Preliminary estimates, not to be quoted

Capital Service Estimates for Indian Economy: A Sectoral Perspective

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Abstract

Capital forms a crucial input in the production process and the most complex of all input measurements. Therefore construction of a time series on capital services by asset type at the level of individual industrial sectors offers major research challenge. In India, studies pertaining to productivity growth of Indian industries have constructed measures of capital input using the fixed capital category, thereby ignoring the asset wise break up of fixed capital and hence raising serious questions about the actual contribution of capital input as a source of productivity growth. The present paper attempts to overcome the methodological deficiencies of previous studies in constructing a capital services series for 31 industrial sectors for the period 1980-2004 on the lines of EU KLEMS capital input measurement using the Jorgenson (1987) approach for capital input construction.

Key words: Capital services; Capital quality; 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 is fundamental to analyzing several different economic problems. In particular, capital services measures are needed to analyze the sources of economic growth by comparing the roles of productivity versus factor accumulation, especially the contribution of capital input to observed growth. Further, disaggregated estimates of capital flow allow assessing the capital contribution both at the economy as well as the sector level in great depth. The conceptual problems involved in the measurement of capital have been extensively researched and documented.[1]Many studies on measurement of productivity growth use capital stock to represent the contribution of capital to production. However, it is now widely accepted that there are several issues connected with using a measure of capital input based on stock.[2]

Despite their importance to the analysis of growth and productivity issues, no attempt yet has been made to provide measure of capital services for the Indian economy. In majority of studies relating to Indian economy including manufacturing, the measure of capital input has been the stock of capital (Goldar 1986, Ahluwalia 1991, Mohan Rao 1994, Balakrishnan and Pushpangadan 1994 and Das 2004). There is an exhaustive literature on capital input estimates for the economy as well as industrial sectors for last several decades.[3] The methodology adopted has either been the "book value of capital" or "the perpetual inventory method."[4] The measurement of capital input that have been used in studies for Indian manufacturing have been far from satisfactory (Goldar 1986).

Therefore the robustness of capital input estimates especially when addressing issues connected with the productivity growth performance in the Indian industrial sector are far from resolved. In addition, there have been no significant attempts at providing a break up by different type of assets.[5] 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

[1] Refer Denison (1957), Ruggles and Ruggles (1967) and Griliches and Jorgenson (1966). The detailed survey of empirical research on measurement of capital input is presented in Jorgenson, D.W. (1989), "Capital as a Factor of Production" in Jorgenson D.W. and Ralph Landau (1989), Technology and Capital Formation, Cambridge MA, MIT Press.

[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).

[3] 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 the immediate reforms period (1992-1999) 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.

[4] In studies that have used the perpetual inventory method, we find differences in the approach to build the capital stock series. Issues like using a gross versus net measure, inclusion of land, using the book value figures of fixed capital considerations of working capital and total productive capital, the bench mark year for calculating the capital stock, gross fixed capital stock at replacement cost, rate of discarding and finally appropriate price deflators have been given due considerations. In addition, issues like comparability of different databases for building time series estimates of capital stock at constant prices have all been important research issues.

[5] Studies by Dholakia (1974) and Sivasubramonian (2004) did make an attempt to study asset wise break up of capital stock for Indian economy.

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.[6] The present study attempts to overcome these gaps, by constructing a capital service measure incorporating different assets to enable an analysis of these issues for India.

Therefore the objective of this paper is to outline the construction of capital services for the broad sectors of the Indian economy. The sectors of the Indian economy in this paper comprise the 31 industry India KLEMS classification which includes subsectors ranging from agriculture, mining and quarrying to real estate activities etc. An attempt is being made to construct a capital service series by type of assets by the Indian economy and different sectors within for the period 1980-2004. The break-up of different asset in the present paper are as follows- building & construction, transport equipment, machinery & equipment (Non ICT) and software, computers and telecommunication equipment (ICT). This paper is realized within the framework of the India KLEMS project, where a documentation of productivity at a detailed industry level by is undertaken by creating a database on measures of productivity growth, employment creation and capital formation.

Construction of a time series on capital stock as well as services by asset type offers major challenge as the sectors covered in the study range from agriculture, mining and quarrying, manufacturing to real estate activities etc, comprises all the three core subsectors- agriculture, industry including manufacturing and services. Further firms/enterprises belonging to all these subsectors have a dualistic structure- the formal and the informal nature with very different production as well as capital structures. Further, though India is a leading ICT software producing country, the hardware usage as an input of production still remains very small across different subsectors. The database for the construction of capital services comes from multiple sources given the nature of the 31 sector India KLEMS industrial classification- the national accounts statistics (CSO), the annual survey of industries covering the formal manufacturing (ASI) and the national sample survey organizations (NSSO) rounds comprising the unorganized manufacturing.[7] The ICT data for constructing the ICT asset is only available for very recent years and for some industries. The dataset for ICT construction is reviewed in section III

The present paper makes several contributions to the literature on capital input measurement for Indian economy and its industries. 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.[8] Three, an attempt is made to decompose the machinery and equipment assets into non ICT as well as ICT capital (software, hardware and telecommunication equipments) to reflect if there is a contribution of ICT to the observed growth in capital input and in turn to the productivity potential of industries. The above contributions of the paper enable us to examine the dynamics

[6] 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.

[7] See section 3

[8] 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.

of investment composition of the Indian economy from perspective of the aggregate economy as well the sectors comprising the economy.

The paper is organized as follows. Section 1 outlines the method used in the construction of capital services. The dataset used for constructing the flow of capital services is discussed in details in section 2. The capital service estimates for the economy as well as 31 sectors are presented in section 3 and final section concludes the paper.

2. Measurement of Capital services: The Methodology

Traditionally two broad measures of capital are considered in the literature-gross/net capital stock and capital services. The concept of capital services is inherently related to the role of capital as a factor of production. Capital services are inputs delivered by capital assets in the production process (Da Sliva , 2010).

Though the use of capital services instead of capital stock is theoretically preferred in productivity analysis, the empirical implementation is complicated by the difficulty to quantify the flow of capital services delivered by a unit of capital. Therefore the usual practice 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.[9] 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 rates have been derived as a weighted growth rate of individual capital assets, where the weights being the compensation shares of each asset, i.e.

$$\Delta \ln K_j = \sum_k \bar{v}^K_{k,j} \Delta \ln K_{k,j} \qquad (1)$$

with weights given by

$$v^K_{k,j} = \frac{p^K_{k,j} K_{k,j}}{p^K_j K_j} \qquad (2)$$

where $\Delta \ln K_{k,j}$ indicates the volume growth of capital asset k and weights are given by the period average shares of each type in the value of capital compensation, such that the sum of shares over all capital types add to unity. Asset wise capital stock can be calculated using standard perpetual inventory method, assuming a geometric depreciation rate. $v_{k,j}$ 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

[9] 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)

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 an important component of capital service measure is the service price (rental price) of capital $p^K_{k,t}$. It 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.[10] In the absence of taxation the equilibrium condition can be rearranged, yielding the familiar cost-of-capital equation (see Jorgenson and Griliches, 1967; and Christensen and Jorgenson, 1969):

$$p^K_{k,t} = p^I_{k,t-1} i_t + \delta_k p^I_{k,t} - \left(p^I_{k,t} - p^I_{k,t-1}\right) \qquad (3)$$

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 nominal rate of return, the rate of economic depreciation and the asset specific capital gains.[11] 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 (see Jorgenson and Yun 1991). 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 MFP (Erumban 2008).

3. The Data and assumptions

The current analysis conducted for the period 1980-2004, and is based on the preliminary version of India-KLEMS database. The India KLEMS database comprises a 31 sector break-up of the Indian economy (see Table1). The advantage of the new India-KLEMS database is that it ensures complete consistency with National Accounts and permits international comparison, as it follows the same approach as in the EU KLEMS (see O' Mahony and Timmer, 2009 for a description of EU KLEMS database)[12]. In addition, India KLEMS database will open avenues to make international comparisons including the emerging economies with similar data. We discuss below the source and construction of the data used in this study to measure capital services.

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[10] 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; Diewart, 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.

[11] 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-□)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 (9).

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

Table 1: Indian Economy: 31 sectors India KLEMS industrial classification

India KLEMS INDUSTRIES	NIC 1998
Agriculture, hunting, forestry & fishing	01 to 05
Mining & quarrying	10 to 14
Food , beverages & tobacco	15 to 16
Textiles, leather & footwear	17 to 19
Wood & products of wood	20
Pulp, paper , printing & publishing	21 to 22
Coke, refined petroleum & nuclear fuel	23
Chemicals & chemical products	24
Rubber & plastics	25
Other non-metallic mineral	26
Basic metals & fabricated metal	27 to 28
Machinery, nec	29
Electrical & optical equipment	30 to 33
Transport equipment	34 to 35
Manufacturing nec; recycling	36
Electricity, gas & water supply	40 to 41
Construction	45
Sale & maintenance of motor vehicles; retail sale of fuel	50
Wholesale trade	51
Retail trade	52
Hotels & restaurants	55
Transport & storage	60 to 63
Post & telecommunications	64
Financial intermediation	65 to 67
Real estate activities	70
Renting of machinery & equipment	71 to 74
Public admin & defence	75
Education	80
Health & social work	85
Other community, social & personal services	90 to 93
Private households with employed persons	95

Source: India KLEMS database

The measurement of capital services by type of activity requires information on two basic inputs: investment series by industry cross classified by type of asset and the price indices of investment goods to deflate the series on yearly investment.

Capital Services

Industry-level estimates of capital input require detailed asset-by-industry investment matrices. We obtained investment by broad industry groups by asset type from the National Accounts

Statistics (NAS).[13] We distinguish between 4 different asset types – construction, transport equipment, non-ICT machinery, ICT equipments (hardware, software and communication equipment). These have been categorized into (i) investment in non ICT assets and (ii) investment in ICT assets. From NAS and other sources we could construct investment series for three asset types, construction, transport equipment and machinery (including ICT). Additional information has been collected to obtain investment series for ICT assets, which will be discussed at some length in the next section. To transform the nominal investment series into volumes, price deflators for each asset type are needed. These prices for the abovementioned three assets are also obtained from the NAS.

