Productivity Dynamics in Indian Industries - Input Reallocation and Structural Change

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Abstract

Indian economy has been growing at a spectacular rate in the last decade and this has attracted much attention in the literature (e.g. Bosworth and Collins, 2008, Eichengreen, Gupta and Kumar, 2010). Economic growth in India during the last decade has bypassed any other country of the similar economic situation, except China. This staggering growth performance has also been accompanied by improved labor productivity growth rates and service led TFP growth. The average labor productivity growth in Indian economy was as low as 1 percent during 1951-1966, which grew only marginally to 2 percent during 1966-1980 and 1981-95, while it improved significantly to 5 percent during 1995-2010 periods (The Conference Board Total Economy Database, January 2014). Overall, the Indian economy registered a TFP growth rate of 1.12 per cent during 1980-2011. For the manufacturing sector, 1990s was a decade of factor accumulation but gradual diffusion of technology through widespread policy reforms in industrial policy and trade may have contributed to surge in productivity growth in the 2000s (Das *et al* 2015). In case of services, the reverse occurred as average TFP growth declined in 2000s. A plausible inference could be that in 2000s, for the services it was a period of capital accumulation.

Keywords: India; structural change; aggregate productivity growth; labor productivity; total factor productivity; industry origins; reallocation effects; manufacturing

JEL classification: D24, L6, F43, O47, O53

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1. *Introduction*

Structural change is one of the most robust features of economic development. As countries grow richer, we observe secular shifts in their allocation of labor and capital across broad sectors of agriculture, manufacturing and services. One important aspect, which is less considered from an overall economy perspective, is the role of productivity growth, which is essential in achieving sustainable economic growth and structural change. Improving productivity and competitiveness was one of the objectives of economic reforms initiated in the 1990s in India. The productivity literature in India is vast, but mostly confined to formal[1] manufacturing sector (see Goldar, 2015; Goldar, 2014; Kathuria et al, 2014; Das and Kalita, 2011; Goldar, 2004; Balakrishnan and Pushpangadan, 1994; Ahluwalia, 1991).[2] Only a few studies have attempted to analyze the aggregate economy productivity (Erumban and Das, 2015; Das et al, 2015; Verma, 2012; Bosworth and Collins, 2008; Brahmananda, 1982). When looked from an aggregate economy perspective, productivity growth can be achieved either by improving productivity growth at industry level or by moving resources from low productive uses to high productive uses – often called the process of structural transformation.

The dynamics of economic growth in India continues to engage economists and still remains an enigma. The trends and patterns of growth observed in India have seen acceleration in growth in Indian economy in the period following macroeconomic reforms and policy changes in investment and trade regimes. It well known that India is now more than two decades into economic reforms (1991-2015). Further reforms have encompassed all segments of Indian economy including manufacturing and services. From a major overhauling of industrial policy, lowering of tariff as well as non-tariff barriers, there has been a lagged but positive impact of reforms (Das 2015). Indian economy has grown at an average annual rate of 7 percent since 1996 for a period of 15 years, with not so much annual deviation from the mean growth rate. Even when the global economy was suffering from recession in 2008 and 2009, Indian economy grew at about 6 to 8 percent, though the rate of growth has slowed down significantly to an average of 5 percent in the last three years. Obviously, the growth in the late 1990s until 2010 was way higher than the average growth rates India had achieved before the 1980s (Das et.al 2015). One important aspect of the observed growth process in India that needs to be raised here concerns India's total factor productivity growth - how has India fared with respect to overall efficiency of resources (TFP). It is often argued that in emerging economies, growth is attributed to input accumulation and not resource efficiency. Further, it is also important to go beyond the numbers and analyze the sectors that contributed to the growth momentum. It is well known by now that services have driven the outstanding growth achieved by India in much of 1990s and 2000s; however what is not known is that how have different industries which constitute the aggregate economy fared in this growth story? Can we understand what has been the contribution of construction, energy, market services - in particular, business and financial services, manufacturing of investment goods versus consumer goods in driving the overall economic growth?

This paper makes an attempt to understand the role of industrial productivity growth and structural change in determining aggregate productivity growth –both labor productivity and total factor productivity growth (TFPG) –in the Indian economy during the last 30 years. Analysis of structural change and detailed sectoral productivity dynamics, considering the entire Indian economy, is

[1] The two terms 'formal' and 'organized' are used synonymously in this paper. So are the terms 'informal' and 'unorganized'.

[2] Goldar (2015) further underscores the importance of distinguishing between imported and domestic raw material inputs while accounting for manufacturing productivity growth, without which the estimated TFPG is underestimated.

hardly available and has been constrained by lack of data[3]. Using the 2015 version of the India KLEMS database, we examine whether the observed economic growth is broad-based, and whether it features the traditionally hypothesized structural transformation, as observed in the development of many of today's advanced countries. This has been accomplished by analyzing the industry origins of India's economic growth, labor productivity growth and total factor productivity (TFP) growth, along with the role of resource reallocation – how the resources, both capital and labor, moved across sectors, during the growth process. The paper differs from previous research in that it uses detailed industry level data to understand the growth process in India. Previous studies on structural change in India have used highly aggregate data in a three-sector framework to analyze the growth process (e.g. Bosworth and Collins, 2008), which masks much possible industry heterogeneity or use measures of partial productivity (de Vries et al, 2012). More importantly, this paper use better measures of capital and labor inputs that take account of heterogeneity among different types of capital assets and different types of labor. India KLEMS provides estimates of employment distinguished between different education levels (e.g. primary, secondary), and capital services distinguished between different asset types (e.g. machinery, transport equipment, buildings), which allows one to account for the difference in their marginal productivities.

We find that the impact of structural change is generally positive, as workers moved from low productivity industries to high productivity industries. However, dynamic structural change effects – movement of workers to fast growing industries – are hardly observed during the period of analysis. This has been primarily because, the large declines in agricultural employment has been compensated by increases in the construction sector, where productivity growth –both labor productivity and TFP – has been consistently low and mostly negative.

The remainder of the paper is presented in seven sections. In the second section we discuss the importance of structural change for economic growth in general, and provide the context of India. In the third section, we discuss the methodology used to decompose aggregate labor productivity growth and TFPG. In the fourth section we discuss the India KLEMS dataset, version 2015 and the construction of variables for the present paper, and the fifth section discusses the changing structure of Indian economy in terms of industry distribution of employment and GDP. Empirical analysis of our decomposition results are documented in section 6. The final section concludes the paper.

2. *Structural Change and Economic Growth*

Structural change has been at the heart of development economics for a long time and has been argued to be an important aspect of economic development. In the famous Lewis model of economic growth, movement of workers from agricultural sector to non-agricultural sector entails the process of development (Lewis, 1954). This model suggests that as the marginal productivity of workers in the primary sector is zero, movement of workers from agriculture will not reduce productivity in the aggregate economy. Rather as workers are released from less productive agricultural activities to more productive industrial sector, industrialization happens, and overall productivity increases. Lewis model was, however, a two-sector model, with no service sector being present. Fisher (1939) has already suggested that as countries develop, a large service sector would emerge, following primary and secondary sectors. This idea has been further developed by Clark (1940), suggesting that structural change is essential for economic progress in capitalist economies,

[3] Exceptions are de Vries, Erumban, Timmer, Voskobynikov and Wu (2012) and McMillan and Rodrik (2011). These studies suggest that the observed structural transformation in India so far has been growth enhancing. de Vries et al (2012) further suggests that the growth enhancing effect of structural change disappears due to massive expansion of informal sector, as more jobs are created in the less productive informal activities.

and at the height of development a large number of workers will be engaged in the service sector. Similar arguments have been postulated in Kuznets (1966) and Chenery and Syrquin (1975), with structural change – narrowly defined as a shift of resources (inputs and output) from agriculture to manufacturing, and further from manufacturing to services – features the process of development.[4] Such structural change patterns featured prominently in post-war economic growth across Western European countries, United States and Japan (Denison, 1967; Maddison, 1987; Jorgenson and Timmer, 2011).

Recent literature on economic growth development reiterates the importance of the nature and the speed of structural transformation in enhancing and sustaining economic growth (Lin, 2011; McMillan and Rodrik, 2011). In the modern literature, structural transformation is viewed as the evolution of an economy's structure from low productivity activities to higher productivity modern activities (Naude et al, 2015; Szirmai, 2013; Lin, 2011; McMillan and Rodrik, 2011). This would mean that structural change could happen within the broadly defined manufacturing or service sectors, and does not have to be necessarily between manufacturing and services. Workers could move from low productive agriculture to high productive industries or services or from low productive manufacturing to high productive manufacturing or from low productive service industries to high productive services. Moreover, technological change typically takes place at the level of industries and therefore, patterns of industry productivity could differ significantly (de Vries et al, 2012). Therefore, taking account of industry heterogeneity at a more detailed level is of high importance in understanding structural change. Such structural transformation is indeed desirable as a source of higher productivity growth and per capita income. As workers and resources move from low productive activities to high productive activities, overall productivity and growth accelerate. Such patterns have been observed not only in Western countries, but also in developing countries such as Africa in the early post-independence years (de Vries et al, 2015). In addition, such movement of resources across sectors helps achieve greater diversity in the economic structure of a country, reducing vulnerability to external shocks (Naude et al, 2015). It requires suitable policies that facilitate the movement of resources from low productive to high productive uses, and therefore understanding structural change and its implications are important for countries like India.

Economic growth in India is often compared with that of neighboring China, despite substantial differences between the two countries in the historical development path and institutional environment (see for instance Eichengreen et al, 2010). A major difference between the observed growth process in India and China is the importance of manufacturing in the aggregate growth in China and that of services in India. While China's development process appears to be more in line with the traditionally hypothesized structural transformation, where resources have moved from primary sector to manufacturing and now increasingly moving into services, India's growth process seems to have substantially bypassed the second stage in the structural transformation.

