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Global Growth Accounting: The role of shifting investment patterns

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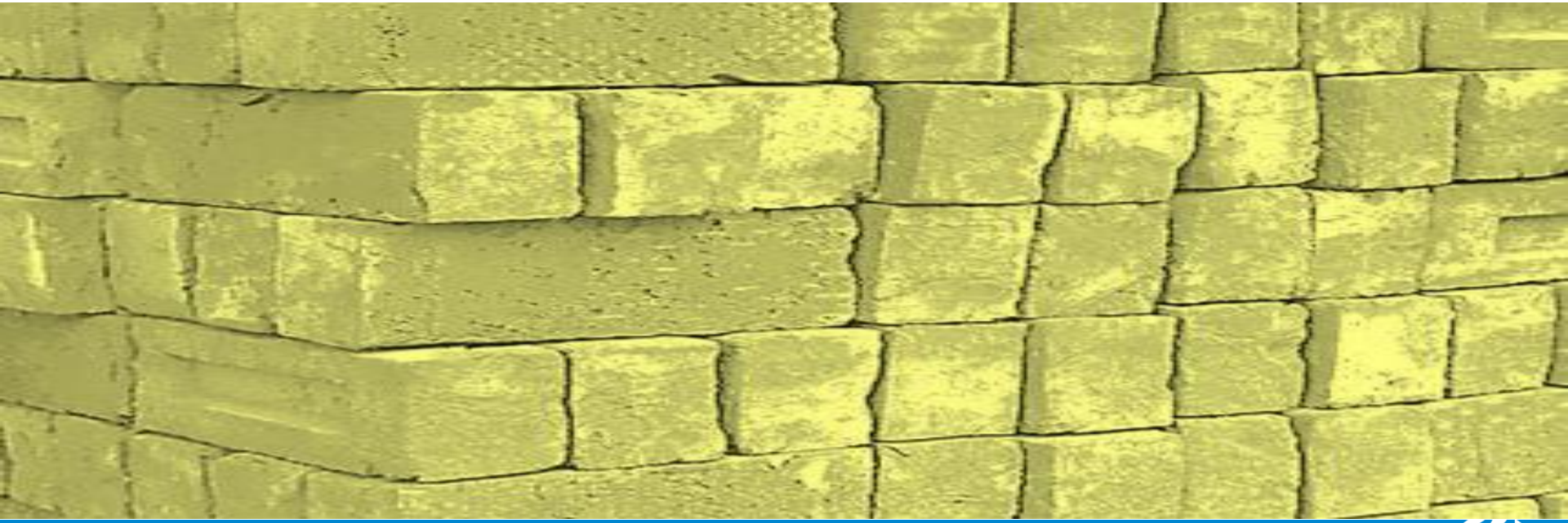

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The background and objectives

- Investment and capital are important factors in understanding cross-country income differences
  - ✓ But there is limited available data, especially on investment by asset
- PWT and TED have investment data for productivity estimation
  - ✓ But these do not yet reflect SNA 2008 changes
  - ✓ And PWT and TED have used different data sources
- Main use PWT: capital and productivity growth and levels
- Main use TED: productivity growth and role of ICT assets