The construction of capital services requires the computation of real capital stock using the using perpetual inventory method (PIM). To arrive at the real capital stock we need the following-(1) estimate of initial capital stock by asset type, (2) a time series of yearly nominal investment by asset type and (3) time series of capital goods price deflators by asset type and (4) rate of discarding by asset type. As indicated before, 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. With a given rate of depreciation δ_k which is assumed constant over time, but different for each asset type, we get:

$$S_{k,T} = S_{k,T-1}(1-\delta_k) + I_{k,T} \qquad (10)$$

Where, I_{kT} is the real investment in asset k. Table 1 provides the depreciation rates used for different asset types.

Assumptions

National Accounts Statistics, CSO provides detailed tables on assumed life of assets for private units, administrative units as well as departmental and non departmental units for categories- buildings, road and bridges, other construction, transport equipments, machinery and equipments and software. In the present study, we have used 80 years as assumed life of buildings (1.25 %), 20 years for transport equipments (5.00%), 25 years for machinery and equipments (4.00%). The depreciation rates for ICT assets- hardware and software and communication equipments were taken from the EU KLEMS rates of depreciation for these assets.

Table 2: Depreciation rates used in the computation of capital input[14]

Asset	Depreciation rate (%)
Buildings	1.25
Transport Equipments	5.00
Machinery (including ICT)	4.00

[13] 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.

[14] Chapter 26 of National Accounts Statistics (2007) -Sources and Methods, CSO provides detailed tables in the appendix.

Hardware and Software	31.5
Communication Equipment	11.5

The estimates of initial capital stock required for computing real capital stock comes statement 17: Net Fixed Capital Stock by industry of use (1999-2000=100). Since this value is provided for broad sectors of NAS and in terms of aggregate capital stock, the adjustments were done to ensure a net fixed capital stock for all 31 Industries as well as for all asset type. This needed two steps. The net fixed capital stock for all the 31 KLEMS sectors was created using the distribution of GFCF for all 31 sectors in 1950-51/1964-65. Second, the 1950-51/1964-65 asset wise distribution of GFCF was used to create net fixed capital stock estimates by asset type for all the 31 sectors.[15]

If it is assumed that the flow of capital services from each asset type k (K_k) is proportional to the stock, capital service flows can be aggregated from these asset types as 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 (7).

The rate of return (i) in equation (9) represents the opportunity cost of capital, and can be measured either as internal rate of return, or as an external rate of return.[16] The present version of the database uses an external rate of return, proxied by average of government securities and prime lending rate[17]. Therefore, we use a real rate, which is net of capital gain. Hence, the capital gain component in equation (9) is excluded while estimating rental price using external rate of return, obtaining

$$p^K_{k,t} = p^I_{k,t-1} i^*_t + \delta_k p^I_{k,t} \qquad (11)$$

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

[15] For sectors belonging to NAS, the initial capital stock at 1980-81 was computed from 1950-51,where as for sectors belonging to non NAS (i.e. manufacturing subsectors) the computation dates back to 1964-65, the first year of availability of ASI yearly volumes pertaining to format of GFCF definition used.

[16] 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 (2008) for a discussion on these issues.

[17] Handbook of Indian Statistics, Reserve bank of India, Annual volumes.

Investment in non ICT capital assets

The basic data source for the non ICT assets comprising construction[18], transport equipment and non ICT machinery is the National Accounts Statistics. However in the public domain, NAS provides information on aggregate capital formation by industry of use (statement 13- Gross fixed capital formation at current price) for 9 broad sectors. The CSO provided on request, asset wise data[19] from 1950-2004 for these broad categories by private and public units. The public units were aggregated from administrative, departmental and non departmental enterprises.

The India KLEMS industrial classification comprises 31 sectors and on mapping it was found that NAS provides data on manufacturing and some broad sectors like Trade, Hotels and Restaurants and Other services. Therefore this required splitting of manufacturing and some broad sectors under service industries. The manufacturing sector was disaggregated into 13 subsectors at the 2 digit level of NIC 1998 whereas sectors like wholesale, retail trade, hotels and restaurants, education, health, other community services and private households were created from the broad aggregates available.[20]

For the manufacturing subsectors, the data source was the yearly volumes of the annual survey of industries. The yearly detailed volumes beginning 1964-65 were used to derive the gross fixed capital formation by asset type directly.[21] The gross fixed capital formation (GFCF) was defined as new purchased+ used purchased +own construction.[22] The manufacturing subsectors were further subdivided into organized and unorganized sectors, given the significance of the unorganized sector in an economy like India. The final database required for creating the gross investment series for the 13 unorganized segments of the manufacturing sub sectors was the various rounds of NSSO. As the study period pertains to 1980-2004, the following rounds on unorganized manufacturing were used -45th round (1989-90), 51st round (1994-95) 56th round (1994-95) and 62nd round (2005-06). NSSO provides asset break up in terms of the different categories in various rounds.[23] Net additions to owned assets during the reference year within the block of fixed assets in taken to represent gross fixed capital formation (GFCF) in fixed capital.

[18] Land has been excluded from the assets to maintain uniformity 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.

[19] NAS files have provided information on buildings, Residential and Buildings, Non Residential Buildings, Construction, Other Construction, Transport Equipment, Machinery Equipments and Software. These categories were aggregated into four asset types- Buildings, Transport Equipment, Machinery Equipment including ICT.

[20] The information on value added series was utilized to create GFCF data for the India KLEMS sectors mentioned in the paper. Two alternative methods one incorporating the value added series and the other the labor input series were assessed and sensitivity check ensured that the value added number be used to break the aggregate GFCF figures.

[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 15.

[22] The previous approach to measuring capital stock was to compute gross investment series via matching two different samples as investment was defined as = book value of asset in period (t) and(t-1)+ depreciation in period (t). The present approach is based on a single year's sample investment series and helps to avoid potential huge negative investment series that arise as a result of the previous approach.

[23] NSSO rounds provided information on categories-land, building and other construction, transport equipment, plant & machinery, software and hardware, tools and other fixed assets. In some years building and construction are two different categories. Similarly for tools and other fixed assets. Software is available only for the recent round (61st). These categories were aggregated into the same four asset classification as described in footnote 15.

The investment series arrived at for four rounds were interpolated to obtain the time series of unorganized gross fixed capital formation by asset type.

Thus we are able to compute gross fixed capital formation (GFCF) by fixed assets for three broad categories- Constructions (inclusive of buildings), transport equipment and machinery equipments.[24] The category- machinery and equipment was disaggregated to form an ICT machinery and non ICT machinery (called non ICT capital). The details of the construction are discussed in the next section.

To convert gross fixed capital formation by asset type- non ICT as well as ICT, at current price, we need price deflators for each of the assets**.** CSO provided asset wise deflators for all the three asset type[25]. We have utilized this price deflator for the 31 KLEMS sectors. We have used the CSO deflator for manufacturing across all the 13 subsectors of manufacturing.

Investment in ICT capital assets

This paper uses the preliminary set of ICT data constructed for 31 industries in India-KLEMS. This section provides a short overview of the approach used in measuring ICT series used in this paper. 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, in order to ensure complete consistency with official statistics.

Following the standard practice, we define ICT investment as the investment in computers or IT hardware, communication equipment and software. Total economy ICT investments (for hardware and communication equipment) series is arrived at using the commodity flow approach.[26] In the commodity flow approach, we estimate the investment in hardware and communication equipment using the information on the total domestic availability of these goods and its investment component. In the case of hardware and communication equipment, we estimate the time-series investment, using the share of domestically produced and net imports of ICT goods invested in bench-mark years, obtained from input-output tables, and the domestic availability of ICT goods in each year from National Accounts. More formally,

$$I_{i,t} = \frac{I_{i,s}^{IO}}{\left(Y_{i,s}^{IO} + M_{i,s}^{IO} - X_{i,s}^{IO}\right)}\left(Y_{i,t} + M_{i,t} - X_{i,t}\right) \qquad (12)$$

where I 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 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

[24] Machinery and equipment series is inclusive of ICT capital as only recent databases both of ASI and NSSO have started to show ICT (software and hardware) as a separate category. In previous volumes and rounds, ICT wherever applicable was treated as part of plant and machinery.

[25] CSO price deflators for investment in asset types are with respect to base 1999-2000=100

[26] See Timmer and van Ark (2005) and de Vries et al (2008) for a good description of the commodity flow approach.

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 (12). Then, using time-series data on gross output obtained from India KLEMS[27] output database, and exports and imports obtained from UN-comtrade statistics, we construct a series of ICT investment using equation (12).

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 (2008) suggest using the elasticities of hardware to software investment, estimated using a fixed effect panel regression of 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 1999-2004 for organized manufacturing sector and NSSO surveys on unorganized manufacturing 62nd 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 1970-2004.

For organized manufacturing sector, total ICT is computed as the sum of registered and non-registered segments for the year 2004 by summing ASI and NSSO data. Subsequently, we compute the ICT/machinery ratio for total manufacturing (organized plus unorganized) for 2004, and this ratio has been extrapolated backward until 1999, using the changes in ICT/machinery ratio for organized sector obtained from ASI. 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 31 sectors. For 1970-89, the ratio has been extrapolated. This way, we compute a complete series of ICT investment series for total manufacturing segment for 1970-2004. This has been sub-dived into hardware, software and communication, assuming the composition as in

[27] India KLEMS provides output and value added data, consistent with National Accounts Statistics.

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.

As indicated before, this is a preliminary set of data and needs to be improved significantly. There are alternative sources (e.g. WITSA) 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.

