using rail transport due to a long-standing government law that prevented any firm with less than 90 acre landholding to book a wagon. On the other end of the spectrum, there is some consensus that a *lack* of legislation that often characterizes major parts of the informal sector is also playing an important role in its perpetuation. The lack of legislation governing street vendors in different Indian cities has often resulted in widespread eviction and bribery (Bhowmik, 2004; Mitullah, 2004).

With this basic structure of the informal sector in mind, it is natural to study how the informal and formal sectors in India have shaped the major macroeconomic variables. A general picture that arises in literature is that the informal sector of India has exhibited the phenomenon of "jobless growth" (Bairagya, 2010; Naik, 2009; Narayana, 2006). Informal employment had a higher share than formal employment for the period 1980-2005. Moreover the increase in formal employment has mainly come through the increase in employment from the informal elements of the formal sector. This general trend is true for broad sectors of the economy as well. On the other hand, the share of the informal sector in India's NDP (net domestic product) has been declining (although the share is still around 60%) (Bairagya, 2010).

The picture of jobless growth is also evident from the fact that the share of labour income in the informal sector has remained at 70 percent while that in the formal sector has decreased to about 55 percent. This is possibly due to the labour intensive technology used in the informal sector and this high labour intensity is the reason for the large employment generation in this sector. Keeping in mind the growing importance of the formal-informal divide and its related problems, an appropriate policy response would require a detailed analysis of the cost-benefits and efficiency of each segment.

2.2 Formal-Informal Split within Manufacturing

The large heterogeneity that encompasses the broad definitions of the formal and informal sectors may often make it difficult to make a cost-benefit analysis and efficiency comparison. However, in India, and indeed in many developing countries, the formal-informal divide is most prominent in the manufacturing sector (WTO, 2009). As a result there have been quite a few studies that focus on studying the characteristics of the formal and informal segments of India's manufacturing sector.

The manufacturing sector in India has undergone significant transformation over the course of the country's post-independence history. Under the first three Five Year plans (1951-65), the manufacturing sector grew rapidly (at around 8% p.a.) and got more diversified due to the well-known import-substitution regime. After a period of stagnation in industrial growth till 1980, India initiated a series of economic reforms (including the reforms following the crisis of 1990). One of the primary objectives of the liberalization of economic policies was to promote the competitiveness and efficiency of the Indian manufacturing sector, thereby enabling it to attain a higher growth path. However, the effectiveness of such policies would depend on the structure of the manufacturing sector, in particular the formal-informal divide in the sector. As has been mentioned above, the manufacturing sector typically comprises of a large informal sector. Traditionally it has been recognized that the firms in the informal segment are less productive than the firms in the formal segment of the manufacturing sector (Dabla-Norris *et al,* 2005). This is due to the general properties of the informal sector that have been extensively discussed

earlier – lack of legislation, small size of the firms, lower access to credit etc (World Bank, 2005).

This general perception of the poorer performance of the informal manufacturing sector is also reflected in the growth rate of value added in each of the segments. The growth rate of total manufacturing has been increasing in each decade for the period 1980-2011, with the formal segment growing faster than the informal segment (Goldar and Sengupta, 2016). However, this growth did not precipitate into lower productivity growth across major industries when we compare them with the informal sector. In terms of employment, the trend has been opposite – while the growth rate of employment in total manufacturing grew at around two percent per annum, it has been the unorganized or informal segment that has grown more than the organized or formal segment of manufacturing (Goldar, 2000).[7]

This employment generation capability of the informal sector is also reflected in the share of labour income. For the entire period 1980-2011, the labour income share in the informal manufacturing segment remained at a high of around 70 percent while in the formal segment the share declined over time (Goldar, 2013; Nagaraj, 2000). The share of wages in gross value added in formal manufacturing fell from about 33 percent in the triennium ending 1995-96 to about 22 percent in the triennium ending 2007-08 (Goldar, 2013). The use of labour intensive technology is probably the main contributor to the large employment generation and by consequence the large income share. Thus we see that the informal segment does indeed play a very significant role[8] even within the manufacturing sector and it makes sense to dwell a bit further into the linkages between the segments.

[7] In the recent period, this trend has radically changed. During 2000-01 to 2010-11, employment in formal manufacturing has grown much faster than that in informal manufacturing. Making use of organized manufacturing data from *Annual Survey of Industries* (CSO) and unorganized manufacturing data from NSSO surveys on unorganized manufacturing, Goldar and Sengupta (2016) find that the growth rate in employment during 2000-01 to 2010-11 was 4.74 percent per annum in organized manufacturing and 1.48 percent per annum in unorganized manufacturing. Ghose (2016) has reported employment estimates for organized and unorganized manufacturing for 1999-00 and 2011-12 based on employment–unemployment surveys of the NSSO. The increase in employment in organized manufacturing was from 9.5 million to 19.1 million between 1999-00 and 2011-12. In the case of unorganized manufacturing, the increase was from 27.3 million to 33.3 million. Evidently, the growth in employment has been relatively much slower in unorganized manufacturing, and the share of the unorganized sector in total manufacturing employment has accordingly fallen from about 72 percent in 1999-00 to about 59 percent in 2011-12, i.e. a fall by about 12 percentage points.

[8] The analysis undertaken by Raj and Sen (2016) provides useful insight into the role of informal (unorganized) manufacturing sector in India. They find that there exists a positive relationship between wages of workers and firm productivity among informal manufacturing firms. They also find that there are social and economic barriers to informal manufacturing firms in raising their level of productivity. Goldar et al. (2011) have analyzed the performance of informal (unorganized) manufacturing in India in the post-reform period. They consider output growth, employment growth, labour productivity growth and employment elasticity, making a comparison between formal and informal manufacturing. They find that labour productivity growth rate was relatively lower in informal manufacturing. But, the elasticity of wages with respect to labour productivity was relatively higher in informal manufacturing than formal manufacturing.

2.3 Linkages between formal and informal sectors

Having provided some insights regarding the significance and the permanence of the informal segment in general and the manufacturing sector in particular, we proceed to discuss in more depths some of the issues faced by this particular segment. One primary issue of interest, as has been discussed above, is the linkages between the formal and informal sector.

One essential way in which the formal manufacturing sector interacts with the informal manufacturing sector is by means of sub-contracting. Many economic relations of production fall somewhere between the two extremes of pure formal segments and pure informal segments. In the manufacturing sector, workers are known to move between points in this spectrum with varying ease and speed (Chen, 2004). For instance, a big garment producing firm may try to reduce its cost of stitching by sub-contracting this work to small tailors working in the informal sector. Likewise, there are many informal enterprises that provide cheap raw materials and labour to the formal segment, thereby making their livelihood contingent on the demand from the formal segment. This is especially true in the case of Indian manufacturing – increasing competition due to openness induces high pressure to reduce costs. This, along with strict labour regulations, provides an ideal scenario for extensive sub-contracting (Mazumdar and Sarkar, 2008; Ramaswamy, 1999).

Now, there are two contending views about the nature of sub-contracting from the formal to the informal segments. In the stagnation view, formal enterprises subcontract with the most labour intensive units among the informal enterprises to minimize labour costs (Portes, 2004; Tokman, 1978). This results in a vicious cycle of worsening labour conditions and downward pressure on wages. On the contrary, the modernization view sees sub-contracting as a vehicle for the modernization of the informal sector. The formal enterprises establish the sub-contracts with the informal enterprises with the capability of using modern technology to ensure certain minimum standards in quality (see e.g. Ranis and Stewart, 1999; Marjit, 2003). Moreno-Monroy *et al,* (2014) adheres to the latter view by showing a significant positive relation between formal sector subcontracting and total employment in the relatively modern segments of the informal sector. However, they also find evidence of a rapid growth of the relatively traditional segments of the informal sector as well. One possible reason for this is the take-over of the more labour intensive industries by these traditional segments. Other possible reasons include strict labour laws governing the formal sector (Besley and Burgess, 2004) and structural production links between the formal and informal segments (Aghion et al., 2008).[9]

[9] Sundaram et al. (2012) have studied whether a complementary relationship exists between formal and informal manufacturing in India. For each manufacturing industry, they consider employment, output and value added in the informal segment of the industry in various states, and find that this is strongly positively correlated (across states) with the same variables in the formal segment. This finding is attributed to agglomeration and outsourcing. The results of their empirical analysis indicate that labour market flexibility enhances this observed complementary relationship between formal and informal segments of manufacturing. Another study on

The other major issue that concerns the informal segment of the manufacturing sector is the issue of legality. There is a widespread notion that most of the enterprises in the informal sector exist there to avoid registration and taxation. Although such arrangements are indeed illegal, it must be kept in mind that this is distinct from illegal goods and services. Most of the products produced in this segment are indeed legal (Thomas, 1992). For example, a street-side bicycle repairing shop may not be paying his taxes, but his output is certainly not illegal. Moreover since the enterprises in the informal manufacturing segments are generally small, their output may not be falling within the taxable bracket or the cost of registration may be too high. This cost disadvantage is evident in a study by Chen *et al.* (2004) where they show that street vendors would welcome the security that can be provided to them upon paying the legal fees. This is in general true for almost all informal workers – there are substantial disadvantages from not being under the purview of legal sanctions. Almost all of these workers are deprived from the worker's benefits and social security that the workers in the formal sector generally enjoy. Hence, it seems rational to believe that the informal workers are stuck in their working environment not by choice, but by their inability to be absorbed into the formal manufacturing segment.

2.4 Efficiency Differences between Formal and Informal Manufacturing

It has been argued extensively in the preceding paragraphs that the informal sector by definition comprises of small enterprises, and hence tends to be less efficient than its formal sector counterparts. However, there has been little systematic analysis of the difference in efficiency levels between informal and formal manufacturing firms. A primary reason for this is the lack of credible data that can allow such comparisons. Data on output and capital stock are difficult to obtain from the small enterprises in the informal sector, especially because they are not registered with the government (Kathuria *et al.* 2013b). Other concerns relate to the self-selection bias that often characterizes the enterprises in the informal manufacturing sector (Straub, 2005; Dessy and Pallage, 2003; Kathuria *et al.* 2013a). In terms of data availability in the Indian context, there is a further concern regarding the inconsistency of definitions of the informal sector. For example the enterprises covered in the informal sector by the Economic Census and National Sample Survey Office (NSSO) data are often incomparable (Guha-Khasnobis et al, 2006). As a result each database has to be analyzed by keeping in mind its own advantages and limitations. Nonetheless, there have been a few studies that did try to compare the efficiency levels of the firms in the formal and informal manufacturing sectors.[10] For instance Goldar and Mitra (2013) find that the firms in the formal manufacturing sector outperform the informal counterparts in terms of technical efficiency. The latter are not impacted

subcontracting among informal manufacturing firms in India worth mentioning here is Sahu (2011). In this study, it is found that subcontracting intensity is pronounced only in a very few industries – tobacco products, textiles and wearing apparels - and that most of the subcontracting work is highly labour intensive.

[10] In the Indian context, comparison of productivity between large scale manufacturing units and small scale manufacturing units can be traced to the study undertaken by Dhar and Lydall (1961). This pioneering study found that small scale units are relatively inefficient as compared to large scale units. Similar conclusions were reached in the study undertaken by Goldar (1988).

by the increase in the availability of infrastructure, and neither have they benefited from the growth process. It should be noted at the same time that the growth rate of labour productivity and total factor productivity (TFP) in the informal manufacturing sector accelerated in the 1990s and the 2000s relative to the 1980s (Goldar and Sengupta, 2016).[11] This may be due to the economic reforms that were undertaken in India during this particular period, leading to a more competitive manufacturing sector.

The general tendency of the superior efficiency of formal segment firms is also reflected in Kathuria et al. (2013a, 2013b). They find that firms in the formal manufacturing sector in India are technically more efficient – both in the relative and absolute sense, than the firms in the informal manufacturing sector. Another finding is that economic reforms have accentuated the efficiency gap between formal and informal sector manufacturing firms. The authors also find significant self-selection of firms into the informal segment for most of the industries in the manufacturing sector.[12] Nevertheless, this strand of literature is still nascent and would improve with the availability of better and more consistent datasets.

To summarize, the informal sector in India comprises of small enterprises that do not fall under the purview of government legislations. It is a major contributor to India's Net Domestic Product but its share has been declining. However, it still remains a large source of employment in India. This general trend is also true in the manufacturing sector in India, where the size of the informal segment is quite extensive. One of the main issues pertaining to the relation between the formal and informal segments of the manufacturing sector is the sub-contracting of labour intensive work to the informal sector and the legality. This raises questions on the efficiency comparisons between the formal and informal manufacturing sectors. Due to lack of comparable databases, studies on this front are still few in number but in general it is found that the formal manufacturing firms are commonly more technically efficient. The non-availability of enough studies on relative productivity level and growth performance of informal and formal manufacturing and the lack of consistent dataset for undertaking such an analysis provide the main motivation of the paper – we use the extensively developed India KLEMS dataset (version 2016) to compare the TFP growth rates as well as relative TFP levels of the informal and formal manufacturing sectors in India.

[11] Goldar et al. (2011) find that the growth rate in labour productivity during 1989-90 to 2005-06 was higher in formal manufacturing than informal manufacturing. Similar findings have been reported by Goldar and Sengupta (2016). They find that the growth rate in labour productivity during 1984-85 to 2010-11 was higher in formal manufacturing than informal manufacturing.

[12] Taynaz (2009) explains productivity gap between formal and informal enterprises in terms of self-selection of entrepreneurs and managers with technical skill shift to the formal sector (in a study of Turkey).

3. Methodology, Data Sources and Measurement of Output, Inputs and Factor Incomes

3.1 Methodology

3.1.1 Measurement of Total Factor Productivity Growth

As mentioned earlier, separate estimates of TFP growth rates have been made for formal and informal segments of 13 major manufacturing industries (see List in Table 1). Such estimates have been made also for each industry taken as a whole without splitting it into the formal and informal segments.