In general, from the conventional perspective, there are at least two reasons why the service sector would emerge and dominate over the primary and secondary sectors in an economy's development process. The income elasticity of demand for services is in general high (e.g. financial services, business services, tourism etc.). As countries develop, and incomes rise, the demand for these services would also increase, thus more resources would be allocated to services sector. Secondly, productivity growth rate in the service sector compared to manufacturing sector is generally slower, as it is often difficult to apply many new technologies in the services sector. As a consequence, prices of services would rise relatively faster compared to non-service sectors where prices would be lowered by technological advancement. This traditional hypothesis, nevertheless, may not be valid

[4] However, structural change might also involve a change in the scale of activities (e.g. mass production), and a shift from self-employed jobs to more organized production. Structural change doesn't have to be confined to economic, but it could also happen to institutions and policies, and often policy changes can stimulate economic structural changes (Naude et al, 2015, Szirmai, 2013).

in many modern services. For instance many market services such as financial and business services benefit substantially from information and communication technologies, helping them improve their productivity. Yet, in the traditional sense, high income elasticity of demand and lower productivity leads to allocation of more income and spending to the service sector of the economy. A third factor, which does not feature in the conventional closed economy models, is the increased tradability of services activities. For instance, software services, a segment of services India has been excelling since the 1990s, constitute about 45 percent of India's export basket, and the factors that helped the growth of this sector includes mathematical ability of Indian programmers, relatively lower labor costs, large English speaking population etc.(Das and Erumban, 2015).

Whatever the mechanism by which structural change takes place, an important insight from the traditional development economic theory and the modern reemergence of the structural change hypothesis (McMillan and Rodrik, 2011; Lin,2011; de Vries et al, 2012) is that growth and development entails structural change. And analysis of structural change should consider more detailed industry data, as technological change typically takes place at industry level, and there exists substantial heterogeneity across industries within manufacturing and services sectors.

3. Methodology

In this section, we discuss the methodology used to construct aggregate estimates of productivity growth and the contribution of individual industries and factor reallocation. We use decomposition methods to understand the contributions of various sectors and structural change to aggregate labor productivity and total factor productivity growth. The labor productivity decomposition is based on the canonical decomposition method suggested in Fabricant (1942). Variations of this approach have been widely used in the literature, where the basic idea is to decompose the growth rate of labor productivity into a within industry productivity growth component and a between effect. [5] The latter term – the reallocation term – out of this decomposition is used as a measure of structural change (e.g. Bosworth and Collins, 2008; McMillan and Rodrik, 2011; de Vries et al, 2012; OECD, 2013; de Vries et al, 2014). The methodology for total factor productivity decomposition is heavily drawn from Jorgenson et al (2007), further discussed and applied in the context of India in Erumban and Das (2015). We use the direct aggregation method, in comparison with aggregate production possibility frontier approach, suggested by Jorgenson et al (2007), which are discussed in detail below.

Estimates of labor productivity growth, total factor productivity growth and output growth are analyzed for 27 industries that cover the entire Indian economy for the time period 1985-2011. In addition, in order to get a detailed picture of the pattern of observed productivity growth, we also provide a graphical representation of the observed industry productivity growth, using the approach suggested by Harberger (1998), and employed in Timmer et al (2010).

3.1 Static and Dynamic Reallocation Effects – decomposition of labor productivity growth

The most common approach to measure aggregate economic growth and its sources is to assume an aggregate production function. Assuming that there exists an aggregate production function (PF)[6], we can obtain aggregate value added (V^{PF}) by summing value added across industries and, aggregate employment (L) as the sum of the number of workers across industries. Then aggregate labor productivity level in year t can be obtained as:

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[5] See de Vries et al (2015) for a detailed discussion on different variations of this decomposition approach.

[6] We discuss this assumption further in the next section.

$$v_t^{PF} = \frac{V_t^{PF}}{L_t^*} \quad (1)$$

where $V_t^{PF} = \sum_i V_{i,t}$, with Vi, being the real value added in industry i and $L_t^* = \sum_i L_{i,t}$ with Li being the number of workers in industry i.

Following de Vries et al (2015), we decompose the annual change in labor productivity levels into within industry productivity change and a reallocation effect using the following decomposition:

$$\Delta v_t^{PF} = \sum_{\mathrm{i}} \Delta v_{i,t} \, . \, u_{i,t-1} + \sum_{\mathrm{i}} \Delta u_{i,t} \, . \, v_{i,t-1} + \sum_{\mathrm{i}} \Delta u_{i,t} \, . \, \Delta v_{i,t} \quad (2)$$

where $u_{i,t}$ is the employment share of industry i in aggregate employment, and the symbol Δ indicates change over previous year (i.e. $\Delta u_{i,t} = [u_{i,t} - u_{i,t-1}]$). The first term in equation (2) is the *within effect*, or the effect of productivity change within each industry. It is nothing but the sum of changes in productivity levels in individual industries, each industry productivity change weighted by its respective employment share in the previous period. The second term is a measure of worker reallocation across sectors; change in employment weighted by levels of productivity. If it is positive, it suggests that workers move to sectors with above-average *productivity levels*, and this term is often considered as a *static reallocation (or static between) effect*. The last term in the equation is an interaction of change in employment share and change in productivity, and thus it measures the combined effect of changes in employment shares and industry productivity – a *dynamic reallocation term* (van Ark, 1996; Timmer, 2000). A positive dynamic reallocation term would suggest workers moving to industries that see positive *productivity growth.* The second term – the static reallocation effect – is the structural change term, which measures whether workers are moving to industries that have higher levels of productivity. Dividing both sides of equation (2) by aggregate labor productivity in the previous period (v_{t-1}^{PF}), we can obtain the decomposition of labor productivity growth rate.

3.2 Contribution of growth of factor inputs and TFPG to Aggregate value added growth

As in the case of labor productivity growth decomposition, using an aggregate production function (PF) approach, aggregate value added (V^{PF}) can be decomposed into contribution from aggregate capital input (K), aggregate labor input (L) and aggregate total factor productivity (A) growth using the standard growth accounting method as:

$$\Delta \ln \mathrm{V}_t^{PF} = \bar{\mathrm{s}}_{\mathrm{K,t}} \Delta \ln \mathrm{K}_t + \bar{\mathrm{s}}_{\mathrm{L,t}} \Delta \ln \mathrm{L}_t + \Delta \ln \mathrm{A}_t^{PF} \quad (3)$$

where s_K is the share of aggregate capital compensation in aggregate nominal value added, and s_L is the share of aggregate labor compensation in aggregate nominal value added, both averaged over the current and previous periods. Aggregate capital and labor compensation are derived from the identity that total nominal value added is the sum of aggregate labor and capital compensation. $\Delta \ln \mathrm{K}$ is the aggregate capital services growth rate and $\Delta \ln \mathrm{L}$ is the aggregate labor input growth rate. Aggregate capital and labor inputs are also the sum of industry labor and capital inputs. $\Delta \ln \mathrm{A}^{PF}$ is the growth of aggregate total factor productivity, assuming an aggregate production function.

The above approach is built on restrictive assumptions on the existence of an aggregate production function, which requires identical industry value added functions. Jorgenson et al. (2005) use a less restrictive production possibility frontier approach, which relaxes the restrictions on industry value-added function. In this approach, the measurement of output differs from the aggregate production function, but the measurement of inputs remains the same (see Jorgenson et al, 2007). Defining aggregate value added growth as a translog index of industry value added growth, and keeping capital and labor unchanged as in (3), equation (3) can be re-written as:

$$\Delta \ln \mathrm{V}_t = \sum_{\mathrm{i}} \bar{\mathrm{s}}_{\mathrm{i,t}} \Delta \ln \mathrm{V}_{\mathrm{i,t}} = \bar{\mathrm{s}}_{\mathrm{K,t}} \Delta \ln \mathrm{K}_t + \bar{\mathrm{s}}_{\mathrm{L,t}} \Delta \ln \mathrm{L}_t + \Delta \ln \mathrm{A}_t \quad (4)$$

where V_i is the real value added in industry i. Note that ΔlnV in equation (4) is different from ΔlnV^{PF} in equation (3), as equation (4) uses a translog aggregation of industry value added growth while equation (3) is the growth rate of simply aggregated value added across industries. The difference between the two is the reallocation of value added across industries.

In (3) and (4), aggregate capital and labor inputs are measured as the flow of services from these inputs to the production process. Aggregate capital and aggregate labor inputs consists of different types of capital assets (e.g. machinery, computers, buildings etc.) and labor types (e.g. low-skilled, high-skilled, old, young etc.), with differing marginal productivities. Therefore, following Jorgenson (1963), we define aggregate capital services and labor input as translog aggregates of heterogeneous types of capital and labor.

$$\Delta \ln K_t = \sum_k \bar{v}_{k,t} \Delta \ln K_{k,t}\,; \text{ and } \Delta \ln L_t = \sum_l \bar{v}_{l,t} \Delta \ln L_{l,t} \tag{5}$$

where v_k is the share of each type of capital k in aggregate capital compensation, and v_l is the share of each type of labor l in total labor compensation, defined as:

$$v_{k,t} = \frac{P_{K,k,t} K_{k,t}}{\sum_K P_{K,k,t} K_{k,t}} \quad \text{and} \quad v_{l,t} = \frac{P_{L,l,t} L_{l,t}}{\sum_l P_{L,l,t} L_{l,t}} \tag{6}$$

where $P_{K,k}$ is the rental price of capital type k, and $P_{L,l}$ is the price (wage rate) of labor type l. As before $\bar{v}$ in (5) is the two-period averages of these shares. In our analysis, we distinguish between five types of labor, and three types of capital assets (see section on data). They are respectively employees with education 1) up to primary; 2) primary school; 3) middle school; 4) secondary and higher secondary school; and above 5) higher secondary school and capital assets are 1) transport equipment; 2) machinery and 3) construction.[7] The above decomposition (equation 4) is used to obtain total factor productivity growth for the aggregate economy. Aggregate economy productivity growth can be attained either by improved productivity within industries or by moving labor and capital from low productivity to high productivity industries.