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 2002; 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. Empirical results

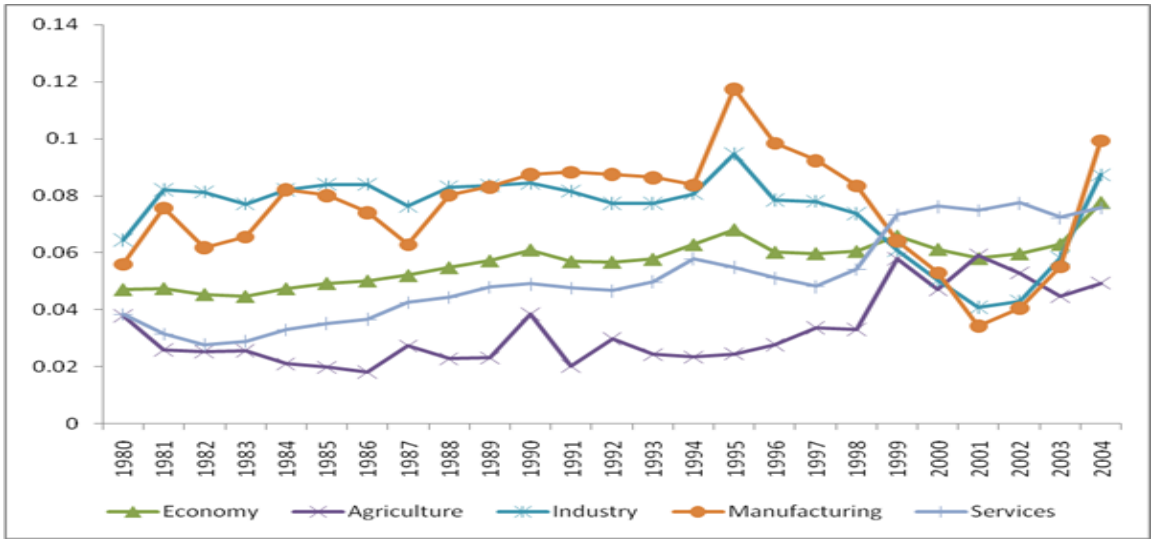
We present estimates of capital input for the 31 industries in our database which comprise the Indian economy. Further, we also attempt to provide estimates of capital input for the aggregate economy and its sub sectors-agriculture, industry and services. The results follow the methodology outlined by the equations in section 2.

The aggregate economy

For the Indian economy and its broad sectors, several sharp observations emerge. Taking the economy as a whole, we distinguish several phases during our period 1980-2004 and thus have subdivided into four-sub periods-1980-85, 1986-90, 1992-96 and 1997-2004. These sub periods reflect differences in policy orientation of the Indian economy during the decades of 1980s and 1990s.[28] Figure 1 provides yearly growth rate of capital services for aggregate economy as well as broad subsectors. The growth in capital services has shown upward trend from the beginning of 1980s with the exception of the agriculture sector. The pattern evident for industry (and manufacturing) reflects the sector's value added growth performance with sharp decline from the mid 1990s and a reversal in the 2000s. For the service sector, we observe steady

[28] The study period has been categorized into four sub periods. The periods 1980-85 and 1986-90 represents piece meal deregulations and pro business market reforms, where as the periods 1992-96 and 1997-2004 represent the policy reforms of 1992-92 and consolidation of those reforms. The year 199192 has been excluded from our analysis on account of being a year of economic crisis.

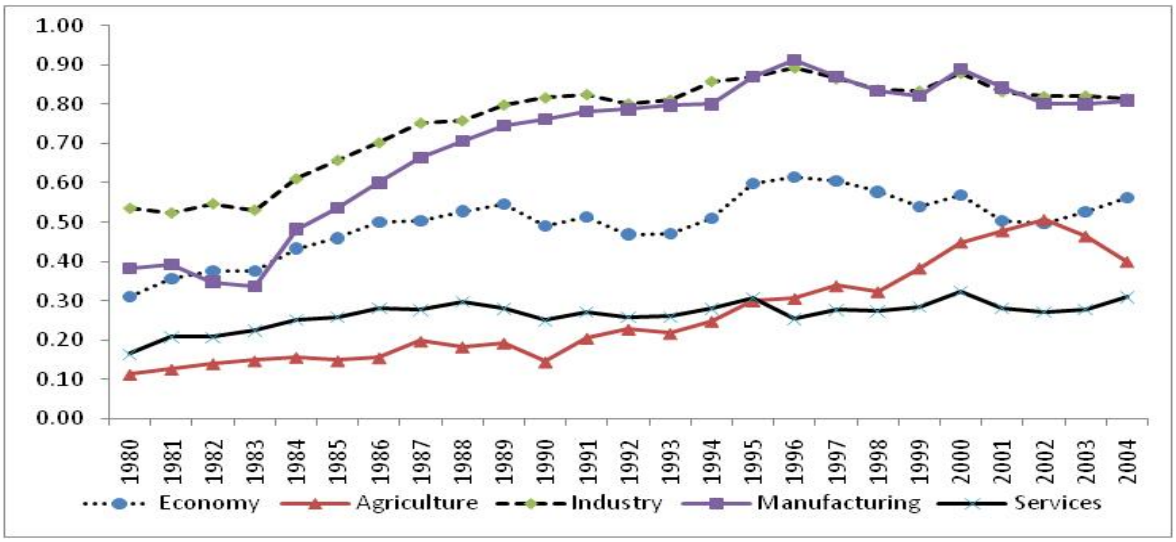
Figure 1: Growth of Capital Services: Economy and Sectors



Source: India KLEMS database

improvement in the 1990s confirming the leading role of service sector in the Indian economy. It would be interesting to supplement the observed capital input growth for the economy and its sectors with the information on share of machinery equipment in the total investment for the period 1980-2004. Figure 2 shows the trends in investment share of machinery versus construction over time.

Figure 2: Investment share of machinery in machinery and construction- Economy and Sectors



Source: India KLEMS database

The graph shows wide variations in the investment share of machinery in total machinery and construction for the economy. For industry (and manufacturing), we observe enhanced share of machinery in industry (and manufacturing) in the 1990s compared to the 1980s and this may be reflection of the liberalization of policies for capital goods within the industrial sector especially

trade policy liberalization from the mid 1980s. The investment share of machinery in services however remains quite low in comparison to the industry and manufacturing[29]

It would be interesting to observe the capital input growth rate for the various sub periods which comprise the overall period of the study 1980-2004. We provide information on both capital stock and capital service growth rates. At the level of the economy, capital service growth rates increased from 4.7% per year during 1980-85, to 5.5% during 1986-90, further to 6.1% during 1992-96 and finally to 6.3% in 1997-04. The increase between the last two sub-periodds is small compared to earlier increases. As is evident from Table 3 below, the industry and manufacturing, growth rates of capital input captured either via service or stock is much higher than the economy growth rate for 1980-2004 as well as the sub periods, however the growth rate observed for service sector is slightly below the economy wide growth rate. For four sub periods, we find positive growth in capital services as well as capital stock for the aggregate economy and its sectors.

[29] De long and Summers L (1991) using data on the components of investment drawn from United Nations International Comparison Project (UNICP) demonstrate a clear, strong and robust statistical relationship between national rates of machinery and equipment investment and productivity growth.

Table 3: Capital Service, Capital Stock and Capital Quality: Economy and Sectors

	1980-85	1986-90	1992-96	1997-04	1980-04
Total Economy					
Capital Service Growth	0.047	0.055	0.061	0.063	0.057
Capital Stock Growth	0.043	0.049	0.054	0.061	0.053
Capital Quality	0.004	0.006	0.007	0.002	0.004
Agriculture					
Capital Service Growth	0.026	0.026	0.026	0.047	0.033
Capital Stock Growth	0.024	0.025	0.023	0.041	0.030
Capital Quality	0.002	0.001	0.003	0.006	0.003
Industry					
Capital Service Growth	0.079	0.082	0.082	0.062	0.074
Capital Stock Growth	0.086	0.077	0.073	0.061	0.073
Capital Quality	-0.008	0.005	0.009	0.000	0.001
Manufacturing					
Capital Service Growth	0.070	0.078	0.095	0.065	0.075
Capital Stock Growth	0.085	0.071	0.081	0.065	0.074
Capital Quality	-0.015	0.006	0.014	0.001	0.001
Services					
Capital Service Growth	0.033	0.044	0.052	0.069	0.051
Capital Stock Growth	0.029	0.040	0.049	0.068	0.048
Capital Quality	0.004	0.004	0.003	0.001	0.003

Source: India KLEMS database

The table also provides information on capital quality computed as the difference between growth rates of capital services and stocks. Capital quality shows positive growth for 1980-2004 as well as the sub periods. However if we compare the 1990s with the 1980s, we find a decline in growth of capital quality in the 1990s for the aggregate economy and this is due to a large declines observed over the same period in industry and manufacturing. What is particularly striking is that despite large improvements in capital quality in the second half of 1980s, the improvement could not be sustained. The mild acceleration in capital quality in the first three sub-periods is worth noting. We need a detailed examination as to what caused the sharp fall in levels of capital quality as an improvement in capital quality suggests the increasing importance of equipment investment from a growth enhancing point of view as well as need for differentiating between assets.[30]

For the Indian economy, we find evidence of factor accumulation as against productivity growth in accounting for economic growth. Further, we find that the capital contribution to growth is more than the contribution of the other input-namely labor[31]. In addition, there exists strong basis for examining if the capital contribution comes via investments in equipment or construction. Table 3 lists the value added growth and the factor inputs- labor and capital along with productivity growth (TFPG). Further capital input contribution is decomposed into non ICT

[30] See Sen (2009)

[31] Das *et al* (2010), India's economic growth: factor accumulation versus productivity , (forthcoming)

capital- construction, transport, machinery equipment and ICT capital. The table throws up some interesting observations.

