Role of Capital in India's Economic Growth: Capital Stock versus Capital Services

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Abstract

Capital forms a crucial input in the measurement of total factor productivity (TFP). However, it is also one of the least understood and widely debated concepts in economics, particularly in the empirical literature. A country's capital stock is characterized by the co-existence of various assets and vintages at the same time. These assets and vintages vary in terms of their marginal productivities, and therefore the services delivered by these assets of various vintages also differ. For productivity analysis, it is essential to aggregate across these various assets of different vintages and efficiency. Past studies on productivity in India have used measures of capital stock constructed using data on aggregate fixed capital. This approach, by ignoring asset composition of capital raises serious concerns about the actual role of capital input as a source of growth. It implicitly assumes that all assets have the same marginal productivities, disregarding the heterogeneity of these assets. This assumption has serious implications for the productivity analysis, as it might underestimate the actual contribution of capital input to output growth and thereby overestimate the measured Total Factor Productivity growth (TFPG). This is particularly true when the share of fast depreciating assets in aggregate capital stock is increasing. The present paper attempts to overcome the methodological deficiencies of previous studies in constructing a capital input series. Using detailed investment data since 1950, we construct a series of capital services, taking account of asset heterogeneity, using a methodology advocated by Jorgenson (1963), for 26 industrial sectors for the period 1980-2011. In order to ensure international comparability both in construction and presentation of data, we follow the outline of capital input measurement in EU KLEMS growth accounting database. Our estimates of capital service show a faster growth in capital services compared to the conventional measures of aggregate capital stock. In particular, the number of industries showing larger capital service growth rate is higher in the 2000s. This has been mainly due to an increasing share of equipment capital in most of the sectors, which leads to a faster pace of aggregate capital service growth rates. The ICT investments, though still small in magnitude, show an increasing trend, particularly during the later part of the 1990s to 2000s. Moreover, we see substantial cross-industry variation in capital service growth rate

Key words: Capital services; capital composition; Structures and Equipments; ICT and Non ICT assets.
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1. Introduction

Capital forms a crucial input in the production process and therefore rigorous measurement of capital input is fundamental to analyzing several economic problems. In particular, empirical analysis of economic growth requires adequate measures of capital input, in order to properly quantify the sources of economic growth in terms of the relative roles of assimilation or productivity versus factor accumulation. More importantly, estimates of capital input at detailed sectoral level helps assessing the sectoral heterogeneity in capital contribution along with the aggregate economy. However, the measurement of capital input is not straight forward; it is perhaps the most complex of all input measurements. The conceptual problems involved in the measurement of capital have been extensively researched and documented.[1] We have no intention to delve deeply into the conceptual debates, rather following the economic theory; we aim to construct proper measures of capital input for productivity analysis in Indian industries. From the perspective of productivity analysis, it has now been widely accepted that a measure of capital services is most appropriate to account for the contribution of capital to production. The services delivered by a single capital input are obviously an input into the production process (Solow, 2007). However, many studies on measurement of productivity growth still use capital stock to represent the contribution of capital to production.[2]The role of capital in the production process is comparable to that of labour as both these inputs share the characteristic of not being consumed in the production process. Just as employees are hired by the firm to render labour services to the production process (measured for instance in terms of number of hours), capital goods are purchased or rented by a firm in order to render capital services that constitute the actual input in the production process. This indicates that it is inconsistent to use capital 'stock' in the measurement of capital's contribution to growth. Rather it should be the 'services' delivered by these 'stocks' that should constitute the appropriate measure of capital input in productivity analysis (Jorgenson, 1963; Jorgenson and Griliches, 1967; Hall and Jorgenson, 1967). More importantly, the services delivered to production process by different types of assets vary substantially, and it is imperative to account for these differences while calculating capital input. Measures of capital stock disregard the differences in asset composition. It implicitly assumes that all assets have the same marginal productivities, disregarding the heterogeneity of these assets. This is a problematic assumption particularly in the context of an increasing share of equipment capital, which is argued to be a prominent source of economic growth (De Long and

[1] Hicks (1974) presents an overview of some aspects of the capital controversy, both among classical and among modern economists. Also see discussions in Denison (1957), Ruggles and Ruggles (1967) and Griliches and Jorgenson (1966). Jorgenson (1989) provides a survey of empirical research on measurement of capital input.

[2] For a discussion on using capital input measure based on stock instead of flow, see the discussion in Box 4 (Measuring Capital OCED Manual, First edition). Further, capital goods are seen as carriers of capital services that constitute the actual input in the production process. Thus for purposes of productivity analysis, capital services constitute the appropriate measure of capital input (Measuring Capital OECD Manual, Second Edition, Need to put the year).

Summers, 1991).[3] Equipment such as machinery depreciates relatively faster than structures and is characterized by relatively higher levels of marginal productivity. If this aspect is not taken into account, the estimated contribution of capital will be biased. For instance, if the share of fast depreciating assets is increasing, actual capital service flows will grow faster than the estimated capital stock, indicating that a measure of capital stock will underestimate the actual contribution of capital input to output growth and hence overestimate the TFPG (Harper et al., 1989; Erumban, 2008a).[4]

There is large literature on capital input estimates for productivity analysis in the Indian economy, and in particular in the organized manufacturing appeared over last several decades.[5] However, the measurement of capital input in studies on India's productivity is far from satisfactory (Goldar, 1986). In majority of studies on Indian economy including those on organized manufacturing, the measure of capital input used has been the stock of capital (Goldar 1986, Ahluwalia 1991, Rao 1994, Balakrishnan and Pushpangadan 1994 and Das 2004). The methodology adopted here has either been to use the "book value of aggregate capital" or "the perpetual inventory method (PIM)" applied to aggregate fixed capital data.[6] In addition to many issue in the data and measurement,[7] the very idea of using PIM to simply aggregate capital stock itself has several limitations. Capital stock in a country is a composite commodity that consists of a wide variety of asset types such as computers, vehicles, buildings etc., that are accumulated at different points in time. These assets and vintages vary in terms of their marginal productivities

[3] In the context of India, Sen (2009) has shown that the high growth rates of the 1980s and 1990s can mostly be attributed to the sharp increase in private equipment investment, which has significantly more growth enhancing effect than public equipment and non-equipment investment.

[4] For instance, many recent studies have shown that the share of ICT capital, which depreciates much faster than other asset types, in total capital stock has increased substantially in many OECD countries (Jorgenson, 2001; Timmer and van Ark, 2005; Jorgenson and Vu, 2005). This increased share of ICT investment is argued to have helped boost economic growth (also see Jorgenson, 2009; Jorgenson and Stiroh, 2000; Basu et al, 2003; Jorgenson et al, 2005). Therefore, a failure of taking this into account leads to an underestimation of the contribution of ICT capital to growth.

[5] Reddy and Rao (1962), Krishna and Mehta (1968), Hashim and Dadi (1973), Mehta (1974, 1975), Narasimhan and fabrcy(1974), Asit Banerjee (1975), Goldar (1986a, b), Ahluwalia (1985, 1991) Balakrishnan et al (1994), Mohan Rao (1994), Das (2004). These studies cover the period prior to economic reforms (before 1991-92) and 1990's thereby highlighting the role of capital input to India's productivity growth. Banerjee (1975) is notable amongst all these studies as it made some careful price adjustments in the construction of the capitals series.

[6] Even in the studies that use capital stock using perpetual inventory method, there have been substantial differences in in their approach in many respects. This includes differences in the use of gross versus net capital stock, the choice of bench mark year for calculating the initial capital stock, treatment of land as a capital good, assumption regarding depreciation and the choice of appropriate investment price deflators. Also often there have been differences in the definitions of investment and capital data used in different studies. While some studies use book value figures of fixed capital, others have used working capital or total productive capital or gross fixed capital stock at replacement cost. Only a few studies have considered the asset break-up of capital while computing capital stock (see for example Dholakia, 1974 and Sivasubramanian, 2004). In addition, issues like comparability of different databases for building time series estimates of capital stock at constant prices have all been an important research issue.

[7] For instance Timmer (1997) shows that estimates of capital stock in Balakrishnan and Pushpangadan is highly overestimated as they do not allow for capital discard. This has been the case with many other studies in India as well, as they do not allow for depreciation of capital, while estimating capital stock.

(see Erumban 2008). For the growth analysis, it is essential to aggregate across these various assets of different vintages and productivity. Further, as we indicated before, these assets are not immediately and fully consumed in the production process, which makes it essential to measure the services delivered by these assets and vintages over several years (see OECD 2009). Despite their importance to the analysis of growth and productivity issues, hardly any attempt has been made to provide measure of capital services for the Indian economy. This inevitably leads to ignoring the contribution made to different types of assets-structures, equipment including machinery as well as information technology- computers and telecommunications to the observed growth in capital input. Two important consequences being- one, the link between investment in structures and equipment to economic growth (De Long and Summers, 1991) is unexplored and second, the economic impact of information technology particularly the role of ICT capital (Jorgenson, 2009) in observed growth in India is yet to be studied.[8]

Therefore the issues concerning with capital measurement for productivity analysis, and thereby the estimated contribution of capital input to economic growth in the Indian economy and its sub-sectors are far from resolved. The present study attempts to overcome these gaps, by constructing a capital service measure for India's aggregate economy and sub-sectors. In this paper we outline the methodology for constructing capital services for Indian economy and presents the results for the period 1980-2011. We provide estimates of capital services for 26 sub-sectors of the Indian economy using India KLEMS industry classification which includes subsectors ranging from agriculture, mining and quarrying to real estate activities etc. Our measure of capital services distinguishes between various asset types, viz. building & construction, transport equipment, machinery & equipment (Non ICT) and software, computers and telecommunication equipment (ICT).

Construction of a time series on capital stock and capital services by asset type for 26 sectors offers a major challenge as the sectors covered in the study range from agriculture, mining and quarrying, manufacturing to real estate activities etc, for which we have to depend on a multiple source of data. We use several sources of information to compile investment series for each sector of the economy, which includes the National Accounts Statistics (CSO), the Annual Survey of Industries (ASI) covering the formal manufacturing and the National Sample Survey Organizations (NSSO) rounds for unorganized manufacturing.[9] Since almost all sectors of Indian economy are still largely dominated by the unorganised sector, which often features significantly different production and capital structure compared to the organized sector, we also try to incorporate this aspect in our estimates. Though India is a leading ICT software producing country, we have little information on the use of ICT in production in Indian industries.

[8] Evidence suggested that investment in information technology provided a strong foundation for revival of American growth (Jorgenson, 2009). See Jorgenson and Stiroh (2000), Oulton (2002), Basu et al(2003), Jorgenson, Ho and Stiroh (2005) for discussions on economic impact of information technology.

[9] See section 5.3

However, we try to exploit most available information to generate a reasonable series of ICT investments for the aggregate economy.

The present paper makes several contributions to the literature on capital input measurement for the Indian economy sectors. First, it is the first exercise in constructing a time series for capital service estimates for Indian economy both at the aggregate and sector level. Two, the asset composition of capital services is attempted to understand the dynamism of investment in structures and equipment for long term growth at the economy and industries therein.[10] Three, an attempt is made to decompose the machinery and equipment capital into non ICT and ICT capital (software, hardware and telecommunication equipments), which helps us delineate the contribution of ICT to the observed growth in capital input and output. The above features of the paper enable us to examine the dynamics of investment composition. Four, while studies in the past are mostly on manufacturing sector, our study covers the entire economy, divided into 26 sub sectors, thus providing a complete and comprehensive database on capital input in Indian economy. Finally, though we use multiple sources of data to construct detailed capital accounts, our final estimates are completely consistent with National Accounts Statistics.[11] Moreover, it permits international comparison, including with that of the emerging economies with similar data developed under the World KLEMS initiative, as it follows the same approach as in the EU KLEMS (see O' Mahony and Timmer, 2009 for a description of EU India KLEMS database)[12].

The paper is organized as follows. Section 2 outlines the methodology used in the construction of capital services. The dataset used for constructing the flow of capital services is discussed in details in section 3. The capital service estimates for the economy as well as 26 sectors are presented in section 4 and final section concludes the paper.

2. Measurement of Capital Input- A Review of Literature

As mention earlier in majority of studies on Indian economy including those on organized manufacturing, the measure of capital input used has been the stock of capital not the service of capital stock. These literature of productivity considered measurement of capital stock is always as most difficult and complex among all variables. There is no universally accepted method for its measurement and, as a result, several methods have been employed to estimate capital stock. The measure of capital input that have been used in the earlier studies for Indian manufacturing

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[10] Sen (2009) has shown that the high growth rates of the 1980s and 1990s can mostly be attributed to the sharp increase in private equipment investment and that this has significantly more growth enhancing effect than public equipment and structures investment.

[11] We take the official data published by the CSO as the benchmark for all our analysis. We do not address many issues regarding the quality of official data raised in the literature (see for example, Manna, 2010; Srinivasan, 2005). Rather, we improve upon the way in which the official data has been used in productivity analysis. Relying on official data, however, does not mean that we ignore many problems in the data. For instance, our capital stock measures are different from the official published capital stock, as we use different pattern of depreciation (see text).

[12] Also see www.euklems.net for the EU KLEMS data and many discussions.

are quite unsatisfactory and have simply used the "book value of aggregate capital" as capital input. In the studies of Narasimham & Fabrycy (1974) the published data on book value of capital stock are used directly without making any price corrections. Where studies by Reddy & Rao (1962), Raj, Krishna & Mehta (1968) and Mehta (1974,1976) have attempted to correct the capital series for price changes, by deflating the value series on capital stock with some price index of capital stock. The major weakness of this procedure is that it does not take into account the fact that the figures on capital stock, as reported, include assets of different vintages, bought at different points of time.

Majority of the studies on productivity estimation adopted "the perpetual inventory method (PIM)" to aggregate fixed capital data. In this method it is the addition to capital stock that is deflated, rather than the stock itself. The stream of investment generated in such a manner is added to a bench-mark estimate. Estimation of capital stock is also sensitive to a measure of true depreciation besides being sensitive to the specific methodology used. Ideally, if it was possible to device a measure of true economic depreciation, it would be desirable to use the estimates of net capital stock other wise use the estimates of gross capital stock. In fact the existing estimates of depreciation are either tax-based accounting concepts or based on certain rules of thumb. Banerji (1975), Hashim & Dadi (1973) and Goldar (1981) believe that measurement of economic depreciation is a very complex exercise, and it is preferable to work with estimates of gross capital stock. However few studies measure net capital stock through perpetual inventory method using existing concepts for estimating depreciation, for example Roychaudhry (1977) used depreciation at book value which is grossly overstated, while [Goldar (2004) and Banga & Goldar (2006)] assumes the rate of annual depreciation is taken as 5 per cent.