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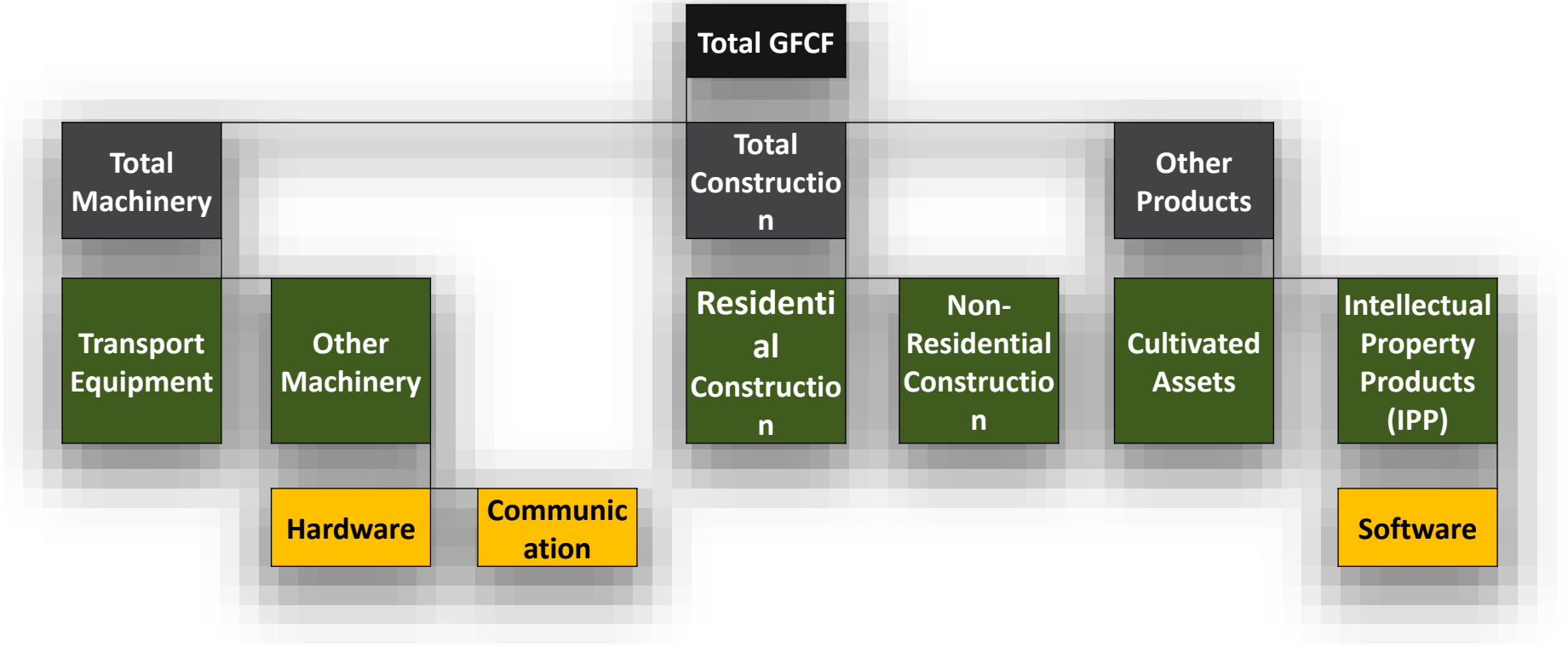
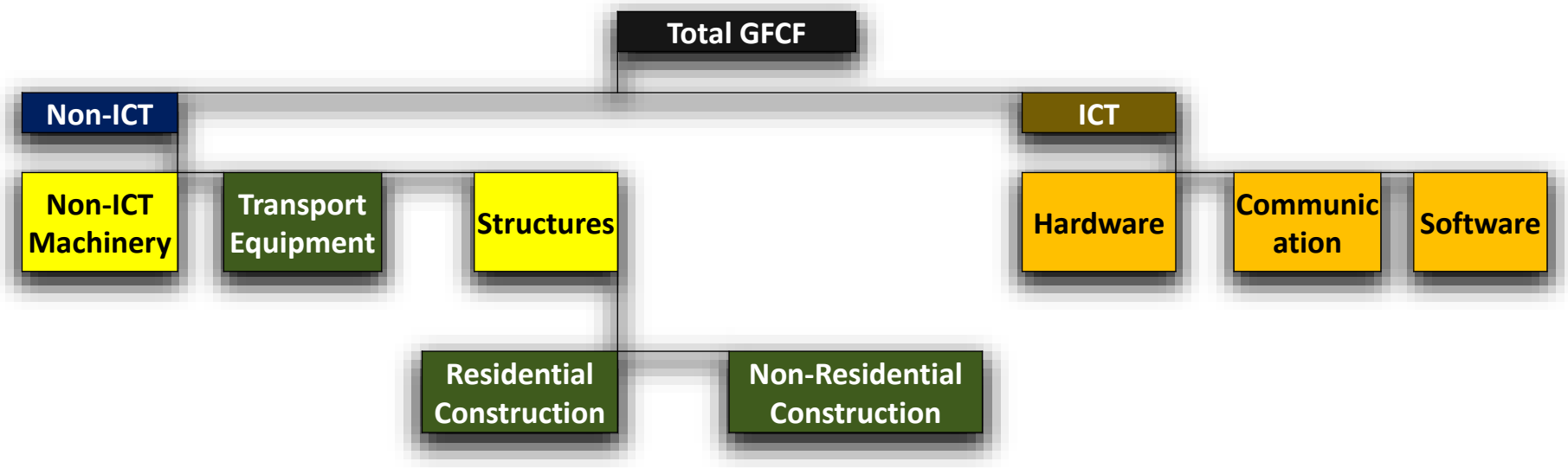
Asset detail



These are further aggregated into ICT and non-ICT categories in TED



- Notes:
  - ✓ In TED: Non-ICT Machinery consists of 'Other Machinery (excluding hardware and communication)', 'IPP' and 'Cultivated assets' (whenever available)
  - ✓ Structures: inclusion of residential structure?

Approach

1. Total gross fixed capital formation from National Accounts
2. Split by asset based on:
   a. National Accounts data
   b. WITSA data (ICT)
   c. Commodity Flow Method
3. Respect national values and prices
   a. Except for ICT assets: harmonized US deflators

Contrast to current data

1. Coverage of all investment, not only non-residential (TED)
2. Broader country coverage and more use of national accounts sources (PWT/TED)
3. More sophisticated estimation of ICT investment from WITSA (TED/PWT)

Methodological approach

1. Asset-wise real investment data
2. Depreciation rates
3. Capital Stock (Perpetual Inventory Method – PIM)
4. Rate of return (internal) – capital compensation share
5. Rental prices
6. Capital services

Initial capital stock, and Perpetual Inventory Method (PIM)

- Perpetual inventory method, capital stock in any individual asset:

$$S_{it} = S_{it-1}(1 - \partial_i) + I_{it}$$

- Initial capital stock
  - ✓ steady state assumption (Solow) – Harberger, 1978 approach:

$$\left(\frac{K}{Y}\right)_0 = \frac{I/Y}{(\partial + g)}$$

  - ✓ assume capital/output ratios in starting year
    - – More robust approach than steady-state/Harberger (1978) approach (Feenstra et al., 2015)