To explain the methodology of TFP growth estimation that has been applied, let us consider the TFP growth estimates for individual industries taken as a whole disregarding the division into the formal and informal segments (for ease of exposition). The same methodology has been applied when the estimates of TFP growth have been made separately for the formal and informal segments of each industry.

The estimates of TFP growth rates at the industry level have been made by using the framework of a gross output function. Since the production function at the industry level has been taken as a gross output function, growth in industry output (Y) for each industry *i* for each year *t* can be decomposed[13] into the contributions from capital (K), labour (L) and intermediate input (X) as:

$$\Delta \ln Y_i = \bar{s}_{K,i}\Delta \ln K_i + \bar{s}_{L,i}\Delta \ln L_i + \bar{s}_{X,i}\Delta \ln X_i + \Delta \ln A_i \qquad \ldots (1)$$

where *i* is the industry subscript, $\Delta \ln Y$ is the growth rate in output (Y) between year *t* and *t*-1 [i.e. $\Delta \ln Y = \ln Y(t) - \ln Y(t-1)$], $\Delta \ln K$, $\Delta \ln L$ and $\Delta \ln X$ are defined accordingly, and s_K, s_L, and s_X are respectively the income shares of capital, labour and intermediate input in total nominal output of industry *i* (the bar over in income shares denotes that average of current year *t* and previous year *t*-1 is to be taken). The residual term, $\Delta \ln A_i$ is the rate of growth in TFP in industry *i* in year *t* over the previous year.

In the growth accounting analysis presented here, X is further subdivided into three inputs: energy (E), materials (M) and services (S). Thus, the equation above may be re-written as:

$$\Delta \ln Y_i = \bar{s}_{K,i}\Delta \ln K_i + \bar{s}_{L,i}\Delta \ln L_i + \bar{s}_{E,i}\Delta \ln E_i + \bar{s}_{M,i}\Delta \ln M_i + \bar{s}_{S,i}\Delta \ln S_i + \Delta \ln A_i \qquad \ldots (2)$$

where s_E, s_M and s_S are the income shares of energy, materials and services in nominal value of gross output of industry *i* (the bar over income shares denotes the average of current and previous year, as explained above).

[13] This involves the assumptions of constant returns to scale and competitive factor and product markets.

Equation (2), which is based on the gross output function, has been used to measure TFP growth rates at industry level.[14] To measure TFP growth rates at the aggregate level, two approaches have been taken, as explained below.

Approach-1: In the first approach, the value added function framework has been used at the aggregate level, i.e. for the manufacturing sector. The computation of TFP growth rate involves the following steps:

(a) For each industry, the growth rate in real value added has been computed from the growth rates in real value of gross output and real value of intermediate input, along with the income share of intermediate input in the nominal value of gross output (see Annexure-1). Then, a Tornqvist index of growth in real value added at the aggregate level has been constructed using the industry level real value added growth rates as explained in Annexure-1.

(b) Aggregate level labour input growth rate has been obtained by constructing a Tornqvist index. It is based on labour input growth rates (i.e. the growth rate in the number of persons employed) in different manufacturing industries; a weighted aggregation is done with the shares of different industries in aggregate labour income taken as weights. The growth rate in labour input at the aggregate level (ΔL) is obtained as:

$$\Delta L = \sum_i \bar{u}_i^L \, \Delta ln L_i \ \ldots (3)$$

where ΔL_i is the growth rate in labour input in industry *i* and u_i^L is the share of labour input employed in industry *i* in total labour compensation in the manufacturing sector.

(c) Aggregate level capital input growth rates have similarly been obtained by constructing a Tornqvist index. It is based on capital input growth rates (i.e. the growth rate in capital services) in different industries; a weighted aggregation is done with the shares of different industries in aggregate capital income taken as weights. The growth rate in capital input at the aggregate level (ΔK) is obtained as:

$$\Delta K = \sum_i \bar{u}_i^K \, \Delta ln K_i \ \ldots (4)$$

where ΔK_i is the growth rate in capital input in industry *i* and u_i^K is the share of capital input used in industry *i* in total compensation of capital input in the manufacturing sector.

(d) Having obtained the growth rates in real value added, labour input and capital input at the aggregate level, and using the income share of labour and capital in gross value added at the aggregate level, the growth rate in TFP in aggregate manufacturing sector has been computed.

[14] This is the Tornqvist index of TFP which is an approximation to the Divisia index. This index of TFP is exact for a translog production function.

Approach-2: In this approach, industry level TFP growth rates have been obtained with help of equation (2) above, and then the aggregate level estimates of TFP growth rate have been made by applying the Domar aggregation procedure. The Domar weights for applying this procedure have been computed from input-output tables (matrices), taking into account *inter alia* the inter-industry transactions within the manufacturing sector. The details are provided in Annexure-2.

The methodology described above dealt with estimation of industry level and aggregate level TFP growth rates when industries are taken as a whole and not broken down into the formal and informal segments. The same methodology has been applied to make separate estimates of TFP growth for formal manufacturing and informal manufacturing, at individual industry level and at the aggregate level. There is one minor change in methodology when the Domar aggregation procedure is applied to formal and informal manufacturing. This relates to derivation of inter-industry transactions within formal manufacturing and within informal manufacturing from the published input-output tables, which is explained in Annexure-2.

3.1.2 Measurement of Difference in TFP Level between Formal and Informal Manufacturing

A simple methodology has been applied to measure TFP difference between formal and informal segments of different manufacturing industries. This analysis is based on the value added function: gross value added is taken as the measure of output, number of persons employed is taken as the measure of labour input and gross fixed capital stock is taken as the measure of capital input.

Let V^j_N, K^j_N and L^j_N denote gross value added, capital input and labour input per enterprise among the informal enterprises in industry j. Similarly, let V^j_F, K^j_F and L^j_F denote gross value added, capital input and labour input per enterprise among the formal enterprises in industry j. Define relative capital productivity (RKP) and relative labour productivity (RLP) between informal and formal segment of industry j as:

$$RKP_j=[V^j_N /K^j_N] / [V^j_F/K^j_F] \quad \ldots (5),$$

$$RLP_j=[V^j_N /L^j_N] / [V^j_F/L^j_F] \quad \ldots (6).$$

Then, relative total factor productivity, RTFP, or relative efficiency may be obtained as (see Annexure-3):[15]

$$\ln RTFP_j = \bar{s}_{K,j} \ln RKP_j + \bar{s}_{L,j} \ln RLP_j \qquad \ldots(7)$$

[15] The same method or a similar method of computation of relative efficiency (or relative TFP) has been used in Ho (1980), Goldar (1988), Wiboonchutikula (2002), and Oguchi, et al. (2006). It should be pointed out that the relative efficiency index is based on a translog production function.

In the above equation, s_K and s_L denote capital and labour shares in gross value added, and the bar denotes that the average between formal and informal segments is to be taken. Note that the above equation may be written as:

$$\ln \text{RTFP}_j = \ln\left(\frac{V_N^j}{V_F^j}\right) - \left[\bar{s}_{K,i} \ln\left(\frac{K_N^j}{K_F^j}\right) + \bar{s}_{L,i} \ln\left(\frac{L_N^j}{L_F^j}\right)\right] \quad \ldots(8)$$

3.1.3 Periodization

As mentioned earlier, the period considered for the analysis is 1980-81 to 2011-12, even though output and input series have been constructed under the India KLEMS database (version 2016) for the period extending up to 2014-15.[16] To analyze trends in TFP growth, three sub-periods are considered. These are 1980-81 to 1993-94, 1994-95 to 2002-03 and 2003-04 to 2011-12. In addition, estimates of average annual growth rate in TFP for the entire period 1980-81 to 2011-12 are presented. For the analysis of TFP level difference between formal and informal segments of manufacturing only the third sub-period is considered, namely 2003-04 to 2011-12.

The division of the time period, 1980-80 to 2011-12 into three sub-periods mentioned above for the purpose of the present analysis of trends in manufacturing productivity follows the periodization adopted by Panagariya et al. (2014, Chapter 2) as reflecting three distinct periods of growth of the Indian Economy. The first sub-period (1980-1993) is one in which India's per capita GDP grew at an average annual rate of 2.9 percent. The second sub-period consists of years 1993-2002, during which India's per capita GDP grew at an average annual rate of 3.9 percent. The final sub-period is from 2003 to 2011 when the per capita GDP grew at the rate of 6.9 percent per year.

3.1.4 Changes in Industry Share in Nominal Value Added

Table 1 provides the list of the India KLEMS industries belonging to manufacturing. Besides providing a list, it serves another useful purpose – it shows how the share of manufacturing industries in aggregate nominal gross value added has changed over time. A comparison of manufacturing sector with other broad sectors of the economy in terms of their share in aggregate nominal gross value added is also presented.

[16] The India KLEMS database, version 2016, covers the period up to 2014-15. However, there are difficulties in constructing time series on output and inputs separately for organized and unorganized components of manufacturing industries beyond 2011-12. The reason is that from 2011-12 a new national accounts series is being brought out by the CSO (Central Statistics Office) which does not contain estimates for organized and unorganized manufacturing, but contains estimates for corporate segment and household segment. This is the reason why the time period covered in this study has been confined to 2011-12.

Table 1: Industry shares in aggregate nominal gross value added, 1980-2011 (percent)

	1980	1990	2000	2011
Agriculture and allied	**36.0**	**29.4**	**23.0**	**18.0**
Manufacturing	**16.4**	**16.2**	**15.3**	**14.0**
Food Products, Beverages & Tobacco products	1.7	1.8	1.7	1.7
Textiles, Leather & Footwear	4.0	3.1	2.8	1.7
Wood & Products of Wood	1.6	0.7	0.8	0.3
Pulp, Paper, Printing & Publishing	0.5	0.6	0.5	0.4
Coke, Refined Petroleum & Nuclear Fuel	0.3	0.7	0.7	0.7
Chemicals & Chemical Products	1.1	1.3	1.8	1.9
Rubber & Plastic Products	0.3	0.5	0.6	0.5
Other Non-Metallic Mineral Products	0.7	1.0	1.0	0.9
Basic Metals & Metal Products	2.2	2.5	2.1	2.2
Machinery, n.e.c.	0.9	1.1	0.8	0.9
Electrical & Optical Equipment	0.7	1.0	0.8	0.8
Transport Equipment	1.0	1.1	1.0	1.2
Mfg., n.e.c. & recycling	1.3	0.8	0.8	0.8
Non-Manufacturing Industries	**8.0**	**10.3**	**10.7**	**12.6**
Mining & Quarrying	1.7	2.6	2.3	2.7
Electricity, Gas & Water Supply	1.6	2.1	2.4	1.6
Construction	4.7	5.5	6.0	8.3
Services	**39.5**	**44.1**	**51.0**	**55.4**

Source: India KLEMS Database, version 2016, Authors' computations

It is evident from the table that the share of services in nominal gross value added has increased over time, but the share of manufacturing has been sluggish with a slight decline between 1980-81 and 2011-12. As regards the individual manufacturing industries, it may be noted that the relative shares of (1) textiles and leather products and (2) wood and wood products in aggregate nominal value added has gone down while the shares of (1) chemicals and chemical products, and (2) coke and petroleum products have increased.

3.2 Data Sources

The analysis presented in the paper is essentially based on the India KLEMS database, version 2016. The main source of data used for the preparation of the India KLEMS database is the *National Accounts Statistics* (NAS), published annually by the Central Statistics Office (CSO). The 2004-05 national accounts series and the corresponding back series have been used. These data are supplemented by Input-Output tables (published by CSO) and *Annual Survey of Industries* (ASI) brought out by the CSO and various rounds of NSSO (National Sample Survey Office) surveys on employment & unemployment and unorganized manufacturing.

3.3 Measurement of Output, Inputs and Factor Income shares

As noted above, the analysis presented in the paper primarily relies on the India-KLEMS database, version 2016. The details of the procedures that have been adopted to construct time series on gross output, gross value added, capital stock and services, labour input (number of persons employed and labour composition index reflecting changes in labour quality), energy input, materials inputs, and services input, and factor income shares for the various industries (27 industries) for India KLEMS database are provided elsewhere.[17] Therefore, the procedures adopted for constructing such series for manufacturing industries are only briefly discussed here.

Gross Value added*:* NAS provides estimates of Gross Domestic Product (GDP) or gross value added (GVA) by industries at both current and constant prices since 1950. Time series on gross value added for the 13 industries (see list of industries and their share in aggregate GVA in Table 1) for the period 1980-81 to 2011-12 have been taken from the National Accounts series with base 2004-05. Data are available at current and 2004-05 prices. GDP estimates are adjusted for Financial Intermediation Services Indirectly Measured (FISIM). The value of such services forms a part of the income originating in the banking and insurance sector and, as such, is deducted from the GVA.

NAS 2004-05 series provides data on gross value added separately for registered and un-registered sectors. These are also referred to as organized and unorganized manufacturing sectors. In this paper, organized sector is being called the formal sector of manufacturing and unorganized sector as the informal sector of manufacturing.

One difficulty that has been faced in drawing data from NAS for constructing the gross value added series for the 13 manufacturing industries is that the classification adopted for the India KLEMS database does not match with that used in the NAS. For those industries within the manufacturing sector, where detailed data are not available from NAS, estimates have been made by making use of data drawn from the Annual Survey of Industries (ASI) for registered

[17] See, for instance, *Estimates of Productivity Growth for the Indian Economy*, Report, Reserve Bank of India, available at https://rbi.org.in/Scripts/PublicationReportDetails.aspx?ID=785.