Table 4: Contribution of Inputs to aggregate Value Added growth: Economy and Sectors

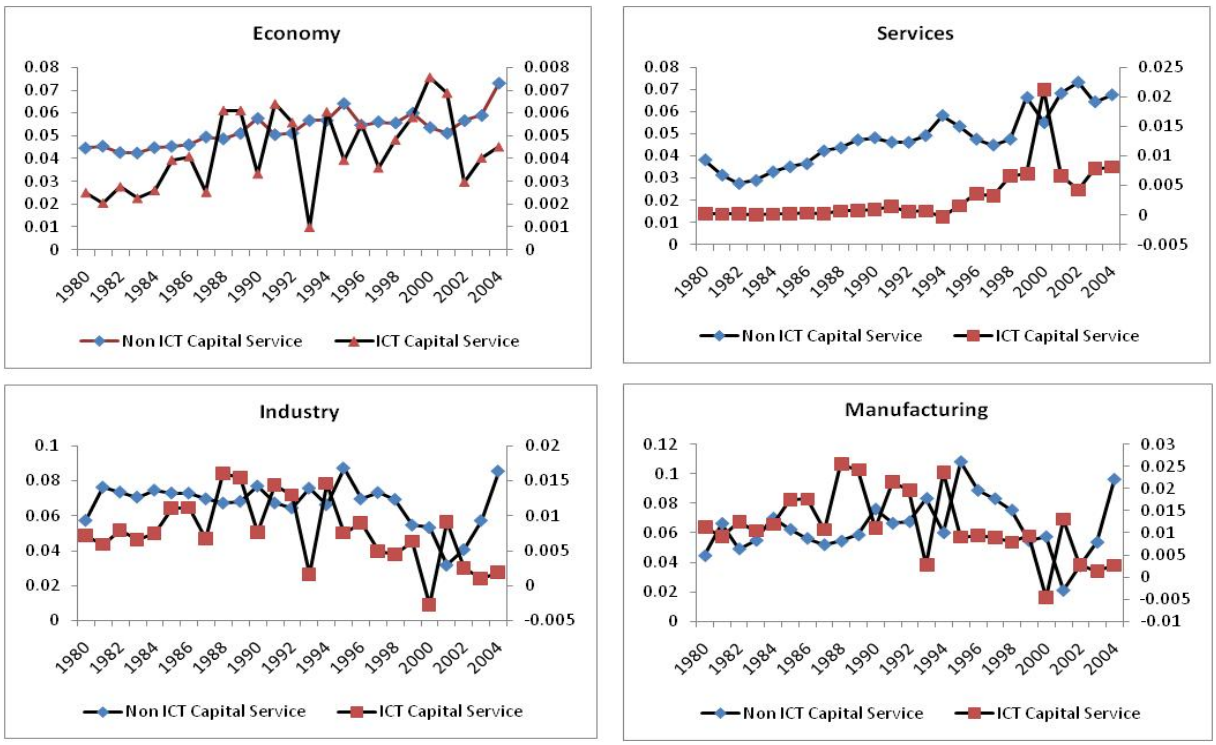
	1980-85	1986-90	1992-96	1997-04	1980-2004
Economy					
Value Added Growth	5.08	5.92	6.49	5.69	5.78
Labour Input	1.63	2.85	1.62	1.75	1.93
Non ICT Capital	1.59	1.69	2.78	2.95	2.34
Construction	0.75	0.65	0.93	1.39	0.99
Transport Equipment	0.07	0.20	0.69	0.16	0.26
Non ICT Machinery	0.77	0.85	1.17	1.41	1.10
ICT Capital	0.14	0.27	0.33	0.23	0.24
TFPG	1.71	1.10	1.77	0.76	1.26
Agriculture					
Value Added Growth	3.15	3.53	4.62	1.75	3.06
Labour Input	0.55	1.08	1.14	0.57	0.80
Non ICT Capital	0.30	0.21	0.68	1.70	0.85
Construction	0.23	0.16	0.38	0.70	0.41
Transport Equipment	0.01	0.01	0.05	0.14	0.06
Non ICT Machinery	0.06	0.05	0.25	0.86	0.38
ICT Capital	0.00	0.00	0.00	0.01	0.00
TFPG	2.30	2.24	2.80	-0.53	1.41
Industry					
Value Added Growth	5.78	7.31	7.31	5.57	6.37
Labour Input	2.76	2.38	1.16	2.01	2.07
Non ICT Capital	3.75	3.35	4.30	3.34	3.64
Construction	1.41	0.67	0.24	0.48	0.67
Transport Equipment	0.11	0.49	2.13	-0.11	0.55
Non ICT Machinery	2.23	2.19	1.93	2.97	2.41
ICT Capital	0.55	1.01	0.93	0.26	0.63
TFPG	-1.28	0.57	0.92	-0.03	0.03
Manufacturing					
Value Added Growth	6.33	7.03	9.07	4.71	6.52
Labour Input	1.12	1.54	0.66	1.07	1.09
Non ICT Capital	3.62	3.57	5.44	4.01	4.14
Construction	2.02	0.92	0.24	0.64	0.91
Transport Equipment	0.12	0.76	3.46	-0.18	0.88
Non ICT Machinery	1.48	1.89	1.74	3.55	2.35
ICT Capital	0.84	1.61	1.45	0.41	0.99
TFPG	0.75	0.31	1.53	-0.77	0.29
Services					
Value Added Growth	6.15	6.71	7.06	7.51	6.94
Labour Input	1.79	4.35	2.08	2.14	2.53
Non ICT Capital	1.28	1.69	3.13	3.25	2.46
Construction	0.76	0.96	1.66	2.13	1.48
Transport Equipment	0.09	0.14	0.25	0.29	0.21
Non ICT Machinery	0.43	0.58	1.22	0.83	0.77
ICT Capital	0.01	0.02	0.17	0.31	0.15
TFPG	3.08	0.66	1.68	1.82	1.81

Source: India KLEMS database

For the economy as a whole, capital input is the single largest contributor to the overall value added growth for the period 1980-2004. The same holds for other sectors- Industry, Manufacturing. For agriculture and services, the difference between labor and capital is not that striking. If we compare the sub periods, we observe that the significant capital contribution in the 1990s as compared to the 1980s. Further, if we observe the period 1980-2004, we find that it is the equipment investment (ICT and Non ICT machinery and transport equipment) that is driving the capital contribution for the economy as well as three other sectors-Industry, Manufacturing and Agriculture.. In the case of services, we find that construction contributed more to the observed capital contribution. Observing the sub periods of 1980s and 1990s, we find that equipments drive capital contribution in the economy as well as industry and manufacturing. For agriculture and services, we do not find evidence in favor of equipments. The substantial contribution of investment in equipments- machineries reflects the large scale policy reforms in trade and industrial sectors in 1991 with some partial liberalization of import policy for capital goods particularly machinery and equipments especially machinery in terms of tariff and non tariff barriers.

It is important to also assess whether the investment in ICT capital or Non ICT capital drives the capital contribution to the overall growth. For our purposes here, non ICT also includes construction part from transport equipment and machines.ICT includes software, hardware and equipment. Figure 3 provides ICT and Non ICT capital services growth rates for economy as well as subsectors.

Figure 3: Growth rates of ICT and Non ICT Capital Service: Economy, Industry, Manufacturing and Services

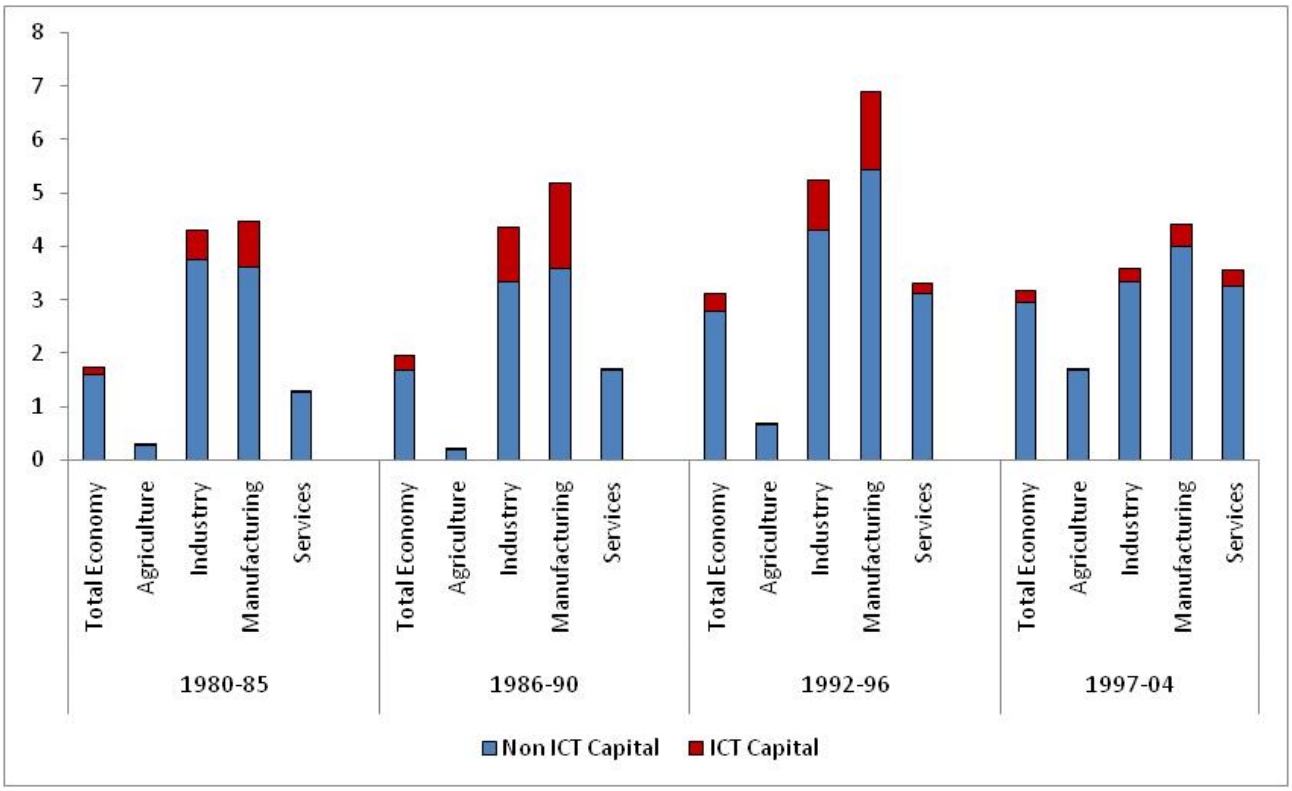


Source: India KLEMS database

At the aggregate economy level, we find that growth in non ICT capital services has been steadily improving since the 1980s. The same however cannot be seen for ICT capital services, where we observe wide fluctuations in the 1980s as well as 1990s. The pattern observed for aggregate economy is mirrored by the growth rates of non ICT and ICT in Industry and manufacturing. The service sector case is particularly striking- from a near stagnant ICT capital services growth for large part of the 1980s we find a sharp jump in the 2000s.