Gross fixed capital stock series at constant prices was derived using the perpetual inventory method based on (1) an estimate of benchmark gross fixed capital stock at purchase value, (2) time series on gross investment and (3) time series of capital goods price. In order to derive the estimates of gross fixed capital stock at purchase value, one need to explicitly account for the cumulative depreciation of the capital stock. Hashim & Dadi (1973) used a sample of 1000 balance sheets of firms to obtain the ratios of purchase value to book value (gross-net ratio) of fixed capital stock for benchmark year and few afterwards studies in the 1990s [Ahluwalia (1985 & 1991), Balakrishnan et al (1994)] applied Hashim & Dadi's gross-net ratio to estimates gross fixed capital stock at purchase value. While recent studies like Das (2004); Virmani and Hashim (2011) used RBI published gross-net ratios available for some broad sector. The annual gross investment is derived by subtracting the book value of fixed assets in the previous year from that in the current year and adding to that depreciation in fixed assets in the current year. For deflating nominal investment series and benchmark gross fixed capital stock studies used price deflator as wholesale price index for machinery and machine tools or an implicit deflator. Implicit deflator for capital stock has been constructed with the help of data on gross fixed capital formation in organised manufacturing at current and constant prices, which obtained from various yearly volumes of the National Accounts Statistics published by CSO, Government of

India. Some studies also tried further refinements by allowing annual rate of discarding of the capital stock (mainly vary between 0 to 5 percent).

3. *Measurement of Capital Services: The Methodology*

Though the use of capital services rather than capital stock is theoretically preferred in productivity analysis, the empirical measurement of capital services is complicated due to the difficulty in quantifying the flow of capital services delivered by a unit of capital. The service delivered by different capital assets is not directly observable (Harper et al., 1989) and therefore, we have to rely on economic theory to derive appropriate measures of capital that takes account of the differences in marginal productivities of assets and vintages.[13] The PIM provides only a partial solution to measure the capital input by capturing the vintage structure of different types of assets. In this approach, capital input is constructed as a weighted sum of past investments, where the weights are based on the relative efficiency decline as the capital ages. The issue of vintage in this approach is dealt with through differences in the price of capital assets of different vintage, under the assumption of marginal product pricing, while the issue of asset composition is not dealt with. The usual practice followed in the literature to measure capital services taking account of asset heterogeneity is to assume proportionality between capital services and capital stock at *individual asset level* (Jorgenson, 1963; Jorgenson and Griliches, 1967; Hulten, 1986). At the aggregate level, however, one should take account of the differences in the service delivered by different asset types, as each asset type differs in terms of its efficiency level. This would mean that even though one would assume proportionality between capital stock and capital service at individual asset level, the weights differ across asset types and over time depending on the marginal productivity of each asset type[14]. Since marginal productivities are unobservable, one could under neoclassical assumptions approximate them by the prices of capital services delivered by each type of asset. Using this line of reasoning, Jorgenson (1963) and Jorgenson and Griliches (1967) have developed aggregate capital service measures that take into account the heterogeneity of assets. Using the Tornqvist approximation to the continuous Divisia index under the assumption of instantaneous adjustability of capital, aggregate capital services growth rate for any given industry is derived as a weighted growth rate of individual capital assets, the weights being the compensation shares of each asset, i.e.

$$\Delta \ln K_t = \sum_k \bar{v}_{k,t} \Delta \ln S_{k,t} \qquad (1)$$

[13] See Erumban (2008a and b) for a detailed discussion on various ways of aggregating capital input and their empirical implications.

[14] Therefore, the assumed proportionality does not imply that capital services grow at the same rate as capital stocks do. This is the underlying assumption made in the studies that use aggregate capital stock as a measure of capital input (see Nehru and Dhareshwar, 1993 for a discussion)

where $\Delta \ln S_{k,t}$ indicates the volume growth of capital asset k, and the weights $\bar{v}_{k,t}$ are the average shares of each asset in the value of total capital compensation such that the sum of shares over all capital types add to unity, i.e.

$$\bar{v}_{k,t} = \left(v_{k,t} + v_{k,t-1}\right)/2 \text{, and } v_{k,t} = \left(\Sigma P^K_{k,t} S_{k,t}\right)^{-1} P^K_{k,t} S_{k,t} \tag{2}$$

where $P^K_{k,t}$ is the rental or service price of asset k. v_{kt} effectively incorporates the qualitative differences in the contribution of various asset types, as the capital composition changes (see Jorgenson, 2001). For instance, as the marginal productivity of ICT capital is higher than that of other assets a change in the composition of capital towards ICT capital will result in higher capital services, which will be captured by a higher value of the v for ICT assets.It is evident from (2) that two important components of capital service measure are the asset wise capital stock, $S_{k,t}$ and the service price (rental price) of capital assets, $p^K_{k,t}$. Asset wise capital stock can be calculated using standard perpetual inventory method, assuming a geometric depreciation rate. With a given rate of depreciation δ_k which is assumed constant over time, but different for each asset type, capital stock in asset *k* in year *t* can be constructed as:

$$S_{k,t} = S_{k,t-1}(1 - \delta_k) + I_{k,t} \tag{3}$$

where, I^t_k is the real investment in asset type *k.*

The rental price of capital $p^K_{k,t}$ reflects the price at which the investor is indifferent between buying and renting the capital good for a one-year lease in the rental market.[15] In the absence of taxation the rental price equation can be derived as (see Jorgenson and Griliches, 1967; and Christensen and Jorgenson, 1969):

$$p^K_{k,t} = p^I_{k,t-1} i_t + \delta_k p^I_{k,t} - \left(p^I_{k,t} - p^I_{k,t-1}\right) \tag{4}$$

with i_t representing the nominal rate of return, δ_k the depreciation rate of asset type *k*, and $p^I_{k,t}$ the investment price of asset type *k*. This formula shows that the rental fee is determined by the

[15] While in capital stock aggregation one can use the asset prices, it should not be used in the aggregation of the capital services. Since it is the services delivered by capital goods that are used in the production process, it is the price of the capital service that must be used in aggregating capital services (see Jorgenson and Griliches, 1967; Diewert, 1980). However, Jorgenson and Griliches (1967) have shown that these two prices are related; the asset prices are the discounted value of all future capital services. They are not proportional though, as there are differences in replacement rates and capital gains among different capital assets. The economic rationale of using the rental prices to calculate a reliable service growth is that the investor expects to get more services in short time from an asset whose price is relatively high (or service life is relatively small).

nominal rate of return, the rate of economic depreciation and the asset specific capital gains.[16] Ideally taxes should be included to account for differences in tax treatment of the different asset types and different legal forms (household, corporate and non-corporate). The capital service price formulas above should then be adjusted to take these tax rates into account. However this refinement would require data on capital tax allowances and rates by industry and year, which is beyond the scope of this database. Available evidence for major European countries shows that the inclusion of tax rates has only a very minor effect on growth rates of capital services and TFPG (Erumban, 2008a).

4. The Data

Construction of a time series on capital stock as well as services by asset type for 26 sectors (see Table 1) offers a major challenge due to the absence of publicly available data and many distinct characteristics of Indian economy. For instance, almost all sectors of Indian economy is characterized by a dualistic structure – the co-existence of a formal and an informal sector – with very different production as well as capital structures. Further, since our measure of capital takes account of asset heterogeneity, it was essential to obtain investment data by asset type. We distinguish between 4 different asset types – construction, transport equipment, non-ICT machinery, ICT equipments (hardware, software and communication equipment). [17] Though India is a leading ICT software producing country, there is little information about the use of ICT an input in the production process across different industries. Therefore, we exploit multiple sources of information for the construction of our database on capital services given the nature of the 26 sector India KLEMS industrial classification. This includes the National Accounts Statistics (NAS) that provide information on broad sectors of the economy, the Annual Survey of Industries (ASI) covering the formal manufacturing sector, the National Sample Survey Organizations (NSSO) rounds for unorganized manufacturing, Input-Output tables and CMIE's Prowess firm level database.[18] Even though we use multiple sources of data, our final estimates are fully consistent with the aggregate data obtained from the NAS. In what follows we discuss the various sources of data and the construction of the relevant variables, in detail.

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[16] The logic for using the rental price is as follows. In equilibrium, an investor is indifferent between two alternatives: earning a nominal rate of return *r* on an investment *q*, or buying a unit of capital collecting a rental *p* and then selling it at the depreciated asset price $(1-\delta)q$ in the next period. Assuming no taxation the equilibrium condition is: $(1+r_T)q_{i,T-1} = p_{i,T} + (1-\delta_i)q_{i,T}$, with *p* as the rental fee and q_i the acquisition price of investment good *i* (Jorgenson and Stiroh 2000, p.192). Rearranging yields a variation of the familiar cost-of-capital equation: $p_{i,T} = q_{i,T-1}r_T + \delta_i q_{i,T-1} - [q_{i,T} - q_{i,T-1}]$, which when dividing the rental fee by the acquisition price of the previous period transforms into equation (4).

[17] Land has been excluded from the assets to maintain consistency with CSO, Government of India. CSO includes buildings, construction, residential and non residential buildings and excludes land in the computation of gross fixed capital formation by industry type.

[18] See section 5.3

Table 1: 26 India KLEMS sectors and corresponding NIC 1998 codes

Sl. No	India KLEMS INDUSTRIES	NIC 1998
1	Agriculture, hunting, forestry & fishing	01 to 05
2	Mining & quarrying	10 to 14
3	Food , beverages & tobacco	15 to 16
4	Textiles, leather & footwear	17 to 19
5	Wood & products of wood	20
6	Pulp, paper , printing & publishing	21 to 22
7	Coke, refined petroleum & nuclear fuel	23
8	Chemicals & chemical products	24
9	Rubber & plastics	25
10	Other non-metallic mineral	26
11	Basic metals & fabricated metal	27 to 28
12	Machinery, nec	29
13	Electrical & optical equipment	30 to 33
14	Transport equipment	34 to 35
15	Manufacturing nec; recycling	36 to 37
16	Electricity, gas & water supply	40 to 41
17	Construction	45
18	Trade	50 to 52
19	Hotels & restaurants	55
20	Transport & storage	60 to 63
21	Post & telecommunications	64
22	Financial intermediation	65 to 67
23	Public admin & defence; Compulsory social security	75
24	Education	80
25	Health & social work	85
26	Other services	70 to 74, 90 to 96

Source: India KLEMS database

4.1 Investment in non ICT capital assets

Industry-level estimates of capital input require detailed asset-by-industry investment matrices. The basic data source for the non ICT assets comprising construction, transport equipment and non ICT machinery is the National Accounts Statistics. [19] However in the public domain, NAS provides only information on aggregate capital formation by industry of use for 9 broad sectors. CSO has provided the detailed asset wise data underlying the published aggregate gross fixed

[19] This data is not publicly available. However, CSO has compiled this data for the India-KLEMS project. In addition, for those sectors for which the investment matrices were not available from CSO, we gather information from other sources (e.g. Annual Survey of Industries for organized manufacturing and NSSO surveys for unorganized manufacturing) and benchmark it to the aggregate investment series from the National Accounts.

capital formation by these broad industry groups, separately for public and private sectors. The public units were aggregated from administrative, departmental and non departmental enterprises. Table 2 provides an overview of asset types available in NAS and their corresponding KLEMS categories.

Table 2: Capital Asset Categories in National Accounts Statistics

NAS Assets	KLEMS Assets
Public Sector	
Buildings	Construction
Other construction	Construction
Transport Equipment[20]	Transport Equipment
Machinery & Equipment	Machinery & Equipment(ICT is excluded)
Software (1999-00 onwards)	ICT
Private Sector	
Residential buildings	Construction
Non-residential building	Construction
Other construction	Construction
Machinery & Equipment (incl. transport equipment)	Machinery & Equipment (transport equipment and ICT are excluded)
Software (1999-00 onwards)	ICT

Total investment in each asset category is calculated as the sum of private and public sector investment in each asset. Investment in transport equipment is not available separately for private sector. Therefore, it has been derived using the ratio of transport equipment to total machinery (including transport equipment) in public sector. Then the sum of transport equipment in public sector and the derived investment in private sector is considered as the total investment in transport equipment. Investment in machinery & equipment, which is defined as the sum of machinery & equipment in public sector and total machinery & equipment excluding the derived transport equipment in Private sector is inclusive of ICT as it was not separately available. ICT has been removed from machinery, after constructing ICT investment series independently, which will be discussed subsequently.

The India KLEMS industrial classification comprises 26 sectors. However, NAS provides data only for 9 broad sectors, which necessitated further splitting of some of the sectors. This includes aggregate manufacturing (registered and unregistered separately) to 13 sub sectors; total trade into 3 sub sectors; other services into 4 sub sectors; and real estate activities and business services into 2 sub sectors. The manufacturing sector was disaggregated into 13 subsectors at the

[20] In some years transport equipment was provides as part of the machinery and equipment, categorized as ‘tools, transport equipment and other fixed assets’. In such cases, we use transport/tools, transport and other fixed asset ratio in the nearest year to separate transport equipment.

2 digit level of NIC 1998 using ASI and NSSO data, which will be discussed in detail subsequently. Investment series in service sector has been split into sub sectors using two alternative approaches – value added shares, and capital/labor ratio in the higher aggregate industry. However, the final data used are based on value added shares, as our sensitivity analysis did not show a significant difference between the two.