(organized) and NSSO surveys for un-registered (unorganized) manufacturing industries. While the former source is used to split aggregate value added data from NAS into sub-sectors in the organized sector, the latter is used for the unorganized sector.

It may be mentioned here that a correction to ASI data for 2011-12 was made by the CSO in January 2016. In the NAS 2004-05 series, the corresponding correction has not been made since the CSO has meanwhile shifted to a new NAS series with base 2011-12. In preparing the data series for this study, this correction in ASI data has been incorporated. The correction affects the estimates of gross output, value added and intermediate input for two industries: (i) chemicals and chemical products and (ii) basic metals and fabricated metal products.

Gross output: Gross Value of Output (GVO) series for different manufacturing industries are mostly derived from the NAS. As in the case of value added, NAS provides gross output series at current and 2004-05 prices for organized (or registered) and unorganized (or unregistered) segments. At certain places, it had been necessary to split the series given in NAS into parts using ASI or NSSO surveys for unorganized manufacturing. For unorganized manufacturing industries, NAS provides gross output data only for the more recent period. Thus, for earlier years, the ratios of GVO to GVA computed from NSSO surveys have been applied to compute gross output.

Intermediate inputs: Nominal values of intermediate inputs are basically the difference between nominal value added and nominal output. The various intermediate inputs going into the production process of output industries are grouped into energy (E), materials (M) and services (S) inputs. The segregation of intermediate inputs in energy, materials and services inputs has been done with the help of input-output tables. The input-output transaction (IOTT) tables for 1978-79, 1983-84, 1989-90, 1993-94, 1998-99, 2003-04, 2007-08 and 2013-14[18] have been used for this purpose. These are the benchmark years for the computation of intermediate inputs. In this way, for each benchmark year, estimates are obtained for materials, energy and services inputs used to produce output in the different industries. For each of the 13 industries, the time series of input proportions among E, M and S are compiled first for the benchmark years and then linear interpolation is done to obtain the complete series for 1980-81 to 2011-12 at current prices.

To generate a price deflator for intermediate inputs, the wholesale price indices published by the Office of the Economic Advisor, Ministry of Commerce and Industry are used along with implicit deflators for services sectors derived from the NAS. For each industry, separate deflators have been constructed for materials, energy and services inputs, and for this purpose weights for different items of inputs have been derived from input-output tables, considering the relevant columns of IOTT for each of the industries.

[18] The table for 2013-14 has been prepared by Singh and Saluja (2016). This is based on the supply-use table for India for the year 2012-13 published by the CSO.

***Employment**:* Employment data are basically obtained from the quinquennial rounds of Employment and Unemployment Surveys (EUS) published by National Sample Survey Office (NSSO). Using the EUS, the total workforce has been estimated by industry groups, as per the National Industrial Classification (NIC). The work participation estimates obtained from EUS are adjusted for population, using various population censuses. In the EUS, the persons employed are classified on the basis of their activity status into usual principal status (UPS), usual principal and subsidiary status (UPSS), current weekly status (CWS) and current daily status (CDS). UPSS is the most liberal and widely used of these concepts. Despite that the UPSS has some limitations,[19] this seems to be the best measure to use given the data and hence estimation of the number of employed persons has been done by using the UPSS definition.

While the India KLEMS database contains time series on labour composition index and labour input is formed by taking into account both number of persons employed and the composition index, in this study the labour input has been measured by the number of persons employed. This has been done because the composition index is not separately available for formal and informal segments of different industries.

Factor income shares: Income shares of energy, materials and services inputs in gross output have been computed for each industry for different years by taking the nominal values of these inputs and dividing by the nominal value of gross output. Income share of labour in gross output is formed by taking first the ratio of labour income to value added and multiplying that by the share of value added in gross output at current prices. Income share of labour in value added has been computed for organized sector manufacturing industries for different years during 1980-81 to 2011-12 using ASI data. For unorganized manufacturing, the income share of labour in value added has been computed by considering data for establishments because for own account enterprises which do not use any hired labour, there is no wage payment.[20] The ratio in question, i.e. wage share in value added, has been computed by dividing wage per hired worker in establishments by gross value added per worker employed (hired or non-hired) in establishments.[21] A weighted average of labour income shares in value added computed for

[19] Problems in using UPSS includes: 1) the UPSS seeks to place as many persons as possible under the category of employed by assigning priority to work; 2) no single long-term activity status for many as they move between statuses over a long period of one year; and 3) usual status requires a recall over a whole year of what the person did, which is not easy for those who take whatever work opportunities they can find over the year or have prolonged spells out of the labour force.

[20] The income share of labour in value added in unorganized manufacturing industries could be computed for certain years (using the NSSO surveys for unorganized manufacturing), between 1994-95 and 2010-11. These have been interpolated for in-between years. The figure for 1994-95 has been used for earlier years, and the figure for 2010-11 has been used also for 2011-12.

[21] An implicit assumption is that the imputed wage rate of non-hired workers in establishments is the same as that of hired workers. Once this assumption is made, the ratio of wage rate of hired workers to gross value added per worker (hired plus non-hired) becomes in effect the total wage bill (actual plus imputed) divided by gross value added. To explain this further, let *h* and *nh* denote hired and non-hired workers. Let *W* be the wage bill of hired worker and *w* be the wage rate (=*W*/*h*) of hired workers, which is taken as the imputed wage rate of non-hired

organized and unorganized manufacturing industries have been taken to form the relevant ratio at the industry level (organized and unorganized segments combined). Having obtained the income shares of labour, energy, materials and services, the income share of capital input is obtained as a residual.

Capital services: Capital services for individual industries in India KLEMS are arrived at using the following equation:

$$\Delta \ln K = \sum_k \bar{v}_k \Delta \ln K_k \quad \ldots(9)$$

where K_k denotes the kth type of capital assets used in an industry, and v_k denotes the share of that type of capital assets in total income accruing to capital input. In order to implement the method indicated in equation (9), it was essential to obtain investment data by asset type. Sectoral investment in three different asset types – construction, transport equipment, and machinery are gathered from NAS for broad sectors of the economy, the *Annual Survey of Industries* (ASI) covering the formal manufacturing sector, and the National Sample Survey Organizations (NSSO) rounds for unorganized manufacturing. These sectoral data are used to construct capital stock using perpetual inventory method, i.e.

$$K_{k,t} = K_{k,t-1}(1 - \delta_k) + I_{k,t-1} \ldots (10)$$

where K_k is the capital stock in asset k, δ_k and I_k are respectively the depreciation rate and the real investment in asset k, and the subscript t stands for year t. The assumed depreciation rates are 8 percent for machinery, 2.5 percent for construction and 10 percent for transport equipment. The rental price of capital $P_{K,k}$ is measured assuming an external rate of return *(r)*, as

$$P_{K,k,t} = P_{I,k,t-1}\, r + P_{I,k,t}\, \delta_k \ \ldots (11)$$

where the external rate of return, r, is represented by a long-run average of real bond rate and market interest rate, obtained from Reserve Bank of India. In this equation, $P_{I,k}$ is the investment price of asset k. The rental prices are used to compute the relative income share of different categories of capital assets in total capital income.

Getting separate data for formal and informal segments: For certain variables, the formal and informal segments are estimated first and then these two are added to compute the value of the variable for the industry, the two segments, formal and informal, combined. This is the method used for gross value added, gross output and capital stock (also holds true for capital service in certain ways). The same applies to total value of intermediate inputs at current prices and income share of labour in gross value added. In these cases, the time series for the relevant variables could readily be obtained for the formal and informal segments of each industry.

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workers. Let *V* denote gross value added and *V*/(*h*+*nh*) be gross value added per worker. Wage share in value added is *w*(*h*+*nh*)/*V* which may also be written as *w*/[*V*/(*h*+*nh*)].

The distribution of intermediate input into energy, material and services is based on the input-output tables. Since the input-output tables do not show input requirements separately for formal and informal segments, the same input structure has been assumed for the two segments, and therefore, the estimated materials, energy and services input for each industry each year has been distributed proportionately between formal and informal segments depending on the value of intermediate inputs at current prices. This is a limitation of the estimates of intermediate inputs of formal and informal segments of different manufacturing industries.

As regards the number of persons employed, the employment in the formal segments of various industries has been obtained from ASI data for various years. Employment in the informal segments has been derived as a residual.[22] Given the total employment in an industry as estimated by using unit level data of NSSO survey on employment and the estimated employment in the formal segment given by ASI, the employment in the informal segment has been computed as the difference between the two. This procedure, though simple and appealing, faced a problem for certain industries for some of the years in the period under study, since it led to very low or even negative estimates of employment in the informal segment (or the estimates showed large fluctuations). To address this problem, the procedure described below has been applied.

Step 1: For benchmark years (1983-84, 1987-88, 1993-94, 1999-00, 2004-05, 2009-10 and 2011-12) and for 1980-81, the employment in the informal segment of each manufacturing industry has been computed as the different between estimate of total employment in the industry based on Employment and Unemployment Surveys (EUS) the NSSO and the employment in the formal segment of the industry obtained from ASI data. Then, to workout employment estimates for various years during the period 1980-81 to 2011-12 except the seven years mentioned above, interpolation of the estimates has been done. This provides the estimate of employment in the informal segment of different industries for different years in the period 1980-81 to 2011-12.

Step-2: For one industry (namely, electrical and optical equipment), the above procedure yielded a very low estimate of employment for 1980-81 as compared to 1983-83 (5 thousand in 1980-81 as against 185 thousand in 1983-83). This was found to be inconsistent with the growth in real gross value added in the informal segment of the

[22] Two approaches may be taken to obtain data on employment in organized and unorganized manufacturing in India. First, data on employment in organized manufacturing may be taken from ASI and data on employment in unorganized manufacturing may be taken from NSS survey results for unorganized manufacturing. Second, data on total employment in manufacturing may be taken from NSS Employment-Unemployment survey results, and then, from the estimate of total employment in manufacturing, the employment estimate for organized manufacturing obtained from ASI may be subtracted to derive an employment estimate for unorganized manufacturing. There are reasons to believe that the second approach yields more reliable estimates. See, in this context, Goldar and Sengupta (2016, p.50).

industry as indicated by NAS data. Therefore, the employment estimate for 1983-84 was extrapolated backward till 1980-81 by using the time series on real gross value added.

Step-3: For (i) coke and petroleum products industry and (ii) transport equipment industry, there are sharp fluctuations in the estimates of employment in the informal segment of the industries obtained by subtracting employment in the formal segment from total employment. For these two industries, a different approach has therefore been taken. Estimate of employment in the informal segment of these industries has been taken directly from the estimates provided in the reports of the NSSO surveys of unorganized manufacturing. Estimates of employment for the two industries were obtained for 1989-90, 1994-95, 2000-01, 2005-06 and 2010-11. These estimates were interpolated or extrapolated to get the estimates of employment for other years. In the case of transport equipment, the estimate of employment for 2010-11 obtained from NSSO survey report was considered along with the estimate for 2011-12 obtained by the difference between total employment and employment in the formal segment of the industry explained above. The average of the two figures has been taken and applied to 2011-12.

Step-4: Having obtained the estimates of formal and informal segments of different manufacturing industries, the total employment in various industries (formal plus informal segments of the industry) has been obtained by adding the two estimates.

It should be mentioned in passing that in the official data sources used for this study, the terms "formal" and "informal" are not used. Instead, a distinction is made between organized and unorganized sectors of Indian manufacturing which are alternatively termed as "registered" and "unregistered" segments of Indian manufacturing in *National Accounts Statistics*. "Organized" or "Registered" segment of India manufacturing in the official data sources refers to those manufacturing establishments which are registered as "Factories" under the Indian Factories Act, 1948 (which applies to factories employing 10 or more workers with the use of power or 20 or more workers without the use of power) or establishments registered as such under the *Bidi* and Cigar workers (conditions of employment) Act, 1966 with similar requirement on employment size). For the present analysis, this segment is being treated as formal manufacturing, and the rest as informal manufacturing. It should be pointed out that while the dominant portion of informal sector establishments have very low employment (median level of employment is probably about two workers), some relatively much bigger establishments with employment much higher than 10 do get included in the unorganized or informal sector because these are not registered under the Factories Act, 1948 (or *Bidi* and Cigar workers (conditions of employment) Act, 1966).

4. TFP Growth: A Comparison between formal and informal segments of manufacturing industries

4.1 TFP Growth Rates in Manufacturing Industries

The average annual growth rates in TFP in formal and informal segments of manufacturing industries in the period 1980-81 to 2011-12 and in the three sub-periods (1980-81 to 1993-94, 1994-95 to 2002-03, and 2003-04 to 2011-12) are shown in Table 2. It is evident from the table that in most industries there was a fall in the rate of TFP growth in the second sub-period, 1994-2002, as compared to the first sub-period, 1980-93. By contrast, there was an improvement in the growth rate of TFP in most industries in the third sub-period, 2003-2011, in comparison with the second sub-period, 1994-2002. This pattern is seen for both the formal segment and informal segment of manufacturing industries. One exception is the basic metals and fabricated metal products industry. In this case, there was an increase in the rate of TFP growth in the sub-period 1994-2002 and a fall in the subsequent sub-period, 2003-2011. This pattern is observed for both the formal and informal segments of this industry.

Considering the entire period, 1980-2011, it is found from the table that the growth rate in TFP was relatively higher for the formal segment than the informal segment of manufacturing industries. Exceptions are (i) Paper, paper products and printing industry and (ii) Rubber and plastic products industry for which the growth rate in TFP in the informal segment is found to be higher than that in the formal segment. In both industries, the informal segment had a better TFP growth performance than the formal segment in the second and third sub-periods, but not in the first sub-period.