Capital services

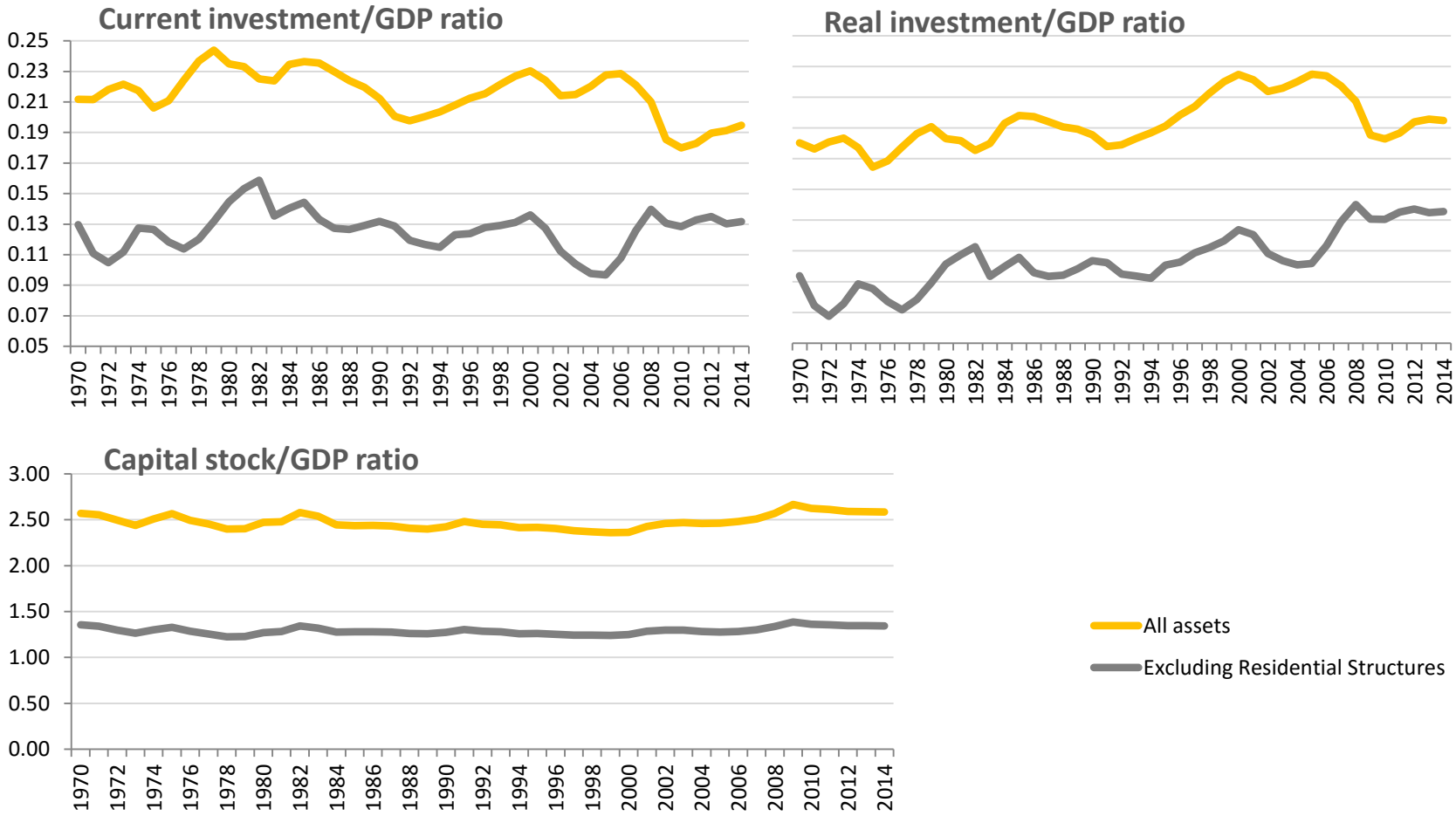
- Capital services growth rates are obtained as a weighted average of individual asset-wise capital stock, the weights being the rental share of each asset in total capital compensation

$$\Delta lnK_t = \sum_{k} \bar{v}^{S}_{i,t} \Delta lnS_{i,t}$$

K=aggregate capital services, $\bar{v}^{S}_{i,t}$=share of asset i in total capital compensation (average for current and previous year)

- Also aggregate over sub-groups of ICT and non-ICT assets
- Capital compensation for each asset is obtained using rental prices (user cost of capital) constructed using internal rate of return
- Total capital compensation obtained after subtracting labor compensation from GDP

Inclusion of residential construction has important implications for aggregate capital/output ratio