Table 3: Asset categories in ASI

ASI Assets	KLEMS Assets
Land	Excluded
Buildings	Buildings and Construction
Plants & Machinery	Machinery &Equipments (ICT is excluded)
Transport Equipment	Transport Equipment
Computer Equipment including Software (from 1998)	ICT equipments
Pollution control equipment (from 2000)	Machinery and Equipments

In order to split the aggregate capital formation in organized manufacturing sector into 13 KLEMS sectors, we use the Annual Survey of Industries. However, the published data does not provide any asset wise information; it consists of only the aggregate capital formation or the book value of fixed capital. The usual approach followed by most studies in the past is to measure gross investment as the difference between book value of asset in period t and in period t-1 and add depreciation in period t to that. This approach has the deficiency of comparing two year's data, where the number of firms/factories might be different. In particular, while using this approach at industry level, for detailed asset categories, it might generate massive negative investment. We follow an alternative approach, following ASI's definition of gross fixed capital formation (GFCF). ASI defines GFCF as actual additions (newly purchased, second hand and own construction) minus deductions plus depreciation adjustment for discarded assets during the year. This approach is based on a single year's sample and helps to avoid potential huge negative investment series, and is also consistent with published ASI GFCF series. The yearly detailed volumes beginning 1964-65 were used to derive the gross fixed capital formation by asset type directly.[21] For the years 1964-1978, the relevant data are obtained from published detailed volumes. For the period, 1983-84 to 2008-09 ASI has generated detailed tables from Block C of ASI schedule that contain data on fixed assets. Missing years are interpolated using the changes in investment using book value method. Table 3 provides an overview of the asset categories available in ASI, and the relevant asset categories in India KLEMS to which they are attributed. Though ASI provides investment in land, for reasons of NAS consistency we exclude it from the KLEMS database. Once investment in each of these assets and industries are generated using

[21] The Annual Survey of Industry provided information on the following categories- land, buildings, plant & machinery, transport equipment, computer equipment including software, pollution control equipment and others. These categories were aggregated into the same four asset classification as described in footnote 30.

ASI data, we apply this industry-asset distribution to the published NAS GFCF series for organized manufacturing sector. It may also be noted that from 1960-61 to 1971-72, ASI data are for the census sector and from 1973-74 on wards they are for the factory sector. In order to make these two series comparable over years, we convert the data prior to 1972 to factory sector using the factory/census ratio in 1973. Thus, after these adjustments, we obtain investment data for 13 manufacturing sectors, by asset types, consistent with the NAS aggregate.

Table 4: Asset categories in NSSO

45th round	51st round	56th round	62nd Round	KLEMS asset
Land	Land			excluded
	Building			Construction
		Land & Buildings	Land & Buildings	Construction (land is excluded)
	Other construction			Construction
Building & other construction				Construction
Plant & machinery	Plant & machinery	Plant and machinery	Plant and machinery	Machinery & Equipment
Transport Equipments	Transport Equipments	Transport equipment	Transport equipment	Transport Equipment
	Tools			Machinery & Equip.
	Other fixed assets			Machinery & Equip.
Tools and other fixed assets		Tools &other fixed assets	Tools and other fixed assets	Machinery & Equip.
			Software & hardware	ICT equipment

Note: in all the cases, if ICT assets are not separately provided, they are excluded from machinery equipment, after estimating ICT investment independently (see section on ICT investment). For 56th and 62nd rounds, land is separated from land & buildings using land/land & building ratio from 51st round.

The data required for creating the gross investment series for the 13 unorganized segments of the manufacturing sector are obtained from various rounds of NSSO surveys on unorganized manufacturing. We use 4 rounds of NSSO surveys that cover the period 1989-2006. These are 45th round (1989-90), 51st round (1994-95) 56th round (1994-95) and 62nd round (2005-06). Unit level data has been aggregated to 13 KLEMS sectors using the appropriate concordance tables. NSSO provides net addition to owned assets during the reference year within the block of fixed assets, and we use this as a measure of our investment. Asset classification in NSSO has changed over various rounds, and therefore, we have tried to match these with our KLEMS classification as shown in Table 4. The investment series arrived at for four rounds were interpolated to obtain the annual time series of unorganized gross fixed capital formation by asset type. As in the case of registered sector, once the investment by asset types across industries are constructed, the asset-industry distribution is applied to the published NAS aggregate GFCF in unregistered manufacturing to obtain NAS consistent GFCF by asset type and industries.

4.2 Investment in ICT assets

Since official statistics on ICT investment is still not comprehensive in India, we rely on alternative sources to impute ICT investment. However, whenever the information is available from official sources, we exploit such information, and ensure consistency with official statistics. Since these estimates are still preliminary, we shall further improve the data if better information is available. Following the standard practice, we define ICT investment as the investment in computers or IT hardware, communication equipment and software. The available information on ICT investment in India include software investment from NAS since 1999-00,[22] ASI's ICT investment series in organized manufacturing sectors since 1998, NSSO 62nd round data on ICT investment in unorganized manufacturing, CMIE's PROWESS firm level data on gross fixed assets in hardware, software and communication equipment (1989-2009) and World Information Technology and Services Alliance (WITSA)[23] 's estimates on ICT spending by broad sectors of the economy since 2000. We make use of all these information in our ICT investment estimates along with investment data available by commodities in input-output tables. It may be noted that there have been attempts in the past to estimate ICT investment in Indian economy. For instance Jorgenson and Vu (2005) have estimated ICT investment for aggregate economy in a cross-section of countries, including India. They apply United States' ICT investment to ICT spending ratio to WITSA ICT spending data for India, to obtain aggregate economy ICT investment. However, this approach may produce a severe bias in the estimated investment. For instance, as argued by de Vries et al, (2007) it might overestimate the actual ICT investment in developing countries, as the investment/spending ration in developing countries might be lower than that of the United States. On the other hand, it is also possible that most of the ICT spending in developing countries is in the form of investment, as consumption spending on ICT in low income countries would be relatively low compared to the US, and therefore, this approach might underestimate the volume of ICT investment in developing countries. In any case, the use of US investment to spending ratio to impute investment in India does not seem to be appropriate. Apart from this, their estimates are not sufficient for our purpose, as their estimates are available only for the total economy; we require investment by industries. In addition, we prefer to be consistent with the available official data, which is not the case with Jorgenson and

[22] Adopting the suggestions of 1993 System of National Accounts (SNA), NAS has included software in its capital formation data. However, it does not include own-account software.

[23] WITSA provides ICT spending data in a cross section of countries through their Digital Planet Report. See http://www.witsa.org/

Vu. In what follows, we describe the approach we follow to construct ICT investment in Indian economy.

Total economy ICT investments (for hardware and communication equipment) series is arrived at using the commodity flow approach.[24] In this approach, investment in hardware and communication equipment can be estimated using the information on the total domestic availability of these goods and its investment component. This requires the use of input-output tables, in combination with NAS and trade statistics. We define the investment in ICT asset i as:

$$I_{i,t} = \frac{I_{i,s}^{IO}}{\left(Y_{i,s}^{IO} + M_{i,s}^{IO} - X_{i,s}^{IO}\right)}\left(Y_{i,t} + M_{i,t} - X_{i,t}\right) \qquad (5)$$

where $I_{i,t}$ is the current investment, Y is gross domestic output, M is imports and X is exports. Superscript IO refers to input-output tables, i.e. for instance, $I_{i,s}^{IO}$ indicates investment in asset type i (since we consider computer hardware and communication equipment, i=1,2, i.e. hardware and communication equipment) in year s (where s is the benchmark year for IO table) obtained from input-output table. All other variables without the superscript IO are time-series data obtained from the NAS. Following the previous studies, we define industry 30 according to ISIC 3.1 (office equipment and machinery) as computer hardware and industry 32 (radio, TV and communication equipment) as communication equipment. We obtain investment in hardware and communication equipment, along with total domestic output, imports and exports for 6 benchmark years, 1983-84, 1989-90, 1993-94, 1998-99, 2003-04, 2006-07 from input-output tables published by the Central Statistical Organization (CSO). There is no strict concordance between ISIC 3.1 and India's input-output table classification, and therefore, we consider the Indian IO sector office computing and accounting machinery as hardware, communication equipment and electronic equipment including TV as communication equipment. This information is used to compute the first part of equation (5). Then, using time-series data on gross output obtained from India KLEMS[25] output database, and exports and imports obtained from UN-comtrade statistics, we construct a series of ICT investment using equation (5).

This approach allows us to generate investment series only for total economy, as an industry break-down is not possible with input-output table. Moreover, this method cannot be used to infer any information on software investment, as the main source of data for this approach, i.e. input output table, contains no information on software. de Vries et al (2007) suggest using the elasticities of hardware to software investment, estimated using a fixed effect panel regression of

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[24] See Timmer and van Ark (2005) and de Vries et al (2007) for a good description of the commodity flow approach.
[25] India KLEMS provides output and value added data, consistent with National Accounts Statistics. See the Chapter on value added series.

software on hardware and a set of control variables. We follow this approach, but not using econometric techniques. Apart from the input-output tables, there are other sources as well, from where we can obtain information about the ICT investment in Indian industries. For instance, latest National Accounts Statistics (NAS) provides investment in software for total economy, Annual Survey of Industries (ASI) provides fixed capital in ICT during 1999-2008 for organized manufacturing sector and NSSO surveys on unorganized manufacturing 62^{nd} round provides ICT investment data in unorganized manufacturing for the year 2005. In addition, Centre for Monitoring Indian Economy (CMIE)'s firm-level database Prowess provides gross fixed assets in hardware, software and communication equipments for companies categorized under NIC 1998. We use all these information to break down aggregate investment series generated using commodity flow approach, to sectoral investment series.

In order to arrive at software investment series, we first compute software-to-hardware ratio for years after 2000. We use the information on software series from NAS and the hardware data obtained using the commodity flow approach. This ratio has been extrapolated linearly backwards until 1970 to generate the software series for previous years. This provides us a complete series of ICT investment, hardware, software and communication, for total economy for the period 1970-2008.

For organized manufacturing sector, total ICT is computed as the sum of registered and non-registered segments for the year 2008 by summing ASI and NSSO data on ICT investments. Subsequently, we compute the ICT/machinery ratio for total manufacturing (organized plus unorganized) for 2008, and this ratio has been extrapolated backward until 1999, using the changes in ICT/machinery ratio for organized sector obtained from ASI data. For years 1989-99 the same has been computed using the changes in ICT/machinery ratio computed from Prowess firm level data, aggregated to KLEMS 26 sectors. For 1970-89, the ratio has been extrapolated. Using the time series of ICT/machinery ratio, along with the data on investment in machinery, we compute a complete series of ICT investment series for total manufacturing segment for 1970-2008. This has been sub-dived into hardware, software and communication, assuming the composition as in the aggregate sector. For non-manufacturing sectors, we first compute ICT/machinery ratio from Prowess data, and apply to total machinery series to impute first set of ICT investments. However, this series will not be consistent with the ICT series obtained using commodity flow approach (we obtain the non-manufacturing segment from commodity flow approach, after subtracting the manufacturing sector data from total economy). Therefore, we apply the industry distribution obtained from Prowess-based derived ICT series to aggregate non-manufacturing sector data obtained using commodity flow approach, in order to arrive at industry wise estimates. The estimated ICT investment has been subtracted from the reported machinery and equipment investment in all the sectors, to obtain the non-ICT machinery investment.

As indicated before, this is a preliminary set of data which needs to be improved significantly. There are many problems in the approach we followed, which includes, inconsistency between aggregated firm level data and published aggregate data (e.g. ASI ICT/to aggregate investment ratio is quite different from PROWESS aggregates for total manufacturing for years in which both data are available), and the assumption of same annual changes in ICT/non-ICT ratio in registered and unregistered manufacturing. In addition, there are alternative sources (e.g. WITSA) to explore and the available information can be used in different ways, including econometric approaches. These options will be explored in the future, and a sensitivity analysis will be performed to understand the deviation of the final estimates from alternative approaches.

4.3 Asset wise Investment Prices

In order to compute asset wise capital stock using PIM (equation 3) and rental price (equation 4), we require asset wise investment price deflators. CSO has provided asset wise deflators for all the three asset type with base 1999-2000. These deflators are directly used for all the non-ICT assets. Price measurement for ICT assets has been an important research topic in recent years, as the quality of those capital goods has been rapidly increasing. Until recently, large differences existed in the methodology to obtain deflators for ICT equipment between countries, and the use of a single harmonised deflator across countries was widely advocated and used (Schreyer 2002; Colecchia and Schreyer 2001; Timmer and van Ark 2005). This deflator was based on the US deflators for computer hardware, which were commonly seen as the most advanced in terms of accounting for quality changes using hedonic pricing techniques (Triplett 2006). For India, we use the harmonisation procedure suggested by Schreyer (2002), where the US hedonic deflators are adjusted for India’s domestic inflation rates.

4.4 Initial Stock, Depreciation Rates and Rate of Return

As is evident from equations 1 to 4, our estimates of capital input requires time-series data on asset wise capital stock. Capital stock has been constructed using perpetual inventory method (PIM), where the capital stock (S) is defined as a weighted sum of past investments with weights given by the relative efficiencies of capital goods at different ages, which requires data on current investment by asset types, investment prices by asset types and depreciation rate. Also, for the practical implementation of PIM to estimate asset wise capital stock, we require an estimate of initial benchmark stock (see Erumban, 2008b for an in-depth discussion on this issue). NAS provides estimates of net capital stock since 1950 for all the broad sectors in its Statement 17: Net Fixed Capital Stock by industry of use. We take the NAS estimate of real net capital stock in 1950 (in 1999-2000 prices) as our benchmark stock for all non-manufacturing sectors, and for manufacturing sectors the same is taken for the year 1964. [26] However, since the NAS estimate is available only for broad sectors and for aggregate capital, we use our industry-asset distribution of GFCF in order to create net fixed capital stock estimates by asset type for all the 26 sectors. NAS also provides detailed tables on assumed life of assets used for computing capital stock, for private units, administrative units as well as departmental and non departmental units by asset types.[27] We use these estimates of lifetime to derive appropriate depreciation rates for non-ICT assets, using a double declining balance rate. We have used 80 years as assumed life of buildings, 20 years for transport equipments, and 25 years for machinery and equipments. The depreciation rates for ICT assets- hardware and software and communication equipments were taken from the EU KLEMS. The final depreciation rates used in the study are given in Table 5 by asset type. Subsequently, we build our capital stock series by asset types for all the 26 industries using our GFCF series from 1950 (1964) onwards for the non-manufacturing (manufacturing) sector.