3.3 Contribution of Industry TFPG and factor reallocation to Aggregate TFPG

In order to trace the industry origins of aggregate total factor productivity, and to quantify the relative importance of various industries and factor reallocation (or structural change) in driving aggregate productivity growth, we use the direct aggregation method suggested by Jorgenson et al (2007). This approach relaxes many assumptions on input and output measurement that exist in the aggregate production function approach. In this approach, aggregate production function is a value added function and the aggregate value added growth is measured as a translog index of industry value added, with weights being the industry share in aggregate nominal value added (as in equation 4). The production function at the industry level, however, is a gross output (Y) function, and therefore, industry output growth can be decomposed into contributions from capital (K), labor (L) and intermediate input (X) as:

$$\Delta \ln Y_{i,t} = \bar{s}_{K,i,t} \Delta \ln K_{i,t} + \bar{s}_{L,i,t} \Delta \ln L_{i,t} + \bar{s}_{X,i,t} \Delta \ln X_{i,t} + \Delta \ln A_{i,t} \tag{7}$$

where s_K, s_L, and s_X are respectively the shares of capital, labor and intermediate input in total nominal output in industry i. Since nominal value of gross output is the sum of nominal value of industry value added and nominal value of total intermediate inputs, the industry output growth can be obtained as a weighted sum of industry value added growth and industry intermediate growth with the weights being respectively the nominal share of value added in output and nominal share of intermediate inputs in output. Assuming that aggregate value added is a translog sum of

[7] See Erumban and Das (2015) for a growth accounting analysis breaking machinery capital further into ICT and non-ICT machinery.

industry value added, we can decompose the aggregate value added growth as (see Jorgenson et al, 2007):

$$\Delta \ln V_t = \sum_i \bar{s}_{i,t} \Delta \ln V_{i,t} = \sum_i \bar{s}_{i,t} \frac{\bar{s}_{K,i,t}}{\bar{s}_{V,i,t}} \Delta \ln K_{i,t} + \sum_i \bar{s}_{i,t} \frac{\bar{s}_{L,i,t}}{\bar{s}_{V,i,t}} \Delta \ln L_{i,t} + \sum_i \bar{s}_{i,t} \frac{1}{\bar{s}_{V,i,t}} \Delta \ln A_{i,t} \quad (8)$$

In equation (8), aggregate value added growth is sum of the weighted contribution of industry capital input, industry labor input and industry TFPG. The weights on capital and labor consists of s_i, the share of industry value added in aggregate value added, $s_{K,i}$ and $s_{L,i}$, the share of industry capital and labor compensation in industry gross output and s_{vi}, the share of industry value added in industry gross output.[8] The first and last components of the input weights (s_i and s_{vi}) are also reflected in the TFPG weights.

Subtracting equation (4) – the production possibility frontier – from (8), and rearranging, we obtain

$$\Delta lnA_t = \sum_i \frac{\bar{s}_{i,t}}{\bar{s}_{V,i,t}} \Delta lnA_{i,t} + \left(\sum_i \bar{s}_{i,t} \frac{\bar{s}_{K,i,t}}{\bar{s}_{V,i,t}} \Delta lnK_{i,t} - \bar{s}_K \Delta lnK_t \right) + \left(\sum_i \bar{s}_{i,t} \frac{\bar{s}_{L,i,t}}{\bar{s}_{V,i,t}} \Delta lnL_{i,t} - \bar{s}_L \Delta lnL_t \right)$$

$$= \sum_i \frac{\bar{s}_{i,t}}{\bar{s}_{V,i,t}} \Delta \ln A_{i,t} + REAL_{K,t} + REAL_{L,t} \quad (9)$$

Equation (9) suggests that aggregate TFPG can be decomposed into weighted average of industry TFPG and the capital and labor reallocation across industries. Note that the weight attributed to industry TFPG in this setting is equivalent to the well-known Domar weight (Domar, 1961). The weight in equation (9) is the ratio of s_i, or industry share in aggregate value added and s_{vi} or the industry value added share in aggregate output, which approximates to the Domar weight, which is the ratio of industry gross output to aggregate value added. These weights will be greater than one, as industry TFP improvement can have a direct effect through industry output, but also an indirect effect through output in other industries, by means of intermediate input sold to other industries (Jorgenson et al, 2012).The difference between Domar weighted TFPG and the aggregate TFPG is the sum of labor and capital reallocation effects, which reflects the movement of these resources across industries.

4. *Moving from aggregate to disaggregate industry analysis – the India KLEMS database version 2015*

While there is significant amount of studies analyzing sources of growth and dynamics of productivity in India's organized manufacturing sector, which constitutes only less than 11 percent of total GDP (National Accounts Statistics, 2014), analysis beyond this sector is constrained by lack of consistent data on investment, employment and value added. The India KLEMS research project, with financial assistance from the Reserve Bank of India, is a major initiative to fill this data gap. It facilitates research on the relationship between labor quality (or educational composition), investment and productivity growth in India. More importantly, since this data has been constructed keeping international standards, ensuring comparability with other freely available KLEMS databases (EU KLEMS[9], Asia KLEMS and World KLEMS), researchers can compare performance of Indian economy with other developing and advanced economies. While the data is completely consistent with national accounts, it provides indicators which are often not publically

[8] These input weights are industry share of capital and labor compensation in aggregate value added, and the TFPG weight is the industry output share in aggregate value added.

[9] See O'Mahony and Timmer (2009) for an elaborate discussion the KLEMS methodology, and also several uses of the KLEMS type of data.

available through national accounts.[10] The India KLEMS provides data on value added, gross output, intermediate inputs (all in both current and constant prices[11]) employment by education levels, labor quality, wage share in GDP including estimates for self-employed workers, capital investment and capital services by asset type along with indicators of labor productivity growth and total factor productivity growth. All these data are available for 27 detailed industries comprising the Indian economy over 1980-2011 period. As such the data is directly applicable in growth accounting analysis to understand sources of output and labor productivity growth in India in different time periods, and across industries, and also to compare with other countries, when combined with other KLEMS databases. It can also be used for studies of inequality and wage setting, and to understand the role of intermediate inputs in production. When combined with input-output databases such as World Input Output Database (WIOD), KLEMS type of data would facilitate in-depth analysis of global value chains, which is of high significance in the context of increased fragmentation of production (see Timmer et al, 2014). The KLEMS database is also useful for analyzing various policy considerations including, tax, innovation, competition, and industrial policies.

The main source of data used in the India KLEMS is the National Accounts Statistics (NAS), published annually by the Central Statistical Organization. This data is supplemented by Input-Output tables, Annual Survey of Industries (ASI) and various rounds of National Sample Survey Office (NSSO) surveys on employment & unemployment and unorganized manufacturing sectors. This section provides a description of the data, their sources, construction of variables and the industrial classifications used in the study. We require industry wise data on nominal and real value added, investment by asset type, number of employees and labor compensation by type of workers and nominal and real values of intermediate inputs. We briefly describe the source and construction of these variables in detail.[12]

Value added: India KLEMS provides estimates of Gross Domestic Product (GDP) by industry at both current and constant prices, which are consistent with NAS 2004-2005 base series. For those industries especially for some subsectors within the manufacturing sector, where detailed data are not available from NAS, estimates have been made using the Annual Survey of Industries (ASI) for registered and NSSO surveys for un-registered 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. The real value added data in NAS are single deflated, except for agriculture. However, in our growth accounting analysis we use double deflated value added series, which are derived using gross output, and intermediate input series obtained from the India KLEMS database.

Gross output: Estimates of gross output in India KLEMS for sectors agriculture, hunting, forestry and fishing, mining and quarrying, construction and manufacturing sectors are directly obtained from NAS at current and constant prices. For splitting some sectors, as in the case of value added, additional information is used from ASI and NSSO. For other sectors, mainly service sectors, where there was no output information available from NAS, input-output transaction tables, which provides output and value added, are used. The ratio of these two is applied to value added in NAS to obtain consistent estimates of gross output. The benchmark input output tables for the years 1978, 1983, 1989, 1993, 1998 2003 and 2007 are used for this purpose, and for the intermediate years the ratios are linearly interpolated.

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[10]We are thankful to CSO for providing detailed data on indicators such as asset wise investment, which is not available publically.

[11]India KLEMS use a double deflation approach to construct constant price value added series (see Balakrishan and Pushpangadan, 1994 for a first use of double deflation in Indian manufacturing).

[12] See Das et al (2015) for a detailed discussion on the construction of these variables.

Intermediate inputs: Nominal values of intermediate input are basically the difference between nominal value added and nominal output. The commodity inputs going into the production process of output industries are aggregated into energy (E), material (M) and service (S) inputs. In this way, for each benchmark year, estimates are obtained for material, energy and service inputs used to produce output in the different industries. The time series of input proportions for industries are compiled for the benchmark years and then linear interpolation is used to obtain the series for 1980 to 2011 at current prices. To generate a price deflator for intermediate inputs, we use wholesale price indices published by the Office of the Economic Advisor, Ministry of Commerce and Industry. We use weighted deflators for materials, energy and service inputs for each of the industries (*ala* Balakrishnan and Pushpangadan, 1994).

Employment and labor composition: Employment data in India KLEMS is based on usual principal and subsidiary status (UPSS) concept, and are obtained from the quinquennial rounds of Employment and Unemployment Surveys (EUS) published by National Sample Survey Office (NSSO). The aggregate labor input, used in this study is obtained as the weighted sum of employment growth rates of workers of various educational levels using equation (5). Employment and wage data by educational categories – up to primary school, primary school, middle school, secondary & higher secondary school, and above higher secondary school –are also available from EUS. Since EUS does not provide self-employed wage compensation, India KLEMS uses econometrically estimated compensation rates, using demographic and socio economic characteristics of workers (see Aggarwal and Erumban, 2013).

Capital services: Capital services for the aggregate economy and for industries in India KLEMS are arrived at using equation (5). In order do this, it was essential to obtain investment data by asset type. Industry level 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 Office (NSSO) rounds for unorganized manufacturing. These industry level data are used to construct capital stock using perpetual inventory method, i.e.

$$K_{K,t} = K_{K,t-1}(1-\delta_K) + I_{K,t-1}$$

where K_K is the capital stock in asset K, δ_K and I_K is 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 $P_{K,k}$ in (6) is measured assuming an external rate of return *(r)*, as

$$\mathrm{P}_{\mathrm{K,k,t}} = \mathrm{P}_{\mathrm{I,k,t-1}}\, r + \mathrm{P}_{\mathrm{I,k,t}}\, \delta_K$$

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.