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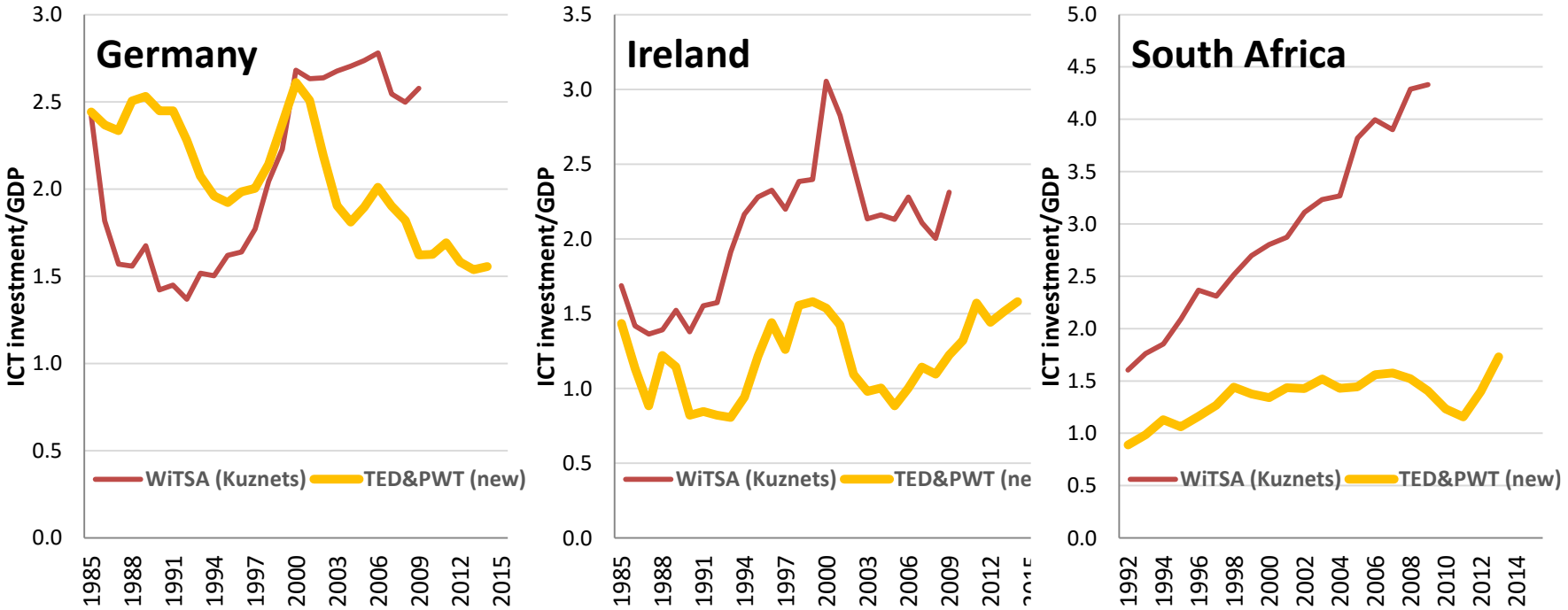
Estimates of ICT using WiTSA and U.S Investment/spending ratio are quite different from actual national accounts data

ICT investment/GDP ratio, WITSA (Jorgenson and Vu, 2013), EU KLEMS and national accounts (TED & PWT)