Table 5: Depreciation rates used in the computation of capital input

Asset types	**Depreciation rate (%)**
Buildings and Constructions	2.5
Transport Equipment	10.00
Non-ICT Machinery	8.00
Hardware and Software	31.5
Communication Equipment	11.5

Note: depreciation rates are derived using NAS life times for each asset assuming a double declining balance rate.
Source: NAS and EU KLEMS

Our measure of capital input is arrived using equation (1), for which we also require estimates of rental prices (see equation 4). Assuming that the flow of capital services is proportional to the capital stock at individual asset level, aggregate capital flows can be obtained using a translog quantity index by weighting growth in the stock of each asset by the average shares of each asset in the value of capital compensation, as in (1). The rate of return (i) in equation (4) represents the opportunity cost of capital, and can be measured either as internal (or *ex post*) rate of return, or as an external (*ex ante)* rate of return.[28] This issue will be addressed in the further revisions of the data. The present version of the database uses an external rate of return, proxied by average of return on government securities and prime lending rate obtained from the Reserve Bank of

[26] This choice is driven by the fact that the first year of availability of ASI data is 1964-65.
[27] Chapter 26, National Accounts Statistics -Sources and Methods, CSO (2007)
[28] We do not intend to delve into the controversies over the use of internal vs. external rate of return in the context of productivity measurement. Rather, given that this is the first version of our data, we use the external rate and in a later stage, we will also use internal rates. See Erumban (2008a and b) for a discussion on these issues.

India[29]. Therefore, we use a real rate, which is net of capital gain. Hence, the capital gain component in equation (4) is excluded while estimating rental price using external rate of return, obtaining

$$p_{k,t}^{K} = p_{k,t-1}^{I} i_t^{*} + \delta_k p_{k,t}^{I} \qquad (5)$$

where i^* is the real rate of return, nominal interest rate adjusted for CPI inflation rate.

5. Estimates of capital Input for aggregate economy and its 26 sectors

Table 6 provides an overview of investment and capital structure in India, in terms of average shares of different asset types in aggregate nominal capital formation and real capital stock. A general picture that is seen in almost all sectors is that of an increasing share of construction investment, and declining share in the capital stock. The decline in investment share of construction is observed only in agriculture, while the mining and quarrying, construction and service sector shows more prominent increase in the construction investment share. The decline in agriculture is compensated predominantly by an increase in the machinery investment. Though the share of ICT investment and capital stock has increased marginally in the 2000s compared to the 1980s and 1990s, they still remain to be small in almost all sectors, with the manufacturing sector showing the highest share.

Table 6: Asset structure of Investment and Capital stock in Indian economy, 1980-2013

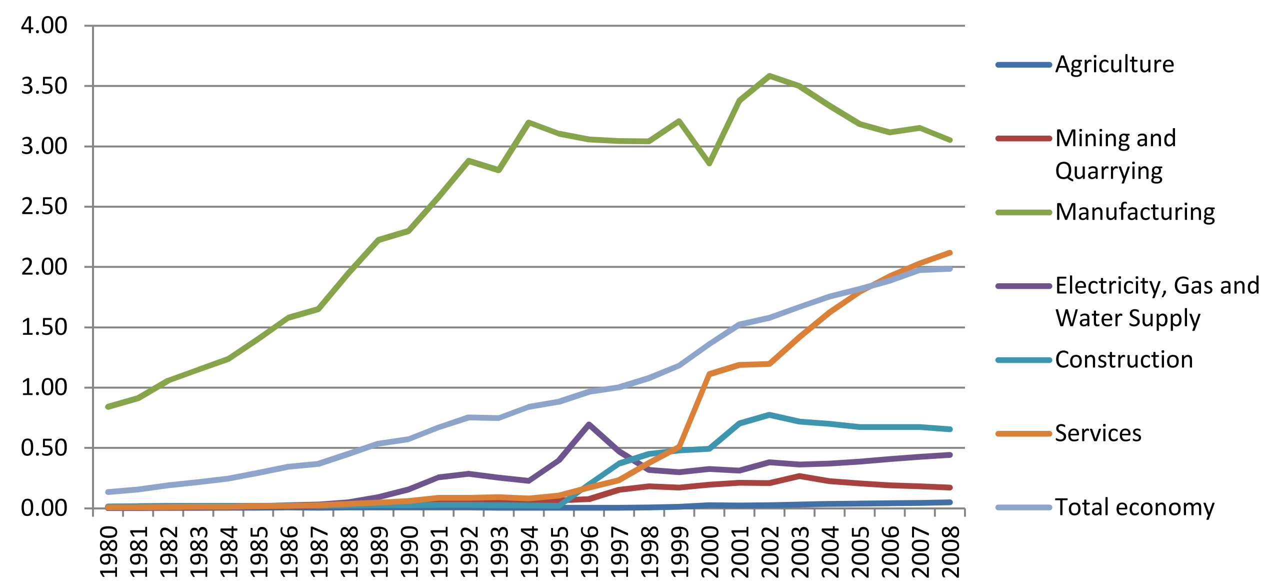
	1980-99	2000-13	1980-13	1980-99	2000-13	1980-13
	Investment share in GFCF			Share in real capital stock		
Total Economy						
Construction	53.4	57.4	55.0	78.8	69.9	75.4
Machinery	37.7	34.3	36.4	17.9	25.0	20.6
Transport Eq	8.9	8.2	8.7	3.3	5.1	4.0
Agriculture						
Construction	85.3	73.1	80.7	95.6	87.7	92.5
Machinery	12.0	21.0	15.4	3.8	10.0	6.2
Transport Eq	2.7	5.8	3.9	0.6	2.3	1.3
Mining and Quarrying						
Construction	41.5	52.4	45.9	58.3	61.2	59.4
Machinery	56.7	43.1	51.2	40.4	36.2	38.8
Transport Eq	1.7	4.5	2.9	1.3	2.5	1.8
Manufacturing						
Construction	28.9	30.9	29.7	50.2	42.8	47.4
Machinery	60.1	56.4	58.6	44.3	48.4	45.8
Transport Eq	11.0	12.7	11.7	5.5	8.8	6.8

[29] Handbook of Indian Statistics, Reserve Bank of India, Annual volumes.

	1980-99	2000-13	1980-13	1980-99	2000-13	1980-13
	Investment share in GFCF			Share in real capital stock		
Electricity, Gas and Water Supply						
Construction	47.9	50.4	48.8	71.0	65.5	68.9
Machinery	51.6	48.4	50.4	28.8	34.0	30.8
Transport Eq	0.5	1.2	0.8	0.2	0.5	0.3
Construction						
Construction	20.9	27.9	23.7	35.5	33.6	34.8
Machinery	65.4	58.4	62.5	56.4	55.1	55.8
Transport Eq	13.7	13.7	13.8	8.2	11.3	9.4
Services						
Construction	69.6	74.1	71.3	88.4	83.2	86.4
Machinery	18.8	19.2	19.0	7.6	12.4	9.5
Transport Eq	11.6	6.6	9.7	4.0	4.3	4.1

Source: India KLEMS database

Figure 1: ICT share in aggregate capital stock, Total economy and broad sectors



Source: India KLEMS database

In Figure 1, we provide a further industry break-up of ICT capital stock, which reveals that the manufacturing sector leads in ICT share. In particular, it is the machinery producing sector (KLEMS sector 29) that has witnessed the highest increase in ICT share over years. Even though the overall service sector shows only moderate increase in ICT share in total capital stock, a detailed look at the industries reveal that financial services have witnessed a faster increase in ICT share, particularly since the late 1990s. In the next section, we present estimates of capital input for the aggregate economy and its broad sectors – agriculture, manufacturing, industry and services. Subsequently, we also provide estimates of capital services for the 26 KLEMS sectors.

5.1 Capital services in the disaggregate 26 KLEMS sectors

Aggregate capital service growth rates for each of the 26 KLEMS sector has been calculated using asset wise investment series at disaggregate industry level, by employing equation (1). In Table 7 we provide the sectoral growth rates of aggregate capital services, and the contribution of equipment and non-equipment capital to aggregate capital service growth. Almost all sectors of the economy have shown a high capital service growth rate in the both sub-periods (1980-99 and 2000-11). In particular, out of 26 sectors 15 sectors have shown a faster capital service growth in the 2000s, compared to that of the 1980s and 1990s. This includes agriculture, hunting, forestry & fishing, manufacturing nec, construction, trade, transport services, real estate, education, health and other services. Sectors that witnessed a sharp decline in average capital service growth rate include rubber & plastics, coke & refined petroleum, other non-metallic mineral, pulp, paper , printing & publishing and textiles, leather & footwear, while most other sectors have shown either an increase or have maintained a comparable growth rate in both periods. In general the manufacturing sectors seem to have registered higher capital service growth rate, perhaps due to rapid expansion of investment in the sector. Service sector also show an increase in the capital services growth rate, suggesting an expansion of investment, though the pace of expansion is not as large as in the manufacturing. Within the service sector, sectors transport & storage, education and health have shown impressive capital service growth rates. It may be noted that the latter three sectors also involve significant public sector investment. It is often argued that in most developing countries, only less than half of the public investment spending is translated into capital and therefore considering these investments would result in an exaggeration of actual capital stock in these countries (see Pritchett, 2000). The argument here is that the objective function of governments need not be profit maximization, while it is the base of conventional treatment of capital in the literature.

The table also provides the contribution of equipment and non-equipment capital to aggregate capital service growth rate. The contribution of equipment has witnessed the largest increase in the 2000s in pulp, paper, printing & publishing. Other sectors that had an improvement in equipment contribution include agriculture, hunting, forestry and fishing, post & telecommunications, education, health & social work and financial intermediation. In case of non-equipment contribution to capital services, hotels & restaurants, public administration, mining & quarrying, machinery, nec. and textiles, leather & footwear have depicted the major improvement in the 2000s.

Table 7: Contribution of equipment and non-equipment capital to aggregate capital service growth rates: 26 KLEMS sectors, 1980-2011

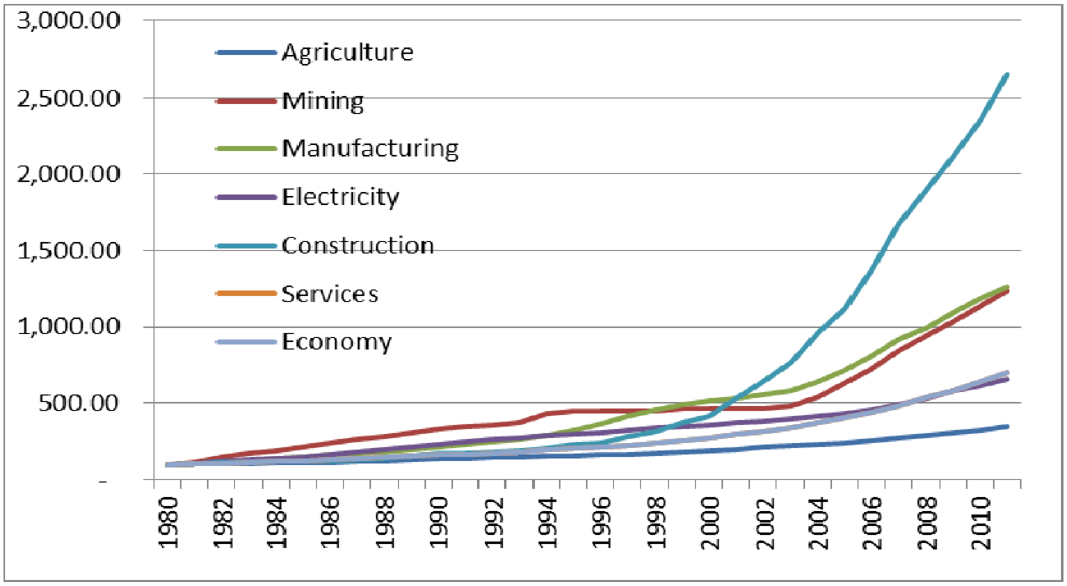
	Capital service growth rates			Contribution (%) of Equipment			Contribution (%) of non-Equipment		
Industry	1980-99	2000-11	1980-11	1980-99	2000-11	1980-11	1980-99	2000-11	1980-11
01 to 05	3.16	5.56	4.05	23.4	40.1	31.9	76.6	59.9	68.1
10 to 14	8.15	7.75	8.17	67.1	53.6	62.0	32.9	46.4	38.0
15 to 16	7.49	7.61	7.42	69.7	65.1	67.9	30.3	34.9	32.1
17 to 19	9.79	6.92	8.62	77.4	64.6	73.3	22.6	35.4	26.7
20	7.86	7.78	7.80	70.0	62.0	67.4	30.0	38.0	32.6
21 to 22	8.69	5.42	7.53	54.3	89.2	64.1	45.7	10.8	35.9
23	16.40	11.32	14.21	88.4	91.3	88.9	11.6	8.7	11.1
24	5.57	4.68	5.18	80.6	73.5	78.1	19.4	26.5	21.9
25	16.17	7.07	12.84	81.6	73.7	79.8	18.4	26.3	20.2
26	12.45	8.90	11.10	81.5	69.8	78.0	18.5	30.2	22.0
27 to 28	7.82	8.42	8.39	82.0	76.3	79.9	18.0	23.7	20.1
29	9.15	8.75	9.09	77.5	64.4	72.4	22.5	35.6	27.6
30 to 33	7.28	7.83	7.33	80.9	70.0	76.0	19.1	30.0	24.0
34 to 35	9.09	10.08	9.33	82.6	82.0	82.0	17.4	18.0	18.0
36 to 37	7.18	9.56	8.18	64.9	64.1	65.1	35.1	35.9	34.9
40 to 41	6.64	5.16	6.14	60.1	57.0	59.2	39.9	43.0	40.8
45	6.73	16.37	10.36	81.0	79.1	79.6	19.0	20.9	20.4
50 to 52	5.52	10.76	7.62	17.9	22.1	19.6	82.1	77.9	80.4
55	7.75	9.84	8.75	69.7	39.4	55.9	30.3	60.6	44.1
60 to 63	3.77	7.84	5.36	77.1	79.5	78.5	22.9	20.5	21.5
64	9.23	9.37	9.25	51.7	68.6	58.5	48.3	31.4	41.5
65 to 67	9.93	7.06	8.62	69.6	75.0	70.7	30.4	25.0	29.3
75	5.67	6.04	5.89	40.6	20.4	32.5	59.4	79.6	67.5
80	8.98	14.03	10.89	49.5	55.9	52.5	50.5	44.1	47.5
85	9.98	14.63	11.78	49.0	55.9	52.2	51.0	44.1	47.8
70 to 74, 90 to 96	3.50	8.26	5.27	8.95	10.92	10.48	91.05	89.08	89.52

Notes: Capital service growth rates are calculated using equation (1) for each industry. Contributions are the sum of individual assets 'Contributions are in percentages, and will add upto 100.

