

Making of Digital India:

The challenges in measuring ICT investment and its growth effects in India

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Challenges in measuring ICT investment in Indian economy

- Lack of detailed data on ICT investments, and ICT prices (taking account of rapid changes in technology)
- Substantial amount of software piracy, which will not end up in firms' official investment accounts, but will contribute to productivity!
- Large informal sector
- Significant inconsistency across available data sources (NAS, Prowess, ASI, WITSA)
- Necessary to combine various sources to create a first estimate of ICT investment (i.e. Software, Hardware, and Communication equipment)

Attempts to measure ICT investment in India's aggregate economy

- Jorgenson and Vu (2005), using WITSA to impute ICT investment
 - ✓ Separate WITSA's total spending on ICT, which includes non-investment spending, using United States' ICT investment to ICT spending ratio.
 - overestimate investment in developing countries, as investment/spending ratio might be lower than in the U.S (de Vries et al, 2010)
 - Underestimate ICT investment, as it is likely that most of the ICT spending in developing countries is in the form of investment, as consumption spending on ICT in the early years in low income countries would be relatively low compared to the US (Erumban and Das, 2016)
- Erumban and Das (2016), combining available data on software investment in national accounts, and commodity flow method to impute hardware investment (to be discussed)

Data on ICT investment in India

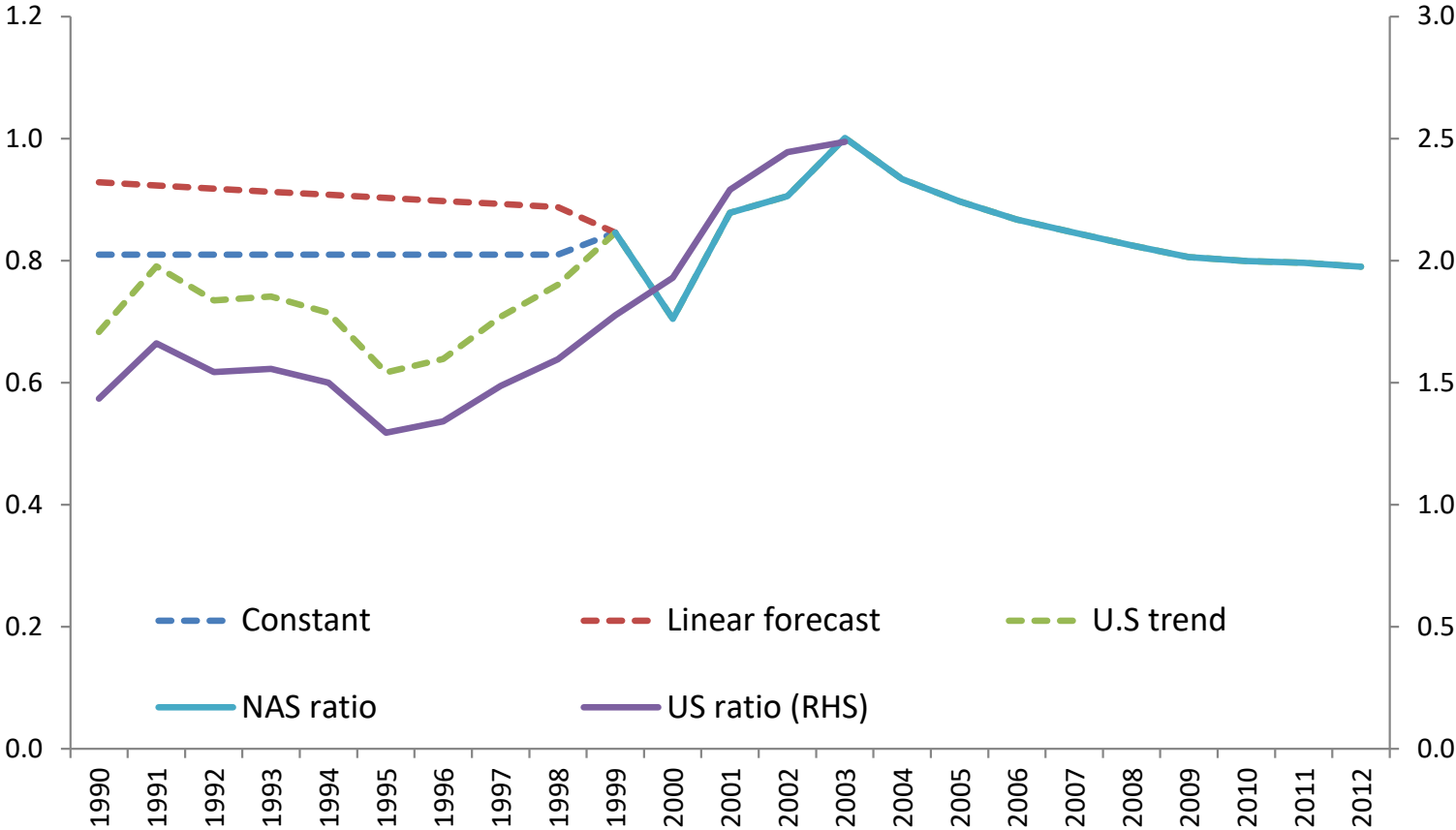
- **Software *investment*** by administrative departments, autonomous bodies, cooperatives, departmental enterprises, household sector, non-departmental enterprises, private corporate sector and public administration from NAS, since 1999 – considered as the benchmark estimate in our data.
- **ICT *investment*** in organized manufacturing since 1993, from ASI
- **ICT *investment*** in unorganized manufacturing, NSSO 62nd round
- PROWESS firm level data on ***gross fixed assets*** in hardware, software & communication equipment
- World Information Technology & Services Alliance (WITSA) 's data on **ICT *spending*** by broad sectors of the economy since 2000.