Moving away from capital services growth by asset type-non ICT and ICT, it would be interesting to examine the ICT and non ICT capital contribution in the observed value added growth at the level of the economy and sub sectors. From Figure 4 below, observing the four sub periods shows the dominance of non ICT in explaining capital contribution to growth for economy as well as broad sectors. It is interesting to observe that for the economy we observe that ICT contribution even though small in comparison to non ICT is increasing throughout the sub periods, except for a decline in the late 1990s reflecting perhaps the global recession. For Industry and manufacturing, we find that ICT presence is quite striking and improving in the period between mid 1980s to mid 1990s. In the case of services, the ICT findings reflect low but increasing trend. This by and large is in line with the observed low equipment contribution in table 4.

Figure 4: Contribution of ICT and Non ICT capital to aggregate Value Added growth



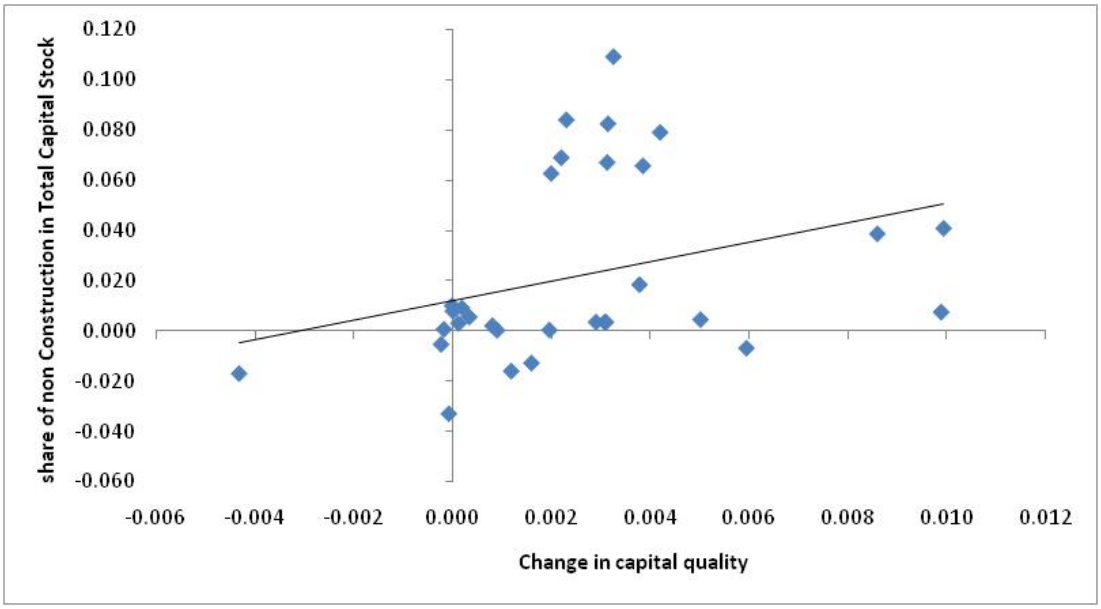
Source: India KLEMS database

In table 1, we compared capital quality for the economy as well as sub sectors for 1980-2004 and periods therein. We observed that capital quality shows positive growth for 1980-2004 as well as the sub periods. Further, from table 2, we observe the period 1980-2004, we find that it is the equipment investment (ICT and Non ICT machinery and transport equipment) is driving the

capital contribution for the economy as well as three other sectors-Industry, Manufacturing and Agriculture. It is interesting to examine if the improvements in capital quality reflects the increasing share of equipment investment (non construction) in total capital stock. This will enable us to infer whether the De Long and Summers (1991) argument that investment has a strong association with growth is also evident from Indian data.

Figure 5 plots average capital quality against the share of non construction investment in total capital stock. The positive association evident from the graph shows that higher non construction share in total capital stock leads to an improvement in capital quality. This is evident for large majority of the industries for the post reform period -1992-2004.

Figure 5: Change in capital quality versus change in share of non construction investment in capital stock



Source: India KLEMS database

The KLEMS Industrial sectors

It is of interest to see how the observed capitals service growth rate at the aggregate economy level relates to the individual sectors of the Indian economy. In addition the industry perspective allows us to examine the linkage between investment by asset type and growth by looking at the sectoral dynamics. In this section, our emphasis is on documenting the trends for the period of 1990s and comparing with the 1980s. we have sub divided the period 1980-2004 into two periods- pre liberalization of trade and industrial policies(1980-1991) and post liberalization of trade and industrial policies (1992-2004). The periodization attempted also allows us to observe the trends in the pre and post economic reforms era of the Indian economy. The issue at hand is whether higher investment drives capital service growth and in turn overall growth of the economy through factor accumulation and secondly if the changes in rules and regulations governing production and trade in India has any role to play?

Table 5 provides the share of machinery investment in the capital stock of the 31 India KLEMS sectors comprising the Indian economy. Machinery here is inclusive of both plant and

machinery as well as ICT machinery including hardware and telecommunication equipment at the industry level. A comparison is made between two periods broadly indentified as pre and post economic reforms. A glance at the table below shows that industries beloning to both manufacturing as well as services show improvements in machinery share as in line with the trends observed at the economy level.

Table 5: Machinery* investment in total capital stock- 31 Industrial sectors

Industry	Pre Reform**	Post Reform
Agriculture, hunting, forestry and fishing	0.006	0.017
Mining and quarrying	0.122	0.066
Food , beverages and tobacco	0.046	0.047
Textiles, textile , leather and footwear	0.066	0.080
Wood and of wood and cork	0.085	0.099
Pulp, paper, paper , printing and publishing	0.033	0.052
Coke, refined petroleum and nuclear fuel	0.042	0.104
Chemicals and chemical products	0.078	0.084
Rubber and plastics	0.090	0.089
Other non-metallic mineral	0.030	0.063
Basic metals and fabricated metal	0.048	0.034
Machinery, nec	0.063	0.068
Electrical and optical equipment	0.037	0.062
Transport equipment	0.056	0.099
Manufacturing nec; recycling	0.062	0.066
Electricity, gas and water supply	0.088	0.068
Construction	0.087	0.125
Sale, maintenance of motor vehicles	0.006	0.015
Wholesale trade and commission trade,	0.006	0.015
Retail trade	0.006	0.014
Hotels and restaurants	0.039	0.032
Transport and storage	0.015	0.030
Post and telecommunications	0.084	0.108
Financial intermediation	0.060	0.069
Real estate activities	0.000	0.002
Renting of machinery & equipment	0.000	0.007
Public admin and defence	0.014	0.011
Education	0.027	0.035
Health and social work	0.030	0.037
Other community, social and personal services	0.017	0.023
Private households with employed persons	0.017	0.021

Note: *Machinery comprises both ICT machinery as well as non ICT machinery excluding transport equipment
** Pre reform period is from 1980 to 1990 and post reform period is documented from 1992-2004

Source: India KLEMS database

If we compare the sectors which have high and increasing machinery shares with those which do not, the table above offers important findings. Considering those industries where machinery equipment forms 50 percent or more share in capital stock, we find the presence of a large number of industries belonging to manufacturing industries. Including mining and quarrying, electricity, gas water and construction, we find that in the top 10 sectors belong to industry including manufacturing. Further most of these industries barring mining and quarrying, rubber and plastics show enhancement in the machinery share in the period of 1990s and 2000s. The

table also reflects that industries with low share of machinery equipment in the early period have also made significant improvements in their share of machinery equipment following the period of reforms. This signals that the easing of restrictions on machinery import and relaxation of norms of manufacturing machines through industrial policy changes in 1985 and in 1991-92 have had a positive effect on firms physical capital structure and in enhancing their potential productive capacity.

As a corollary to the above and given that the Indian economy has been witnessing an ICT spur to the overall growth and productivity in the 1990s. The next line of enquiry would be to assess if the ICT share in overall machinery equipment also shows similar experience as in the case of machinery equipment. Table 4 computes the share of ICT in total machinery investment for the 31 sectors of the Indian economy and provides a comparison between the period of 1980s (1980-1990) called pre reform and period of 1990s (1992-2004) labeled post reforms.

Table 6: ICT* investment in total machinery investment-31 Industrial sectors

Industry	Pre Reform**	Post Reform
Agriculture, hunting, forestry and fishing	0.001	0.002
Mining and quarrying	0.000	0.008
Food , beverages and tobacco	0.019	0.048
Textiles, textile , leather and footwear	0.123	0.117
Wood and of wood and cork	0.009	0.138
Pulp, paper, paper , printing and publishing	0.124	0.148
Coke, refined petroleum and nuclear fuel	0.154	0.465
Chemicals and chemical products	0.003	0.142
Rubber and plastics	0.004	0.074
Other non-metallic mineral	0.001	0.049
Basic metals and fabricated metal	0.008	0.224
Machinery, nec	0.120	0.195
Electrical and optical equipment	0.312	0.21
Transport equipment	0.249	0.213
Manufacturing nec; recycling	0.010	0.158
Electricity, gas and water supply	0.002	0.015
Construction	0.000	0.010
Sale, maintenance of motor vehicles	0.002	0.066
Wholesale trade and commission trade,	0.000	0.015
Retail trade	0.039	0.157
Hotels and restaurants	0.025	0.047
Transport and storage	0.002	0.067
Post and telecommunications	0.012	0.039
Financial intermediation	0.000	0.124
Real estate activities	0.019	0.489
Renting of machinery & equipment	0.000	0.483
Public admin and defence	0.000	0.229
Education	0.001	0.072
Health and social work	0.000	0.009
Other community, social and personal services	0.008	0.024
Private households with employed persons	0.000	0.002

Note: * We define ICT investment as the investment in computers or hardware, communication equipment and software.

** Pre-reform period is from 1980 to 1990 and post reform period is documented from 1992-2004

Source: India KLEMS database

As with the previous table, we only concentrate on those industries where the ICT share in total machinery share is 10 percent and above. It is not surprising to find that most of the industries here belong to the manufacturing sub sectors. As with the table 3, most of the industries show an improvement in ICT share in the post reform period. Also noteworthy from the table is that sectors where in the 1980s we find ICT share is zero and or negligible, we find substantial improvements taking place. On the whole, there seems to have been an enhancement in ICT share for the Indian economy as captured by 29 of the 31 sectors comprising the Indian economy.