5. Changing structure of Indian economy

As mentioned before, this study is conducted taking into account the significant industry heterogeneity within the Indian economy and its consequences for aggregate economic growth using data on 27 industrial sectors of the economy. However, for analytical feasibility, we aggregate the 27 industry groups into different sub-sectors using appropriate aggregation procedures (see Tables 1 for the industry groups). In our industry discussions we will mostly follow these groupings. Since agriculture is a major employment providing sector in Indian economy, which is often argued to be an important and key sector for future sustainability of India's economic growth (Balakrishnan, 2010), we keep it as a distinct sector. Mining, utilities and construction are clubbed into one single sector, which we call as other goods production. Manufacturing is divided into two broad groups, consumer and intermediate goods manufacturing and investment goods manufacturing, where the latter includes machinery and transport equipment manufacturing. Service sector is divided into five distinct sectors; trade and distributive services, business services, financial services, all other market services and non-market services. [13]

Table 1: Industry groups, and corresponding ISIC codes

sl Nr.	Industry Group (Sector)	ISIC	Industries in the Group
1	Agriculture & allied activities	AtB	Agriculture, hunting & fishing
Goods Production			
Manufacturing			
2	Consumer & intermediate goods Mfg.	15to28+36to37	Mfg., excluding machinery, electrical & transport equipment
3	Investment goods Mfg.	29t35	Machinery, nec.; Electrical & Optical Equipment; Transport Equipment
4	Other goods production	C+E+F	Mining & Quarrying; Electricity, Gas & Water; Construction
Services			
Market Services			
5	Trade and distribution	G+60t63	Wholesale & Retail trade; Transport & Storage
6	Finance services	J	Financial Services
7	Business Services	71t74	Renting of Machinery & Business services
8	Other market services	H+64+K+O+P	Hotels & Restaurants; Post & Telecommunication & all other market Services
9	Non-market services	L+M+N	Public Administration & Defense; Compulsory Social Security ; Education; Health & Social Work

Note: A detailed industry classification consisting of all 27 industries considered in the analysis is given in Appendix Table 1

In this section, we document the changing industry shares of value added and employment in Indian economy since 1980. Industry shares of value added and employment in 27 industries of the aggregate economy are provided respectively in Tables 2 and 3 respectively. In addition, in Figures 1 and 2, we depict the time-series of changing structure of Indian economy in terms of value added and employment shares since 1980 for a few select industry aggregates. As the theory suggests, the share of agriculture has declined steadily over the past three decades. In terms of value added the share of agriculture declined from 36 percent in 1980 to 17.9 percent in 2011 and in terms of employment it declined from 69.8 percent to 48.1 percent. This decline, however, is not mirrored in an increase in the manufacturing share. The size of manufacturing value added declined from 16.4 percent to 14.7 percent and the share of employment increased only marginally from 10.4 percent to 11.4 percent in the course of 3 decades. Except for a slight increase in value added share during the mid-1990s, the stagnation in manufacturing is visible throughout.

[13] Since investment in information and communication technologies is often considered to be an important driver of productivity change, an industry grouping based on ICT intensity will also be of high interest. However, this paper does not make that distinction. Such an attempt is made in Erumban and Das (2015), who document the growing importance of ICT using sectors in Indian economy

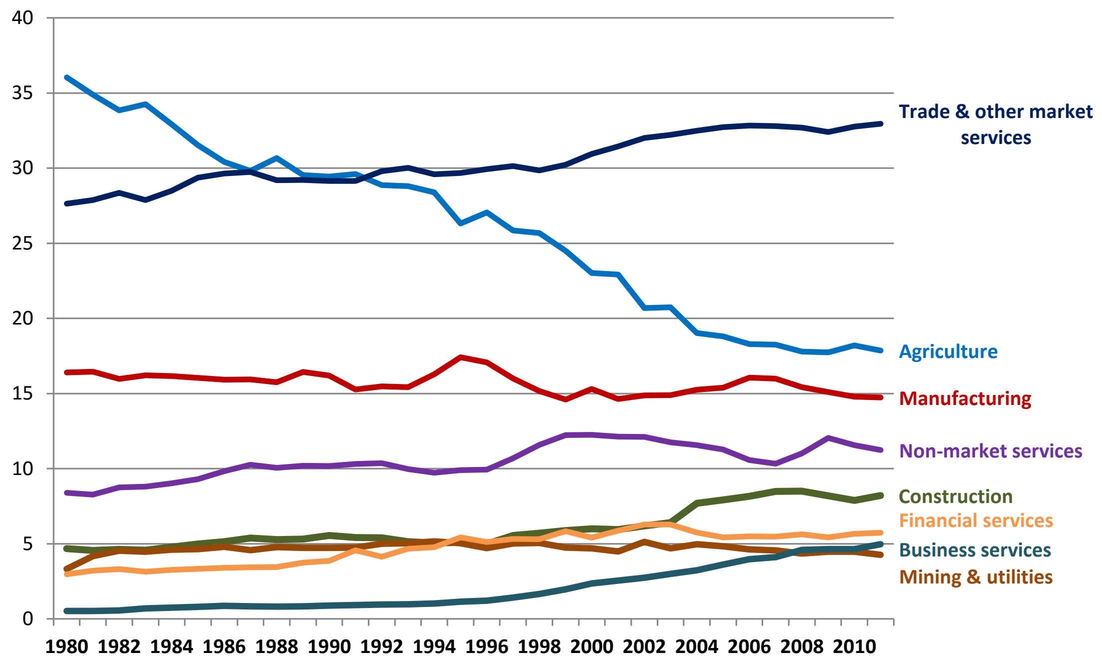


Figure 1: Sectoral shares in aggregate nominal value added, 1980-2011

Notes: Trade & other market services includes Trade, transport & storage, hotels and restaurants, post & communication and other services; Mining & utilities include mining, electricity, gas and water supply.

Source: India KLEMS dataset, version 2015

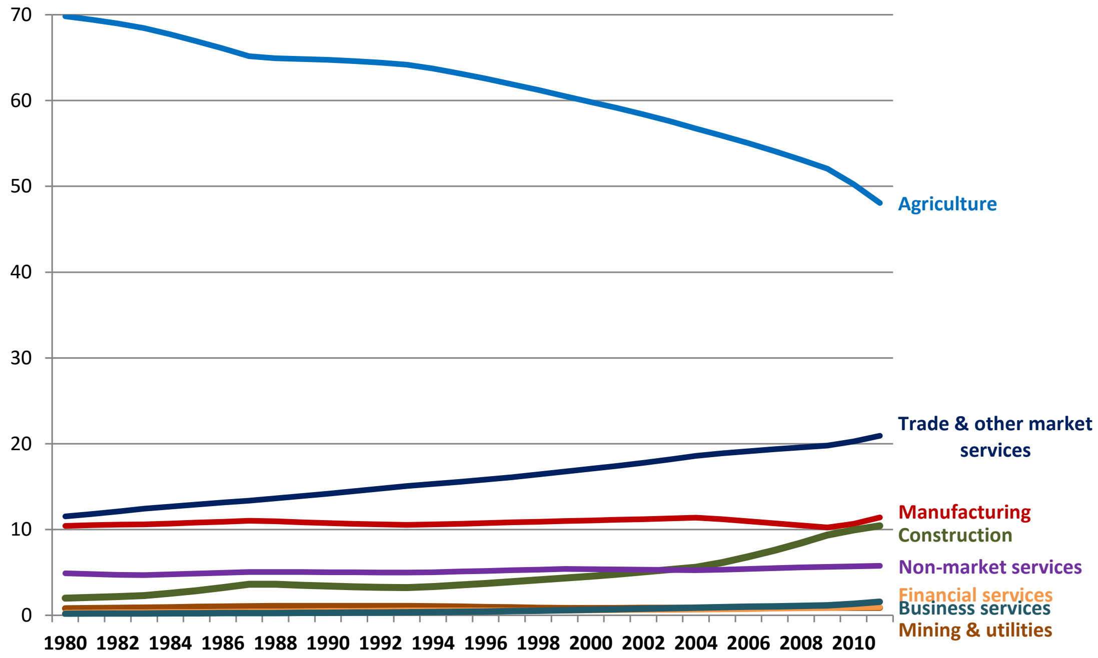
Table 2: Industry shares in aggregate nominal value added, 1980, 1990, 2000 and 2011

Industry/Industry Group	1980	1990	2000	2011
Agriculture	**36.0**	**29.4**	**23.0**	**17.9**
Goods Production	**24.4**	**26.5**	**26.0**	**27.2**
Manufacturing	**16.4**	**16.2**	**15.3**	**14.7**
Consumer & Intermediate MFG.	***13.8***	***12.9***	***12.8***	***11.8***
Food Products, Beverages & Tobacco	1.7	1.8	1.7	1.6
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, Ref. Petroleum & Nuclear Fuel	0.3	0.7	0.7	0.7
Chemicals & Chemical Products	1.1	1.3	1.8	2.0
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	2.9
Mfg., nec. recycling	1.3	0.8	0.8	0.8
Investment Goods MFG.	***2.7***	***3.3***	***2.6***	***2.9***
Machinery, nec.	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
Other Goods Production	**8.0**	**10.3**	**10.7**	**12.5**
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	8.2
Services	**39.5**	**44.1**	**51.0**	**54.9**
Market Services	***31.1***	***33.9***	***38.7***	***43.7***
Trade & Distribution	*14.5*	*16.9*	*19.3*	*22.1*
Trade	10.7	11.7	13.2	15.9
Transport & Storage	3.8	5.2	6.1	6.3
Financial Services	*3.0*	*3.9*	*5.4*	*5.7*
Renting of Mach. & Business services	*0.5*	*0.9*	*2.4*	*5.0*
Other Market Services	*13.1*	*12.2*	*11.6*	*10.8*
Hotels & Restaurants	0.8	1.0	1.3	1.5
Post & Telecommunication	0.6	0.9	1.5	1.1
Other Services	11.8	10.3	8.8	8.3
Non-Market Services	***8.4***	***10.2***	***12.3***	***11.2***
Public Administration & Defense etc.	5.0	5.9	6.5	5.9
Education	2.5	3.1	4.1	3.9
Health & Social Work	0.9	1.2	1.6	1.4
Total	**100**	**100**	**100**	**100**

Source: India KLEMS dataset, version 2015

Within manufacturing sectors, sectors that did not witness a decline in value added share are mostly investment goods manufacturing and some consumer and intermediate goods manufacturing (such as petroleum refining, chemicals, rubber &plastics, non-metallic minerals, basic metals &metal products). Together these sectors constitute 67 percent of total manufacturing value added in 2011; an increase of 22 percentage points from 45 percent in 1980. The overall size of these sectors in the economy has, however, increased only from 7 percent to 10 percent, not sufficient enough to offset the decline in the share of other sectors. Textiles group has witnessed the highest decline in value added share within manufacturing, from 4 percent in 1980 to 1.7 percent in 2011.

Figure 2: Sectoral shares in aggregate employment, 1980-2011



Notes: Trade & other market services includes Trade, transport & storage, hotels and restaurants, post & communication and other services; Mining & utilities include mining, electricity, gas and water supply.

Source: India KLEMS dataset, version 2015

Employment share in aggregate economy did not change much across different manufacturing sectors. Textiles constituted 36 percent of employment within manufacturing in 1980, which declined to 25 percent by 2011, the largest decline in employment share within the manufacturing sector. This has resulted in a decline of its share in aggregate employment from 3.7 percent in 1980 to 2.9 percent in 2011. Sectors that gained in terms of employment share include rubber & plastic, basic metals & metal products, machinery, electrical & optical equipment and transport equipment. Thus within manufacturing, while traditional sectors lost their importance, some modern segments, including engineering and chemicals did see moderate improvement in absorbing workers, suggesting some positive structural transformation within the sector. Ye, the fact that manufacturing did not absorb the workers released from agriculture defies the conventional structural transformation hypothesis.