5.2 Capital services in the aggregate economy and its broad sectors

Aggregate capital service growth rates for the aggregate economy and its broad sectors are calculated using two alternative approaches. The first is to use investment series aggregated across industries, and then compute capital service growth rates using equation (1). The second is to use the computed capital service growth rates for each industry (as presented in the previous section) and then compute the aggregate capital service growth rates (for total economy and broad sectors) using a Tornqvist quantity index, which is a discrete time approximation to a Divisia index. In this aggregation approach we weight sectoral capital service growth rates using annual moving weights based on averages of the sectoral share in total capital compensation, in adjacent points in time. A major advantage of the Tornqvist index is that it belongs to the preferred class of superlative indices (Diewert 1976). More precisely, it exactly replicates a translog model which is highly flexible, that is, a model where the aggregate is a linear and quadratic function of the components and time. The difference between these two aggregation results may be attributed to the sectoral heterogeneity and therefore, the preferred measure is a Tornqvist. Figure 2 provides the indices of aggregate capital services in total economy and its broad sectors. Capital services show a faster growth rate in construction sector, compared to all other sectors of the economy. This is in conformity with what we observed at the detailed industry level. However, the service sector seems to show a faster growth in capital services in the 2000s, compared to the 1980s and 1900s. Agricultural sector has witnessed only very negligible growth in capital services over years; while capital services in construction sector grew by almost 9 times over the period of a quarter of a century, capital services in the agricultural sector has only increased by 3 times. These observations are further confirmed if we look at the average growth rates of capital services in these sectors over the period, presented in Table 8. Compared to the 1980s, both construction, service and agriculture sectors and consequently the aggregate economy has witnessed a higher growth in the 2000s, with the construction sector facing the highest among these three sectors. It may be noted that service sector has been the fastest growing sector in Indian economy, which might be partly due to the high growth of capital services in the sector. Manufacturing, on the other hand, is seen to have shown a slight decline in its capital service growth rates. In Table 8 we also provide the average growth rate of capital services using Tornqvist and simple aggregation procedures. The effect of Tornqvist aggregation has been very minimal when the economy is taken as a whole, largely due to negligible effect in agriculture and services. However, manufacturing sector shows a slightly higher industry composition effect. The overall effect on aggregate growth is however, minimal.

Figure 2: Indices of Capital Services, Aggregate Economy and broad sectors, 1980-2011(1980=100)



Note: Capital service growth rates are calculated using equation (1) and indexed to 1980. All the aggregates are obtained using a Tornqvist aggregation procedure.
Source: India KLEMS database

Table 8: Growth rate of capital services, Aggregate Economy and broad sectors

	1980-99	2000-11	1980-11
Agriculture	3.2	5.6	4.1
Mining and Quarrying	8.1	7.7	8.2
Manufacturing	9.6	8.0	8.1
Electricity, Gas and Water Supply	6.6	5.2	6.1
Construction	6.7	16.4	10.4
Services	7.1	9.8	6.2
Total economy	8.2	8.7	6.6

Note: Capitals ervice growth rates are calculated using equation (1). Tornq. Are aggregate capital servie growth rates obtained by aggregating sectoral growth rates using a Tornqvist aggregation procedure. Sim,ple are aggregate capitals ervidce ghrowth rates obtained using equation (1) with aggregate investment data for each broad sector. The difference btween the two (Tornq. - Simple), reflects the effect of sectoral heterogeneity.

In general, the overall picture is that of a high growth rate of capital input, both capital stock as well as capital services, in Indian economy and many of its sub-sectors. There are many possible reasons for this, which might include the liberalization policies which relaxed many capacity constraints firms had to face in the past. Also, we may add a few caveats that can also have an effect on the measured capital input growth rates. Since we take official National Accounts data as our benchmark, part of the observed higher growth rate of capital in the recent years may be a reflection of the recent upward revisions in NAS, which has raised concerns over the reliability of the investment data (Shetty, 2006). Yet, another possibility is the low depreciation rates used in our capital measurement. Our knowledge of actual lifetime of capital assets in Indian economy is quite fragile, and therefore, we opted to use the NAS assumed lifetimes of assets to derive our depreciation rates. There exists diverging views on whether the lifetime of capital in developing countries will be different from the richer countries. For instance, they are viewed to be longer as the maintenance cost in developing countries will be lower (Summers and Heston, 1995). On the other hand, they could be shorter due to under-maintenance or low efficacy of public investment (Bu, 2004; Pritchett, 2000). These issues, however, warrant further detailed examination.

As noted before, when computing capital stock, most studies in the Indian context have either assumed no depreciation rates, or used a common depreciation rate for the aggregates of all assets, i.e. the total capital stock. These common depreciation rates hovers around 5 to 6 % (e.g. Bosworth and Collins, 2008; Goldar, 1986a). Since we use different depreciation rates for different asset types, we do not have an aggregate depreciation rate. However, we can derive the implicit aggregate depreciation rate, which is a weighted depreciation rate of individual assets, as $\delta_t=1-[(S_t- I_t)/ S_{t-1}]$, with δ being the rate of depreciation, S and I are respectively capital stock and Investment in year t. The obtained rates are given in Appendix Table 1. The rates vary across industries and over period, due to changes in the asset composition. However, one general observation is that these rates appear to be low, particularly in the early years. The overall depreciation rate for the entire period is about 4%, with agriculture showing the lowest 3% and manufacturing showing the highest 6%. These rates are low compared to many previous aggregate studies in the context of India (Boseworth and Collins, 2008), and also many cross-country studies (e.g. Easterly and Levine, 2001). Also, compared to many cross-country databases such as the Penn World Tables (PWT) or EU KLEMS, the assumed depreciation rates for individual assets are low. For instance the PWT rates respectively for assets construction, machinery and transport equipment are 3.5%, 15% and 24% while the respective rates we used are 2.5%, 8% and 10%. The observed higher capital input growth rate may partly be due to low depreciation rates used in our analysis. This issue will be addressed in the further revisions of the data.

5.3 Capital services vs. Capital Stock: The composition effect

Table 9 provides the growth rates of capital stock by asset types for the aggregate economy and broad sectors. The growth rates of capital stock for 26 individual industries are provided in Appendix Tables 2 to 5. On average the aggregate capital stock in Indian economy has shown a lower growth rate than capital services (Table 7) during the same period. This higher growth of capital services is obviously due to faster growth of machinery and transport equipment, compared to construction capital (see the discussion that follows this section). Agriculture has shown less than 4 percentage growth in construction during the period, while the equipment capital in this sector has shown a remarkable growth rate (about 11 % o in transport equipment, and 9% in machinery and equipment). This might suggest that Indian agriculture has been increasingly becoming capital intensive; in particular the pace of mechanization in the sector has been faster. Mining, manufacturing, electricity,construction and services show a similar pattern, where the equipment investment grows faster than construction investment, with the transport equipment dominating the machinery equipment for mining, manufacturing, electricity and costruction in both the periods. Interestingly, service sector has also shown a faster growth in machinery equipment than transport equipment. This is not surprising as the rapid expansion of service sector might have necessitated more intense use of non-residential construction such as office equipments.

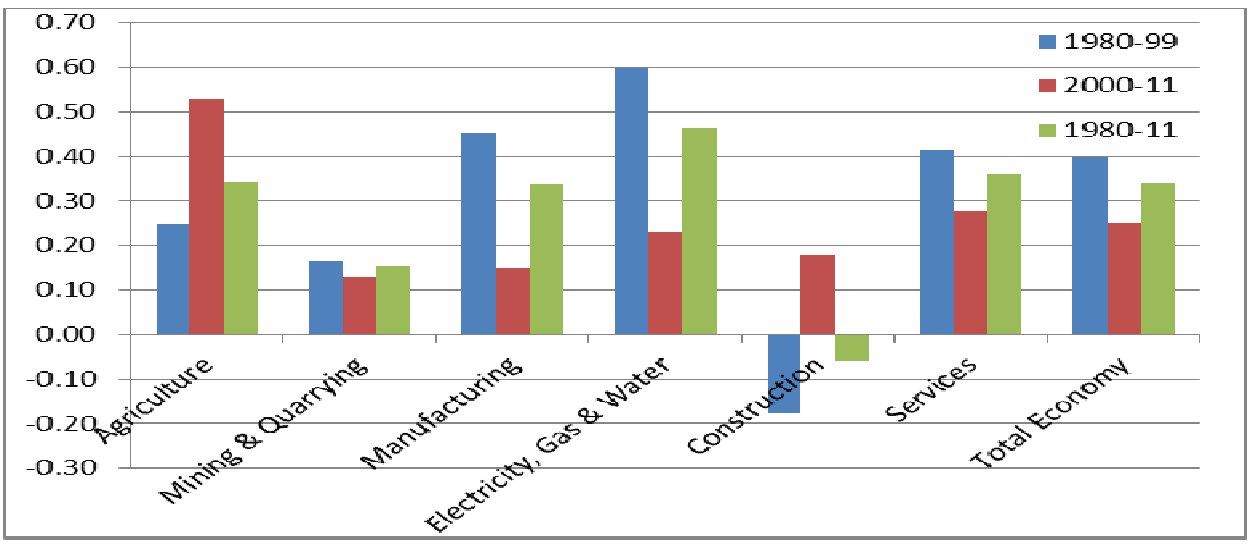
Table 9: Growth Rate of Capital Stock by Asset types: Economy and Broad Sectors (% per annum)

	1980-99	2000-11	1980-11
Economy			
Total Capital Stock	**5.48**	**7.54**	**6.30**
Construction	4.27	6.73	5.24
Transport Equipment	7.89	11.02	9.20
Machinery	8.29	8.79	8.50
Agriculture			
Total Capital Stock	**2.91**	**5.03**	**3.71**
Construction	2.68	4.11	3.22
Transport Equipment	8.03	15.75	10.71
Machinery	7.22	11.74	8.65
Mining and Quarrying			
Total Capital Stock	**7.98**	**7.62**	**8.02**
Construction	7.80	7.36	7.80
Transport Equipment	2.53	21.78	10.36
Machinery	8.50	7.22	8.17
Manufacturing			
Total Capital Stock	**7.80**	**7.58**	**7.75**
Construction	6.69	6.80	6.77
Transport Equipment	10.02	10.87	10.48
Machinery	8.66	7.58	8.26
Electricity, Gas and Water Supply			
Total Capital Stock	**6.04**	**4.93**	**5.67**
Construction	5.27	4.13	4.87
Transport Equipment	5.44	16.44	9.80
Machinery	8.07	6.17	7.43
Construction			
Total Capital Stock	**6.91**	**16.19**	**10.42**
Construction	7.48	15.50	10.62
Transport Equipment	7.16	19.36	11.89
Machinery	6.56	15.99	10.03
Service			
Total Capital Stock	**4.48**	**8.08**	**5.87**
Construction	4.04	7.60	5.41
Transport Equipment	6.45	9.25	7.63
Machinery	8.01	11.09	9.18

S*ource: India KLEMS database*

We have argued that capital services that account for asset heterogeneity is a better and preferred measure of capital input in productivity analysis than the standard measure of aggregate capital stock. We compare the growth rates of capital stock measures,[30] with that of our measures of capital services. The difference between the growth rates of capital service and capital stock is often considered as an indicator of the quality of capital (Jorgenson, 2001). The premise of this view is that the difference between growth of capital services and capital stock represents the substitution toward assets with higher marginal products. For instance, a shift toward ICT capital increases the quality of capital, as these equipments have relatively high marginal products. As is evident from our methodology section, the difference between the two is primarily a result of accounting for the changes in asset composition while aggregating capital services across different assets. Therefore, following Harper et al (1989), it is also called as a 'composition effect'. It is important to know the magnitude of the composition effect in order to understand the possible bias in the measured contributions of capital and TFPG when capital stock measures are used instead of capital services.