Our observations from the trends in capital services growth rate at the aggregate economy level shows that the share of machinery equipment in investment dominates. Further, machinery equipment emerges as the single largest contributor to the observed capital services growth. A

comparison of growth of non ICT capital with ICT capital services shows that non ICT capital services which includes construction, transport equipment as well as machinery equipment is growing at high rates in comparison to non ICT assets. As regards capital quality, we find a positive association between machinery share and capital quality. Trends available from the industrial sectors confirm by and large the observations at the aggregate level. For majority of the sectors, we find an increase of machinery in capital stock in the post reform era of the Indian economy. The ICT share through pretty small for most sectors nevertheless shows signs of increasing. Our empirical findings point towards the presence of an association between equipment and growth, which needs to be examined in depth. Further, we find evidences of enhancement of ICT in total capital stock, though it remains a very small component of capital services.

5. Conclusions

This paper is an attempt to measure the flow of capital services for the aggregate economy and the 31 sectors which comprise the Indian economy for the period 1980-2004 and its sub periods including periods of pre and post reforms. The paper is the first exercise in computing capital services flow for the Indian economy. The rationale for using this as a measure of capital input stems from the recognition of enormous heterogeneity of capital assets. Therefore, the asset composition of capital services is an attempt to understand the significance of investment in structures and equipment for long term growth at the economy and industries therein. The American growth resurgence in the mid 1990s and the resultant role played by information technology are now well known and researched. However for the Indian economy, there is a severe dearth of literature, due to data limitations on attempts to assess the economic impact of information technology. This paper makes an important contribution to fill that gap as an attempt is made to decompose the machinery and equipment assets into non ICT and ICT capital (software, hardware and telecommunication equipments) to find out if there is a potential contribution of ICT to the observed growth in capital input and in turn to the productivity potential of industries. The above contributions of the paper enable us to examine the dynamics of investment composition of the Indian economy from perspective of the aggregate economy as well the sectors comprising the economy.

Our findings are two-fold. One set of results are arrived at for the aggregate economy and the other for the 31 India KLEMS industrial classification. We bear in mind that the several asset types were considered for building the capital stock as well as services growth rate- construction, transport equipment, machinery and ICT machinery. From these four broad aggregates, in addition we are able to comment on equipment versus structures as well as non ICT machinery versus ICT machinery.

Our economy capital services growth reflects the following- we observe the share of machinery versus construction across sectors and over the years. The share is improving over the years, though the pace of improvements in broad sectors- agriculture, industry including manufacturing and services varies. The shares are high in some sectors- industry and manufacturing when compared to services. We document the trends in both, capital stock as well as services for the period 1980-2004 and its sub periods. We also find evidences of improvements in capital quality. Further there is a positive relationship between share of non construction in capital stock and capital quality. At the economy level, we find evidence of large contribution by machinery equipment to capital input growth. We find that growth in non ICT capital services has been

steadily improving since the 1980s. The same however cannot be seen for ICT capital services, where we observe wide fluctuations in the 1980s as well as 1990s. The pattern observed for aggregate economy is mirrored by the growth rates of non ICT and ICT in Industry and manufacturing. The service sector case is particularly striking- from a near stagnant ICT capital services growth for large part of the 1980s we find a sharp jump in the 2000s. Finally, it is also found that there is a dominance of non ICT assets in explaining capital contribution to overall growth.

At the industry level, two issues were examined- one if the share of machinery investment in total capital stock shows any changes between the pre and post reform periods of the Indian economy. Two, if some similar evidences can found in the share of ICT in total machinery for the same periods. For majority of the manufacturing sub sectors, we find an increase of share of machinery investment in total capital stock in the post reform era of the Indian economy. The ICT share though pretty insignificant for most sectors, yet shows signs of increase and has to be understood keeping in mind that the role of information technology in India is not very impressive as far as application is concerned.

The detailed analysis in the present paper allows us to track the industry origins of the aggregate trends and also quantify the importance of the economy as a whole. Further, the paper uses the preliminary set of ICT data constructed for 31 industries in India-KLEMS and some of the assertions need to be treated with caution. Our future research agenda concerns creating sophisticated ICT indicators- hardware, software and telecommunication as this make possible the inference of whether low utilization of information technology acts as a barrier to enhancing the growth and productivity of the Indian economy.

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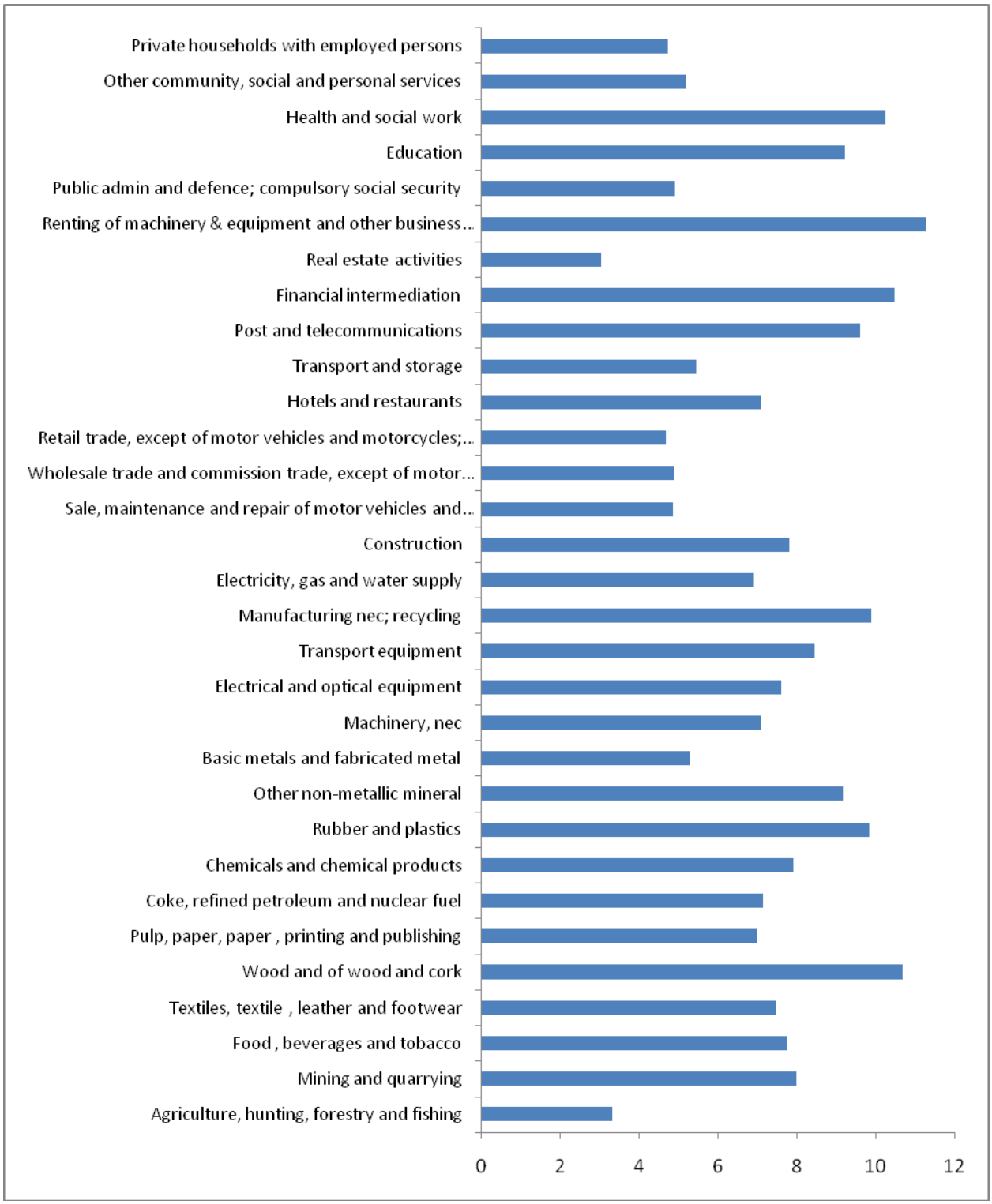
Appendix:

Figure A1: Capital Service growth (1980-2004): 31 India KLEMS industries



Source: India KLEMS database

Table A1: Capital Service Growth Rate – Asset: Building and Construction

NIC Code	Industry	1980 - 85	1986 -90	1992 - 96	1997 - 04	1980 - 04
AtB	Agriculture, hunting, forestry and fishing	1.97	1.95	1.51	1.92	1.96
C	Mining and quarrying	0.98	0.75	0.40	0.49	0.88
15t16	Food , beverages and tobacco	8.86	2.44	0.34	0.81	5.94
17t19	Textiles, textile , leather and footwear	0.69	0.96	0.62	1.01	0.81
20	Wood and of wood and cork	1.36	1.34	0.92	2.49	1.35
21t22	Pulp, paper, paper , printing and publishing	4.90	4.33	0.40	0.34	4.64
23	Coke, refined petroleum and nuclear fuel	0.08	0.38	0.15	0.33	0.22
24	Chemicals and chemical products	0.36	0.69	0.07	0.68	0.51
25	Rubber and plastics	0.98	1.22	0.90	0.46	1.09
26	Other non-metallic mineral	12.78	-0.18	0.14	1.15	6.89
27t28	Basic metals and fabricated metal	0.56	1.90	0.21	1.01	1.17
29	Machinery, nec	2.18	1.09	0.31	0.90	1.68
30t33	Electrical and optical equipment	6.95	1.97	-0.05	0.71	4.68
34t35	Transport equipment	0.53	0.71	0.18	0.66	0.61
36t37	Manufacturing nec; recycling	1.29	1.35	2.42	3.65	1.32
E	Electricity, gas and water supply	1.13	1.28	1.02	1.03	1.20
F	Construction	0.06	0.09	0.09	0.31	0.07
50	Sale, maintenance of motor vehicles	2.61	3.54	3.44	4.60	3.03
51	Wholesale trade and commission trade,	2.61	3.54	3.44	4.66	3.03
52	Retail trade	2.61	3.54	3.44	4.22	3.03
H	Hotels and restaurants	3.44	3.12	2.50	2.15	3.29
60t63	Transport and storage	0.26	0.42	0.36	0.60	0.34
64	Post and telecommunications	1.44	1.14	1.17	0.77	1.30
J	Financial intermediation	2.70	4.15	6.71	1.30	3.36
70	Real estate activities	0.82	1.99	2.85	4.95	1.35
71t74	Renting of machinery & equipment and other business activities	3.52	6.54	10.32	18.91	4.89
L	Public admin and defence	3.66	2.98	3.48	3.64	3.35
M	Education	3.30	4.89	4.83	8.18	4.02
N	Health and social work	3.99	5.57	5.28	8.65	4.71
O	Other community, social and personal services	1.89	2.61	3.05	4.98	2.22
P	Private households with employed persons	1.89	2.51	2.16	4.83	2.17
	Industry Mean	2.59	2.22	2.02	2.92	2.42
	Industry Median	1.89	1.95	1.02	1.15	1.96