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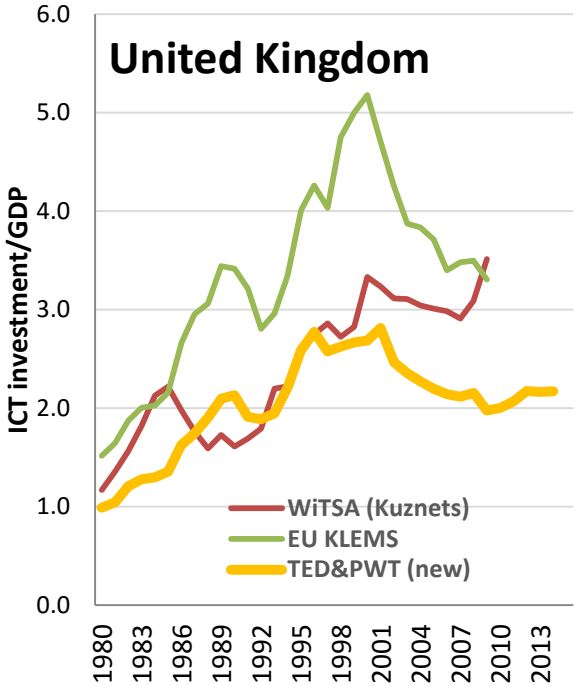
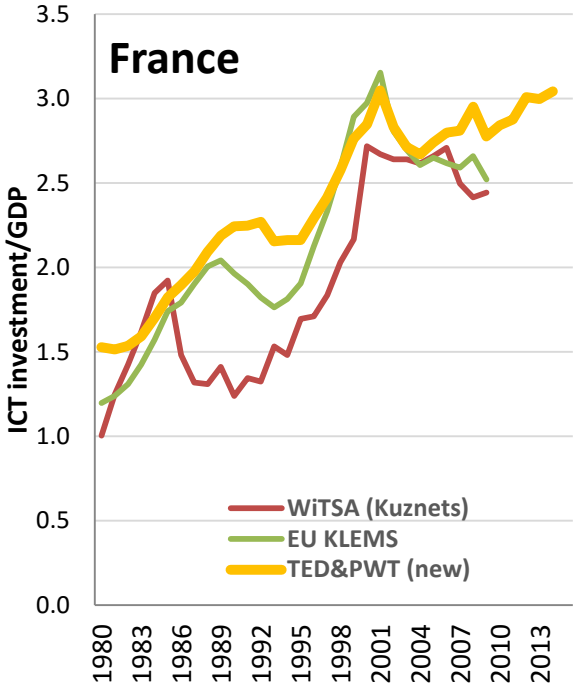
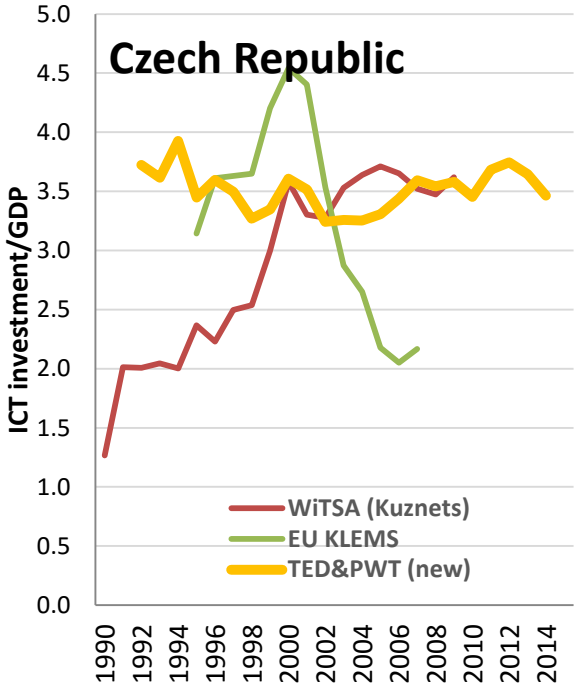
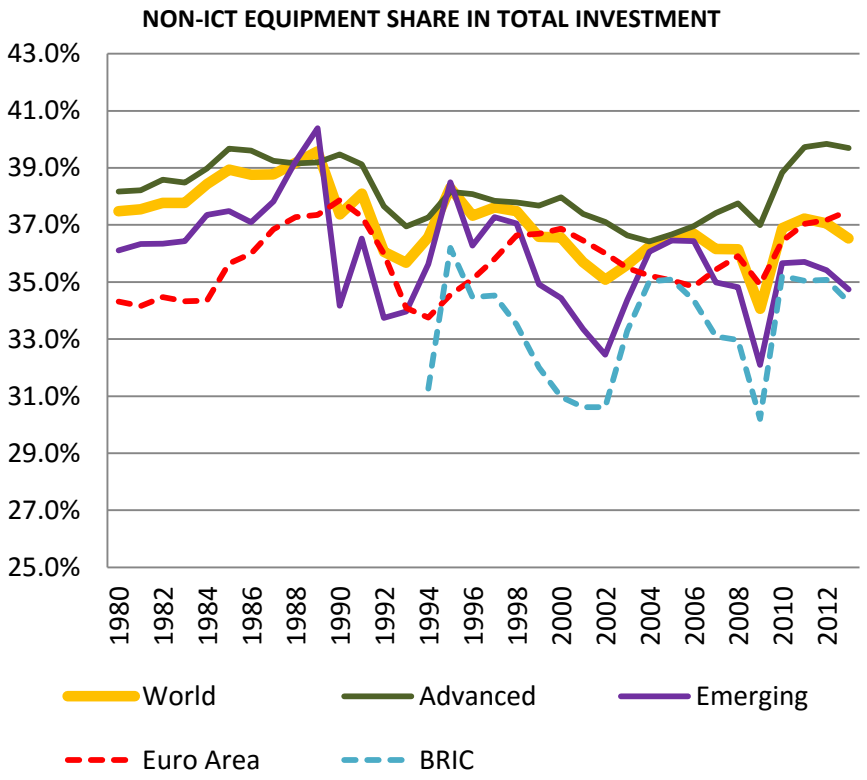
ICT investment in EU KLEMS is also different from national accounts data (SNA 2008) for some countries