Measuring software investment in aggregate economy

- Nominal Investment in Software
 - NAS data since 1999 (SNA 1993: software, but excludes own account)
 - For pre-1999, use software/hardware ratio to measured hardware series (to be discussed)
 - Use a constant software/hardware spending ratio from WITSA in 1999 for all years
 - Use a linearly forecasted software/hardware ratio from WITSA
 - Generate a series of software/hardware ratio using the trend in software/hardware ratio in the United States.
 - U.S, being the ICT leader, may provide a realistic picture of the required hardware/software ratio, particularly in the early years
 - The trend in software/hardware ratio for the U.S during 2000-2007 moves in the same direction as that of the Indian data (the simple correlation between the two is 0.8).
 - The U.S data has been obtained from EU KLEMS.

Software/Hardware ratio – the three approaches

Software/hardware ratio, total economy



Measuring Hardware & communication equipment investment in aggregate economy

- No separate data in National Accounts, but is buried in machinery.
- For 1999-2011 period, we apply hardware/software ratio from WITSA to NAS software data, an approach suggested by de Vries et al (2010)
- For years before 1999, we use Commodity Flow Approach

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

- Investment to domestic availability ratio of ICT hardware from benchmark Input -Output Tables (IO) is applied to annual availability of ICT hardware in the domestic economy