Considering the formal segment of manufacturing industries, it is found that relatively high average rates of TFP growth during the period 1980-2011 were achieved by Electrical and optical equipment, Transport equipment, Other machinery, Textiles and leather products, Chemicals and chemical products, and the miscellaneous manufacturing products group. In the relatively more recent time period, 2003-2011, the industries that achieved a relatively higher growth rate in TFP include Electrical and optical equipment, Transport equipment, Other machinery, Textiles and leather products, Paper, paper products and printing, Chemicals and chemical products, Rubber and plastic products, and Coke and petroleum products. The Coke and petroleum products industry experienced a marked fall in TFP in the second sub-period, 1994-2002, which was made up by the marked increase in TFP it attained in the third sub-period, 2003-2011.

Table 2: TFP Growth Rates, Manufacturing Industries, Formal and Informal Segments and Combined (percent per annum)

KLEMS Industry Description	Formal Segment of manufacturing industry				Informal Segment of manufacturing industry				Total, formal + informal segments of manufacturing industries			
	1980-93	1994-2002	2003-11	1980-2011	1980-93	1994-2002	2003-11	1980-2011	1980-93	1994-2002	2003-11	1980-2011
Food Products, Beverages and Tobacco products	1.72	-0.35	0.63	0.80	0.28	0.33	0.48	0.35	1.04	-0.13	0.64	0.59
Textiles, Textile Products, Leather and Footwear	0.79	0.46	1.83	1.00	0.68	-0.17	1.94	0.80	0.73	0.26	1.99	0.96
Wood and Products of wood	-1.07	-1.26	-0.66	-1.01	-3.15	-5.41	0.70	-2.69	-3.03	-4.61	0.52	-2.46
Pulp, Paper, Paper products, Printing and Publishing	0.93	-1.38	1.70	0.48	0.86	0.43	1.83	1.02	0.75	-0.85	1.86	0.61
Coke, Refined Petroleum Products and Nuclear fuel	0.64	-2.22	2.70	0.41	-1.76	0.04	2.24	-0.07	0.62	-2.21	2.70	0.40
Chemicals and Chemical Products	1.80	-0.74	2.13	1.16	0.17	-1.36	1.78	0.20	1.63	-0.77	2.21	1.10
Rubber and Plastic Products	0.90	-0.34	2.05	0.87	-0.03	1.44	2.32	1.08	0.71	-0.01	2.19	0.93
Other Non-Metallic Mineral Products	0.50	0.87	-0.03	0.45	-1.36	-1.72	1.14	-0.74	0.18	0.70	0.40	0.39
Basic Metals and Fabricated Metal Products	0.51	1.37	-2.31	-0.06	-1.75	1.15	-0.66	-0.59	0.18	1.18	-1.82	-0.11
Machinery, n.e.c.	0.60	0.78	2.36	1.16	0.22	0.32	0.76	0.40	0.19	0.65	2.22	0.91
Electrical and Optical Equipment	2.34	1.21	2.77	2.14	-0.21	-0.78	1.81	0.21	2.03	0.84	2.55	1.83
Transport Equipment	0.87	0.49	1.64	0.98	-1.88	-0.16	1.26	-0.47	0.82	0.51	1.64	0.97
Manufacturing, n.e.c.; recycling	6.60	-1.30	-0.90	2.13	3.41	0.60	-0.56	1.44	4.37	0.30	-0.60	1.75

Source: India KLEMS Database, version 2016; Authors' computations

As regards the informal segment of manufacturing industries, the average growth rate in TFP during the entire period 1980-2011 was relatively high for Rubber and plastic products, Paper, paper products and printing, Textiles and leather products, and the miscellaneous manufacturing industrial group. For the wood and wood products industry which has a bigger presence in the informal segment than in the formal segment of manufacturing, the average growth rate in TFP is found to be significantly negative. Interestingly, this industry experienced marked fall in TFP in the first two sub-periods, 1980-1993 and 1994-2002, but had a modest increase in TFP in the more recent sub-period 2003-2011. A somewhat similar pattern of TFP growth is found for the formal segment of wood and wood products industry.

Taking the formal and informal segments of different manufacturing industries together, the average growth rate in TFP during the entire period 1980-2011 was relatively high for Electrical and optical equipment, Transport equipment, Other machinery, Textiles and leather products, Chemicals and chemical products, Rubber and plastic products, and the miscellaneous manufacturing industrial group. The average TFP growth rate is found to be negative for Basic metals and fabricated metal products industry and Wood and wood products industry. These were the worst performers among the 13 industries or industrial groups considered. Confining attention to the more recent sub-period, 2003-2011, it is found that the average rate of TFP growth was relatively high for the following industries: Electrical and optical equipment, Transport equipment, 'Other machinery', Textiles and leather products, Chemicals and chemical products, Rubber and plastic products, and Coke and petroleum products. Basic metals and fabricated metal products industry experienced a marked decline in TFP during 2003-11. The growth rate in TFP was negative also for the miscellaneous manufacturing industrial group during this period.

4.2 Aggregate Level TFP Growth based on Value Added Function Framework

Table 3 shows TFP growth rates at an aggregate level. These growth rates in TFP have been computing by using the value added function framework. As explained earlier, aggregate level growth rates in real value added, labour input and capital input have been computed and then the growth rate in TFP has been accordingly derived. Growth rates in TFP are shown in the table for aggregate of formal segment of India manufacturing and aggregate of informal segment of Indian manufacturing, along with TFP growth rates of total Indian manufacturing, combining the formal and inform segments. The average growth rates in TFP are shown for the entire period 1980-81 to 2011-12, and for the three sub-periods, 1980-81 to 1993-94, 1994-95 to 2002-03 and 2003-04 to 2011-12. The year-wise growth rates in TFP are depicted in Figure 1 after applying smoothening.

Table 3: TFP Growth Rate in Manufacturing at the Aggregate Level, Based on Value Added Function (annual average growth rate, percent per annum)

Industry Segment	1980-81 to 1993-94	1994-95 to 2002-03	2003-04 to 2011-12	1980-81 to 2011-12
Formal segment of the manufacturing sector	5.92	0.26	6.16	4.35
Informal segment of the manufacturing sector	0.11	-1.36	3.09	0.55
Total manufacturing sector	3.33	-0.18	5.42	2.92

Source: India KLEMS Database, version 2016; Authors' computations

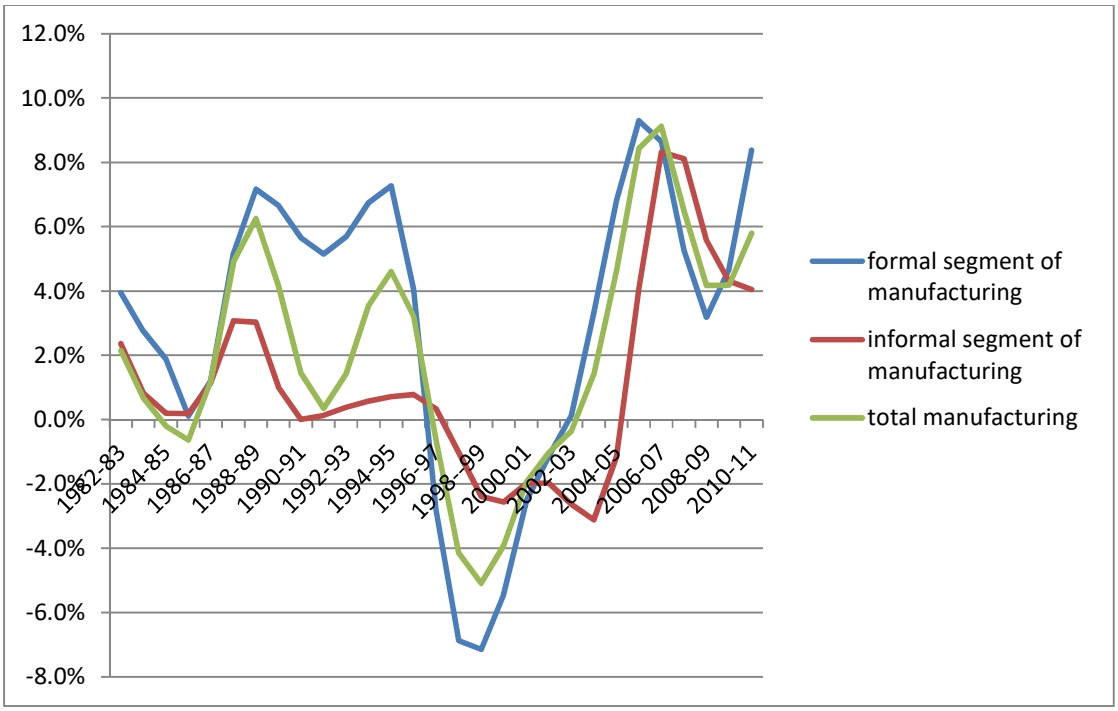


Figure 1: TFP Growth Rates in Different Years, Based on Value Added Function, Smoothened Time Series, Formal Segment, Informal Segment and Total Manufacturing

Source: India KLEMS Database, version 2016; Authors' computations

For the aggregate manufacturing sector, the average growth rate in TFP is found to be about 3.3 percent per annum for the sub-period 1980-1993, about -0.2 percent per annum for the sub-period 1994-2002 and about 5.4 percent per annum for the period 2003-2011. Growth rate in real gross value added in manufacturing (double deflated, computed by applying the Tornqvist index) was about 9.1 percent per annum during 1980-93, 5.7 percent per annum during 1994-2002 and 12.4 percent per annum during 2003-2011. Thus, TFP growth accounted for a substantial part of real value added growth in both the first and the third sub-periods. During the recent sub-period 2003-2011, TFP growth accounted for about 44 percent of the real value added

growth in Indian manufacturing. For the entire period, 1980-2011, the average growth rate in TFP is found to 2.92 percent per annum while the average growth rate in real value added in the manufacturing sector was about 9.1 percent per year.[23] Thus, TFP growth accounted for nearly one-third of real value added growth.

Turning to the formal and informal segments of manufacturing, it is seen from Table 3 that there was a dip in the rate of TFP growth in the second sub-period and a recovery in the third sub-period. The difference between the growth rates in the third sub-period and second sub-period is 4.5 and 5.9 percentage points per annum for informal and formal manufacturing respectively. The finding of a marked increase in TFP in formal manufacturing at the average rate of about 6.2 percent per annum during 2003 to 2011 is broadly consistent with the estimate presented in Goldar (2015a). The finding of a low growth rate in TFP in informal manufacturing during 1980-93 and a negative growth rate in TFP in informal manufacturing during 1994-2002 means that the performance of informal manufacturing in regard to TFP growth was poor. This is broadly in agreement with the findings of studies on TFP growth in India's informal manufacturing undertaken by Unni et al. (2001) and Kathuria et al. (2014). A negative growth rate in TFP in India's informal manufacturing was reported by Unni et al (2001) for the period 1978 to 1995. According to their estimates, growth rate in TFP in India's unorganized manufacturing was (-)2.7 percent per annum during 1978-79 to 1989-90 and (-)3.1 percent per annum during 1989-90 to 1994-95. The average growth rate in TFP during 1978-1994 was thus about (-)3 percent per annum. The study undertaken by Kathuria et al. (2014) found a higher rate of fall in TFP in India's informal manufacturing during 1994-95 to 2005-06. Taking an average of state-wise estimates presented by them, the average growth rate was found to be about (-)8.5 percent per annum, which indicates a much steeper fall in TFP in India's informal manufacturing that what is indicated by the estimates of Unni and associates. For the period 1980-81 to 2002-03, this study finds the average rate of growth in TFP in India's informal manufacturing to be about (-)0.5 percent per annum, which matches the findings of Unni et al. (2001) and Kathuria et al. (2014) in terms of the direction of change in TFP. But, the rate of fall in TFP in India's informal manufacturing in the period 1980 to 2002 indicated by the estimates obtained in this study is much lower than the rates of fall in TFP indicated by the estimates of Unni et al. (2001) and Kathuria et al. (2014). It seems to the authors of the paper that the estimates presented in this study are more reliable.[24]

[23] The conventional method of computing double deflated gross value added by subtracting value of intermediate input at constant prices from the value of output at constant prices yields a similar average annual growth rate (8.5 percent per annum). For single deflated GVA (as given in NAS), the corresponding figure is 6.3 percent per annum. This indicates that single deflated GVA understates the growth rate of Indian manufacturing. A graphic presentation of the three series on real value added is made in Annexure-1.

[24] Goldar and Sengupta (2016) report that, between 1984-85 and 2000-01, labour productivity in India's unorganized (informal) manufacturing grew at the average rate of about three percent per annum (based on NSSO survey results on unorganized manufacturing). This is compatible with the modest fall (rather than a significant fall) in TFP in informal manufacturing during 1980-2002 indicated by the TFP growth rates presented in Table 3. For the period 2000-01 to 2010-11, Goldar and Senguta report that the growth rate in labour productivity in

The year-wise growth rates in TFP shown in Figure 1 indicate that the negative growth rate in TFP in total Indian manufacturing in the second sub-period observed in Table 3 can be traced to a sharp decline in TFP in both formal and informal manufacturing during the late 1990s and early 2000s (a closer and more detailed examination of the data reveals that the fall in TFP is traceable mostly to Coke and petroleum products industry and Food products, beverages and tobacco products industry in the case of formal manufacturing, and Wood and wood products industry and Food products, beverages and tobacco products industry in the case of informal manufacturing). There has been a smart recovery after 2003 which continued till about 2006/2007 and there has been a deceleration in TFP growth thereafter.

4.2 Domar Aggregation of Industry Level TFP Growth Rates

Let us now consider TFP growth rates at the aggregate level obtained by applying Domar aggregation to industry level TFP growth rates (which are based on the gross output function framework and were presented in Table 2 above). The TFP growth rates at the aggregate level obtained by this procedure are presented in Table 4.