A large part of the decline in agricultural employment is reflected in an increase in the construction sector, which has increased from 2 percent in 1980 to 10 percent in 2011 and in trade and other market services that increased from 12 to 21 percent. However, the output share of construction increased only from 5 to 8 percent and in trade and other market services from 28 to 33 percent, thus suggesting a decline in productivity levels.

Clearly, the emergence of service sector as the largest contributor to aggregate GDP is an important feature of structural transformation of Indian economy. Service sector has been the single largest contributor to value added in the post-1980 period. The share of the service sector in overall GDP increased from 39.5 in 1980 to 54.5 percent in 2011. Within which market services[14] constituted 31.1 percent of overall GDP in 1980, which increased more rapidly to 43.7 percent, with greater acceleration since the 1990s. However, in terms of employment, the service sector is still less than 1/3rd of the economy, with the market services being at slightly below a quarter of overall employment. The market services share in employment increased from 12 percent to 23.4 percent, and that of total (including non-market sector) services increased from 16.9 percent to 29.2 percent.

Within the market services, business services increased its output share from half a percent to 5 percent, whereas its employment share increased from a trivial 0.2 percent to 1.6 percent. Financial services doubled its output share from 3 to 6 percent, post &telecom increased from 0.6 to 1.1 percent, trade sector from 11 percent to 16 percent and transport and storage from 4 percent to 6 percent. However, the employment shares of these sectors did not increase in tandem with their output shares. Employment share of financial services increased from 0.3 percent to nearly 1 percent, post &telecom from 0.1 percent to 0.4 percent, trade from 6 to 10 percent and transport from 2 to 4 percent.

[14] Market services include trade, transport services, financial services, business services post & telecom and hotels & restaurants services.

Table 3: Industry shares in aggregate employment, 1980, 1990, 2000 and 2011

Industry/Industry Group	1980	1990	2000	2011
Agriculture, Hunting, Forestry & Fishing	**69.8**	**64.7**	**59.8**	**48.1**
Manufacturing	**10.4**	**10.7**	**11.1**	**11.4**
Consumer & Intermediate MFG.	***9.9***	***10.1***	***10.3***	***10.3***
Food Products, Beverages & Tobacco	2.2	2.3	2.5	2.4
Textiles, Leather & Footwear	3.7	3.4	3.0	2.9
Wood & Products of Wood	0.9	0.9	1.1	0.8
Pulp, Paper, Printing & Publishing	0.3	0.3	0.3	0.3
Coke, Ref. Petroleum & Nuclear Fuel	0.0	0.0	0.0	0.0
Chemicals & Chemical Products	0.4	0.4	0.5	0.4
Rubber & Plastic Products	0.1	0.1	0.2	0.2
Other Non-Metallic Mineral Products	0.9	0.9	0.9	1.0
Basic Metals & Metal Products	0.7	0.8	0.9	0.9
Mfg., nec. recycling	0.7	0.9	0.8	1.3
Investment Goods MFG.	***0.5***	***0.7***	***0.8***	***1.1***
Machinery, nec.	0.2	0.2	0.3	0.4
Electrical & Optical Equipment	0.2	0.2	0.3	0.4
Transport Equipment	0.2	0.2	0.2	0.3
Other Goods Production	**2.8**	**4.5**	**5.4**	**11.3**
Mining & Quarrying	0.5	0.7	0.6	0.6
Electricity, Gas & Water Supply	0.3	0.4	0.3	0.3
Construction	2.0	3.4	4.6	10.4
Services	**16.9**	**20.0**	**23.7**	**29.2**
Market Services	***12.0***	***15.0***	***18.3***	***23.4***
Trade & Distribution	*7.7*	*9.9*	*12.5*	*13.8*
Trade	5.8	7.4	9.2	9.7
Transport & Storage	1.9	2.6	3.4	4.1
Financial Services	*0.3*	*0.5*	*0.6*	*0.9*
Renting of Mach. & Business services	*0.2*	*0.3*	*0.7*	*1.6*
Other Market Services	*3.8*	*4.3*	*4.5*	*7.1*
Hotels & Restaurants	0.8	0.9	1.2	1.7
Post & Telecommunication	0.1	0.2	0.3	0.4
Other Services	2.9	3.1	3.0	5.1
Non-Market Services	***4.9***	***5.0***	***5.4***	***5.8***
Public Administration & Defense etc.	2.8	2.8	2.5	1.8
Education	1.6	1.6	2.2	3.0
Health & Social Work	0.6	0.6	0.7	1.0
Total	**100**	**100**	**100**	**100**

Source: India KLEMS dataset, version 2015

Even though during the process of development, employment and output share of primary sector declined, it still employs nearly half of Indian workers. The low pace of industrialization is indeed visible at the aggregate level, despite moderate increase in diversity and sophistication within manufacturing, causing some positive dynamics within the sector. Much of the employment generated in non-agricultural sector has been in construction, trade, and high-skilled services.

6. Industry origins of aggregate growth, and the role of structural change – empirical results

This section discusses the decomposition results for labor productivity growth rates for Indian economy during 1980-2011. The period of analysis roughly covers the three phases of economic reforms in India, say the pre (or partial) reform period, the transition period and the full reform period. For convenience of analysis, we subdivide the entire period 1980-2011 into 3 sub-periods that roughly tally with the pre and post reform era –1981-1993, 1994-2002 and 2003-2011.

6.1 Labor productivity and MFP for disaggregate Industry by sub-sectors for the period 1980-2011

Labor Productivity growth rates (per cent) are provided for three different sub periods and the overall period 1980-2011. We find that on an average a range of around 3-6 percent growth in labor productivity for majority of the subsectors. Agriculture and allied activities have recorded around 5 percent growth in the period 2003-2011. Post and Telecommunication have the highest growth of 20 per cent per annum in the period 2003-2011. We also find impressive performances from manufacturing subsectors- chemicals, non- metallic minerals, electrical and transport equipments in terms of growth in labor productivity. The service sectors, other than post and telecommunication which show growth in excess of 4 per cent per annum are- financial services, business services public administration. Two important sectors namely- health and education show moderate growth of around 3 percent.

Table 4: Labor productivity growth in industries by sub period: 1980 - 2011 (% per annum)

	1981-1993	1994-2002	2003-2011	1981-2011
Agriculture, Forestry & Fishing	1	1	5	3
Mining & Quarrying	2	6	3	4
Food Products, Beverages & Tobacco	3	5	6	5
Textiles, Leather & Footwear	5	3	6	4
Wood & Products of Wood	-4	-8	8	-2
Pulp, Paper, Printing & Publishing	4	-1	8	4
Coke, Ref. Petroleum & Nuclear Fuel	3	6	1	3
Chemicals & Chemical Products	5	6	11	7
Rubber & Plastic Products	3	4	8	5
Other Non-Metallic Mineral Products	5	7	6	6
Basic Metals & Metal Products	1	4	6	4
Machinery, nec.	-2	6	9	3
Electrical & Optical Equipment	2	6	9	5
Transport Equipment	4	6	4	5
Mfg., nec. recycling	3	3	5	3
Electricity, Gas & Water Supply	4	7	4	5
Construction	-2	-1	1	-1
Trade	1	4	7	4
Hotels & Restaurants	3	4	4	4

	1981-1993	1994-2002	2003-2011	1981-2011
Transport & Storage	1	2	5	3
Post & Telecommunication	2	9	20	9
Financial Services	3	6	6	5
Renting of Mach. & Business services	2	6	5	4
Public Administration & Defense etc.	4	7	8	6
Education	3	4	3	3
Health & Social Work	5	3	1	4
Other Services	3	3	-1	2

***Source**: Authors calculations based on India KLEMS dataset version 2015.*

We next look at improvements in total factor productivity (TFP) over the period 1980-2011 and the underlying sub periods- 1981-1993; 1994-2002 and 2003-2011. Unlike growth in labor productivity, the TFP performance remains low for most of the subsectors. The service industries – post and telecommunication and public administration are the only two sectors which show TFP growth of more than 3 per cent per annum.[15]In the case of telecommunication sector, we have witnessed major deregulation beginning 1992 along with the onset of major liberalization in manufacturing and trade sectors. Further, it may be important to note that the reforms policies in this sector have recognized the need to have many more participants than the incumbent operator in the process of telecommunications network expansion and service development thereby brining in competition which made the sector efficient in terms of TFP dynamics. In case of business services low TFP reflects the major contribution by capital input in accounting for the overall growth. We argue that the fall in prices of capital goods industries especially office, computing and accounting machinery and parts as reflected by the sharp fall in nominal tariff rates from around 62 percent (1990s) to around 17 percent (2000s) could have been the trigger for increased role of capital input in the observed growth.[16] The overall low TFP in manufacturing is reflected across the board in terms of various sub sectors with machinery- electrical and others along with chemicals which show positive growth in TFP. When comparing the sub periods, we find some improvements in the sub sectors of manufacturing in the period of 2003-2001 notably for –textiles, petroleum, chemicals, plastics and machinery and equipments. Two important sub sectors- health and education continue to remain low in terms of TFP. These raises concern for regulatory and other barriers which inhibit improvements in productivity for these sectors.

Table 5: Total factor productivity growth in industries by sub period: 1980 - 2011 (% per annum)

	1981-1993	1994-2002	2003-2011	1981-2011
Agriculture, Forestry & Fishing	0.37	-0.20	1.48	0.53
Mining & Quarrying	-1.55	2.17	-4.54	-1.34
Food Products, Beverages & Tobacco	1.16	-0.04	0.74	0.69

[15] The high TFP reflected in public administration and defense arises due to low input accumulation and relatively high rates of growth in value added as well as output. IO tables do not provide details distribution of material, energy and services inputs in total intermediate inputs for public administration and defense. We used the ratio of individual commodities to all commodities in total Government Final Consumption Expenditure for computing each of the intermediate inputs and this may reflect possible measurement issues.