Figure 4: Capital composition effect, 1980-2011



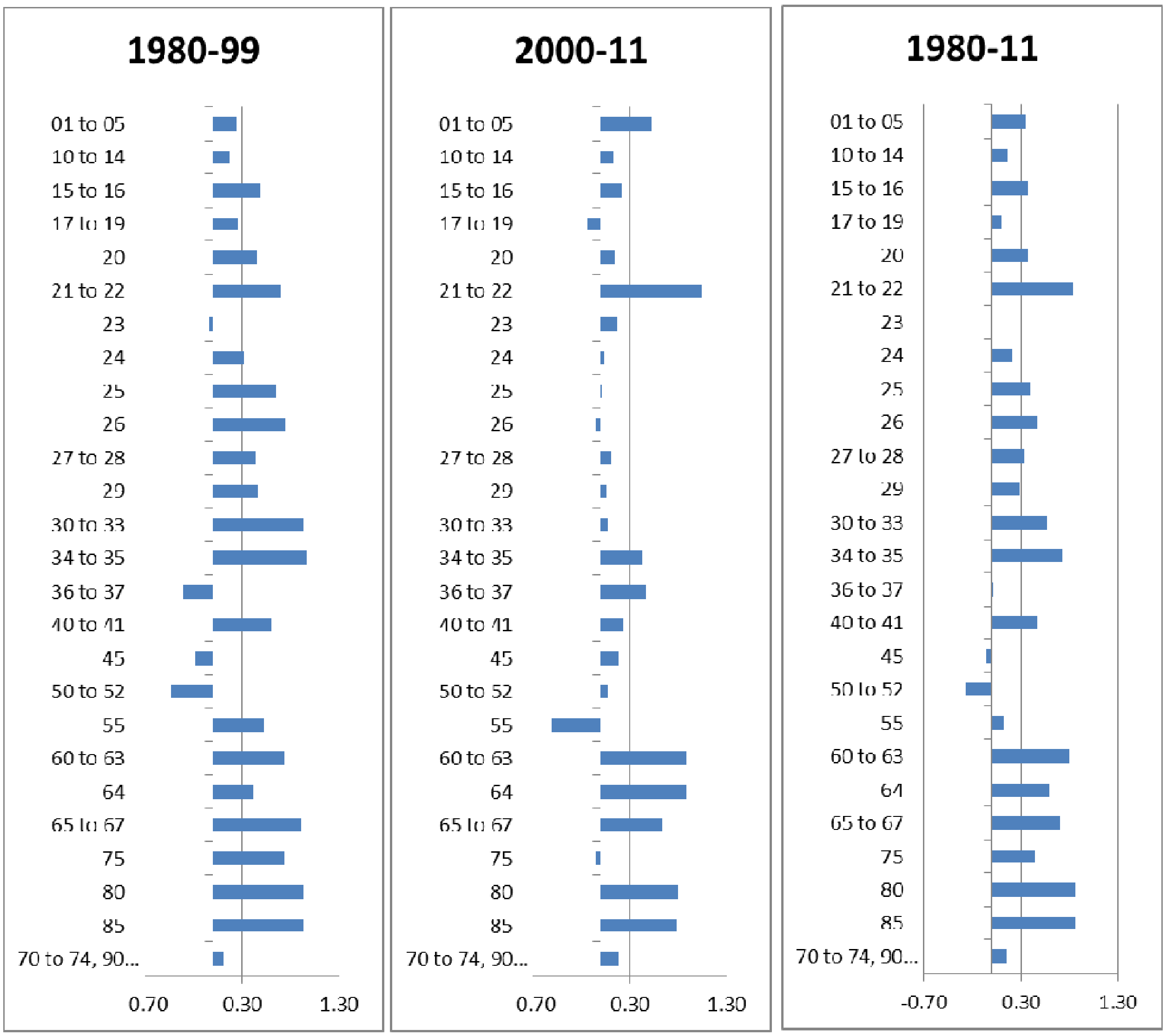
Note: capital composition effect is measures as capital service growth rate minus capital stock growth rate, where the aggregate capital services in each broad sector and total economy are obtained by aggregating sectoral capital service growth rates using Tornqvist aggregation.
Source: India KLEMS database

Figure 4 provides the magnitude of capital composition effect averaged over the period 1980-2008. From the figure, it is evident that the composition effect is more prominent in the electricity & gas, followed by manufacturing, agriculture and services both in the 1980s &1990s and in the 2000s. This suggest that the use of the conventional measure of capital stock would

[30] It may be noted that our measure of capital stock is still different from most previous studies as we use asset wise depreciation rates while calculating capital stock of individual assets using PIM, and then aggregates across asset types. Most previous studies, apply PIM to aggregate investment, often with no depreciation allowances or a common depreciation rate for all assets.

overestimate TFPG in all the sectors of the economy, with manufacturing sector witnessing the highest bias in the estimated TFPG. It is widely recognized that the service sector in India has been growing very rapidly, particularly in the 2000s, however, the capital composition effect in the service sector is far below the one we observe in the agriculture sector.

Figure 5: Capital composition effect: 26 KLEMS industries, 1980-2011

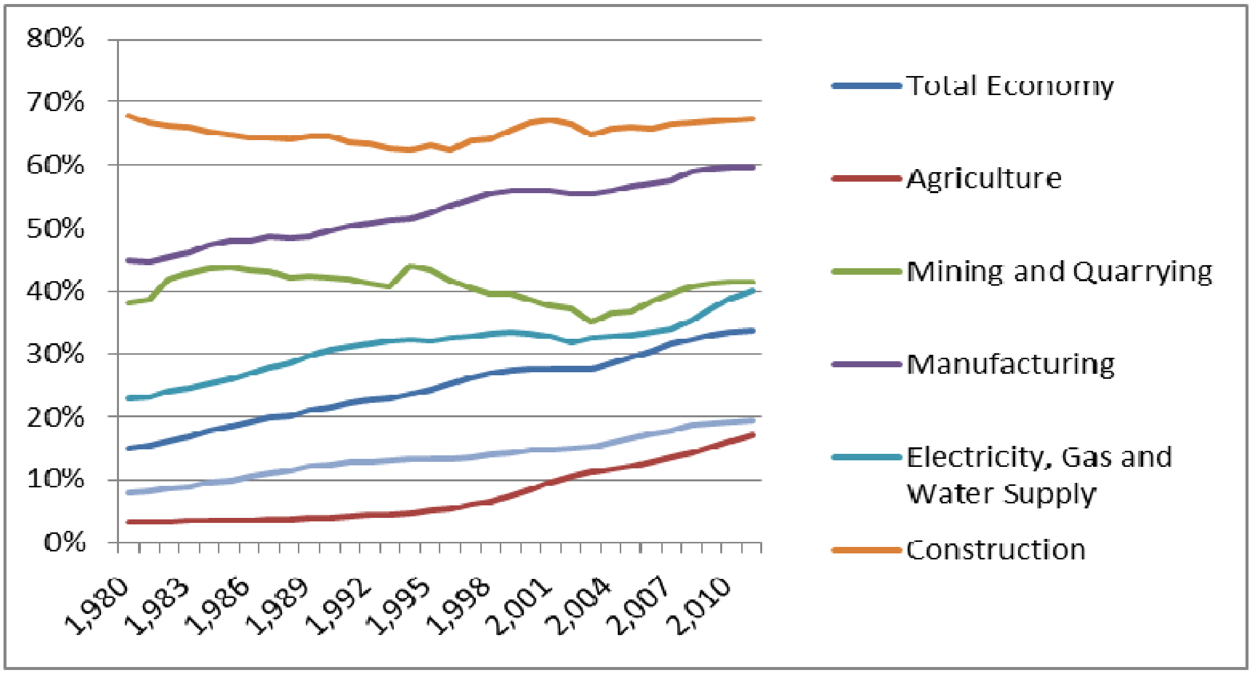


Source: India KLEMS database

The capital composition effect observed at the aggregate economy and broad sectors are a reflection of the sectoral composition effect, as is evident from Figure 5 where we provide the composition effect in 26 KLEMS industrial sectors. As seen in the aggregate picture, manufacturing industries have witnessed higher capital composition effect, which includes paper, printing & publishing, transport equipment, machinery, electrical and optical equipment, basic metals and chemicals sectors. Within the service sector, transport & storage, health, education, financial intermediation and communication sectors have witnessed relatively higher capital quality improvement. Industries with lower composition effects are mostly manufacturing sector industries, such as petroleum, Manufacturing nec and wood & products of wood.

Naturally, one would like to understand why the capital composition effect, or the quality of capital, has grown so fast in India, in particular in the manufacturing sector. In order to explore this, we provide the share of equipment capital in aggregate capital stock in total economy and its broad sectors during 1980-2008 in Figure 6. The figure reveals that the share of equipment capital (sum of machinery and transport equipment including ICT) in total capital stock in India is increasing over years. Erumban (2008b) has shown a similar picture in a cross-section of countries using Penn World Tables data. In particular, his results suggest increasing equipment share in fast growing countries as part of their development process, confirming the importance of equipment investment in attaining growth (De Long and Summers, 1991). The increasing equipment share is particularly prominent in manufacturing and industry sectors, while the share of equipment investment has not increased at a faster pace in the service sector. A detailed look at the sectoral equipment share (see Appendix Figure 2) further reveals that the industrial sector had higher equipment share throughout the period, with many manufacturing sectors facing a faster increase in equipment share. This includes sectors electrical and optical equipment, transport equipment, non-metallic minerals, basic metals, chemicals machinery. Within the service sector financial intermediation and post and communication are the only sectors that witnessed a remarkable increase in equipment share. Though construction sector shows a higher equipment share in both sub-periods, it has witnessed only a marginal increase over years. As we indicated before, investment in non-residential buildings might still be expanding in the service sector, resulting in a relatively lower increase in the equipment share.

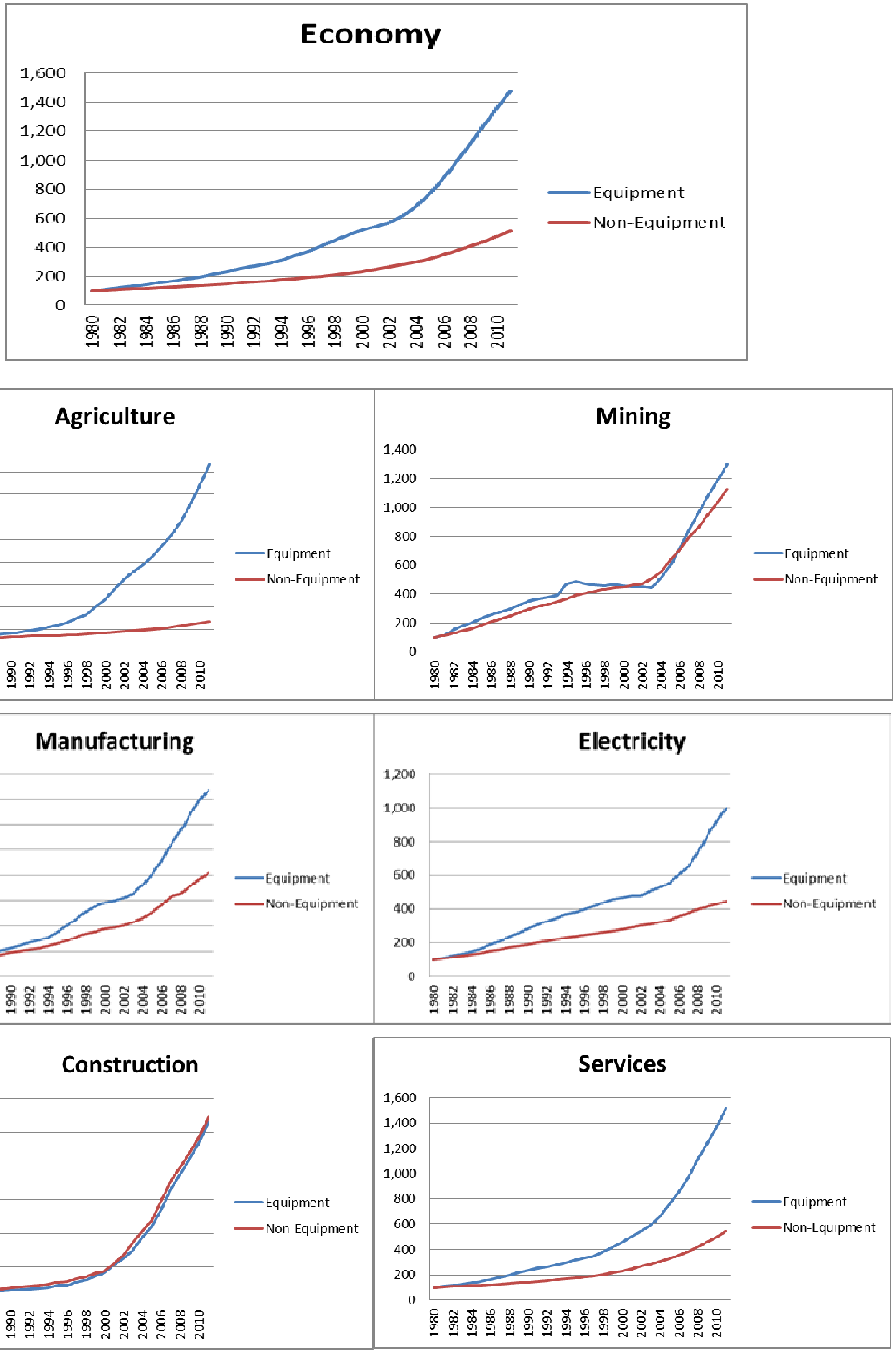
Figure 6: Equipment Share in Aggregate Capital Stock, 1980-2011



Note: Equipment capital stock is defined as the sum of machinery and transport equipment (including ICT).
Source: Authors' calculations

The increasing share of equipment capital will naturally lead to a faster growth of equipment capital compared to non-equipment capital assets, which will have consequences for the aggregate capital input growth. In Figure 7 we also compare the growth of equipment capital with that of non-equipment capital stock in Indian economy. Evidently, the equipment capital grows faster than non-equipment capital. Also, the gap between equipment growth and non-equipment growth is less prominent in manufacturing compared to service sector and agriculture. Equipment capital in manufacturing sector overtakes the growth of non-equipment capital and shows a faster growth since the early 1990s. Similarly, agriculture also shows a sharp increase in equipment capital since the late 1990s. This faster growth of equipment capital, and the resultant increasing equipment share, by adding assets of higher marginal productivity which are expected to deliver more capital services in short period of time, will result in higher capital service growth rates compared to growth rates based on capital stock measures. This would suggest that the use of capital stock growth rates would lead to severe underestimation of the actual contribution of capital input to output growth and thereby overstate the TFPG.