Hardware assets: IO and trade concordance

Input Output Table (IOT) and ICT asset concordance

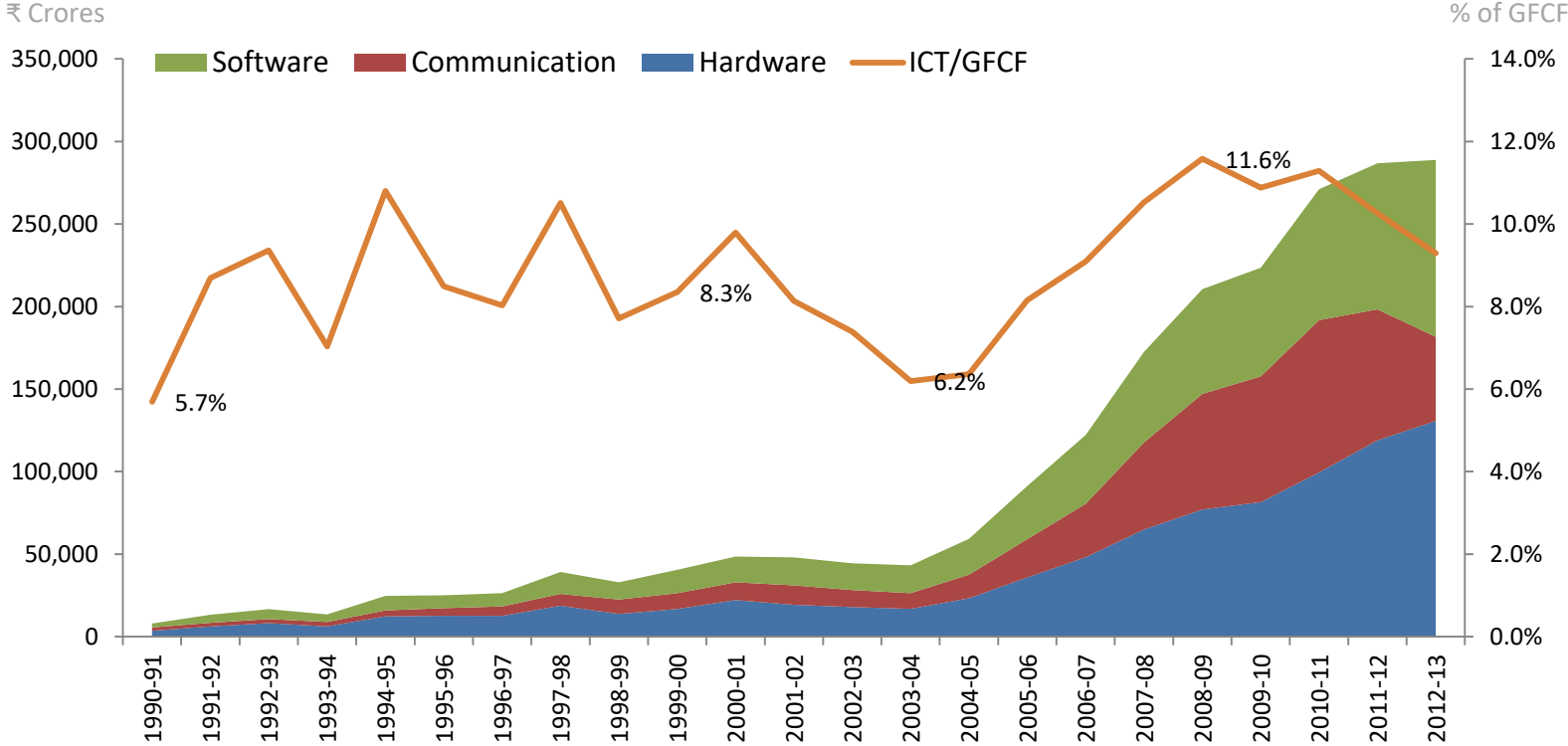
| Benchmark years | IOT sectors | ISIC industries | ICT asset |
|-------------------------|-------------------------------|------------------------|-------------------------|
| 1983, 1989, 1993 & 1998 | Office computing machines | 30 | Hardware |
| | Electronic equipment(incl.TV) | 30 | Hardware |
| | Communication equipment | 32 | Communication equipment |
| 2003 & 2007 | Electronic equipment(incl.TV) | 30 | Hardware |
| | Communication equipment | 32 | Communication equipment |

Trade data and (Comtrade) and ICT asset concordance

| HS revision | HS code | HS industry | ISIC industries | ICT asset |
|--------------------|----------------|------------------------------|------------------------|-------------------------|
| 3 (1998 and after) | 714 | Office machines | 30 | Hardware |
| | 724 | Telecommunications apparatus | 32 | Communication equipment |
| 1 (before 1998) | 75 | office machines, and mach. | 30 | Hardware |
| | 76 | Telecomm, sound equip etc. | 32 | Communication equipment |

ICT investment in India – Estimated data

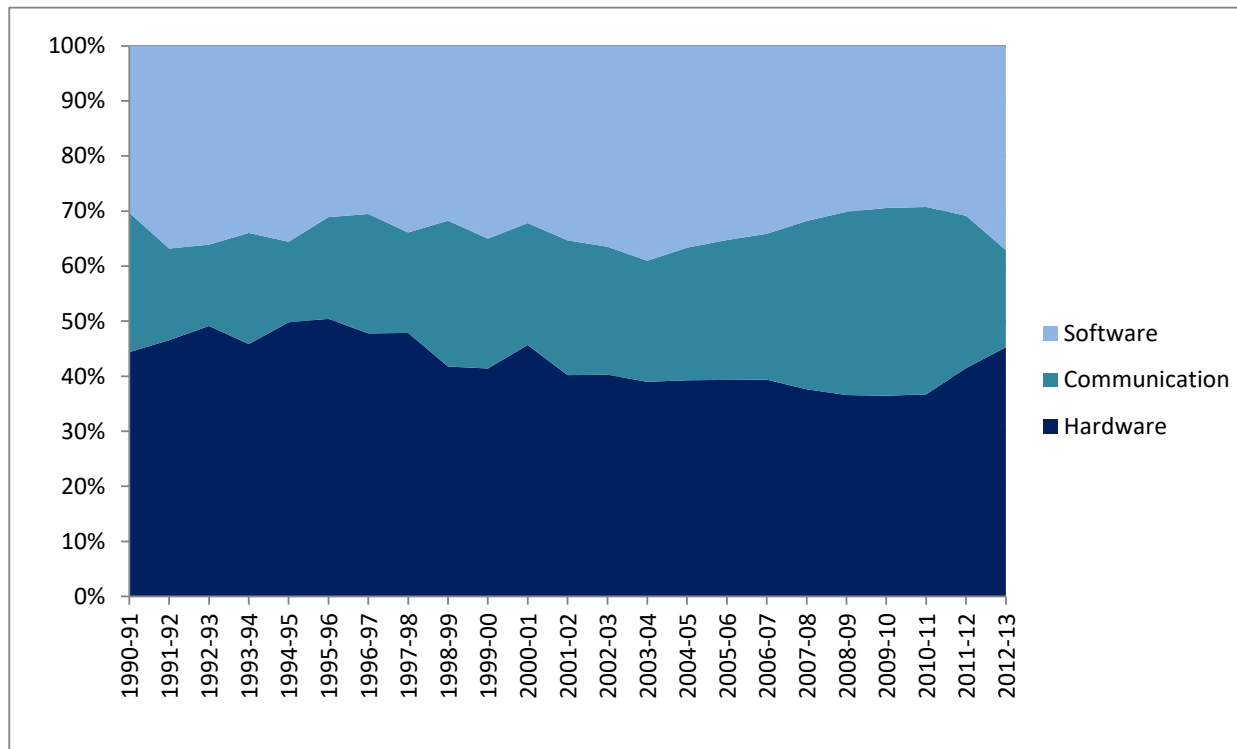
ICT investment (Rs. Crores) and its share in GDP