[16] Refer Das D K (2015) : Trade Liberalization Indicators by Industry- India DATABASE- unpublished

	1981-1993	1994-2002	2003-2011	1981-2011
Textiles, Leather & Footwear	0.42	-0.10	1.70	0.64
Wood & Products of Wood	-3.26	-5.11	0.33	-2.76
Pulp, Paper, Printing & Publishing	0.89	-0.91	1.92	0.67
Coke, Ref. Petroleum & Nuclear Fuel	0.58	-2.47	3.16	0.45
Chemicals & Chemical Products	1.52	-0.75	2.38	1.11
Rubber & Plastic Products	0.65	-0.01	2.22	0.91
Other Non-Metallic Mineral Products	0.07	0.73	0.40	0.36
Basic Metals & Metal Products	0.02	1.12	-1.38	-0.07
Machinery, nec.	0.10	0.58	2.35	0.90
Electrical & Optical Equipment	1.76	0.96	2.80	1.83
Transport Equipment	0.44	0.23	1.72	0.75
Mfg., nec. recycling	3.96	0.01	-0.59	1.49
Electricity, Gas & Water Supply	1.22	1.56	1.55	1.41
Construction	-2.15	-1.87	-0.88	-1.70
Trade	0.20	1.99	-0.95	0.39
Hotels & Restaurants	-0.84	1.56	-0.94	-0.18
Transport & Storage	-0.78	0.63	1.09	0.17
Post & Telecommunication	-1.21	7.46	13.48	5.57
Financial Services	1.87	0.02	5.13	2.28
Renting of Mach. & Business services	0.84	-0.60	0.14	0.22
Public Administration & Defense etc.	1.64	3.81	4.31	3.05
Education	0.79	-0.07	-1.64	-0.17
Health & Social Work	-0.61	0.12	-3.08	-1.12
Other Services	2.46	-0.14	-1.86	0.45

***Source**: Authors calculations based on India KLEMS dataset version 2015.*

Overall, we find that service sub sectors continue to show better improvements in both labor and overall TFP performance for the period 1980-2011. Post and Telecommunication show by far the largest improvement in efficiency of input use- be it labor or all inputs. The disaggregated industry analysis show wide variations across sectors and over time. It is important to note that with the easing of rules and regulations (policies) towards manufacturing subsectors, improvements still seem to remain confined to services sub groups and a few machinery based industries thereby reflecting the possibilities of other barriers- infrastructure (power, water, land) and rigidity of labor markets prevailing in the lack of dynamism in industries.

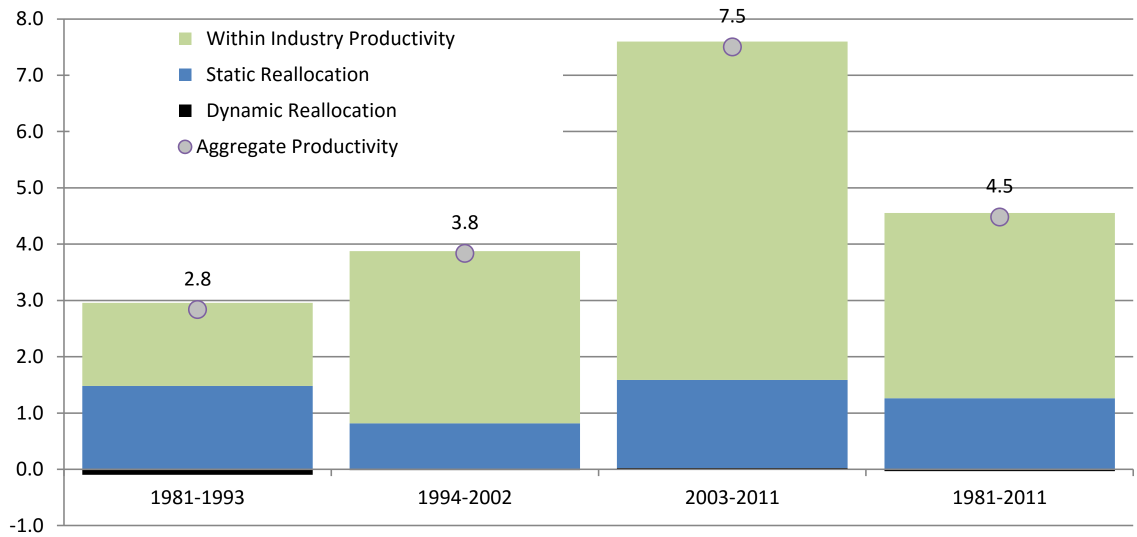
6.2 Sources of Labor productivity growth: within industry growth or labor reallocation effects

In this section, we look into the contribution of different sectors and structural change in terms of workers' movement across sectors, to aggregate labor productivity growth. The growth rate of labor productivity, measured as output per worker, over 1981-2011 period, broken down to within industry productivity growth, and static and dynamic reallocation is depicted in Figure 3. Labor productivity growth increased from 2.8 percent during 1981-1993 to 3.8 percent during 1994-2002. In the mid-1990s through early 200s, labor productivity did further increase by more than 3.5 percentage point, reaching at 7.5 percent.

The figure also provides the magnitude of the reallocation effects – both static and dynamic in relation to the within industry productivity growth. If workers are moving into industries with above average productivity levels, the static reallocation term will be positive, and if workers are moving to industries that witness faster productivity growth, the dynamic reallocation term will be positive. In general, 50 to 80 percent of aggregate productivity growth is explained by within industry productivity growth, and the rest can be attributed to structural change. Clearly, the impact of overall reallocation has been positive throughout, which is also in accordance with the recent findings in McMillan and Rodrik (2011) and de Vries et al (2012). On average the structural change effect has been larger during 2003-2011 period, followed by first half of the 1981-1993, whereas it has been lower during the mid-1990s through early 2000s.

When looked at static and dynamic effects separately, we observe that on average there have been almost no dynamic reallocation effects throughout the period. It has been contributing less and mostly negative in most of the years, suggesting that employment was hardly generated in sectors which were witnessing faster productivity growth. The magnitude of the static reallocation effect has been lower during 1994-2002 period, compared to the first and last periods of analysis. Apparently, the employment share in industries with higher productivity level has increased in the 1980s, while it declined drastically during the second half of the 1990s, i.e. 1994-2002, and has increased subsequently since 2003. In the most recent period, 2003-2011, the dynamic effect is also positive, though very tiny. In general the effect of structural change, in terms of workers moving to sectors of high productivity level, on labor productivity growth has been positive, though the magnitude of the effect varies substantially over the sub-periods.

Figure 3: Decomposition of labor productivity growth, 1981-2011 average annual – 3 sub-periods

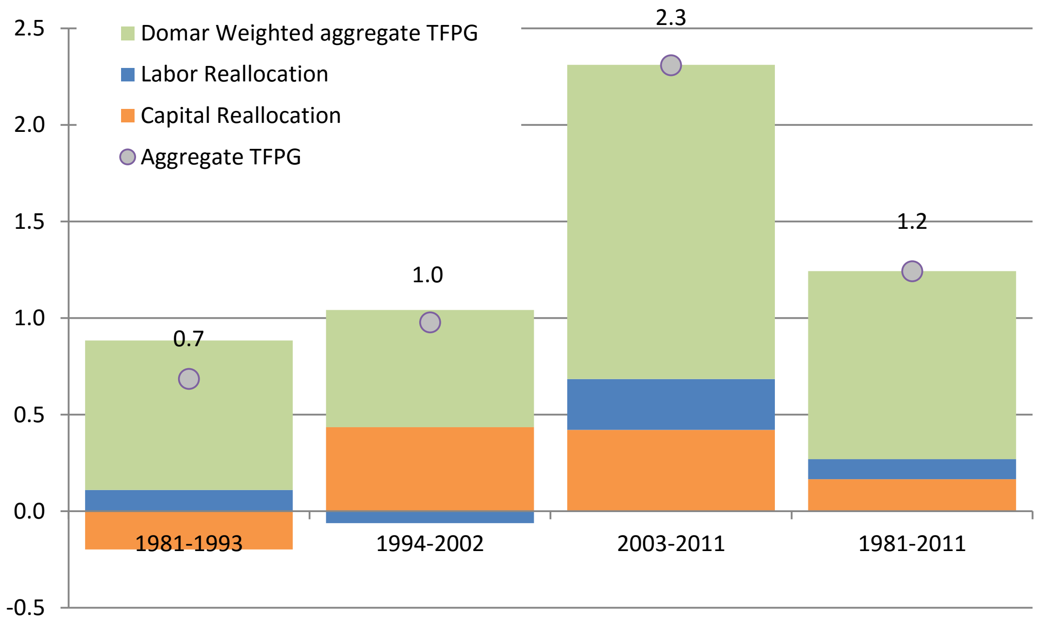


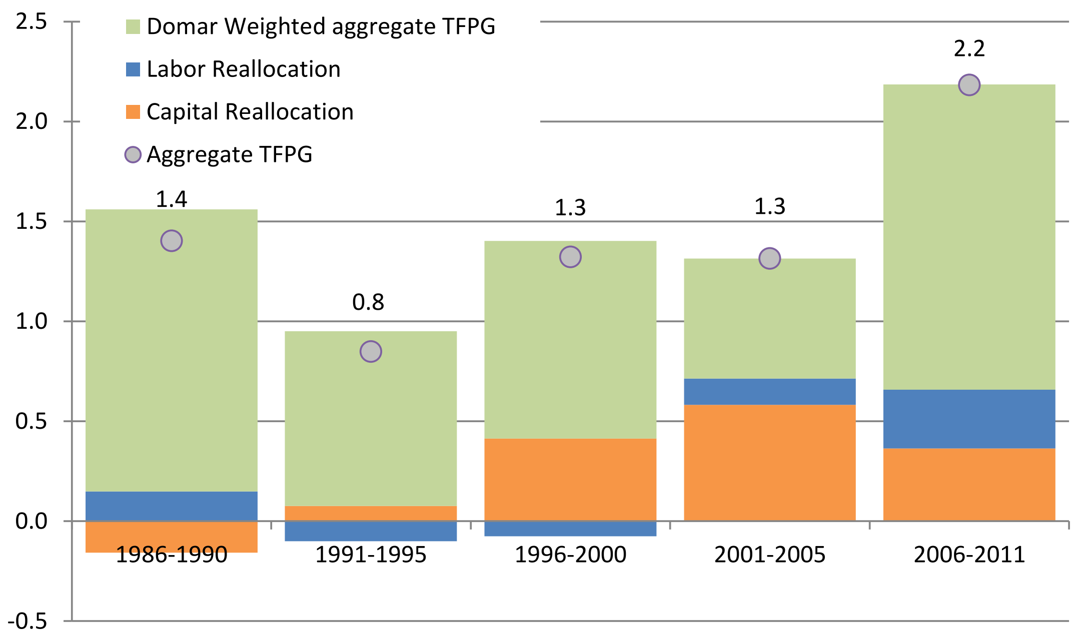
Source: Author calculation using India KLEMS dataset, version 2015

6.3 Sources of Total Factor productivity: within industry growth or factor reallocation effects

In Figure 5, we consider the decomposition of aggregate TFPG obtained using aggregate production possibility frontier, into contributions from within industry productivity growth, as discussed in the previous two sections and the reallocation of capital and labor across sectors. Note that the factor reallocation effects discussed here would be different from the labor productivity decomposition in the previous section as the methodologies used in the two decompositions are significantly different. The main observation that comes out from Figure 6 is that the aggregate TFPG is primarily a reflection of TFPG in the underlying industries, or the within industry productivity change (Domar weighted TFPG) is significantly reflected in aggregate TFPG, particularly before 1994. It explains more than 100 percent of aggregate TFPG in this period, whereas the overall reallocation effect was negative and therefore dragged productivity growth down by 0.09 percentage point. The aggregate TFPG in this chart – TFPG based on aggregate production possibility frontier – is the sum of Domar weighted TFPG, presented in Table 5 and the capital and labor reallocation terms (see equation 9). Overall the average reallocation effect is about 0.27 percentage point, which however varies considerably over periods, with 1981-1993 being the only period with a negative overall reallocation effect. The reallocation term increased to 0.37 percentage point during 1994-2002 and further to 0.68 during 2003-2011 (respectively consisting of 16 and 29 percent of aggregate TFPG).