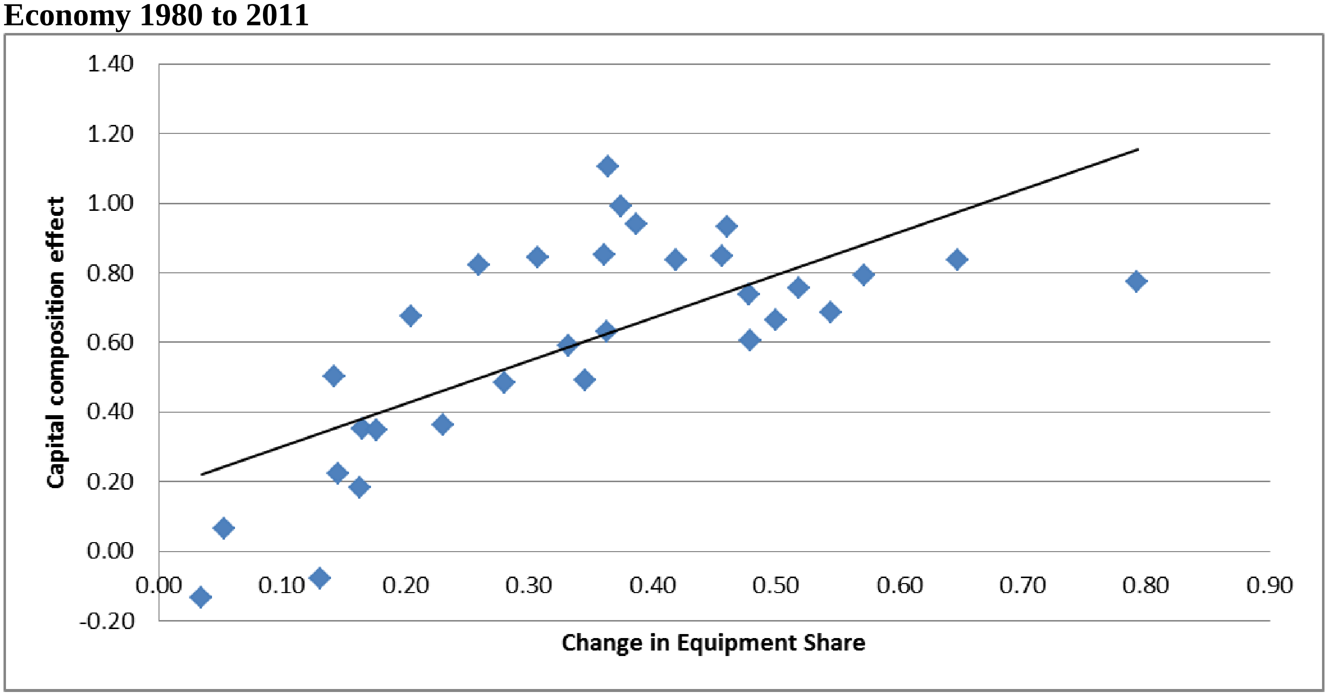
Figure 7: Growth of Equipment capital stock vs. non-Equipment capital stock, 1980=1



Note: EQ=Equipment capital stock; nEQ=non-equipment capital stock. Equipment capital stock is defined as the sum of machinery and transport equipment (including ICT). Capital stock is indexed to the first year.

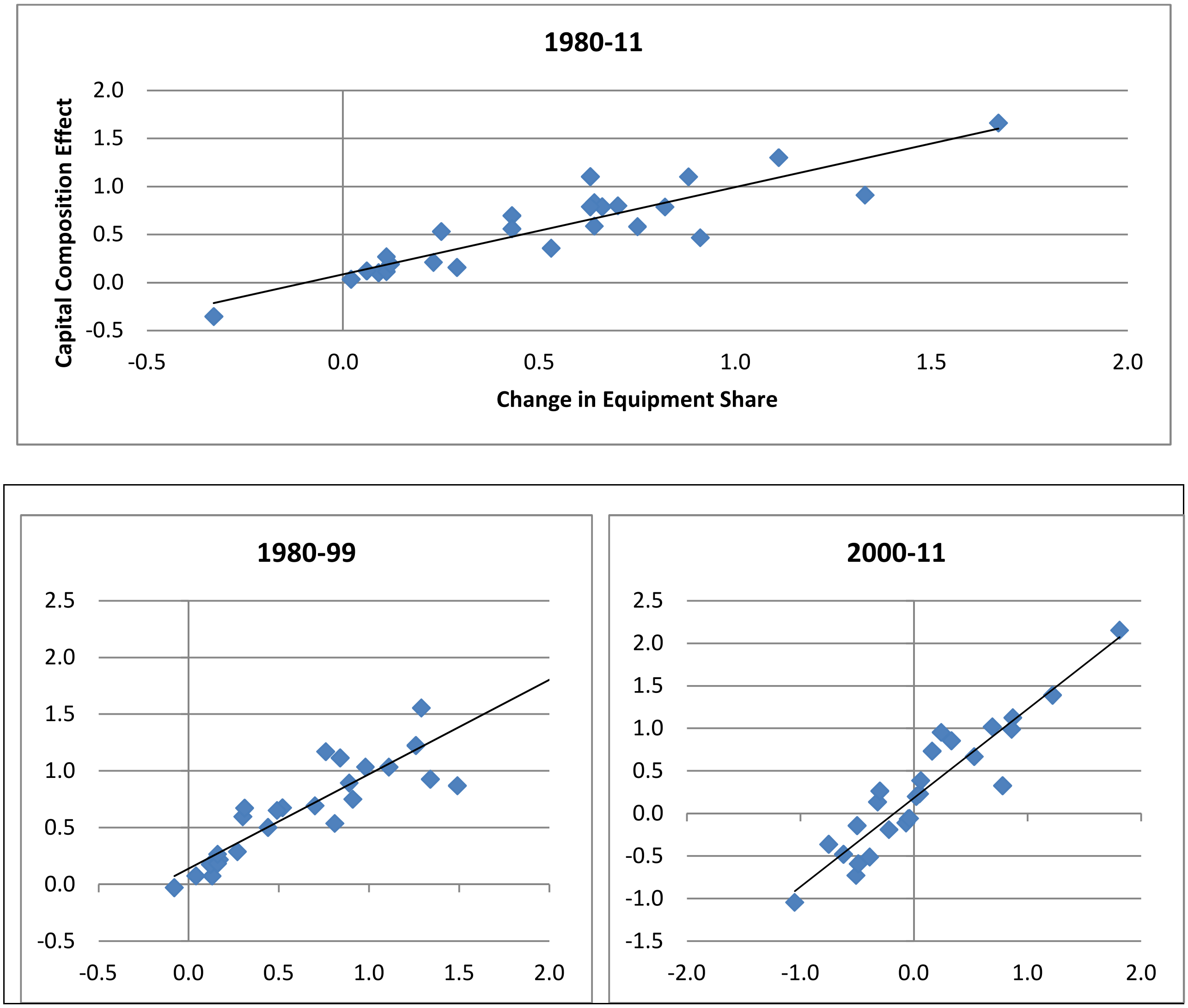
Thus the picture emerges is that of an increasing share of equipment capital, and also a faster growth of the same in Indian economy, and its sub sectors, predominantly in the manufacturing sector. The relationship between capital quality or composition effect and the observed increasing share of equipment capital in India is more evident from Figure 8, which provides scatter plots of change in equipment share against capital composition effect in the overall economy. We observe a strong positive correlation between capital composition effect and increasing equipment share. Moreover, equipment share and consequently capital composition effect have shown an increasing trend in most of the years (as observed in our earlier graphs also). Similar relationship is observed at the detailed industry level also. In Figure 9 we plot composition effect averaged across years, against average change in equipment share over the period, across 26 KLEMS industries. We see a positive relationship in general, and a more prominent one in the 2000s, suggesting more industries with increasing equipment share and consequently faster capital service growth rate. These observations further suggests that the use of conventional measures of capital stock would overestimate the contribution of TFPG in Indian economy, as the share of fast depreciating assets tend to show an increasing trend.

Figure 8: Change in Equipment Share and Capital Composition Effect, Aggregate Economy 1980 to 2011



Note: Capital composition effect is measured as capital service growth rate minus capital stock growth rate. A positive relationship shows that higher the increase in the equipment share, higher the capital composition effect.
Source: Authors' calculations

Figure 9*: Change in Equipment Share *and capital composition effect, 26 KLEMS industries



There may be many reasons why there is an increase in the share of equipment capital in Indian economy, particularly in the manufacturing sector. This might be due to the easing of restrictions on machinery import and relaxation of norms of manufacturing machines through industrial policy changes in 1985 and further in the early 1990s. This requires further detailed analysis. However, as a first step, we have looked at the correlation between imported capital goods, FDI inflow and equipment share in Indian economy. Both FDI inflow and imported capital goods as a percentage of gross fixed capital formation has grown after the onset of economic reforms in India. The correlation between capital goods import and equipment share in aggregate capital is 0.64, while the correlation between FDI inflow and equipment share is 0.7.[31] Though these

[31] See appendix figures 3 and 4 where we provide FDI/GFCF and import of capital goods/GFCF. Note that the correlations are calculated for 1987-2004 in the case of import of capital goods, and 1990-2004 in the case of FDI inflow. This choice was guided by the availaility of data on these variables.

results may be taken as suggestive only, they are indicative of the possible reasons for the increasing share of machinery capital in Indian economy. Thus evidently, our new measures of capital shows a faster growth of capital services, as the share of equipment capital is increasing and thereby adding more productive assets to the aggregate capital stock.

6. Conclusions

This paper provides new estimates of capital input for productivity analysis in Indian economy and 26 sectors for the period 1980-2011. Compared to conventional measures of capital stock, our measure of capital services are theoretically pertinent, as it takes asset heterogeneity into account, while aggregating capital services. This is of particular importance, given the importance of equipment investment for economic growth, which is growing faster in the Indian economy. Measures of capital services are increasingly preferred in the international academic sphere, over the conventional measures of capital stock. However there is hardly any attempt to construct a proper measure of capital service in the Indian economy. This paper makes an important contribution by providing estimates of capital services. Using several sources of official data (including those which are not publically available), we construct aggregate capital service measures, considering asset heterogeneity. We distinguish between asset types, non-ICT machinery (construction, non-ICT machinery, transport equipment) and ICT machinery (hardware, software and communication equipment). This distinction also helps us examine the dynamics of investment composition in the Indian economy, in particular in terms of a change in the composition favouring equipment investment.

Our results suggest an increasing share of equipment capital in the aggregate economy and its broad sectors, dominantly in the manufacturing sector. While the service sector shows relative lower growth in the transport equipment capital, manufacturing, industry and agriculture shows high growth rates. This is particularly true in the 2000s, compared to the 1980s &1990s. A detailed look at the disaggregated industry results further reveals faster growth of equipment capital in many manufacturing sectors, which includes electronics, machinery and chemical sectors, while a similar trend is observed only in a few service sectors, such as communication and financial services. Our estimates of ICT investment suggest that the ICT intensity is still low in most of the sectors. Though the ICT share has increased in manufacturing and services sectors over years, the shares are still low.

The observed increase in equipment share has translated to a higher growth rate of our new measure of capital input, compared to conventional measure of capital stock. The difference between the two measures, the composition effect of capital, has seen to be quite high, particularly in the electricity & gas and manufacturing sector. This measured gap between conventional measure of capital stock and our improved measures of capital service will have consequences for growth analysis. Therefore, it may be interesting to look into the causes of increasing quality of capital in Indian economy, led primarily by an increasing share of equipment capital. One may attribute the increasing share of machinery and equipment in aggregate capital stock to the many policy reforms in the 1980s and 1990s that helped firms ease many capacity constraints, and relaxed many restrictions on import of capital goods and foreign direct investment, particularly in the manufacturing sector. These might have helped expand the machinery investment in the economy, predominantly in the manufacturing sector. However, the benefit of this has triggered to the other sectors of the economy as well, though not to the extent of manufacturing. The effect of taking account of this quality aspect of measured capital input would be that we will be able to measure the TFPG more precisely, by attributing that part of the output growth that is due to the capital composition changes. In other words, we may see a higher capital contribution to output growth, and a lower TFPG growth, which is close to reality, than what have observed in the past by many studies. This will be further explored in the productivity Chapter.

Notwithstanding the improvements we have made in the measurement of capital input for Indian economy, it should be noted that our capital measures may still reflect any limitation of the official data. Also there is still room for improvement, such as the use of alternate depreciation pattern, which might have an effect on the measured growth rate of capital input and the treatment of land. We assumed that the capital stock consists of (only) machinery, transport equipment and construction, while the role of land as a capital input is not taken into account. Even though some studies have shown that the contribution of land to aggregate growth is negligible (e.g. Bosworth and Collins, 2008), it may still be an important aspect, particularly in the agricultural sector. Similarly, we do not make a distinction between public and private investment, which is often argued to be an important aspect in the context of developing countries. However, a quick look at the investment structure of India reveals that the share of public sector investment has been declining in the recent years. Yet another aspect is associated with the measurement of rates of return and rental prices that are crucial for the proper measurement of capital service growth rates. We assumed an external rate of return in our rental price calculation. Nevertheless, an important issue in the context of rates of return is what should be the ideal measure of the rate of return. There are different ways of deriving rate of return and consequently rental prices, depending upon the assumptions one makes about their components. Erumban (2008b) shows that the choice between an internal rate and an external rate has empirical implications for aggregate capital services and thereby measured TFP growth rates, while the growth rates are less sensitive to other alternatives. These issues warrant further detailed examination and some of them will be addressed in the further revisions of the database.