Source: India KLEMS, Authors' computations using data from National Accounts Statistics, and EU KLEMS

Composition of ICT investment in India – Estimated data

shares of software, hardware and communication equipment in total ICT investment



Source: India KLEMS; Authors' computations using data from National Accounts Statistics, and EU KLEMS

Approach to measure ICT investment for organized manufacturing industries

- Annual Survey of Industries provides (covers industries in the formal sector)
 - ✓ Gross Fixed Capital Formation in current prices for total assets (Factory sector)
 - ✓ Investment in Fixed Assets for 7 individual assets (Land; Building; Plant & Machinery; Transport equipment ; **Computer equipment including software**; Pollution Control Equipment; Others)

- GFCF for any asset (including ICT) from the Fixed assets data obtained as:

$$GFCF_{i,t}^{j_asi} = NVF_{i,t}^{c,j_asi} - NVF_{i,t}^{o,j_asi} + D_{i,t}^{j_asi} - ADR_{i,t}^{j_asi}$$

(Net value of fixed assets (NVF), on closing – NVF on opening + Depreciation during the year – addition due to revaluation)

- ✓ ICT as defined by ASI includes software and hardware, but not communication equipment.

ASI fixed assets schedule: Example of industry food production (15) in 2007-2008 (all values in Rs. Lakhs)

| Types of Assets | Gross Value (Rs. 000') | | | | Depreciation (Rs. '000') | | | | Net Value (Rs.) | |
|---|------------------------|--------------------------|------------------|--|--------------------------|----------------------|--------------------------|-------------------------|------------------------|------------------------|
| | Opening as on ---- | Addition during the year | | Deduction & Adjustment during the year | Closing as on ---- | Up to year beginning | Provided during the year | Up to year end (8+9) | Opening as on ----- | Closing as on ----- |
| 2 | Due to revaluation | Actual Addition | 6 | | (3+4+5-6) | | | | 8 | 9 |
| 1 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 Land | 346,496 | 25,224 | 67,623 | 6,525 | 417,839 | 3,805 | 490 | 4,229 | 396,582 | 482,568 |
| 2 Building | 1,427,116 | 15,543 | 250,910 | 11,518 | 1,651,114 | 399,857 | 81,554 | 459,616 | 1,249,114 | 1,424,485 |
| 3 Plant & Machinery | 5,181,320 | 24,921 | 1,118,921 | 68,849 | 6,157,510 | 2,285,977 | 392,100 | 2,607,042 | 3,251,903 | 3,951,832 |
| 4 Transport equipment | 199,423 | 45 | 59,819 | 13,960 | 228,716 | 101,475 | 30,002 | 116,230 | 155,769 | 177,168 |
| 5 Computer equipment including software | 63,249 | 9 | 12,781 | 1,099 | 73,871 | 42,548 | 9,146 | 49,867 | 22,594 | 26,005 |
| 6 Pollution Control Equipment | 54,622 | 2 | 9,697 | 139 | 64,053 | 25,033 | 3,740 | 28,374 | 31,338 | 37,200 |
| 7 Others | 475,123 | 1,657 | 82,990 | 11,080 | 539,896 | 248,120 | 41,657 | 280,660 | 257,574 | 294,437 |
| 8 Sub-total (2 to 7) | 7,400,853 | 42,177 | 1,535,117 | 106,645 | 8,715,160 | 3,103,009 | 558,198 | 3,541,789 | 4,968,291 | 5,911,128 |
| 9 Capital work in progress | 474,152 | 0 | 302,488 | 328,053 | 434,456 | 299 | 215 | 722 | 498,310 | 439,788 |
| 10 Total (1+8+9) | 8,221,501 | 67,401 | 1,905,228 | 441,223 | 9,567,455 | 3,107,113 | 558,903 | 3,546,740 | 5,863,183 | 6,833,484 |
| GFCF | | - R | | | | | + D | | - O | + C |