Source: India KLEMS database

Table A2: Capital Service Growth Rate – Asset : Transport Equipment

NIC Code	Industry	1980 - 1985	1986 -1990	1992 - 1996	1997 - 2004	1980 - 2004
AtB	Agriculture, hunting, forestry and fishing	0.09	0.08	0.16	0.40	0.09
C	Mining and quarrying	0.37	0.17	-0.01	-0.02	0.28
15t16	Food , beverages and tobacco	0.17	1.00	4.79	-0.23	0.55
17t19	Textiles, textile , leather and footwear	0.24	0.54	2.12	-0.02	0.37
20	Wood and of wood and cork	0.07	1.08	5.56	-0.27	0.53
21t22	Pulp, paper, paper , printing and publishing	0.25	0.45	2.27	0.99	0.34
23	Coke, refined petroleum and nuclear fuel	0.04	0.36	2.39	0.16	0.18
24	Chemicals and chemical products	0.04	1.25	6.15	-0.50	0.59
25	Rubber and plastics	-0.09	1.15	6.31	-0.59	0.47
26	Other non-metallic mineral	0.07	1.19	6.04	-0.53	0.58
27t28	Basic metals and fabricated metal	0.22	1.79	6.53	-0.32	0.94
29	Machinery, nec	0.17	0.77	4.78	-0.19	0.44
30t33	Electrical and optical equipment	-0.01	2.08	8.42	-1.24	0.94
34t35	Transport equipment	0.17	0.68	2.73	0.54	0.40
36t37	Manufacturing nec; recycling	0.16	0.79	4.66	-0.16	0.44
E	Electricity, gas and water supply	0.22	1.46	6.28	-0.02	0.78
F	Construction	3.08	2.68	1.89	1.42	2.90
50	Sale, maintenance of motor vehicles	0.03	0.02	0.00	0.00	0.02
51	Wholesale trade and commission trade,	0.01	0.00	0.00	0.00	0.00
52	Retail trade	0.03	0.01	0.03	0.01	0.02
H	Hotels and restaurants	0.03	0.01	0.03	0.01	0.02
60t63	Transport and storage	0.03	0.01	0.03	0.01	0.02
64	Post and telecommunications	0.03	0.01	0.03	0.01	0.02
J	Financial intermediation	1.27	1.16	1.55	0.21	1.22
70	Real estate activities	1.93	3.17	3.25	2.56	2.50
71t74	Renting of machinery & equipment and other business activities	2.14	3.62	3.93	3.33	2.81
L	Public admin and defence	0.09	0.14	0.06	0.05	0.11
M	Education	0.00	0.00	0.02	0.12	0.00
N	Health and social work	-0.11	0.06	0.31	0.97	-0.03
O	Other community, social and personal services	0.00	0.00	0.00	0.00	0.00
P	Private households with employed persons	0.00	0.00	0.00	0.00	0.00
	Industry Mean	0.35	0.83	2.59	0.22	0.57
	Industry Median	0.07	0.54	2.12	0.00	0.37

Source: India KLEMS database

Table A3: Capital Service Growth Rate – Asset: Non ICT machinery

NIC Code	Industry	1980 - 85	1986 -90	1992 - 96	1997 - 04	1980 - 04
AtB	Agriculture, hunting, forestry and fishing	0.54	0.58	0.93	2.40	0.56
C	Mining and quarrying	13.21	9.03	5.67	2.44	11.31
15t16	Food , beverages and tobacco	4.53	3.71	3.03	3.63	4.16
17t19	Textiles, textile , leather and footwear	1.14	0.52	5.40	5.75	0.86
20	Wood and of wood and cork	7.34	6.73	1.83	8.48	7.06
21t22	Pulp, paper, paper , printing and publishing	1.42	1.23	2.26	5.00	1.33
23	Coke, refined petroleum and nuclear fuel	-1.37	-0.11	-0.60	13.40	-0.80
24	Chemicals and chemical products	3.11	7.81	1.66	6.43	5.25
25	Rubber and plastics	6.87	7.52	9.00	4.57	7.16
26	Other non-metallic mineral	1.93	4.33	3.94	5.90	3.02
27t28	Basic metals and fabricated metal	2.61	1.81	-2.54	1.80	2.24
29	Machinery, nec	1.27	3.51	2.42	4.00	2.29
30t33	Electrical and optical equipment	-2.81	-0.29	2.03	5.59	-1.66
34t35	Transport equipment	-2.46	1.06	6.39	7.39	-0.86
36t37	Manufacturing nec; recycling	5.24	4.16	3.45	4.01	4.74
E	Electricity, gas and water supply	7.17	7.56	4.46	4.24	7.35
F	Construction	4.52	6.14	5.70	11.70	5.26
50	Sale, maintenance of motor vehicles	0.33	0.90	1.15	1.64	0.59
51	Wholesale trade and commission trade,	0.33	0.91	1.21	1.97	0.59
52	Retail trade	0.29	0.57	-0.19	2.10	0.42
H	Hotels and restaurants	4.81	2.75	2.75	2.43	3.88
60t63	Transport and storage	0.85	1.51	1.08	2.29	1.15
64	Post and telecommunications	5.63	8.82	9.81	7.22	7.08
J	Financial intermediation	5.45	8.09	13.38	1.12	6.65
70	Real estate activities	0.00	0.00	-0.03	-0.08	0.00
71t74	Renting of machinery & equipment and other business activities	0.00	0.00	-0.24	-0.86	0.00
L	Public admin and defence	1.72	1.39	0.44	-0.21	1.57
M	Education	2.15	3.29	2.45	3.19	2.67
N	Health and social work	2.74	3.83	2.82	4.38	3.24
O	Other community, social and personal services	0.88	1.53	1.41	2.19	1.17
P	Private households with employed persons	0.89	1.47	0.79	2.27	1.15
	Industry Mean	2.59	3.24	2.96	4.08	2.88
	Industry Median	1.72	1.81	2.26	3.63	2.24