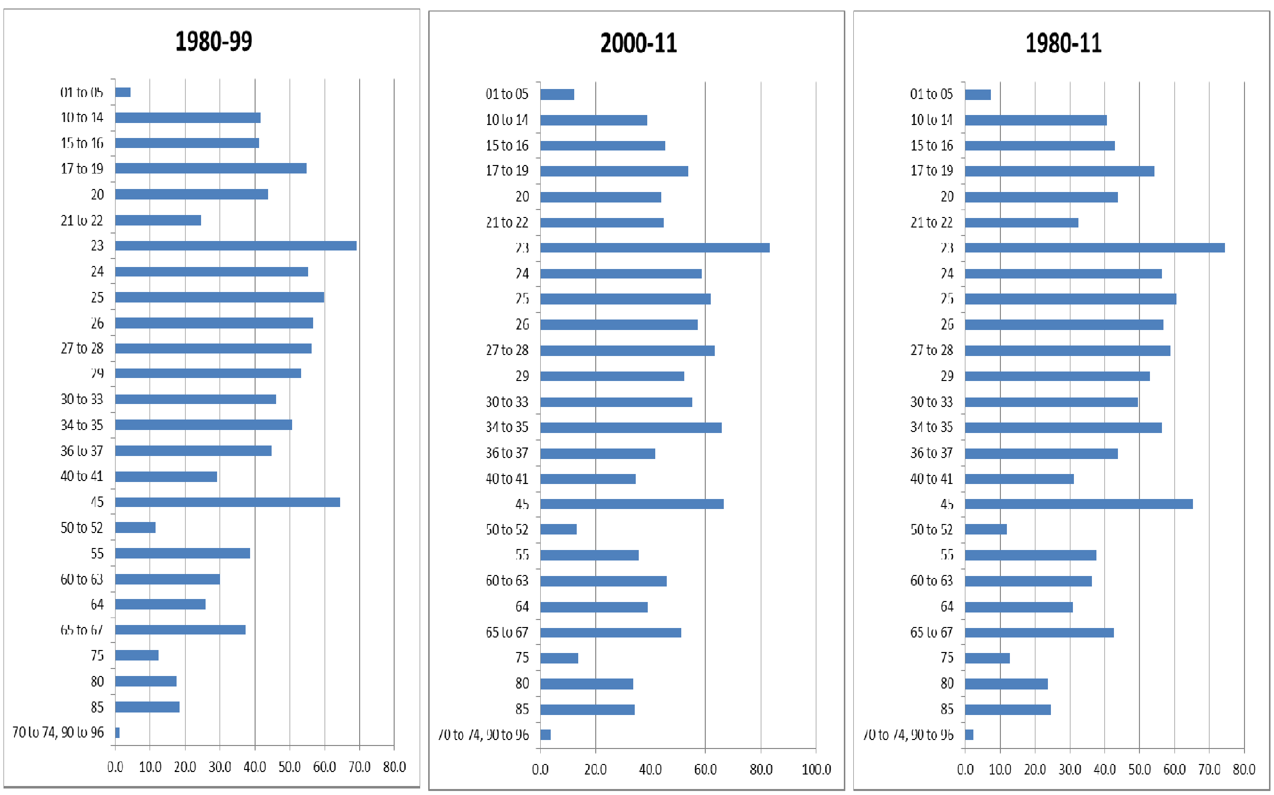
Appendices

Appendix Table 1: Derived depreciation rate for aggregate capital

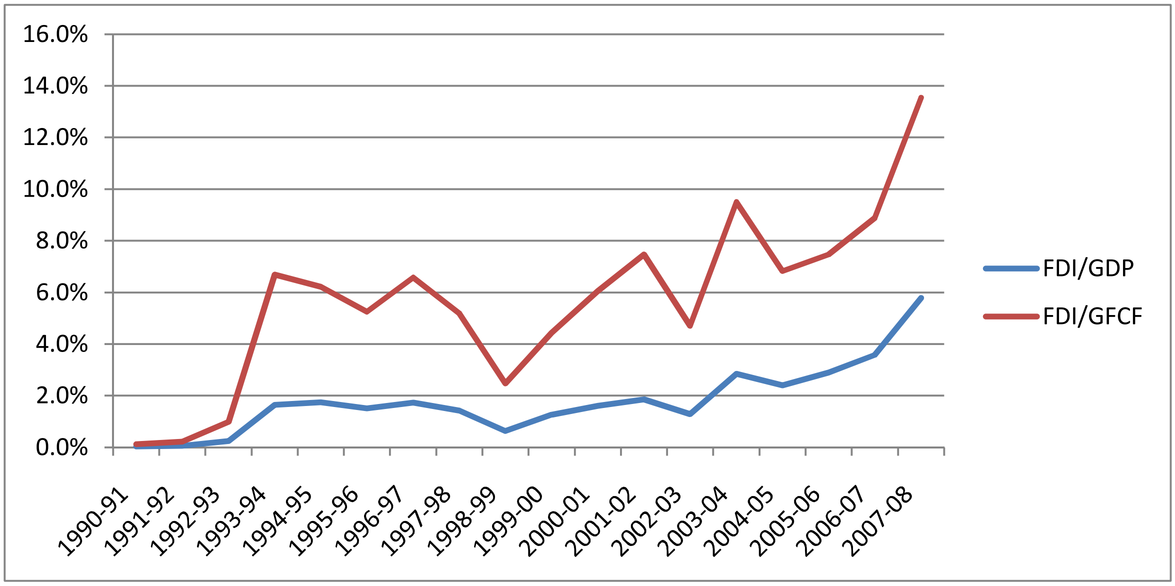
	1965-75	1976-86	1987-97	1998-11	1965-11
Total Economy	3.4	3.8	3.8	4.2	3.7
Agriculture	2.6	2.8	2.7	3.1	2.8
Manufacturing	5.1	5.4	5.4	5.8	5.3
Industry	5.6	5.8	5.0	5.4	5.3
Services	3.3	3.4	3.3	3.5	3.3

Note: Aggregate depreciation rates (δ) are derived as $\delta_t=1-[(S_t- I_t)/ S_{t-1}]$, where S and I are respectively capital stock and Investment in year t.

Appendix Figure 2: Equipment share in Aggregate capital stock, 26 industries, 1980-2011

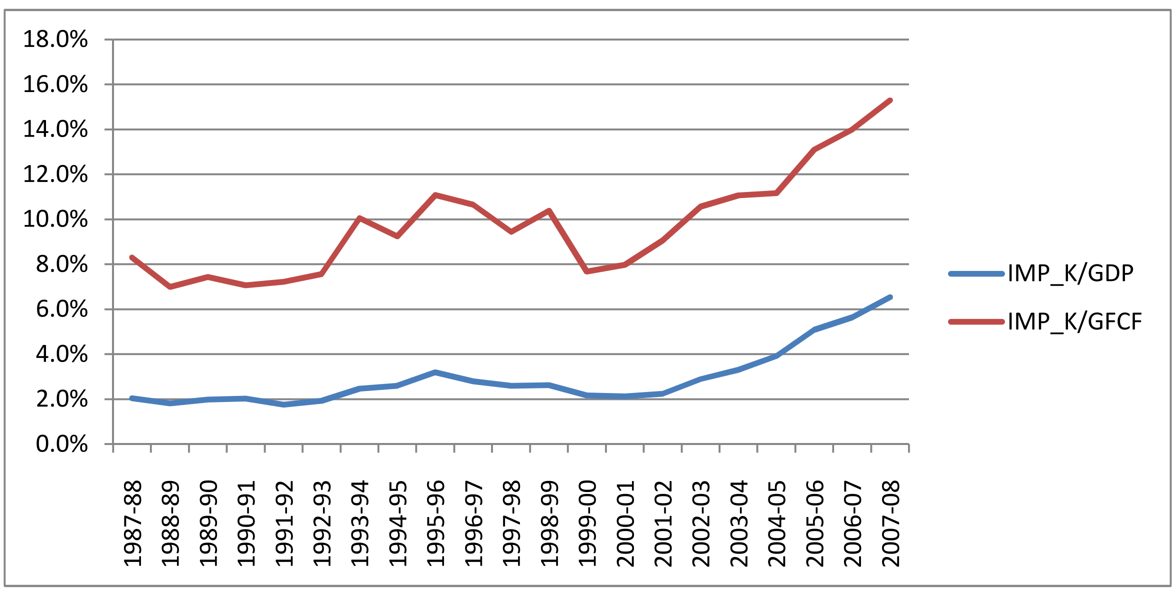


Appendix Figure 3: FDI inflow to Indian Economy, 1990-2008



Note: FDI/GDP is the ratio of foreign direct investment (FDI), direct and portfolio investment to current GDP; FDI/GFCF is the ratio of FDI to gross fixed capital formation
Source: Reserve Bank of India

Appendix Figure 4: Import of Capital Goods, 1987-2008



Source: Reserve Bank of India
Note: IMP_K/GDP is the ratio of imported capital goods to current GDP; IMP_K/GFCF is the ratio of imported capital goods to current gross fixed capital formation

Appendix Table 2: Growth rate of capital stock for two sub-periods and the whole period by 26 industries.

Industry No.	Industry description	1980 to 1999	2000 to 2011	1980 to 2011
1	Agriculture, Hunting, Forestry and Fishing	2.91	5.03	3.71
2	Mining and Quarrying	7.98	7.62	8.02
3	Food Products, Beverages and Tobacco	7.01	7.38	7.04
4	Textiles & Leather Products	9.54	7.06	8.52
5	Wood and Products of wood	7.41	7.63	7.44
6	Pulp, Paper, Paper products, printing and publishing	7.99	4.38	6.70
7	Coke, Refined Petroleum products and Nuclear fuel	16.45	11.15	14.21
8	Chemicals and Chemical Products	5.25	4.64	4.97
9	Rubber and Plastic Products	15.52	7.06	12.44
10	Other Non-Metallic Mineral Products	11.70	8.95	10.64
11	Basic Metals and Fabricated Metal Products	7.38	8.31	8.05
12	Machinery, nec.	8.69	8.70	8.80
13	Electrical and Optical Equipments	6.34	7.76	6.75
14	Transport Equipment	8.12	9.65	8.60
15	Manufacturing, nec	7.49	9.09	8.16
16	Electricity, Gas and Water Supply	6.04	4.93	5.67
17	Construction	6.91	16.19	10.42
18	Trade	5.95	10.69	7.88
19	Hotels and Restaurants	7.21	10.35	8.63
20	Transport and Storage	3.03	6.96	4.57
21	Post and Telecommunication	8.81	8.49	8.65
22	Financial Services	9.02	6.42	7.92
23	Public Administration and Defence	4.93	6.09	5.45
24	Education	8.04	13.24	10.03
25	Health and Social Work	9.05	13.85	10.92
26	Other services	3.38	8.08	5.12

Source: India KLEMS database

Appendix Table 3: Growth rate of Construction for two sub-periods and the whole period by 26 industries.

Industry No.	Industry description	1980 to 1999	2000 to 2011	1980 to 2011
1	Agriculture, Hunting, Forestry and Fishing	2.68	4.11	3.22
2	Mining and Quarrying	7.80	7.36	7.80
3	Food Products, Beverages and Tobacco	6.37	6.63	6.37
4	Textiles & Leather Products	9.17	7.67	8.55
5	Wood and Products of wood	6.97	7.20	6.93
6	Pulp, Paper, Paper products, printing and publishing	7.10	1.42	4.98
7	Coke, Refined Petroleum products and Nuclear fuel	15.33	9.68	13.37
8	Chemicals and Chemical Products	4.53	4.32	4.42
9	Rubber and Plastic Products	14.29	7.04	11.70
10	Other Non-Metallic Mineral Products	10.03	9.19	9.65
11	Basic Metals and Fabricated Metal Products	5.97	7.90	6.94
12	Machinery, nec.	8.03	9.06	8.57
13	Electrical and Optical Equipments	4.59	7.58	5.73
14	Transport Equipment	5.91	8.07	6.78
15	Manufacturing, nec	7.99	7.92	7.96
16	Electricity, Gas and Water Supply	5.27	4.13	4.87
17	Construction	7.48	15.50	10.62
18	Trade	6.16	10.64	8.03
19	Hotels and Restaurants	6.46	11.70	8.71
20	Transport and Storage	2.00	4.27	2.89
21	Post and Telecommunication	8.23	5.95	7.31
22	Financial Services	7.67	4.97	6.62
23	Public Administration and Defence	4.55	6.15	5.23
24	Education	7.11	11.62	8.86
25	Health and Social Work	8.13	12.26	9.77
26	Other services	3.30	7.82	4.97

Source: India KLEMS database

Appendix Table 4: Growth rate of Machinery for two sub-periods and the whole period by 26 industries.

Industry No.	Industry description-phase II	1980 to 1999	2000 to 2011	1980 to 2011
1	Agriculture, Hunting, Forestry and Fishing	7.22	11.74	8.65
2	Mining and Quarrying	8.50	7.22	8.17
3	Food Products, Beverages and Tobacco	7.49	7.97	7.52
4	Textiles & Leather Products	9.41	6.06	8.02
5	Wood and Products of wood	7.34	6.64	7.08
6	Pulp, Paper, Paper products, printing and publishing	10.18	7.94	9.45
7	Coke, Refined Petroleum products and Nuclear fuel	16.90	11.13	14.39
8	Chemicals and Chemical Products	5.55	4.68	5.13
9	Rubber and Plastic Products	15.93	6.83	12.59
10	Other Non-Metallic Mineral Products	13.42	7.86	11.29
11	Basic Metals and Fabricated Metal Products	8.63	7.82	8.68
12	Machinery, nec.	8.88	7.11	8.27
13	Electrical and Optical Equipments	7.97	7.78	7.62
14	Transport Equipment	9.92	10.12	9.78
15	Manufacturing, nec	7.42	8.95	8.06
16	Electricity, Gas and Water Supply	8.07	6.17	7.43
17	Construction	6.56	15.99	10.03
18	Trade	4.77	10.41	6.81
19	Hotels and Restaurants	8.50	7.47	8.23
20	Transport and Storage	8.45	11.22	9.36
21	Post and Telecommunication	10.45	11.13	10.66
22	Financial Services	10.86	7.46	9.63
23	Public Administration and Defence	5.94	7.75	6.75
24	Education	12.27	16.14	13.62
25	Health and Social Work	13.05	16.63	14.34
26	Other services	8.88	14.12	11.06

Source: India KLEMS database

Appendix Table 5: Growth rate of Transport Equipment for two sub-periods and the whole period by 26 industries.

Industry No.	Industry description	1980 to 1999	2000 to 2011	1980 to 2011
1	Agriculture, Hunting, Forestry and Fishing	8.03	15.75	10.71
2	Mining and Quarrying	2.53	21.78	10.36
3	Food Products, Beverages and Tobacco	10.32	9.30	9.90
4	Textiles & Leather Products	14.11	9.14	12.21
5	Wood and Products of wood	11.75	11.91	11.90
6	Pulp, Paper, Paper products, printing and publishing	12.36	10.10	11.46
7	Coke, Refined Petroleum products and Nuclear fuel	11.02	21.62	14.86
8	Chemicals and Chemical Products	8.55	6.03	7.76
9	Rubber and Plastic Products	20.17	8.14	15.75
10	Other Non-Metallic Mineral Products	12.08	13.85	12.94
11	Basic Metals and Fabricated Metal Products	6.79	13.72	9.88
12	Machinery, nec.	12.42	12.64	12.52
13	Electrical and Optical Equipments	11.53	8.48	10.36
14	Transport Equipment	12.44	13.05	12.64
15	Manufacturing, nec	5.72	13.00	8.83
16	Electricity, Gas and Water Supply	5.44	16.44	9.80
17	Construction	7.16	19.36	11.89
18	Trade	4.54	13.91	8.13
19	Hotels and Restaurants	8.49	10.27	9.45
20	Transport and Storage	2.97	8.77	5.44
21	Post and Telecommunication	9.01	35.81	17.94
22	Financial Services	14.17	12.55	10.88
23	Public Administration and Defence	16.64	2.53	11.30
24	Education	13.03	20.17	15.87
25	Health and Social Work	13.87	20.68	16.63
26	Other services	9.86	17.86	13.33

Source: India KLEMS database

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