Table 4: TFP Growth Rate in Manufacturing at the Aggregate Level, Domar Aggregation of Industry Level TFP Growth Rates (annual average growth rate, percent per annum)

Industry Segment	1980-81 to 1993-94	1994-95 to 2002-03	2003-04 to 2011-12	1980-81 to 2011-12
Formal segment of the manufacturing sector	1.19	-0.23	1.98	0.97
Informal segment of the manufacturing sector	0.01	-0.46	1.33	0.22
Total manufacturing sector	0.96	-0.30	2.29	0.94

Source: India KLEMS Database, version 2016; Authors' computations

It is seen from Table 4 that there was a fall in the TFP growth rate in both formal and informal manufacturing in the period 1994-2002 as compared to 1980-1993 and there was acceleration in TFP growth in the period 2003-2011 as compared to 1994-2002. Also, considering the entire period under study, 1980-2011, it is found that TFP growth in the formal segment of manufacturing was much higher than that in the informal segment of manufacturing (which holds true for the three sub-periods as well). These findings match the findings from Table 3.

unorganized manufacturing was higher at about 5.7 percent per annum. The growth in real capital stock per worker in unorganized manufacturing in this period was probably somewhere around 10 percent per annum (and capital income share in value added was about 0.4). Thus, the finding of a significant acceleration in TFP growth in informal manufacturing in the period 2003-2011 as compared to the period 1994-2002 seems acceptable.

It is important to note, however, that the TFP growth rates reported in Table 4 are much lower than those reported in Table 3. For the aggregate manufacturing, taking formal and informal segments together, the growth rate in TFP during 1980-2011 reported in Table 3 is about 2.9 percent per annum, while that reported in Table 4 is much lower at about 0.9 percent per annum. This difference is expected because the TFP growth rates presented in Table 3 are based on the value added function and show how the shifts in the value added function have contributed to value added growth, whereas the TFP growth rates presented in Table 4 are based on the concept of sectoral output and estimated TFP growth rates are therefore based on a different framework.

The Domar aggregation procedure makes it possible to compute the contributions of different industries to aggregate level TFP growth. Such an analysis for total manufacturing sector for the period 1980-81 to 2011-12 is presented in Figure 2. The top contributors to TFP growth in the manufacturing sector are the following industries: Chemicals and chemical products, Electrical and optical equipment, Textiles and leather Products, Coke and petroleum products, Machinery n.e.c., and Transport equipment.

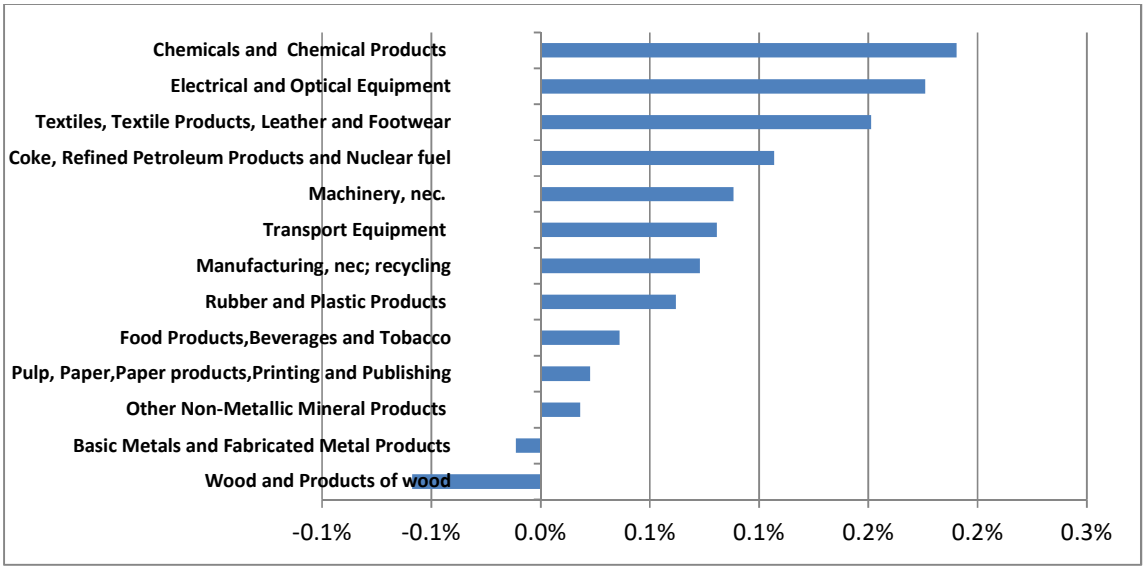


Figure 2: Industry Contributions to TFP Growth in Aggregate Manufacturing, 1980-81 to 2011-12, percent per annum

Source: India KLEMS Database, version 2016; Authors' computations

Similar analysis done for formal and informal segments of the manufacturing industries separately (see Table 5) reveals that the major contributors to TFP growth of formal manufacturing sector during 1980-2011 were Electrical and optical equipment, Chemicals and chemical products, Coke and petroleum products, Textiles and leather Products, Machinery

n.e.c., and Transport equipment (in that order), while the major contributors to TFP growth in informal manufacturing were Textiles and leather products, the Miscellaneous manufacturing industries group and Chemicals and chemical products.

Table 5: Industry Contributions to TFP Growth in Formal and Informal Manufacturing, 1980-81 to 2011-12, percent per annum

Formal manufacturing		Informal manufacturing	
Industry description	contribution	Industry description	contribution
Electrical and Optical Equipment	0.20%	Textiles, Textile Products, Leather and Footwear	0.16%
Chemicals and Chemical Products	0.18%	Manufacturing, nec; recycling	0.11%
Coke, Refined Petroleum Products and Nuclear fuel	0.12%	Chemicals and Chemical Products	0.07%
Textiles, Textile Products, Leather and Footwear	0.11%	Rubber and Plastic Products	0.04%
Machinery, nec.	0.11%	Pulp, Paper, Paper products, Printing and Publishing	0.04%
Transport Equipment	0.09%	Electrical and Optical Equipment	0.02%
Rubber and Plastic Products	0.06%	Machinery, nec.	0.01%
Food Products, Beverages and Tobacco Products	0.05%	Transport Equipment	0.00%
Manufacturing, nec; recycling	0.03%	Coke, Refined Petroleum Products and Nuclear fuel	0.00%
Other Non-Metallic Mineral Products	0.02%	Food Products, Beverages and Tobacco Products	0.00%
Pulp, Paper, Paper products, Printing and Publishing	0.01%	Other Non-Metallic Mineral Products	-0.03%
Basic Metals and Fabricated Metal Products	0.01%	Basic Metals and Fabricated Metal Products	-0.04%
Wood and Products of wood	-0.01%	Wood and Products of wood	-0.16%
Aggregate	0.97%	**Aggregate**	0.22%

Source: India KLEMS Database, version 2016; Authors' computations

An analysis of the changes in the contributions of different industries towards manufacturing TFP growth and how this explains the fall in the rate of TFP growth in Indian manufacturing between the first and second sub-period (i.e. between 1980-93 and 1994-2002) and the increase in the rate of TFP growth between the second and third sub-period (i.e. between 1994-2002 and 2003-2011) is graphically presented in Figures 3 and 4. Figure 3 deals with the fall in TFP growth between the first and second sub-periods, while Figure 4 deals with the increase in the rate of TFP growth between the second and third sub-periods.

From the analysis, it appears that the dip in the rate of TFP growth in Indian manufacturing in the second sub-period as compared to the first sub-period is mostly attributable to the changes that took place in the contributions of Food products, beverages and tobacco products, Coke and petroleum products, Chemicals and chemical products, Basic metals and metal products, and the Miscellaneous manufacturing industries group in the case of formal manufacturing, and to the changes that took place in the contributions of Food, beverages and tobacco products, Textiles and leather products, Wood and wood products, Chemicals and chemical products, and the Miscellaneous manufacturing industries group in the case of informal manufacturing. On the other hand, the acceleration in TFP growth in Indian manufacturing in the period since 2003 seems mostly attributable to the enhanced contributions of Coke and petroleum products, Food products, beverages and tobacco products, Chemical and chemical products and Textiles and leather products, in the case of formal manufacturing, and mainly to the enhanced contributions made by Textiles and leather products, Wood and wood products, Food products, beverages and tobacco products, and Chemicals and chemical products in the case of informal manufacturing.

It is interesting to observe that within the formal segment of manufacturing there was a marked fall in growth rate of TFP in Basic metals and fabricated metal products industry in the period 2003-04 to 2011-12. The TFP growth rate came down from 1.37 percent per annum during 1993-94 to 2002-03 to (-)2.31 percent per annum during 2003-04 to 2011-12 (Table 2). Despite this fall in the rate of TFP growth in Basic metals and fabricated metal products industry, the formal manufacturing sector could achieve an appreciable increase in the growth rate of TFP in the period 2003-04 to 2011-12 as compared to the period 1993-94 to 2002-03 because of enhanced contributions of Coke and petroleum products, Food products, beverages and tobacco products, and Chemical and chemical products industries along with increases in the contributions of several other industries such as Electrical and optical equipment, Textiles and leather products industries and Machinery n.e.c.

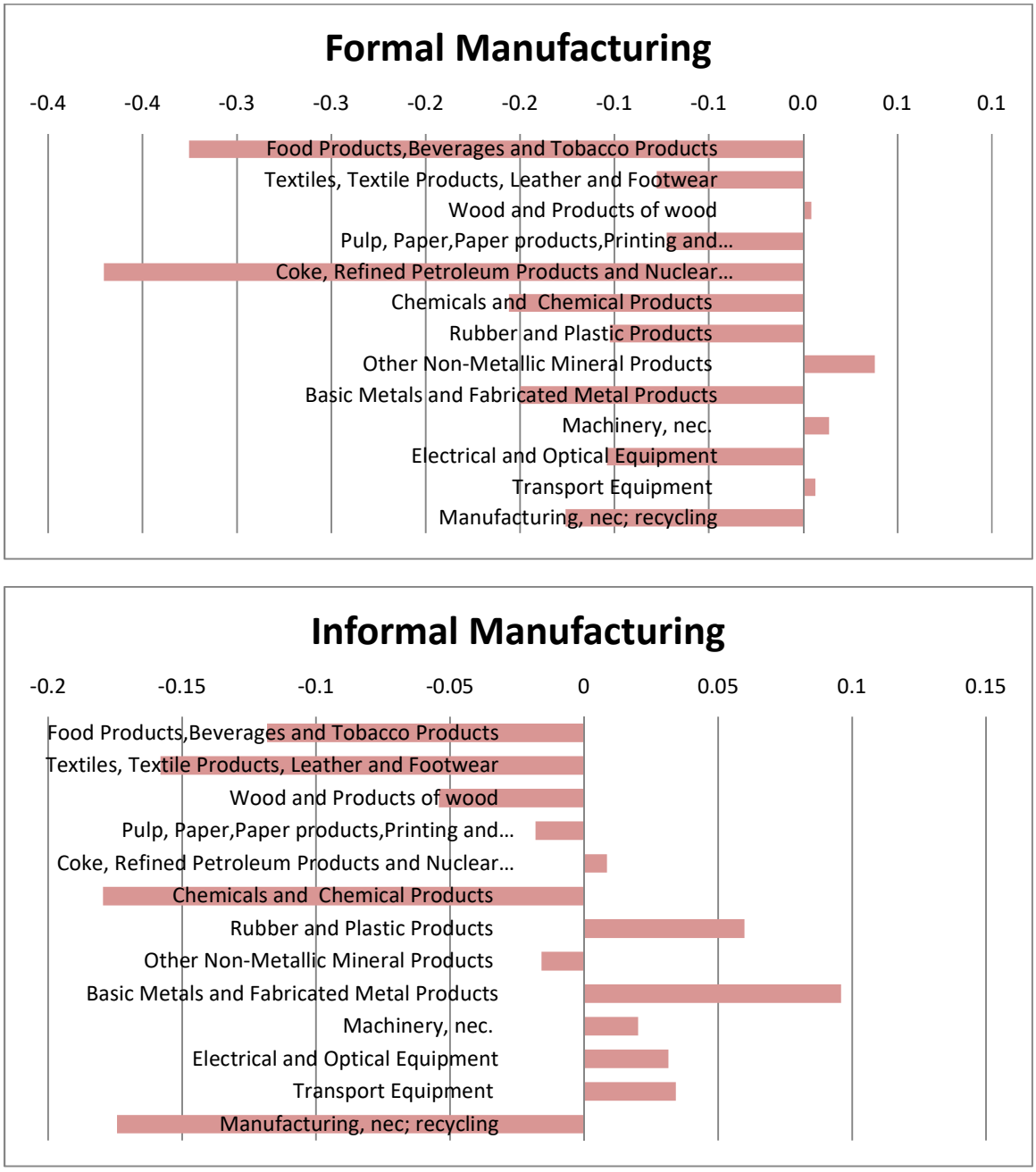
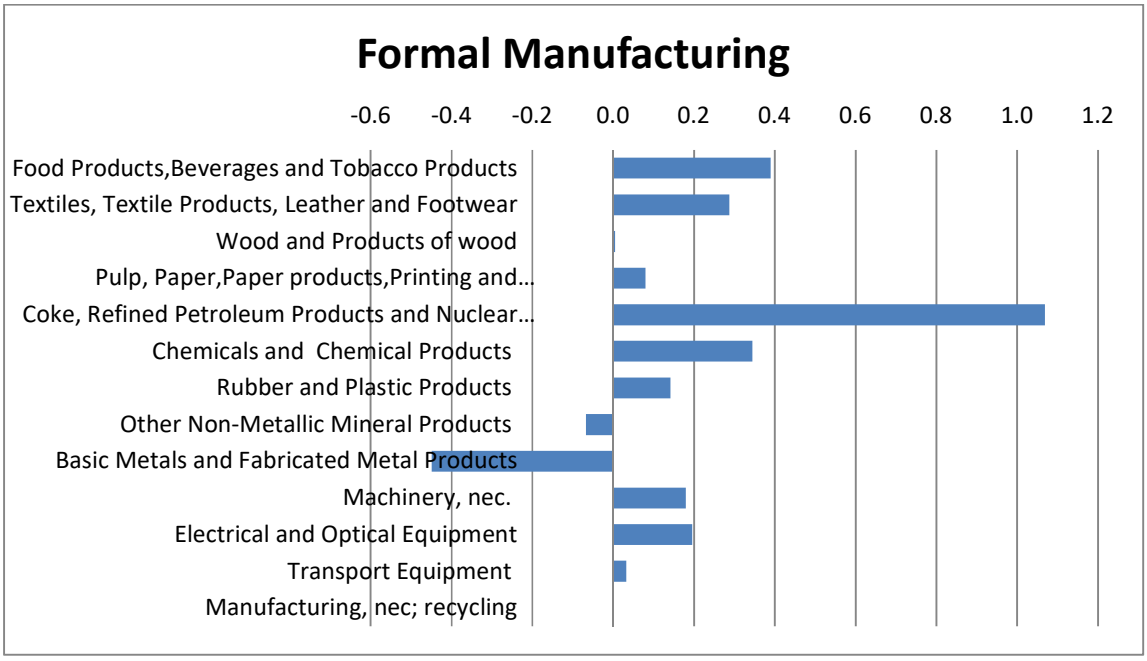