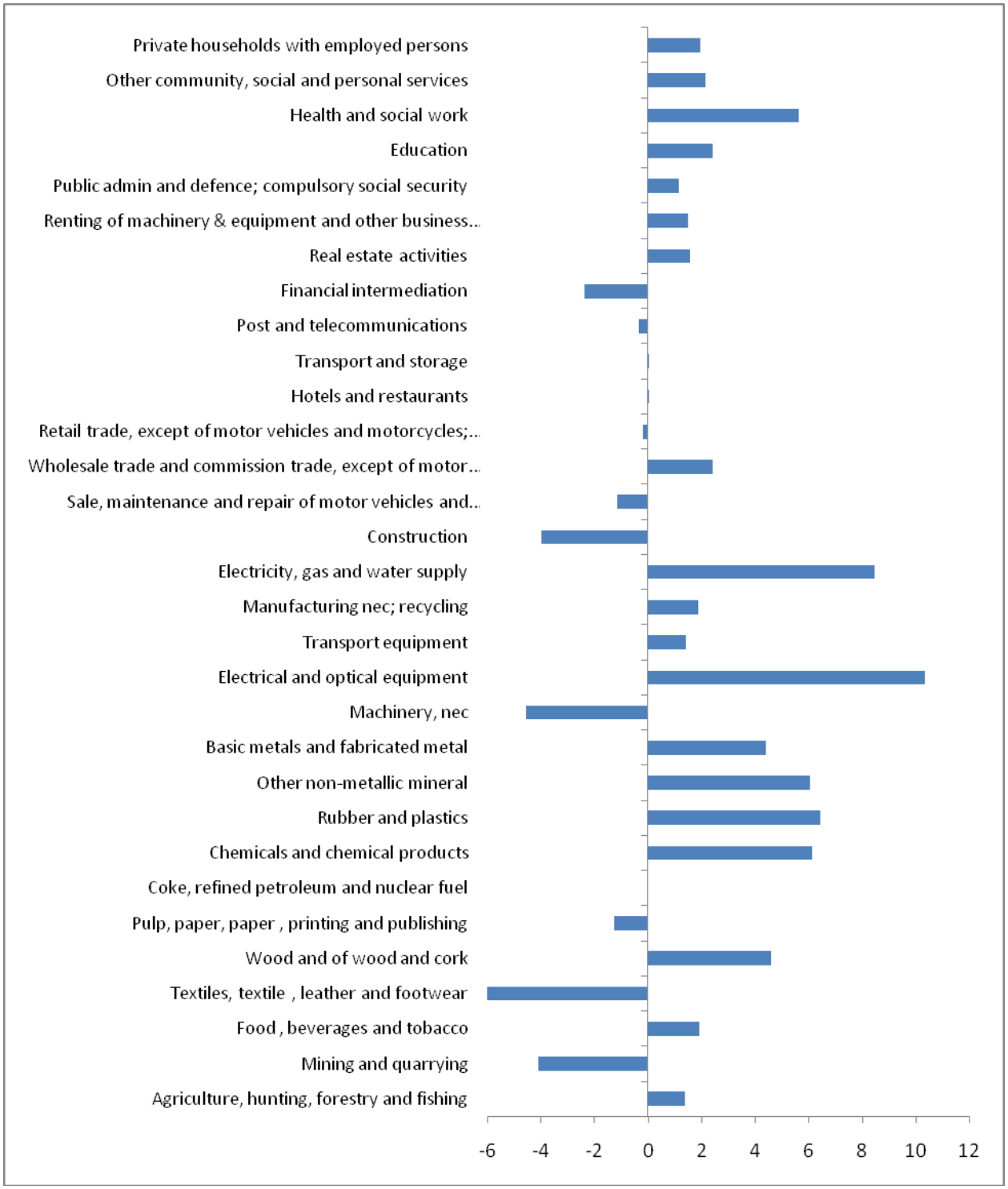
Source: India KLEMS database

Table A4: Capital Service Growth Rate – Asset : ICT Machinery

NIC Code	Industry	1980 - 85	1986 -90	1992 - 96	1997 - 04	1980 - 04
AtB	Agriculture, hunting, forestry and fishing	0.00	0.00	0.00	0.01	0.00
C	Mining and quarrying	0.02	0.03	0.04	0.07	0.02
15t16	Food , beverages and tobacco	0.21	0.78	0.36	0.11	0.47
17t19	Textiles, textile , leather and footwear	2.14	5.18	0.97	0.18	3.52
20	Wood and of wood and cork	0.29	0.37	4.85	1.41	0.33
21t22	Pulp, paper, paper , printing and publishing	2.06	1.87	0.36	0.90	1.97
23	Coke, refined petroleum and nuclear fuel	1.61	2.55	3.24	-0.09	2.04
24	Chemicals and chemical products	0.00	1.17	3.72	0.52	0.53
25	Rubber and plastics	0.00	0.61	2.10	0.15	0.28
26	Other non-metallic mineral	0.01	0.12	0.85	0.22	0.06
27t28	Basic metals and fabricated metal	0.00	2.23	3.93	0.69	1.02
29	Machinery, nec	3.01	2.21	2.00	1.46	2.65
30t33	Electrical and optical equipment	4.25	4.97	1.03	0.81	4.58
34t35	Transport equipment	4.83	4.10	0.92	1.75	4.50
36t37	Manufacturing nec; recycling	0.11	0.73	3.02	0.97	0.39
E	Electricity, gas and water supply	0.01	0.14	0.42	-0.09	0.07
F	Construction	0.01	0.01	0.19	0.35	0.01
50	Sale, maintenance of motor vehicles	0.00	0.00	0.07	0.38	0.00
51	Wholesale trade and commission trade,	0.00	0.00	0.02	0.09	0.00
52	Retail trade	0.04	0.34	1.41	-0.26	0.18
H	Hotels and restaurants	0.21	0.96	-0.75	0.44	0.55
60t63	Transport and storage	0.01	0.01	0.03	0.86	0.01
64	Post and telecommunications	0.31	0.59	0.45	1.25	0.44
J	Financial intermediation	0.00	0.00	0.67	1.12	0.00
70	Real estate activities	0.00	0.00	0.08	0.58	0.00
71t74	Renting of machinery & equipment and other business activities	0.00	0.00	0.39	2.45	0.00
L	Public admin and defence	0.00	0.00	0.01	1.22	0.00
M	Education	0.01	0.03	0.08	1.10	0.01
N	Health and social work	0.00	0.00	0.00	0.17	0.00
O	Other community, social and personal services	0.05	0.05	0.01	0.20	0.05
P	Private households with employed persons	0.00	0.00	0.00	0.03	0.00
	Industry Mean	0.62	0.94	0.98	0.61	0.76
	Industry Median	0.01	0.14	0.39	0.44	0.07

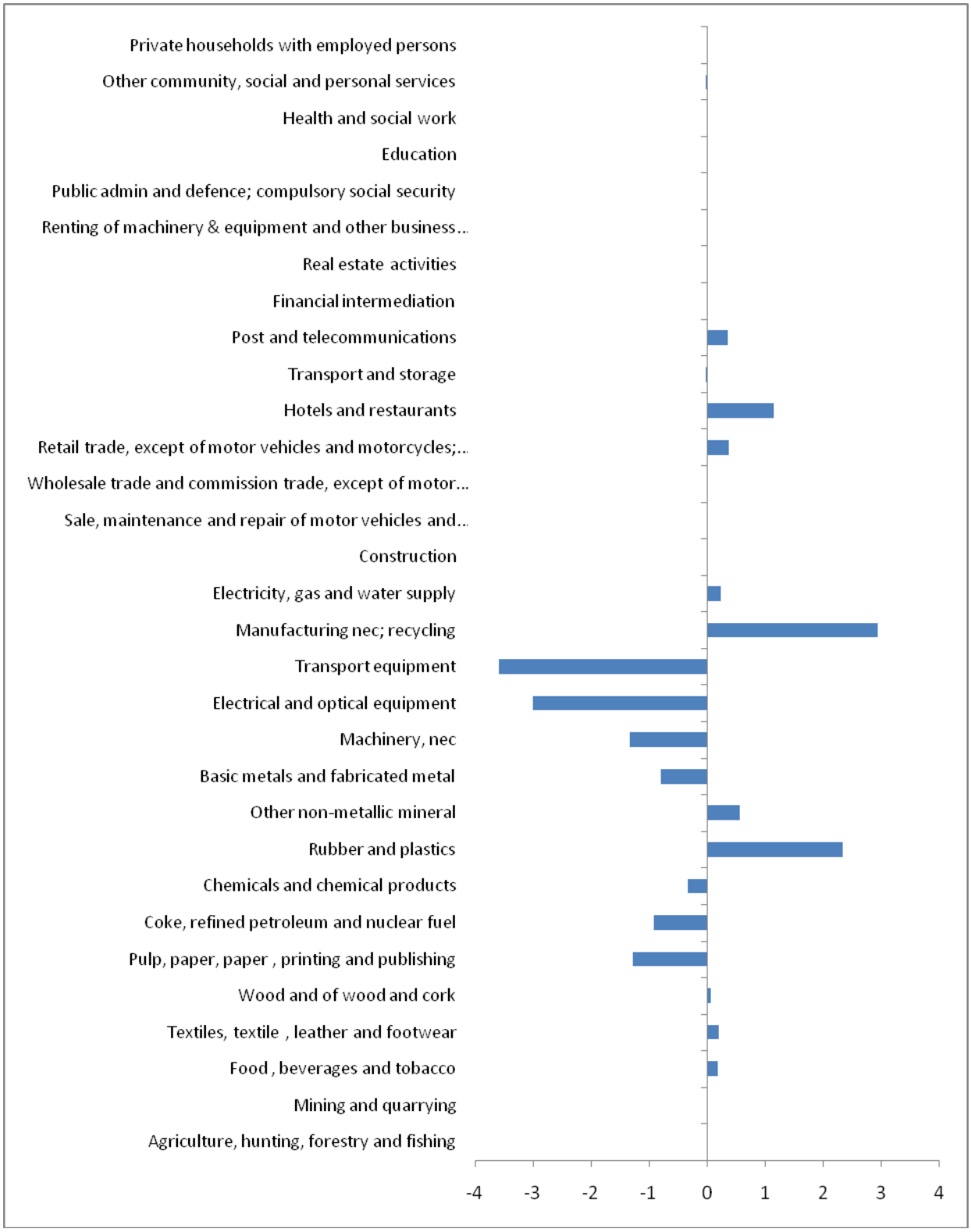
Source: India KLEMS database

Figure A2: Change in Capital Service Growth Rate in Non ICT assets between 1990s and 1980s



Source: India KLEMS database

Figure A3: Change in Capital Service Growth Rate in ICT assets between 1990s and 1980s



Source: India KLEMS database

Table A5: Changes in Capital Quality: 31 India KLEMS Industrial sectors

NIC Code	Industry	1980 - 85	1986 -90	1992 - 96	1997 - 04	1980 - 04
AtB	Agriculture, hunting, forestry and fishing	0.17	0.14	0.30	0.63	0.34
C	Mining and quarrying	0.85	0.21	0.11	-0.06	0.26
15t16	Food , beverages and tobacco	-1.51	1.99	0.92	0.27	0.18
17t19	Textiles, textile , leather and footwear	-0.62	-0.18	0.74	0.19	-0.02
20	Wood and of wood and cork	0.45	0.93	-0.69	-0.45	0.15
21t22	Pulp, paper, paper , printing and publishing	-0.12	0.89	0.79	0.85	0.57
23	Coke, refined petroleum and nuclear fuel	-0.81	-0.47	-4.35	2.97	-0.10
24	Chemicals and chemical products	-0.94	0.38	0.47	0.23	-0.03
25	Rubber and plastics	-0.29	-0.42	1.02	1.12	0.18
26	Other non-metallic mineral	0.83	0.95	0.88	0.88	0.79
27t28	Basic metals and fabricated metal	-0.40	-1.04	3.82	-0.54	0.20
29	Machinery, nec	-0.81	1.01	0.12	0.30	0.12
30t33	Electrical and optical equipment	-2.76	1.62	1.15	0.45	-0.01
34t35	Transport equipment	-0.83	0.08	-1.14	1.42	0.04
36t37	Manufacturing nec; recycling	0.57	0.69	-0.69	-0.76	-0.08
E	Electricity, gas and water supply	0.25	0.22	-0.01	0.00	0.11
F	Construction	0.03	0.03	0.02	-0.01	0.02
50	Sale, maintenance of motor vehicles	0.05	0.19	0.27	0.33	0.22
51	Wholesale trade and commission trade,	0.05	0.19	0.27	0.33	0.22
52	Retail trade	0.05	0.19	0.27	0.30	0.21
H	Hotels and restaurants	1.24	0.51	0.25	0.22	0.54
60t63	Transport and storage	0.11	0.16	0.19	0.01	0.11
64	Post and telecommunications	0.20	0.66	0.41	0.34	0.39
J	Financial intermediation	0.70	0.61	0.54	0.38	0.54
70	Real estate activities	0.00	0.00	0.02	0.26	0.09
71t74	Renting of machinery & equipment and other business activities	0.00	0.00	0.05	0.56	0.20
L	Public admin and defence	0.52	0.30	-0.13	0.12	0.21
M	Education	0.01	0.19	-0.03	0.06	0.06
N	Health and social work	0.04	0.19	-0.05	0.04	0.05
O	Other community, social and personal services	-0.09	0.09	-0.01	0.07	0.02
P	Private households with employed persons	-0.18	0.02	-0.10	0.06	-0.04
	Industry Mean	-0.10	0.33	0.18	0.34	0.18
	Industry Median	0.03	0.19	0.19	0.26	0.15

Source: India KLEMS database