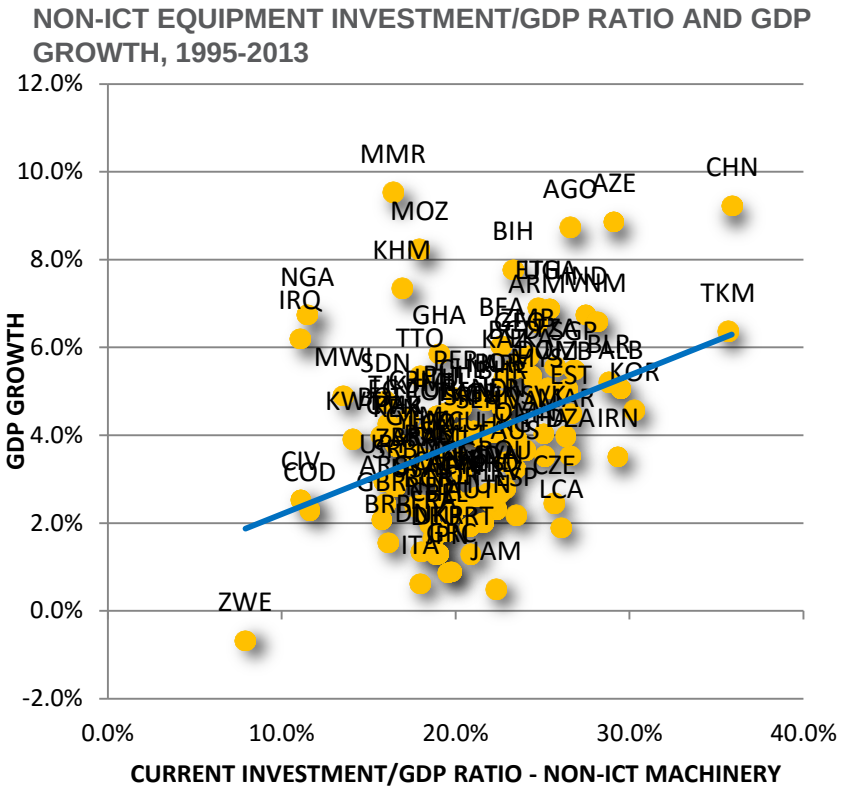






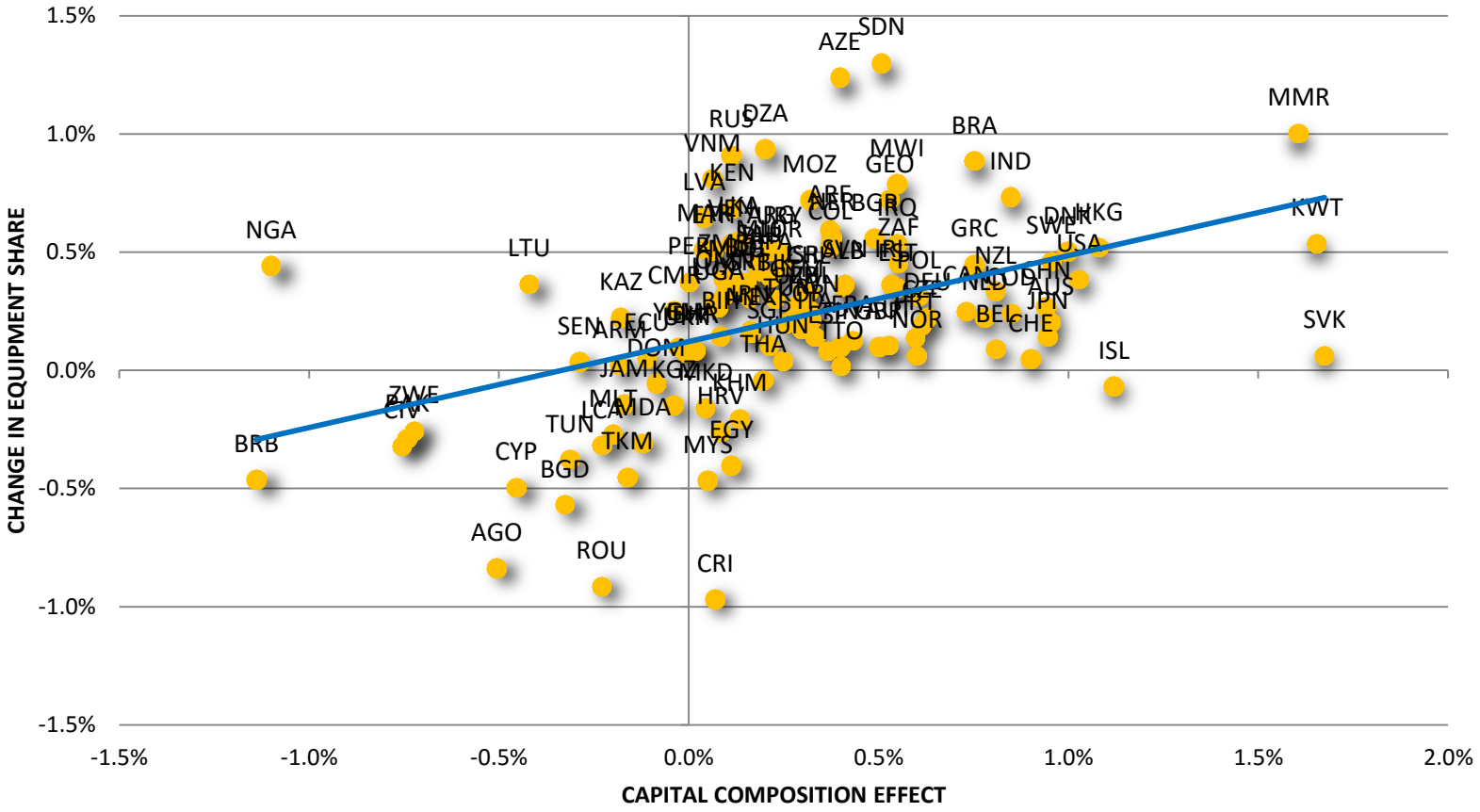
There is a strong correlation between investment in equipment capital and GDP growth





Equipment investment in general results in higher capital composition effect, as the share of productive assets increases