Figure 3: Change in Industry Contribution to TFP Growth in Manufacturing, 1994-2002 less 1980-1993, percent points per annum

Source: India KLEMS Database, version 2016; Authors' computations



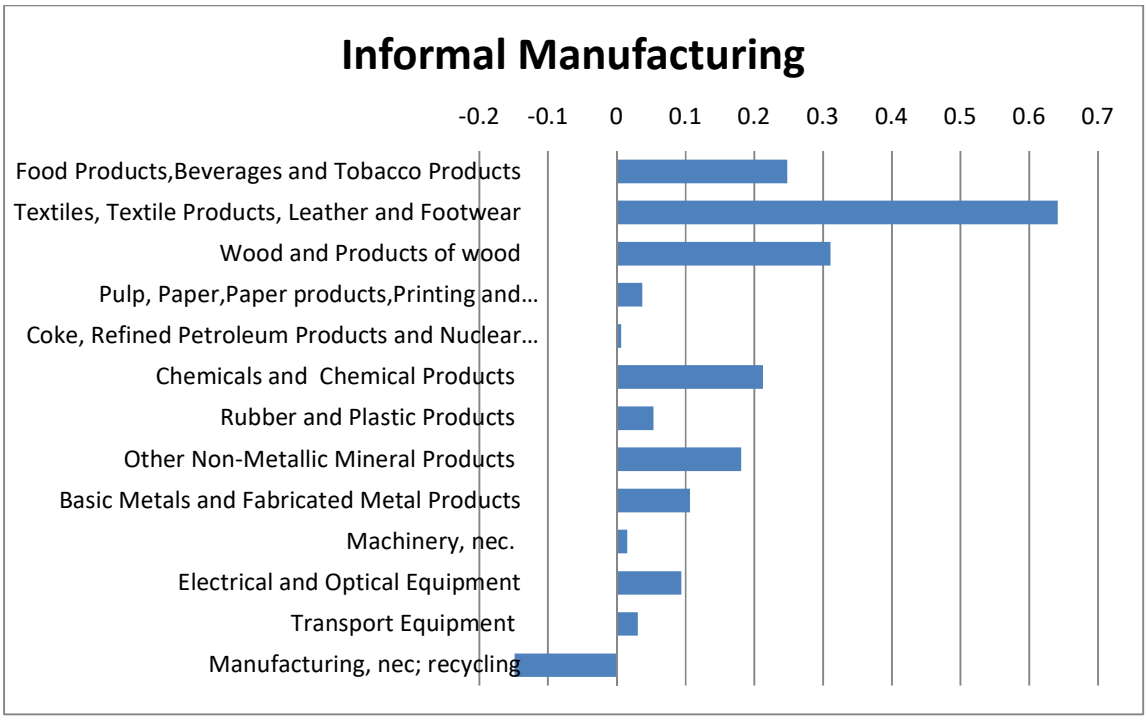


Figure 4: Change in Industry Contribution to TFP Growth in Manufacturing, 2003-2011 less 1994-2002, percent points per annum

Source: India KLEMS Database, version 2016; Authors' computations

5. Productivity differential between formal and informal segments of manufacturing industries

This section is devoted to an analysis of productivity differential between formal and informal segments of manufacturing industries. It is divided into two sub-sections. In Section 5.1, productivity differentials between formal and informal manufacturing are analyzed in respect of the 13 manufacturing industries considered for the analysis presented in Section 4 above. This makes use of the India KLEMS database (version 2016), and the analysis is done for the years 2003-04 to 2011-12. In Section 5.2, a similar analysis is presented for a larger number of industries. This makes use of ASI and NSSO survey of unorganized manufacturing enterprises; the year of comparison is 2010-11.

5.1 Analysis for India KLEMS Industries

Table 6 presents estimates of formal-informal enterprises productivity differential for 13 manufacturing industries for the years, 2003-04 to 2011-12. The period under study is divided into two sub-periods: 2003-04 to 2007-08 and 2008-09 to 2011-12. While the first period is prior to 2008 global financial crises, the second one is of post crises. The relative TFP index shown in the table indicates that if the level of TFP of organized or formal segment of the industry is taken as one, then how much is the level of TFP of unorganized/informal segment of the industry. The simple average of relative TFP level across industries is shown in the last row and the simple average of relative TFP index over the period 2003 to 2011 for each industry is presented in last column. Thus, the last row shows the average of relative TFP from 2003 to 2011(average across industry) and the last column shows the average of relative TFP of each industry over the period.

It is evident from Table 6 that there is a large variation in relative TFP index across industries. However, for each industry, the difference between the two periods is not large. It is observed that on average the level of TFP for unorganized industry has been lower than that of the organized industry. It has only slightly increased over the second period (2008-2011) than the first period (2003-2007), implying that the average of relative efficiency of unorganized industry over organized industry has been by and large stable over the two periods. Thus, over the years not only the relative TFP of unorganized industries has remained stable and they have 25% less TFP in second period as compared to 28% less relative TFP in the first period. So, it seems, there has been no substantial impact of 2008 financial crises on the average efficiency of unorganized enterprises relative to that of organized enterprises. Some of the industries, e.g. Textile and leather products, Wood and products of wood; Chemicals and chemical products; Rubber and plastic products; and Transport equipment have high relative TFP index indicating that, in terms of the level of TFP, these industries of unorganized manufacturing are not in disadvantage vis-à-vis their counterparts in the organized industry. In other cases, the relative TFP index indicates that TFP is low in unorganized (informal) as compared to organized (formal) sector.

Table 6: Relative TFP of Informal Manufacturing vis-à-vis Formal Manufacturing, By industry, 2003-04 to 2011-12 (Formal Segment = 1)

Period\Industry	2003-04 to 2007-08	2008-09 to 2011-12	2003-04 to 2011-12
Food Products, Beverages and Tobacco	0.53	0.45	0.50
Textiles, Textile Products, Leather and Footwear	1.00	0.92	0.96
Wood and Products of wood	0.70	1.04	0.85
Pulp, Paper, Paper products, Printing and Publishing	0.37	0.39	0.38
Coke, Refined Petroleum Products and Nuclear fuel	0.42	0.31	0.37
Chemicals and Chemical Products	1.37	1.37	1.37
Rubber and Plastic Products	0.86	0.74	0.81
Other Non-Metallic Mineral Products	0.62	0.63	0.62
Basic Metals and Fabricated Metal Products	0.78	1.15	0.94
Machinery, nec.	0.37	0.23	0.31
Electrical and Optical Equipment	0.58	0.57	0.55
Transport Equipment	1.55	1.63	1.59
Manufacturing, nec; recycling	0.26	0.29	0.28
Simple Average	0.72	0.75	0.73

Source: Authors' calculations, based in India KLEMS database, version 2016.

The inter-industry trend shows that the relative TFP over the entire period ranges from 1.59 in Transport equipment and 1.37 in Chemical industry to 0.28 in miscellaneous manufacturing industries group. It may be pointed out that the Chemical industry is still (2011-12) dominated by organized sector in terms of value added (91%), and the unorganized sector in it has been experiencing higher TFP because of high relative labour and capital productivity. The same applies to transport equipment. The relative share of the organized sector in 2011-12 was about 82%. The reverse has been the case with the miscellaneous manufacturing industries group where the share of organized sector is only 31% in value added. In this case, the relative TFP index of unorganized manufacturing is low. Thus, it is interesting to observe that there are industries in which the informal segment forms a small part of the industry and relative TFP is high, and there are other industries in which the informal segment forms a large part of the industry and the relative TFP is low. The informal sector is almost missing in Coke, refined petroleum and nuclear fuel industry with just a 0.3% share in Value added. The relative TFP index is found to be low. The informal sector accounts for about half of the value added in textiles and leather industry, and the relative TFP is found to be high.

5.2 Analysis at the Level of Two-Digit Industries

The section presents an analysis of relative TFP for the year 2010-11 (based on data from ASI for 2010-11and NSSO unorganized enterprises survey for 2010-11) for a larger number of industries (mostly two-digit level industries, according to NIC-2008) with the informal segment of various manufacturing industries being further split into own account manufacturing enterprises (OAME) (relatively small within the informal sector, these are household enterprise with no hired workers) and establishments (an enterprise not registered as factory and having at least one hired worker). It has been done to examine the differences in relative TFP based on the size of the enterprises.[25] The results are presented in Table 7.

It is generally expected that enterprises with small size of employment would have lower relative TFP both within unorganized sector as well as compared to organized sector. The results as presented in Table 7 confirms this, where we find that relative TFP for all the OAME (0.232) is less than that of Establishments (0.355). The same trend is observed for most of the 25 industries. However, there are four industries, viz. manufacture of beverages (industry number 3); manufacture of chemicals (industry number 12); manufacture of basic metal (industry number 16); and manufacture of furniture (industry number 23) in which we find that relative TFP in Establishments is lower than OAME. These are among the industries where we find very high - more than double - the average relative TFP in OAME of these industries. Within establishments the relative TFP is only 0.121 in manufacture of coke and refined petroleum, a highly organized industry, thus indicating that in this industry the TFP of large size unorganized sector is almost 90% lower than the organized sector. The other extreme is of manufacture of basic metals with relative TFP of 0.986, implying that the relative TFP in establishment part of unorganized sector and organized sector of the industry have similar level of TFP. Between the two extremes there are quite a few industries where relative TFP in the establishment segment of the unorganized sector is less than 40 to 70% of the organized sector. There is thus a lot of variation even in the relative TFP of the relatively large unorganized (establishment) industries. So, it cannot be definitely concluded that small size firms always have low TFP as compared to large size firms. There may be some industries where small size may not necessarily be an obstacle and the TFP may depend upon nature of product and the technology available and used.

[25] It should be pointed out that while ASI reports net book value of fixed assets, NSSO survey report on unorganized enterprises reports market value of own and rented fixed assets. The ASI data on fixed capital for the years 1990 onwards have been used to make an estimate of replacement value of capital stock in various two-digit industries for 2010-11, using the perpetual inventory method.

Table 7: Relative TFP of informal to formal segments of manufacturing industries in 2010-11

Sr. No	Industry description (NIC-2008)	Relative TFP(OAME+ Establishment)	Relative TFP(OAME)	Relative TFP (Establishment)
1	Cotton ginning, cleaning and bailing	0.165	0.091	0.220
2	Manufacture of food products	0.231	0.200	0.274
3	Manufacture of beverages	0.400	0.492	0.418
4	Manufacture of tobacco products	0.198	0.192	0.288
5	Manufacture of textiles	0.636	0.481	0.802
6	Manufacture of wearing apparel	0.351	0.312	0.416
7	Manufacture of leather and related products	0.410	0.343	0.463
8	Manufacture of wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials-	0.462	0.433	0.635
9	Manufacture of paper and paper products	0.361	0.161	0.446
10	Printing and reproduction of recorded media	0.356	0.234	0.385
11	Manufacture of coke and refined petroleum products	0.115	0.058	0.121
12	Manufacture of chemicals and chemical products	0.777	0.912	0.778
13	Manufacture of pharmaceuticals, medicinal chemical and botanical products	0.414	0.337	0.418
14	Manufacture of rubber and plastics products	0.344	0.200	0.407
15	Manufacture of other non-metallic mineral products	0.792	0.709	0.826
16	Manufacture of basic metals	0.979	1.085	0.986
17	Manufacture of fabricated metal products, except machinery and equipment	0.428	0.349	0.450
18	Manufacture of computer, electronic and optical products	0.438	0.321	0.450
19	Manufacture of electrical equipment	0.307	0.281	0.312
20	Manufacture of machinery and equipment n.e.c	0.297	0.209	0.306
21	Manufacture of motor vehicles, trailers and semi-trailers	0.436	0.393	0.438
22	Manufacture of other transport equipment	0.344	0.209	0.363
23	Manufacture of furniture	0.430	0.483	0.413
24	Other manufacturing	0.261	0.199	0.327
25	Repair and installation of machinery and equipment	0.208	0.164	0.248
	Total Manufacturing activities	0.290	0.232	0.355

Source: Authors' calculations, based on data drawn from ASI for organized (formal) manufacturing and NSSO survey of unorganized enterprise (67th Round) for unorganized (informal) manufacturing enterprises.