Figure 5: Domar Weighted TFPG and Capital and Labor reallocation across industries





Source: Authors' calculation using India KLEMS dataset, version 2015

When looked at the reallocation effects of capital and labor separately, we see that, in general, the capital reallocation term has been positive except in the first period. From a theoretical perspective, the reallocation term quantify the deviation of the data from assumptions on capital and labor in the PPF. For instance, a positive capital reallocation would suggest that prices of capital differ across industries, and capital is moving to sectors with high capital prices. If prices are assumed to be proxies of productivities, then it would suggest movement of capital to productive sectors. The large reallocation of capital, particularly since the mid-1990s, therefore indicates that industries where capital was more productive witnessed faster expansion of investment. It has been negative during 1981-1993, suggesting that investment was taking place in industries which are relatively less productive. During the last period, 2003-2011, there seem to have acceleration in investment in industries that have higher return over capital, as reflected in a positive capital reallocation term. During this period, nearly 20 percent of aggregate TFP growth was due to positive capital reallocation.

Labor also shows a positive reallocation term in the TFPG decomposition, except during 1994-2002 period, indicating a movement of labor from low wage to high wage sectors. Employment seems to have been growing slowly in sectors with higher wages during the entire mid-1990s through early 2000s; the labor reallocation during this period was negative. This is not in consistency with the labor productivity decomposition, where we found positive, though relatively tiny, reallocation during this period. While a strict comparison is hard to make, it might suggest that wages and productivity does not go hand in hand. It is likely that wage levels in several consumer and intermediate goods manufacturing such as food products, textiles and wood products, and services like trade and hotels and restaurants are not higher, or even in some cases, lower than other sectors because of large presence of informal sector. Also, the level of wages could be higher in sectors such as financial services, telecommunication services, and some public sector services, where no substantial employment has been generated. [17] Moreover, the labor reallocation in labor

[17] It would be interesting to examine the movement of real wages in comparison with labor productivity growth to see the evolution of the gap between productivity growth and real wage (wages adjusted for consumer prices) growth. This could happen due to changing composition of capital and labor income share in GDP, which can be caused by, among other factors, the rapid expansion of informal sector, or the changes in workers' terms of trade (relative price of goods that workers produce and they purchase). See Erumban and de Vries (2016).

productivity was also lower during this period compared to other periods. Since 2003, however, the reallocation again moved to positive territory. In general, the trend in labor reallocation term in both labor productivity decomposition and TFPG decomposition are quite comparable, except for the opposing signs during 1993-2002.

7. Concluding remarks

The importance of structural change for attaining higher levels of economic development was stressed in the development economics literature as early as in the 1940s. The recent developments in this literature reiterate the importance of workers and resources moving from less productive to more productive sectors, in determining the speed of economic growth. This paper is an attempt to document the evolution of India's aggregate productivity growth, decomposed into the contributions of detailed industrial sectors and structural change since the 1980s. Using the India KLEMS database, version 2015, which provides comprehensive and consistent industry level data on Indian economy, we trace the industry origins of labor productivity and total factor productivity growth (TFPG), along with the contribution of factor reallocation. In the labor productivity decomposition, we examine both static – movement of workers from low productive to high productive sectors – and dynamic – movement of workers from slow growing to fast growing sectors – reallocation effects, in comparison with within industry productivity growth.

Even though the relative shares of agriculture in total employment and output have diminished substantially over time, agriculture still remains as the major employment provider in the Indian economy. It appears that job losses in agriculture are largely absorbed in the construction sector, followed by some increases in the employment share of market services, in particular, trade and distributive services, financial services and business services. Manufacturing job creation has been very low. Given the relatively higher productivity levels in these sectors compared to agriculture, the static structural change – movement of workers to industries with higher productivity levels – has been positive in India, whereas as the dynamic productivity gains – movement of workers to fast growing sectors – has been limited or absent. Productivity growth in the construction sector, which has been rapidly expanding in employment creation, has been consistently negative.

In general, the observed total factor productivity growth is not broad based. Rather it is more *mushroom-like*, as there are many industries that contributed negatively to aggregate productivity growth. If the pattern of productivity was more broad-based the aggregate productivity gain would have been much larger. While some industries lost their relative importance as contributors to aggregate productivity, some industries emerged as important contributors. The 1980s was a period of notable TFPG contribution from manufacturing, which eroded in the second period, 1994-2002, when services dominated in terms of relative contribution to aggregate TFPG. Yet manufacturing did witness a diversification during this period, with a shift in productivity contribution towards investment goods from consumer goods production. This was also a period of productivity acceleration in non-market services. In the last period, 2003-2011, however, manufacturing revived significantly, breaking its own past record, and services lost its relative importance significantly in contributing to aggregate TFPG.

The capital reallocation term in our TFPG decomposition has been positive since 1994, suggesting expansion of investment in sectors with high returns from capital. Labor reallocation has, however, been negative during 1994-2002 period; employment doesn't seem to have expanded in sectors with relatively higher levels of wages. This, which is in contrast with our static reallocation effect, seems to suggest that wages and productivity does not go hand in hand.

Yet, India's structural change, which defies the success story of several advanced economies, poses major challenges. Evidence from several of today's advanced economies both in Asia and elsewhere suggests that no country has achieved a higher level of development without a solid manufacturing sector. Even today, with the GDP growth being driven primarily by the services sector, nearly half of India's workers is employed in the primary sector, suggesting further potential for structural change. It is hard to argue, particularly given the fact that the pace of job creation in high productive services has been slow, India can sustain higher long-term growth rates without a solid manufacturing sector. Indeed, India still has substantial catch-up potential in the manufacturing, and given its large pool of young population and underdeveloped infrastructure, it can excel in manufacturing only if it focuses on improving its human capital and infrastructure. However, poor quality of and accessibility to education, hindering its human capital development, poor quality of infrastructure, slow pace of reforms, and the co-existence of a modern formal and a traditional informal sector offers major challenges for further positive structural change. Achieving growth-enhancing structural change requires adequate policies that would ease the reallocation of resources from less productive to high productive sectors. The reforms in the manufacturing sector are less complete, particularly from the perspective of formal job creation, as the rigid labor market and weak infrastructure provided hardly any incentive for formal job creation.

Bibliography

Acharya, S., I. J. Ahluwalia, K. L. Krishna, and I. Patnaik (2003), India: Economic Growth, 1950-2000, Global Research Project on Growth, Indian Council for Research on International Economic Relations, New Delhi

Aggarwal, S.C., and A.A. Erumban, (2013), Labor input for measuring productivity growth in India: Methodology and estimates, *Mimeo*.

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

Balakrishnan, P (2010) Economic Growth in India: History and Prospect, New Delhi: Oxford University Press.

Balakrishnan, P., and K. Pushpangadan (1994), Total factor productivity growth in manufacturing industry: A fresh look, *Economic and Political Weekly*, 29, 2028-2035;

Bhagwati, J., and A. Panagariya, (2013), *Why Growth Matters: How Economic Growth in India Reduced Poverty and the Lessons for Other Developing Countries.* New York: Public Affairs.

Bosworth, B., S.M. Collins (2008), Accounting for growth: Comparing China and India, *Journal of Economic Perspectives*, 22(1): 45-66.

Brahmananda, P. R.(1982), Productivity in the Indian Economy: Rising Inputs for Falling Outputs, Himalaya Publishing House, 1982

Chenery, Hollis B. and Moises Syrquin (1975), *Patterns of Development: 1950–1970*, New York: Oxford University Press for the World Bank

Clark, C (1940), The Conditions of Economic Progress, London: Macmillan

Das, D.K., and Kalita,G. (2011). Aggregate productivity growth in Indian manufacturing: An application of Domar aggregation, *Indian Economic Review*, 46, 2.

Das, D.K., A.A. Erumban., S. Aggarwal and S. Sengupta(2015), Productivity growth in India under different Policy Regimes, In Jorgenson, D., M.P.Timmer and K.Fukao (eds),*The World Economy: Growth or Stagnation?*, Cambridge University Press

De Vries, G. J., Erumban, A. A., Timmer, M. P., Voskoboynikov, I., and Wu, H. X. (2012), Deconstructing the BRICs: Structural transformation and aggregate productivity growth, *Journal of Comparative Economics*, *40*(2), 211-227.

de Vries, G.,M.P Timmer and de Vries, K (2015), Structural Transformation in Africa: Static Gains, Dynamic Losses, The Journal of Development Studies, 51(6)

Denison, Edward F., 1967. Why Growth Rates Differ. Brookings, Washington, DC.

Domar, E D (1961), "On the Measurement of Technological Change", Economic Journal, 71

Eichengreen, B., P. Gupta., and R. Kumar (2010), Emerging Giants: China and India in the World Economy, Oxford, Oxford University Press.

Erumban. A.A and D.K. Das (2015), Information and communication technology and economic growth in India, Telecommunications Policy, In Press.