CAPITAL COMPOSITION EFFECT AND CHANGE IN EQUIPMENT SHARE, 1995-2013



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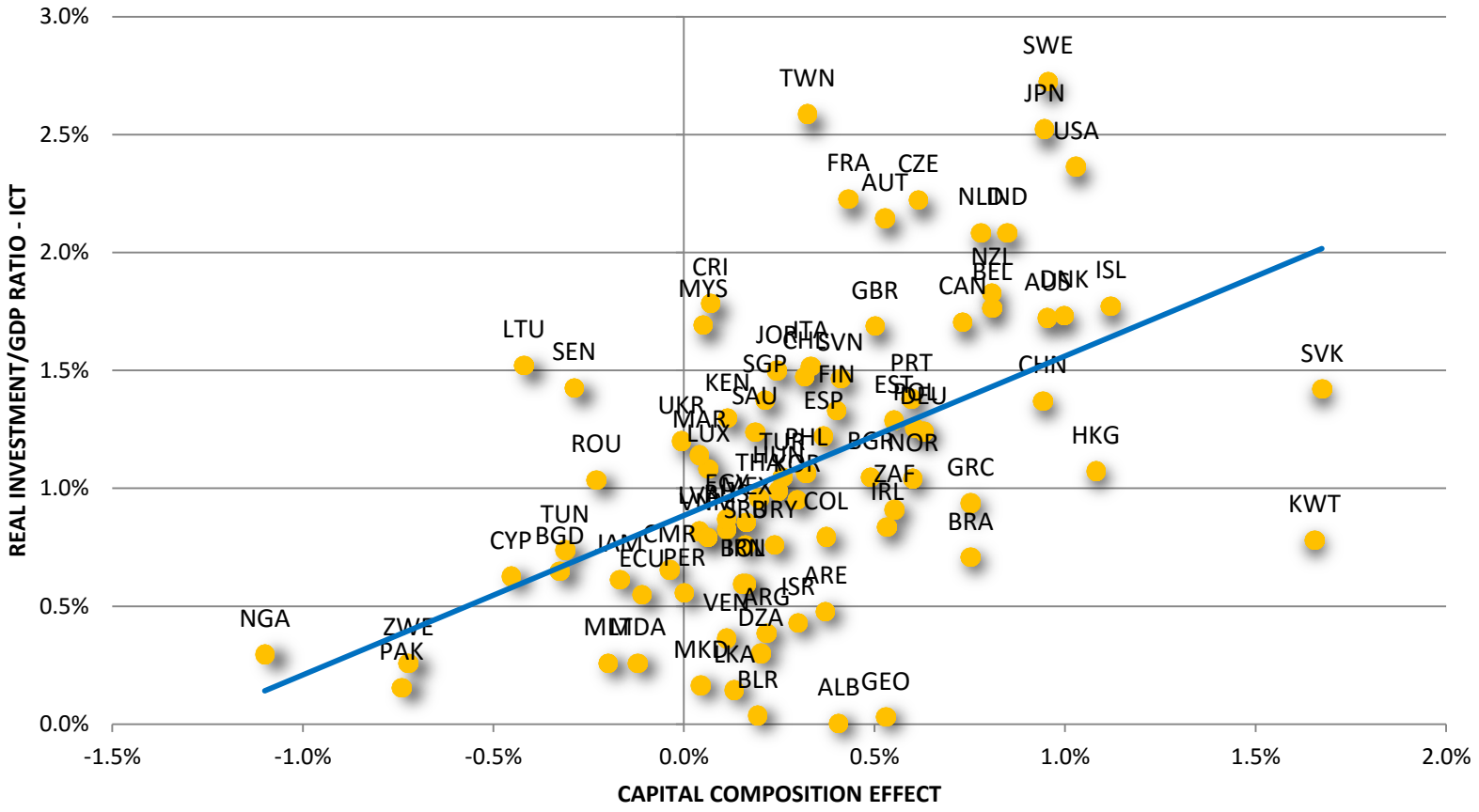
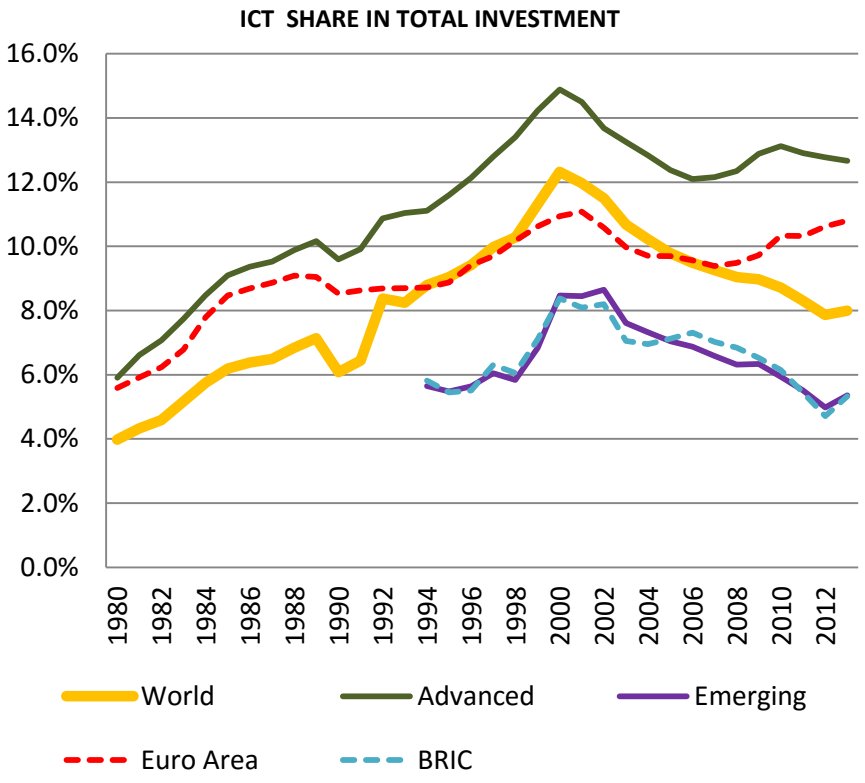
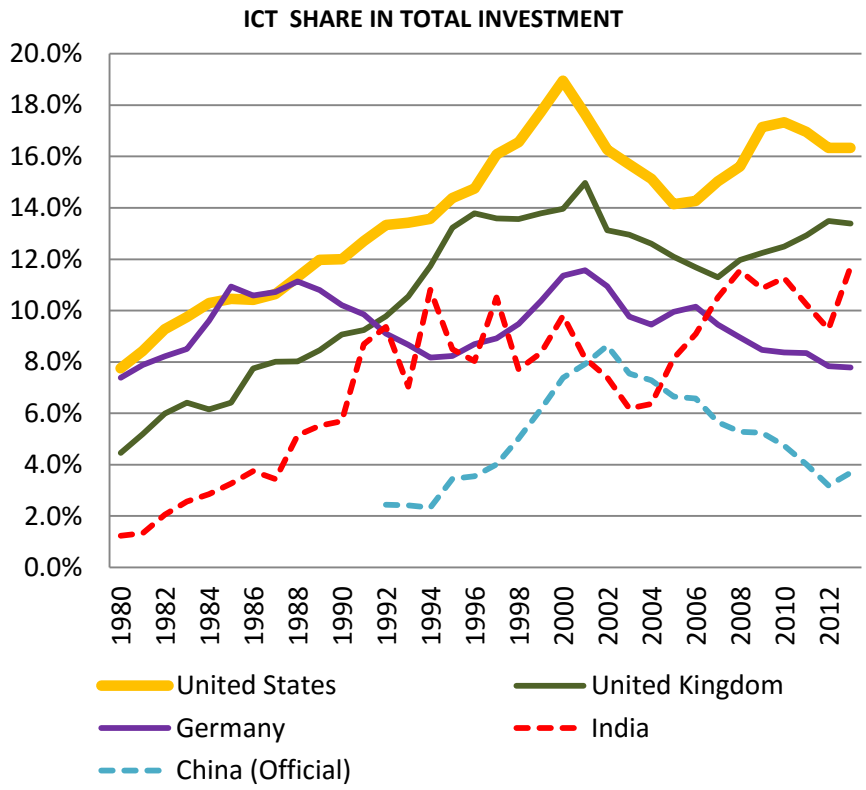
Increases in the ICT investment share results in higher capital composition effect