Within the relatively small size enterprises of the unorganized sector (OAME) also we find very large variations in the relative TFP with organized sector. While manufacture of Coke and refined petroleum has almost zero presence of OAME, so the relative TFP is also very small - just 0.058. But on the other extreme is the manufacture of basic metals in which the relative TFP in OAME is not only higher than establishments but also higher than the organized sector of the industry - the value being greater than one. But ignoring the extremes we find that majority of the industries have relative TFP between 0.2 to 0.4, indicating that the TFP in OAME segment of unorganized industries has been lower by 80 to 60% as compared to the organized segment of the industries.

The combined picture of OAME and establishments together is not much different. The relative TFP of the total unorganized (OAME + Establishment) segment of the industries in 2010-11 is 0.29 as compared to organized manufacturing. Most of the 25 industries show relative TFP of less than 0.5 for unorganized segment relative to the organized one. It seems only a few (e.g. textiles, chemicals, other non-metallic and basic metal industries) have a somewhat comparable TFP of unorganized and organized segments within the industry.

While the time series analysis of 13 manufacturing industries over the period 2003-04 to 2011-12 indicated that relative TFP of unorganized/informal segment in an industry as compared to organized sector is on average about 70 to 75 percent, the results of relative TFP for 25 two-digit industries of ASI for 2010-11 indicate that the relative TFP is on average somewhere in the range of 20 to 30 percent and support the hypothesis that enterprises with small size of employment (OAME) tend to have lower TFP as compared to large firms (Establishments).

Why the mean relative TFP of informal manufacturing is found to be much lower in the analysis presented in Table 7 than that in Table 6 remains an issue to be investigated further. This discrepancy seems to be caused by some degree of underestimation of industry level value added in the NSS survey results for unorganized manufacturing as compared to the estimates of value added provided by National Accounts Statistics which is the basis for the data used for Table 6.[26] Yet, ignoring this discrepancy between the two sets of estimates, it seems right to say that the results as a whole indicate that the level of TFP is generally low in informal manufacturing enterprises than that in their counterparts in the formal sector, and there is scope for improving TFP of the unorganized sector of the Indian manufacturing industries.

[26] According to *National Accounts Statistics*, gross value added (GVA) (at current prices) in unorganized manufacturing in 2010-11 was Rs 3179 billion, whereas the NSS unorganized manufacturing sector reports gives a figure of Rs 1547 billion for that year. There is a large difference. This is perhaps a reflection of under-estimation of value added for unorganized manufacturing in the NSS survey results (possibly along with some degree of over-estimation in National Accounts data). This would help to reconcile the difference in average relative TFP for informal manufacturing reported in Tables 6 and 7. It may be added here that according to the NSS unorganized manufacturing sector reports, real GVA in unorganized manufacturing grew by 1.48 percent per annum between 2000-01 and 2010-11 (Goldar and Sengupta, 2016, Table 3.15). But, according to National Accounts data, the growth rate in real GVA in unorganized manufacturing between 2000-01 and 2010-11 was more than five percent per annum.

6. Main Findings and Concluding Remarks

Productivity trends in Indian manufacturing have been analyzed above with a particular focus on the differences between the formal and informal segments of Indian manufacturing. A comparative analysis of growth in total factor productivity (TFP) in the formal and informal segments of Indian manufacturing industries was undertaken covering the period 1980-81 to 2011-12 (sub-divided into 1980-93, 1994-2002, and 2003-2011), along with an analysis of differences in the level of TFP between these two segments of Indian manufacturing covering the period 2003-04 to 2011-12.

Analysis of industry level TFP growth rates indicated that in most industries there was a fall in the rate of TFP growth in the second sub-period, 1994-2002, as compared to the first sub-period, 1980-93, and there was an improvement in the growth rate of TFP in most industries in the third sub-period, 2003-2011, in comparison with the second sub-period, 1994-2002.

Considering TFP growth attained by various industries in the period 1980-2011, it was found that relatively high average rates of TFP growth during this period were achieved by Electrical and optical equipment, Transport equipment, Other machinery, Textiles and leather products, Chemicals and chemical products, and the miscellaneous manufacturing products group in formal manufacturing, and Rubber and plastic products, Paper, paper products and printing, Textiles and leather products, and the miscellaneous manufacturing industrial group in informal manufacturing. Taking the formal and informal segments of different manufacturing industries together, the average growth rate in TFP during the entire period 1980-2011 was relatively high in Electrical and optical equipment, Transport equipment, Other machinery, Textiles and leather products, Chemicals and chemical products, Rubber and plastic products, and the miscellaneous manufacturing industrial group. The average TFP growth rate was found to be negative for Basic metals and fabricated metal products industry and Wood and wood products industry. In terms of TFP growth attained, these two industries were the worst performers among the 13 industries (or industrial groups) considered.

The analysis of trends in TFP at the aggregate level, based on TFP growth rates derived from the value added function framework, revealed that the average growth rate in TFP in informal manufacturing during 1980-2011 was significantly lower than that in formal manufacturing (0.6 percent per annum as against 4.4 percent per annum). Both formal and informal manufacturing experienced a fall in the rate of TFP growth during 1994-2002 as compared to 1980-1993, and then achieved a marked acceleration in TFP growth during 2003-11 (corroborating the pattern observed across industries). The growth rate in TFP in formal segment of Indian manufacturing was about 6 percent per annum during 2003-2011 and that in the informal segment of Indian manufacturing was about 3 percent per annum in this period. Between the second and third sub-periods, there was an increase in the rate of TFP growth by about 4.5 percentage points per annum in the case of informal manufacturing and about 5.9 percent per annum in the case of formal manufacturing. TFP growth made a substantial contribution to real value added growth in

Indian manufacturing in the third sub-period under study, 2003-2011. About 44 percent of the real value added growth in the aggregate manufacturing sector during 2003-2011 was contributed by TFP growth.

When trends in TFP growth at the aggregate level were assessed by applying Domar aggregation to industry level TFP growth rate, the findings were quite similar to those emerging from the analysis of aggregate level TFP trends based on the value added function, except that the growth rate in TFP at the aggregate level obtained by Domar aggregation was found to be much lower than that obtained by direct aggregation of value added, and labour and capital inputs, and application of the value added function framework. From the TFP growth rates obtained by Domar aggregation, it was found there was a fall in the TFP growth rate in both formal and informal manufacturing in the period 1994-2002 as compared to 1980-1993 and there was acceleration in TFP growth in the period 2003-2011 as compared to 1994-2002. Also, TFP growth in formal manufacturing was found to be significantly higher than that in informal manufacturing.

The Domar aggregation procedure made it possible to compute the contributions of different industries to aggregate level TFP growth. Analysis of industry-wise contributions revealed that the acceleration in TFP growth in Indian manufacturing in the period since 2003 was mostly attributable to the enhanced contributions of Coke and petroleum products, Food products, beverages and tobacco products, Chemical and chemical products and Textiles and leather products in the case of formal manufacturing, and mainly to the enhanced contributions made by Textiles and leather products, Wood and wood products, Food products, beverages and tobacco products, and Chemicals and chemical products in the case of informal manufacturing.

Comparison of level of TFP between formal and informal segments of Indian manufacturing revealed that the informal manufacturing enterprises are relatively less efficient. This is consistent with the findings of several earlier studies including Goldar (1988) and Goldar and Mitra (2013). The results of analysis of relative TFP for 25 ASI industries for the year 2010-11 supported the hypothesis that enterprises with small size of employment (OAME) tend to have lower TFP as compared to larger enterprises (Establishments). All the results thus indicate the scope for improving TFP of the unorganized segment of the Indian manufacturing industries. Based on the findings of this analysis, it may be concluded that a restructuring in Indian manufacturing with increased investment, employment and output share of the formal sector will push up the rate of TFP growth. Similarly, it appears that a restructuring within the informal sector from own account enterprises to establishments will be TFP enhancing.

Finally, a few words may be added on limitations of the measures of labour and capital inputs that have been used for the analysis TFP growth and the analysis of differences in TFP level between formal and informal manufacturing presented in the paper.

For the analysis TFP growth and TFP level differences based on India KLEMS dataset (version 2016), the measure of labour input used for this study is the number of worker or the number of persons employed. This applies also to the comparison of TFP level between formal and informal manufacturing that has been done with the help of ASI data along with unorganized manufacturing sector data of the NSSO. The measure of labour input based on headcount is obviously deficient because it does not take into account the changes that have taken place in labour quality (in terms of education, training and experience) in manufacturing over time. Also, it does not take into account the differences in the level of labour quality between formal manufacturing units and informal manufacturing units. It may be pointed out here that trend in the index of labour quality constructed for the manufacturing sector has been studied in another paper prepared under the India KLEMS project (**Trends and Patterns in Labour Quality in India at Sector Level**) (Krishna, et al. 2018b). These estimates indicate that labour quality in manufacturing grew at the rate of about 1.1 percent per year during 1980-81 and 2014-15. It is needless to say that if the contribution of labour quality improvement was properly accounted for, the estimated growth rate in TFP would have been slightly lower for both formal and informal manufacturing. The estimates of labour quality growth rate made for formal manufacturing for the period 2000-01 to 2014-15 is 0.59 percent per year and that for informal manufacturing is 0.66 percent per year. On the basis of a back-of-the-envelope calculation, it seems that incorporation of labour quality in the analysis would call for a downward adjustment in the estimated annual TFP growth for unorganized manufacturing for the period 2003-04 to 2011-12 by about 0.4 percentage points, and a downward adjustment by about 0.12 percentage points in the estimated annual TFP growth rate for organized manufacturing for the same period.

As regards the comparison of productivity levels between formal and informal manufacturing, it seems reasonable to argue that the quality of labour used in formal manufacturing is far better than the quality of labour engaged in informal manufacturing. It follows therefore that if these differences in labour quality were properly accounted for, then the gap in TFP levels between formal and informal manufacturing would have been smaller than what the estimates presented in the paper indicate.

Turing now to capital input, the quality aspect is to a large extent already incorporate in the measure used for TFP growth analysis because capital input has been measured in terms of capital services taking into account the changes in the composition of capital assets. It should be pointed out, however, that in the method applied to compute growth in capital services, a distinction has not been made between ICT (information communication technology) investment and non-ICT investment. If a proper distinction was made between ICT capital stock and non-ICT capital stock, the growth rate of capital services would have been higher than estimated. As a result, the estimated TFP growth would have been slightly lower. In the absence of solid estimates of ICT capital stock in various manufacturing industries in various years of the period under study, it is difficult to rectify this limitation of estimates of capital services utilized in this paper. Economy level estimates available in the *Total Economy Database* of the Conference

Broad reveals that during 2003 to 2011, ICT investment contributed about 1.35 percentage points to India's GDP growth while the contribution of non-ICT investment was about 5.18 percent points. Obviously, ICT investments have been making a significant contribution to India's economic growth in recent years and it is important that this be incorporated in the analysis of TFP growth in formal and informal manufacturing sectors. This aspect has received attention in another paper prepared under the India KLEMS project (**ICT investment and economic growth in India: A sectoral perspective**) (Krishna, et al. 2018a). According to the estimates made in that paper, the contribution of ICT capital to value added growth in formal manufacturing during 2001-2011was about 0.2 percentage points per annum which forms a very small part of the growth rate in real value added achieved by formal manufacturing in this period.

It needs to be pointed in this context that in the comparison of TFP levels, the capital stock figures have been directly used as the measure of capital input, disregarding the issue of composition of assets. Inasmuch as the composition of fixed assets differs between organized and unorganized manufacturing (for instance, the latter may have greater investment in ICT and pollution control than the former), the indices of relative TFP computed in this study are affected. This remains a limitation of the estimates of relative TFP presented in the paper.

Another interesting issue to which attention needs to be drawn is the issue of self- selection and the endogenous movement of manufacturing plants from informal to formal sector in India particularly after 1991 with industrial de-licensing. There is a possibility that a relatively more efficient firm may self-select into the formal sector. Also, it may be argued that a portion of the relatively more efficient informal sector manufacturing firms may have over time increasingly shifted to the formal sector. Obviously, these factors may have impacted to some extent the comparisons of TFP growth and TFP levels between formal and informal manufacturing presented in the paper. Arguably, productivity performance of the formal and informal segments, pre- and post-1991, is not strictly comparable due to the endogenous movement of firms from informal to formal sector. It is difficult to make corrections for self-selection and endogenous movement of plants from informal to formal sector, and hence it has not been attempted in the paper. However, it seems that the key findings of the study would remain intact even if corrections could be made for self-selection endogenous movement from informal to formal sector.

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Annexure-1: Indices of Real Gross Value Added in Indian Manufacturing

In this annexure, three alternate indices of real value added (base 2004-05=100) in India's aggregate manufacturing sector are compared. These three series are: (a) single deflated gross value added (GVA), (b) conventional double deflated GVA, and (c) Tornqvist index of real GVA.

The series on single deflated GVA series is the same as given in *National Accounts Statistics* (CSO). The conventional double deflated GVA series is obtained by subtracting the value of intermediate inputs at constant prices (2004-05 prices) (materials, energy and services, each deflated separately) from the value of gross output at constant prices. The Tornqvist quantity index of real value added for the manufacturing sector is also a double deflated GVA series but it is different from the conventional double deflated value added series. It involves computation of real value added growth rate for each industry for each year considering the growth rate in real output and real intermediate input and then aggregating these growth rate figures across industries using the relative shares of the industries in aggregating manufacturing value added at current prices. This is explained further below.