Erumban. A.A and K. de Vries (2016), Wage-Productivity Growth Gap: An Analysis of Industry Data, The Conference Board Working Paper, EPWP1601 https://www.conference-board.org/publications/publicationdetail.cfm?publicationid=7143

Fabricant, S. (1942). *Employment in manufacturing, 1899–1939*. New York: NBER.

Fisher, A.G.B (1939). Primary, Secondary and Tertiary Production, Economic Record. 15, 24–38.

Goldar, B.N (2004), Indian manufacturing: productivity trends in pre- and post-reform periods, *Economic and Political Weekly*, 39(46/47), 5033-5043

Goldar, B.N (2014),"Productivity in Indian manufacturing in the post-reform period, in Kathuria, V. et al (2014), *Productivity in Indian Manufacturing- Measurements, Methods and Analysis*, Routledge, New Delhi and UK.

Goldar, B.N (2015), Productivity in Indian Manufacturing (1999–2011) - Accounting for Imported Materials Input, *Economic and Political Weekly,* 40(35), 104-111

Harberger, A.C (1998), A vision of the growth process, *American Economic Review*, 88(1) 1-32

Jorgenson D W & Mun Ho & Jon Samuels, 2011. "Information technology and U.S. productivity growth: evidence from a prototype industry production account," Journal of Productivity Analysis, Springer, vol. 36(2), pages 159-175, October.

Jorgenson, D., M.S. Ho, and K.J. Stiroh, (2005), *Information Technology and the American Growth Resurgence,* Cambridge , The MIT Press.

Jorgenson, D.W (1963), Capital theory and investment behavior, *American Economic Review*, 53 (2), 247-259.

Jorgenson, D.W., & Timmer, M.P. (2011). Structural change in advanced nations: A new set of stylised facts. *Scandinavian Journal of Economics*, *113*(1), 1-29.

Jorgenson, D.W.,Ho, M.S.,Samuels, J.D., &Stiroh, K.J. (2007). Industry origins of the American productivity resurgence. Economic Systems Research, 19(3),229–252

Kathuria, V, S.N.R. Raj and K. Sen (2010), Organised versus unorganised manufacturing performance in the post-reform period, *Economic and Political Weekly*, 45(24), 55-64

Kathuria, V., S.N.R. Raj., K.Sen (2014), *Productivity in Indian Manufacturing- Measurements, Methods and Analysis*, Routledge, New Delhi and UK.

Kochar, K., Kumar, U., Rajan, R., Subramanian, A., Tokatlidis, I. (2006). India's patterns of development: What happened, what follows? *Journal of Monetary Economics, 53* (5), 981-1019.

Kuznets, S. (1966). *Modern economic growth: Rate, structure and spread*. London: Yale University Press.

Lin, J. (2011). New structural economics: A framework for rethinking Development. *The World Bank research observer, 26* (2), 193-221.

Lewis, W.A. (1954). "Economic Development With Unlimited Supplies of Labour". Manchester School of Economic and Social studies, vol. 22, pp.139-191.

Maddison, A. (1987). Growth and slowdown in advanced capitalist economies: Techniques of quantitative assessment. *Journal of Economic Literature, 25* (2), 649–698.

Moreno-Monroy, A. I., J. Pieters , and A.A, Erumban (2014), Formal sector subcontracting and informal sector employment in Indian manufacturing, *IZA Journal of Labor & Development*, 3(22), 1-17.

McMillan, M., & Rodrik, D. (2011). *Globalization, structural change, and productivity growth* (NBER working paper 17143). Cambridge: NBER

Naude W., A Szirmai and N. Haraguchi (2015), Structrual Change and Industrial Development in the BRICS, Oxford, Oxford University Press.

OECD (2013). "Structural Transformation and Natural Resources in Africa". African Economic Outlook 2013: Structural Transformation and Natural Resources. OECD Publishing, pp.111-189.

Panagariya, A, (2008), *India the Emerging Giant*, New York: Oxford University.

Rodrik, D (2013), the past, present, and future of economic growth, *Global Citizen Foundation Working Paper 1*, https://www.sss.ias.edu/files/pdfs/Rodrik/Research/GCF_Rodrik-working-paper-1_-6-24-13.pdf

Szirmai, A (2013). Manufacturing and Economic Development, in A. Szirmai, W. Naude, and L. Alcorta (eds), Pathways to Industrialization intThe 21st Century, New Challenges and Emerging Paradigms, Oxford, Oxford University Press.

The Conference Board (2014), The Conference Board Total Economy Database™, January 2014, https://www.conference-board.org/data/economydatabase/

Timmer, M. P. (2000). The Dynamics of Asian Manufacturing. A Comparison in the late Twentieth Century. Edward Elgar Publishers, Cheltenham.

Timmer, M. P., E. Dietzenbacher., B. Los., R.Stehrer, and G.J. de Vries (2015), An illustrated user guide to the World Input–Output Database: the case of global automotive production, *Review of International Economics.*

Timmer, M.P., G.J. de Vries, and K. de Vries (2014). "Patterns of Structural Change in Developing Countries." GGDC research memorandum 149.

Timmer, M.P., R. Inklaar., M. O'Mahony and B. van Ark, B (2011), Economic Growth in Europe: A Comparative Industry Perspective, Cambridge, Cambridge University Press.

Timmer, M.P., R. Inklaar., M. O'Mahony and B. van Ark (2010), *Economic Growth in Europe: A Comparative Industry Perspective*, Cambridge University Press, 2010

Timmer, Marcel P., Abdul Azeez Erumban, Bart Los, Robert Stehrer, and Gaaitzen J. de Vries (2014). "Slicing Up Global Value Chains." Journal of Economic Perspectives, 28(2): 99-118.

Vaidyanathan A and K L Krishna, (2007) Institutions and markets in India's Development: Essays for K.N. Raj. Oxford University Press, New Delhi

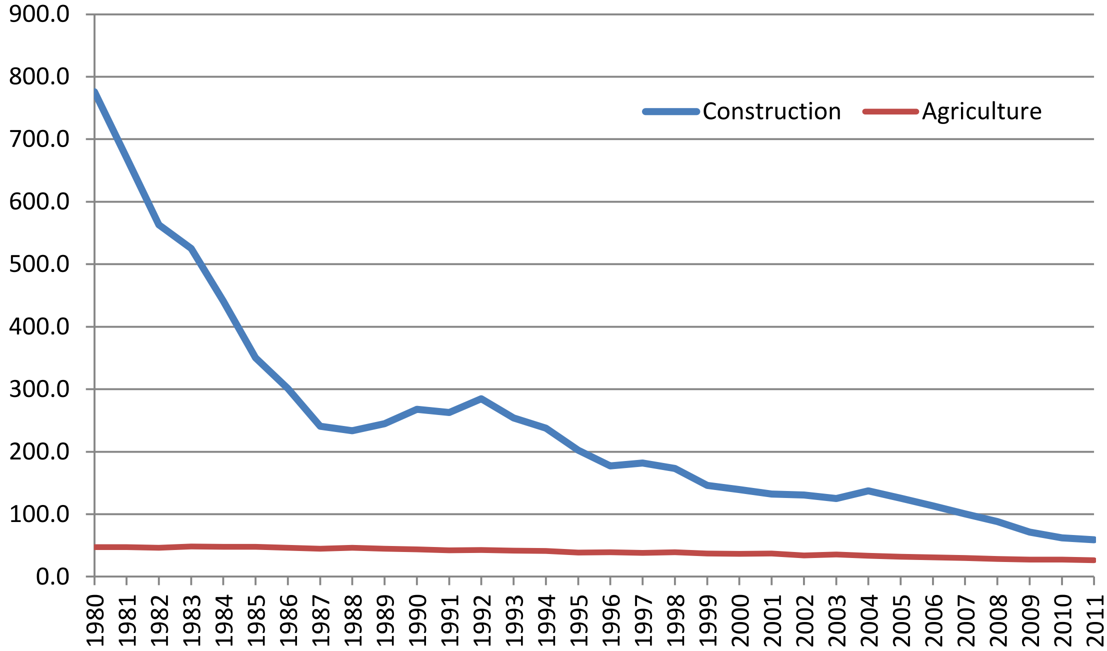
van Ark, B (1996). "Sectoral Growth Accounting and Structural Change in Post-war Europe." Chapter 3 in B. van Ark and N. Crafts (1996), Quantitative Aspects of Post-war European Economic Growth. Cambridge University Press.

Verma, R (2012), Can total factor productivity explain value added growth in services?, *Journal of Development Economics*, 99(1), 163-177

Appendix Table 1: Industries and industry groups in India KLEMS database, version 2015

	Industry	ISIC	Industry group
1	Agriculture, Hunting, Forestry & Fishing	AtB	Agriculture
2	Mining & Quarrying	C	Other goods production
3	Food Products, Beverages & Tobacco	15t16	Consumer & intermediate Mfg.
4	Textiles, Leather & Footwear	17t19	Consumer & intermediate Mfg.
5	Wood & Products of Wood	20	Consumer & intermediate Mfg.
6	Pulp, Paper, Printing & Publishing	21t22	Consumer & intermediate Mfg.
7	Coke, Ref. Petroleum & Nuclear Fuel	23	Consumer & intermediate Mfg.
8	Chemicals & Chemical Products	24	Consumer & intermediate Mfg.
9	Rubber & Plastic Products	25	Consumer & intermediate Mfg.
10	Other Non-Metallic Mineral Products	26	Consumer & intermediate Mfg.
11	Basic Metals & Metal Products	27t28	Consumer & intermediate Mfg.
12	Machinery, nec.	29	investment goods Mfg.
13	Electrical & Optical Equipment	30t33	investment goods Mfg.
14	Transport Equipment	34t35	investment goods Mfg.
15	Mfg., nec. recycling	36t37	Consumer & intermediate Mfg.
16	Electricity, Gas & Water Supply	E	Other goods production
17	Construction	F	Other goods production
18	Trade	G	Trade & distribution
19	Hotels & Restaurants	H	Other market services
20	Transport & Storage	60t63	Trade & distribution
21	Post & Telecommunication	64	Other market services
22	Financial Services	J	Finance services
23	Renting of Mach. & Business services	71t74	Business Services
24	Public Administration & Defense etc.	L	Non-market services
25	Education	M	Non-market services
26	Health & Social Work	N	Non-market services
27	Other Services	70+O+P	Other market services

Appendix Figure 1: Relative levels of labor productivity in construction and agricultural sectors (Aggregate economy labor productivity =100), 1980-2011



Note: Productivity level is defined as the ratio of output per worker in the given sector to the level of output per worker in the aggregate economy
Source: India KLEMS