ASI fixed assets schedule: Example of industry food production (15) in 2007-2008 (all values in Rs. Lakhs)

| Types of Assets | Gross Value (Rs. 000') | | | | Depreciation (Rs. '000') | | | | Net Value (Rs.) | | |
|---|------------------------|--------------------------|---------------|--|--------------------------|----------------------|--------------------------|-------------------------|------------------------|------------------------|------------------|
| | Opening as on ---- | Addition during the year | | Deduction & Adjustment during the year | Closing as on ---- | Up to year beginning | Provided during the year | Up to year end (8+9) | Opening as on ----- | Closing as on ----- | |
| ----- | Due to revaluation | Actual Addition | (3+4+5-6) | | (3-8) | | | | (7-10) | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 Land | | | | | | | | | | | |
| 2 Building | | | | | | | | | | | |
| 3 Plant & Machinery | | | | | | | | | | | |
| 4 Transport equipment | | | | | | | | | | | |
| 5 Computer equipment including software | | | 9 | | | | | 9,146 | | 22,594 | 26,005 |
| 6 Pollution Control Equipment | | | | | | | | | | | |
| 7 Others | | | | | | | | | | | |
| 8 Sub-total (2 to 7) | | | | | | | | | | | |
| 9 Capital work in progress | | | | | | | | | | | |
| 10 Total (1+8+9) | | | 67,401 | | | | | 558,903 | | 5,863,183 | 6,833,484 |
| GFCF | | | - R | | | | | + D | | - O | + C |

Total GFCF as reported in Factory Sector ASI results:

1,461,802

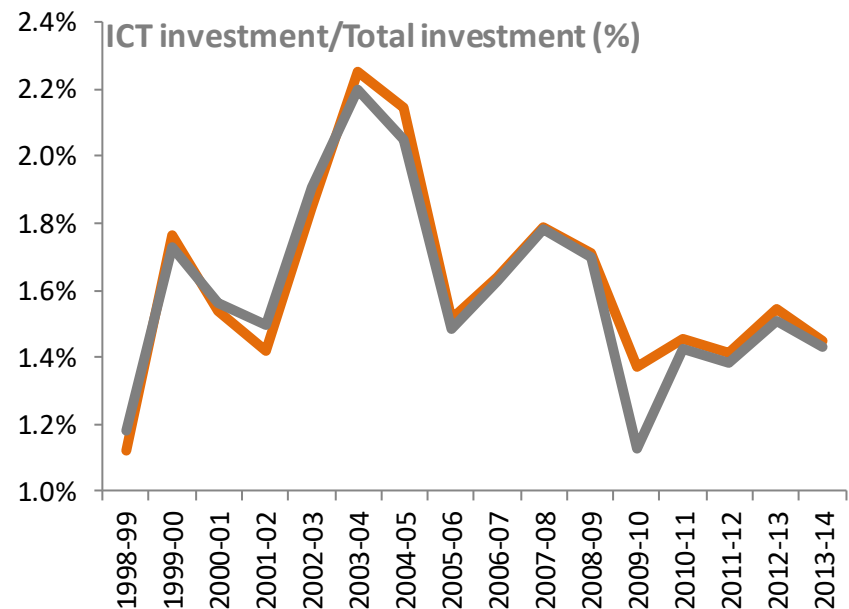
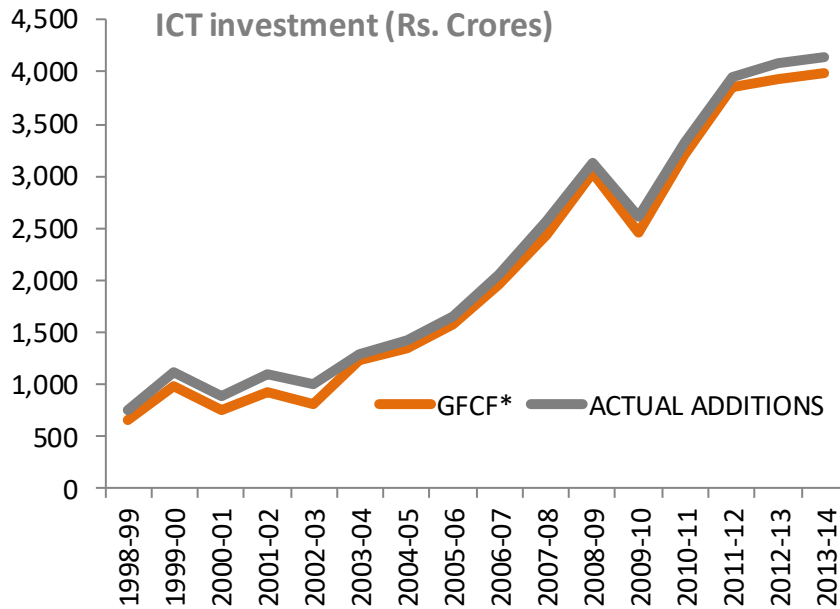
Estimated GFCF from ASI Fixed Assets Schedule , as: 12 - 11 + 9 - 4:

1,461,803

Estimated GFCF in ICT from ASI Fixed Assets Schedule:

12,548

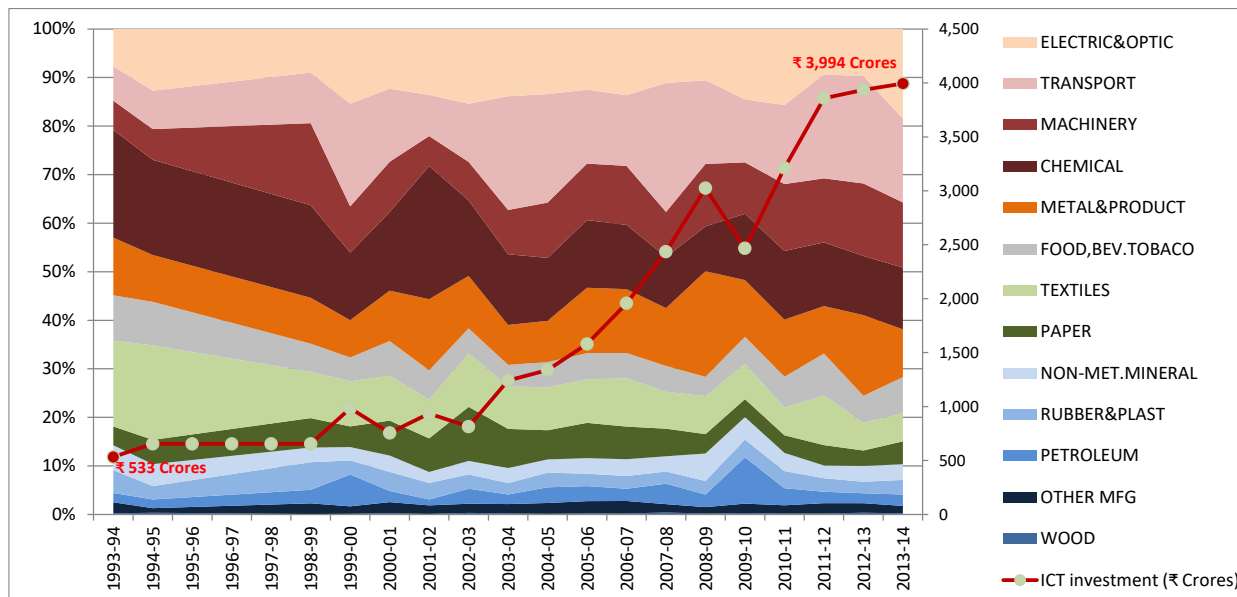
While the absolute level of ICT investment has increased over time, it has not increased at the same speed as other forms of investment in organized manufacturing



Note: *GFCF is obtained using ASI tabulation procedure, i.e. actual additions to ICT assets – deductions during the year
 Source: Annual Survey of Industries

Electric & optical equipment, transport equipment, machinery and Chemical sectors absorb a major chunk of ICT investment in formal manufacturing

Sectoral composition of ICT investment in registered manufacturing % of total GFCF