For each industry *i*, the relation between growth rates in real value added (V), real value of gross output (Y) and real value of intermediate input (X) is given by:

$$\Delta lnY_i = \bar{v}_{V,i}\Delta lnV_i + \bar{v}_{X,i}\Delta lnX_i \quad \ldots (A1.1)$$

where v_V is the share of value added in industry nominal gross output and v_X is the share of intermediate input in industry nominal gross output, and the bar over these shares denotes that the average for the current and previous year is to be taken (see, Jorgenson et al. 2005, p.374). Using data on nominal and real value of gross output, and nominal and real value of intermediate input, and applying equation (A1.1), growth rate in real value added (ΔlnV_i) is computed for each industry *i* for each year. Given the growth rate in industry level real value added, the aggregate level growth in real value added (denoted by ΔlnV) is computed for each year by:

$$\Delta lnV = \sum_i \bar{w}_i \Delta lnV_i \quad \ldots (A1.2)$$

In this equation, w_i denotes the share of i'th industry in aggregate value added (nominal) in manufacturing. The bar denotes that average for the current and previous year has to be taken (see, Jorgenson et al. 2005, p.370).

The three alternate indices of real value added (base 2004-05=100) in India's aggregate manufacturing sector are shown in Figure A1.1. The series on single deflated GVA and conventional double deflated GVA which are in Indian Rupees at constant prices get readily converted into an index with base 2004-05=100. In the case of the third series, i.e. the Tornqvist index, ΔlnV (the growth rate in aggregate level real value added) has been computed for each

year and then applying these growth rate, an index representing the aggregate level of real GVA (with base 2004-05=100) has been formed.

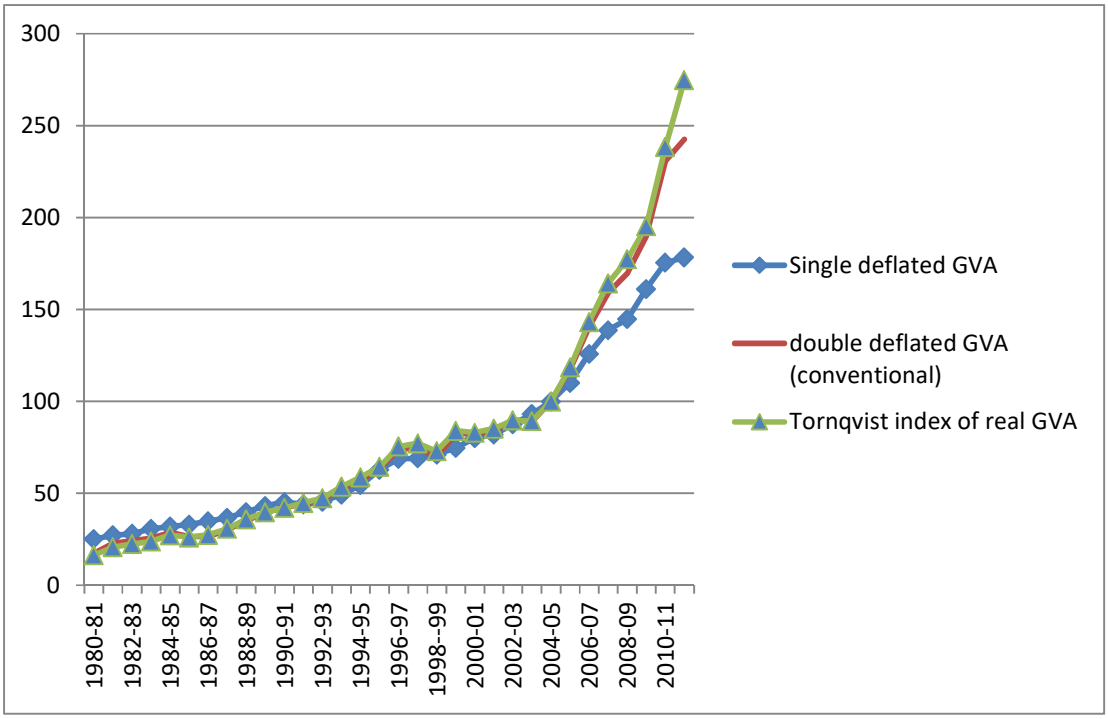

Figure A1.1: Indices of Real Gross Value Added, Aggregate Indian Manufacturing

It is seen from the graph above that the Tornvist index of real GVA and the index of conventional double deflated GVA have a similar behavior over time and there is clear indication that the growth rates in conventional double deflated GVA and the Tornqvist index of real value added are higher that the growth rate in single deflated GVA. The difference in growth rate is relatively larger for the period after 2004-05. The gap in growth rate between single deflated value added and the Tornqvist index of value added is on average about 1.8 percentage points per annum in the period up to 2004-05 and about 6.2 percentage points per annum in the period after 2004-05.

Annexure-2: Domar Aggregation of Industry Level TFP Growth Rates

After computing industry level TFP growth rates (for each year) based on a gross output function framework (see equation (2) in Section 3.1), denoted here by μ_j, the aggregate level TFP growth rate i.e. TFP growth rate for aggregate manufacturing has been computed by applying Domar weights. This is known in the literature as Domar Aggregation (see Domar, 1961; Hulten, 1978; Gollop, 1979; Jorgenson et al., 1987a; and Jorgenson et al., 2005; among others).[27] Domar aggregation has been used by Das and Kalita (2011) for measuring aggregate level TFP growth rates in two-digit manufacturing industries in India. The same method has been used in this study. Following Das and Kalita (2011), the Domar weight for industry j has been taken as the ratio of the nominal value of gross output of industry j to the nominal value of gross output of the manufacturing sector after deducting the value of sales made by manufacturing industries to other manufacturing industries, i.e. after removing inter-industry transactions within manufacturing. The equation for computing the aggregate level TFP growth (μ^A) may accordingly be written as:

$$\mu^A = \sum_j \frac{q_j Y_j}{\sum_i q_i Z_i} \mu_j = \sum_j \theta_j \mu_j \quad \ldots \text{(A2.1)}$$

The weights to be used for aggregation are denoted by θ_j. In the equation above, q denote price and Y denotes real gross output. Thus, $q_j Y_j$ is the nominal value of gross output of industry j. Z_j denotes the portion of real value of gross output of industry *i* that is not destined to be used by industries considered within the aggregate (i.e. within the manufacturing sector) and q_i is the corresponding price. Thus, the term in the denominator of the fraction [$\sum_i q_i Z_i$] is the total nominal value of gross output of manufacturing industries after deducting inter-industry transactions within the manufacturing sector.

The computation of weights has been done by using input-output tables (published by the CSO). Input-output tables for the years 1983-84, 1989-90, 1993-94, 1998-99, 2003-04 and 2007-08 have been used for computing the Domar weights. The weights based on the input-output table for 1983-84 have been used for 1983-84 and also for the earlier years. Similarly, the weights computed for 2007-08 using the input-output table for 2007-08 have been used for that year and for all subsequent years till 2011-12. The weights computed for 1983-84 and 1989-90 have been interpolated to obtain weights for the in-between years. Similar interpolation has been done with the weights computed for other benchmark years with the help of input-output tables.

[27] To analyze the contribution of different industries to aggregate economy level TFP growth in India, the Domar aggregation procedure has been used by Goldar et al. (2017). In a comparative study of TFP growth rates in the Indian and Chinese economy and the contributions made by industries to the aggregate economy TFP growth, the Domar aggregation procedure has been used by Wu et al. (2017).

It is important to note here that for the analysis presented in the paper, TFP growth estimates have been computed separately for formal and informal segments of manufacturing industries and also for formal and formal segments combined. The method discussed above applies when aggregation is done across industries without breaking them down into formal and informal segments. But, when Domar aggregation is applied to the industry level TFP growth rate estimates of the formal segment of manufacturing industries, or for the informal segment of manufacturing industries, consistent derivation of the weights (anchored in the concept of sectoral output as above) requires that inter-industry transactions within formal manufacturing and such transactions within informal manufacturing be considered. To take the case of the formal segment of a particular manufacturing industry say basic metals and fabricated metal products, the portion of output sold to the formal segment of the manufacturing sector is to deducted from total output but the portion of output sold to the informal segment of the manufacturing sector is not be deducted, since that portion of the manufacturing is not within the aggregate being considered. A similar treatment has to be given to the informal segment of the basic metals and fabricated metal products industry in the process of computation of Domar weights.

In the input-output tables published by the CSO which are used for this study, the formal and informal segments of manufacturing industries are not segregated. Therefore, certain simplifying assumptions have been made for splitting the manufacturing related rows and columns of the input-output tables and accordingly deriving the Domar weights, so that the application of equation (A2.1) given above may be made to the formal and informal segments of manufacturing industries. The rows and columns of input-output tables belonging to manufacturing have been clubbed so as to correspond to the 13 manufacturing industries considered for the study. Then, the row for each manufacturing industry has been split proportionately according to the shares of formal and informal segments in gross value of output of that industry at current prices (needless to say that for making the split, an assumption of proportionality is made). Similarly the column for that industry has been split according to the shares of formal and informal segments of that industry in gross value of output at current prices (again, an assumption of proportionality is made). By applying this procedure, the 13x13 inter-industry transactions matrix among the 13 major manufacturing industries gets converted into a 26x26 matrix, making it possible to compute separately the sectoral output of the formal manufacturing sector (after excluding transactions within the formal manufacturing sector) and that of the informal manufacturing sector. Such computations have been done for the input-output tables for six years mentioned above using data on gross output for the corresponding years.

Annexure-3: Translog Index of Difference in Technology

The relative efficiency index used in this study for comparing the level of TFP between formal and informal manufacturing plants in different industries (equation 7 in Section 3.1 of the paper) is akin to the Translog index of difference in technology used by Jorgenson and Nishimizu (1978) for making productivity level comparison between US and Japan (also see, Jorgenson et al. 1987b and Islam, 2001).

For each two-digit industry, let the specification of the production function (value added function, functional form taken as translog) be:

$$\ln(V) = \alpha + \beta_L lnL + \beta_K lnK + \beta_D D + 0.5 * \beta_{LL}(lnL)^2 + 0.5 * \beta_{KK}(lnK)^2 + 0.5 * \beta_{DD}(D)^2 + \beta_{LK}(lnL * lnK) + \beta_{LD}(lnL * D) + \beta_{KD}(lnK * D) + \beta_t t + 0.5 * \beta_{tt} t^2 + + \beta_{Lt}(lnL * t) + + \beta_{Kt}(lnK * t) + + \beta_{Dt}(D * t) \ldots (A3.1)$$

In this equation, V denotes output, i.e. real value added, L labour input, K capital input and t time. The equation contains a dummy variable D which takes value one for formal sector units (denoted hereafter by F) and zero for informal sector units (denoted hereafter by N).

An additional assumption made is that there are constant returns to scale. This assumption imposes the following restrictions on parameters:

$$\beta_L + \beta_K = 1;\ \beta_{LL} + \beta_{LK} = 0;\ \beta_{LK} + \beta_{KK} = 0;\ \beta_{LD} + \beta_{KD} = 0;\ \beta_{Lt} + \beta_{Kt} = 0$$

The conditions of producers' equilibrium (an additional assumption regarding producer behavior) lead to equality between income shares of factors of production and the elasticity of output with respect to the two inputs. The income shares of labour and capital, denoted by ν_L and ν_K, are equal to [wL/pV] and [rK/pV] respectively, where w is the price of labour input (wage rate), r is the price of capital input (rental) and p is the price of output (pV is nominal value added). Since the factor income shares are equal to elasticity of output with respect to labour and capital (because of the assumptions of constant returns to scale and producer equilibrium), the following relations are derived:

$$\nu_L = \frac{\partial lnV}{\partial lnL}(L.K.D,t) = \beta_L + \beta_{LL} lnL + \beta_{LK} lnK + \beta_{LD} D + \beta_{Lt} t \ \ldots (A3.2)$$

$$\nu_K = \frac{\partial lnV}{\partial lnL}(L.K.D,t) = \beta_K + \beta_{KK} lnK + \beta_{LK} lnL + \beta_{KD} D + \beta_{Kt} t \ldots (A3.3)$$

Note here that because of the assumption of constant returns to scale, $\nu_L + \nu_K = 1$.

The difference in technology between formal and informal units of an industry is given by the logarithmic difference between output of an informal sector unit vis-à-vis a formal sector unit after holding labour input, capital input and time constant. This is obtained as the partial derivative of lnY with respect to D, i.e.

$$\nu_D = \frac{\partial lnV}{\partial D}(L.K.D,t) = \beta_D + \beta_{DD}D + \beta_{LD}lnL + \beta_{KD}lnK + \beta_{Dt}t \quad \ldots(A3.4)$$

Given the above framework, one may derive the following equation (see, Jorgenson and Nishimizu, 1978, p.721) (F denoted formal sector units and N denotes informal sector units):

$$\ln V(F) - \ln V(N) = \bar{v}_L[lnL(F) - lnL(N)] + \bar{v}_K[lnK(F) - lnK(N)] + \bar{v}_D \quad \ldots(A3.5)$$

Where

$$\bar{v}_L = \frac{1}{2}[v_L(F) + v_L(N)] \ldots(A3.6)$$

$$\bar{v}_K = \frac{1}{2}[v_K(F) + v_K(N)] \ldots(A3.7)$$

$$\bar{v}_D = \frac{1}{2}[v_D(F) + v_D(N)] \ldots(A3.8)$$

Since $\nu_L(F) + \nu_K(F) = 1$ and $\nu_L(N) + \nu_K(N) = 1$, equation (A3.5) may be re-written as:

$$\bar{v}_D = \bar{v}_L[\{\ln V(F) - lnL(F)\} - \{\ln V(N) - lnL(N)\}] + \bar{v}_K[\{\ln V(F) - lnK(F)\} - \{\ln V(N) - lnK(N)\}] \quad \ldots(A3.9)$$

It can easily be seen that this expression for the Translog index of difference in technology is related to the relative efficiency index used in the paper – it bears a reciprocal relationship with equation (7) given in Section 3.1.