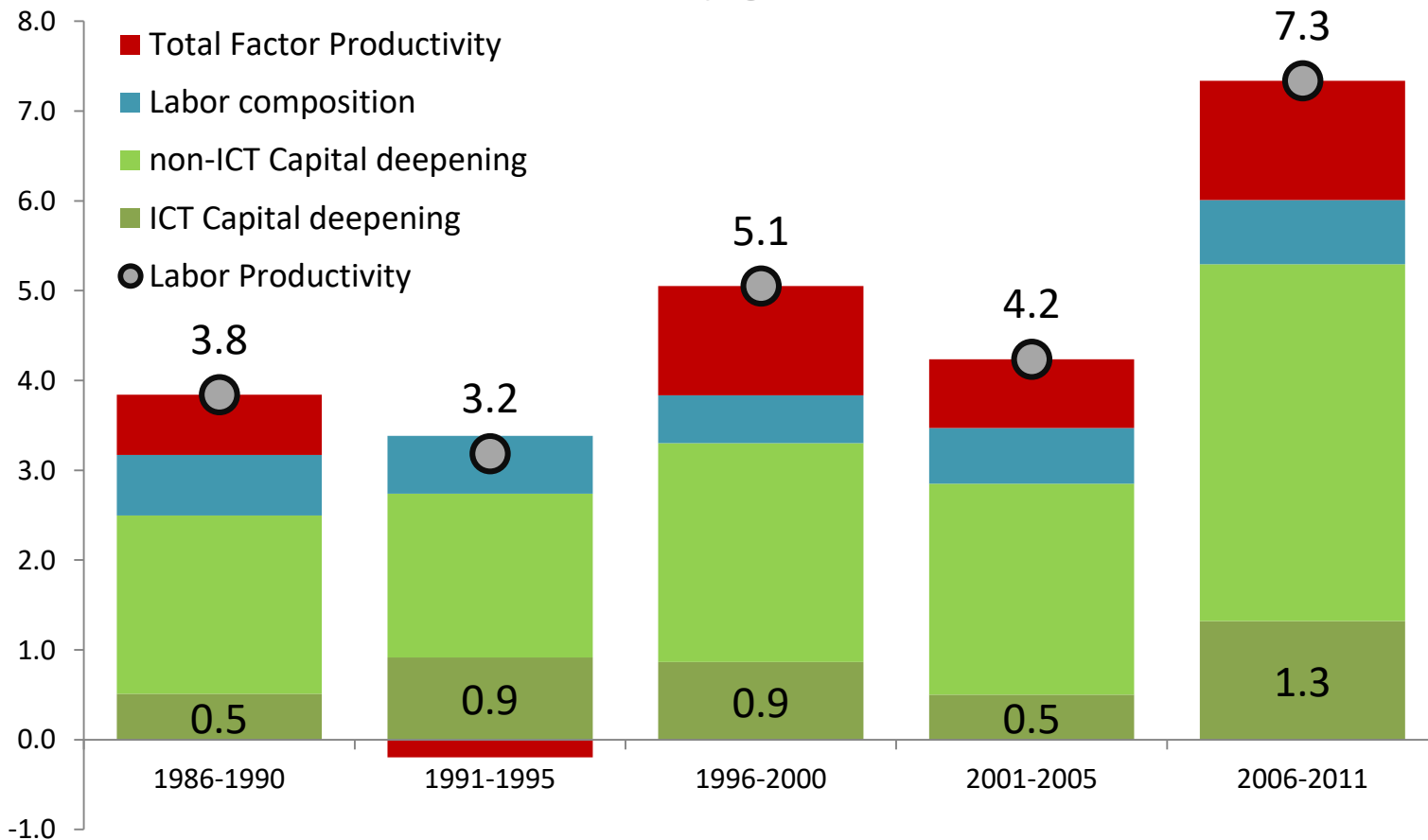


Note: industries are ranked in order of their relative ICT investment size in 2013-2014. All numbers are consistent with ASI factory sector data, and not necessarily consistent with national accounts data.

Source: Authors' computations using data from Annual Survey of Industries

ICT deepening contribution to labor productivity growth has increased in India over time

Decomposition of labor productivity growth

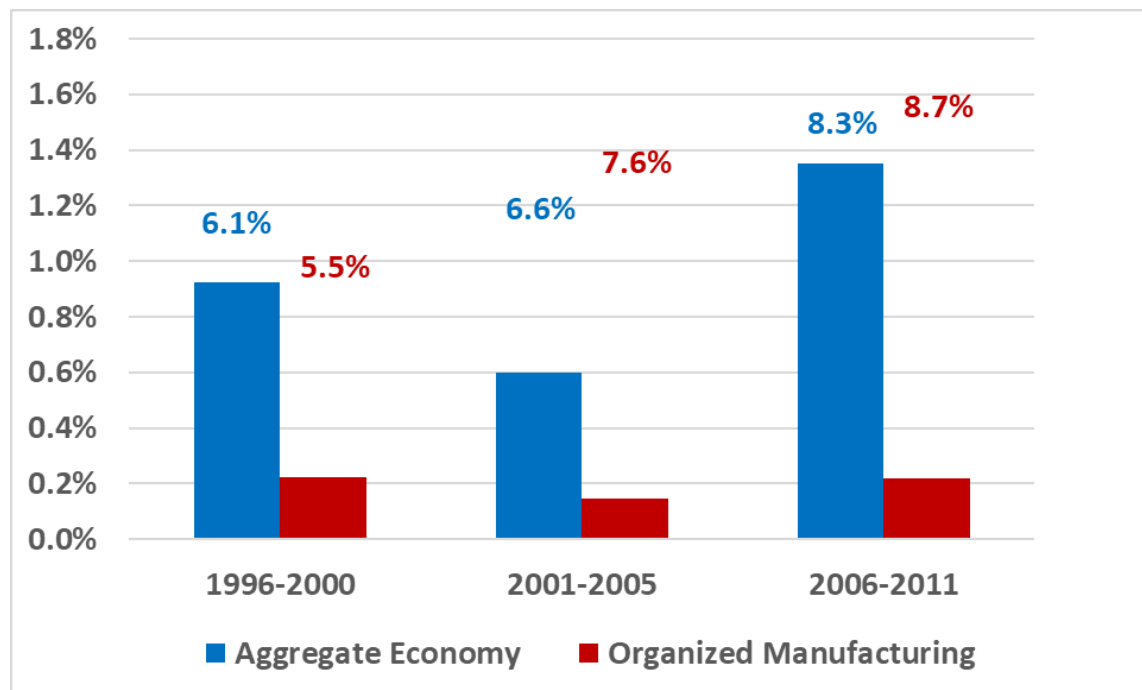


Source: India KLEMS version 2015, Erumban and Das (2016)

Note: aggregate growth accounting using production possibility frontier approach

Data seem to suggest that most of India's ICT growth contribution is in the services sector?

Contribution of ICT (hardware and software only) capital to value added growth



Note: The results in this chart are made consistent with national accounts data (see text).
Source: Authors' computations using data from ASI and NAS.

- Contribution of ICT to growth has increased in organized manufacturing over 2001-2005 to 2006-2011
- But the magnitude of increase is relatively small compared to the magnitude of increase in the aggregate economy.
- Part of it is due to the exclusion of communication equipment in ICT in manufacturing
- But that alone may not explain, perhaps more use of ICT is in India's service economy

ICT contribution to manufacturing growth increased from 2001-2005 to 2006-2011 period, but that varies across industries.

Contribution of ICT (hardware and software only) capital to value added growth, Registered Manufacturing Sector



- Contribution of ICT capital (excluding telecommunication equipment) in registered manufacturing sector is about 0.2 percentage point over the period 2001-2011
- paper, printing and publishing, and electrical and optical equipment industries did see massive decline in ICT's contribution.
- 11 out of 13 industries have witnessed an increase, albeit small in magnitude, in the absolute contribution of ICT to growth

Note: The results in this chart are made consistent with national accounts data (see text).

Source: Authors' computations using data from ASI and NAS.

Consistency with National Accounts reported ICT investment: Some caveats

- Aggregate economy data is fully consistent with available data on Software in NAS, and imputed data using commodity flow approach
- The estimated ICT in organized manufacturing sectors does not include communication equipment.
- The software data available in NAS for organized manufacturing is not consistent with the software data obtained from ASI
- Imposing consistency with NAS by applying ICT/ Total GFCF ratio in ASI to Total GFCF in NAS $GFCF_{ICT,t}^j = [GFCF_{ICT,t}^{j-asi} / GFCF_t^{j-asi}] GFCF_t^j$ underestimates total manufacturing ICT (hardware + software) investment, as it produces an investment value much smaller than NAS reported software investment.

To sum up

- Creating an ICT investment series for India is challenging due to lack of data, and the inconsistency between available sources
- Our estimates for the aggregate economy suggests a continued increase in nominal ICT investment, since the early 2000s, but not at the same pace as the overall investment expansion.
- The composition of ICT investment remained by and large constant over time, yet, there has been a decline in communication equipment recently, while both software and hardware did increase
- In the organized manufacturing also absolute levels of investment has increased, but not relative to total investment.
- Much of the ICT investment is in tech sectors – electrical and optical equipment, transport equipment, machinery and chemical sectors.
- Manufacturing sector lags quite behind the aggregate economy in using IT to improve GDP growth, implicitly suggesting a rather intense ICT use in services
- Dealing with inconsistency in NAS data and ASI data poses a major challenge