CAPITAL COMPOSITION EFFECT AND REAL ICT INVESTMENT/GDP RATIO , 1995-2013

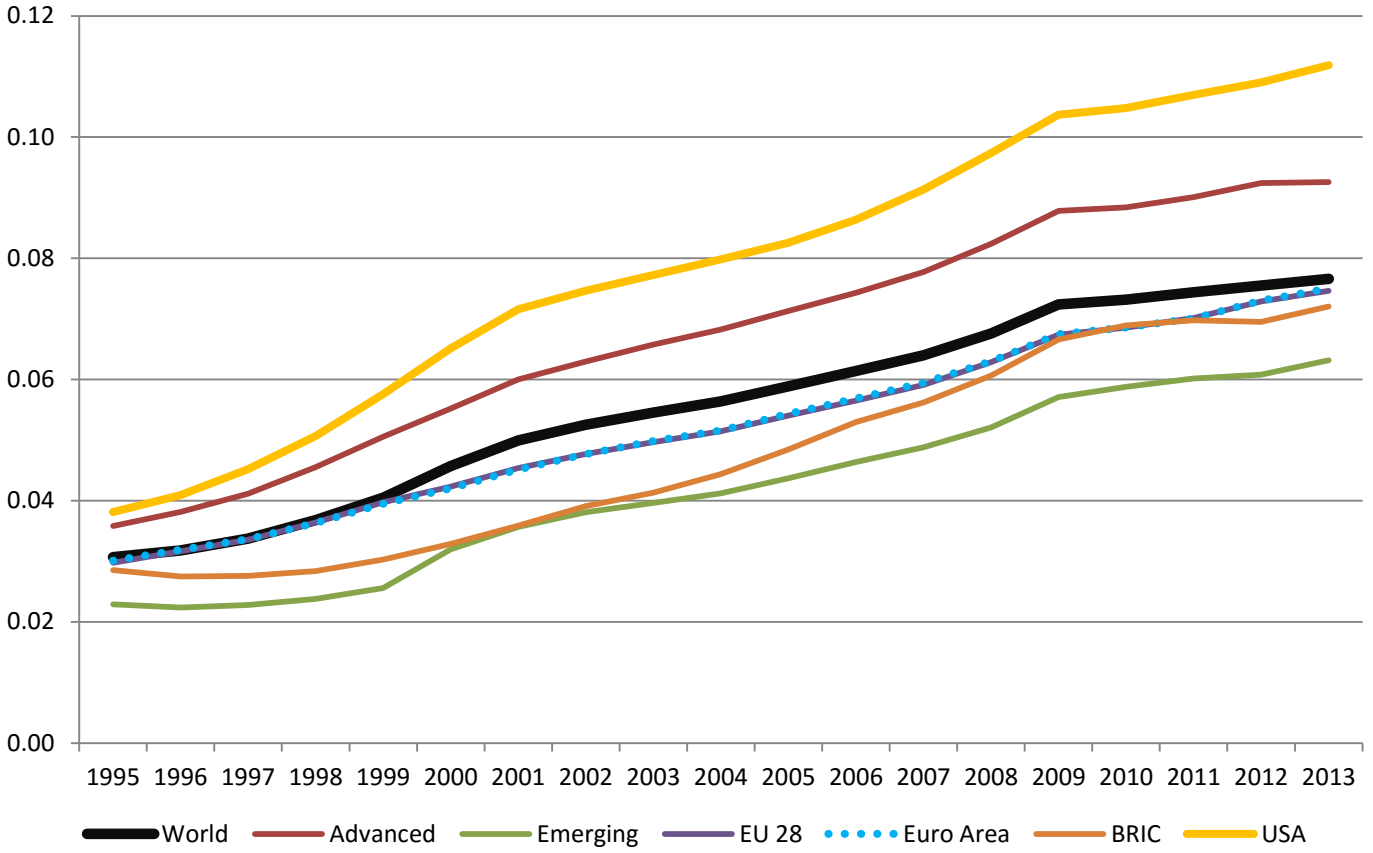


ICT share in investment has declined after the peak in early 2000s in most countries



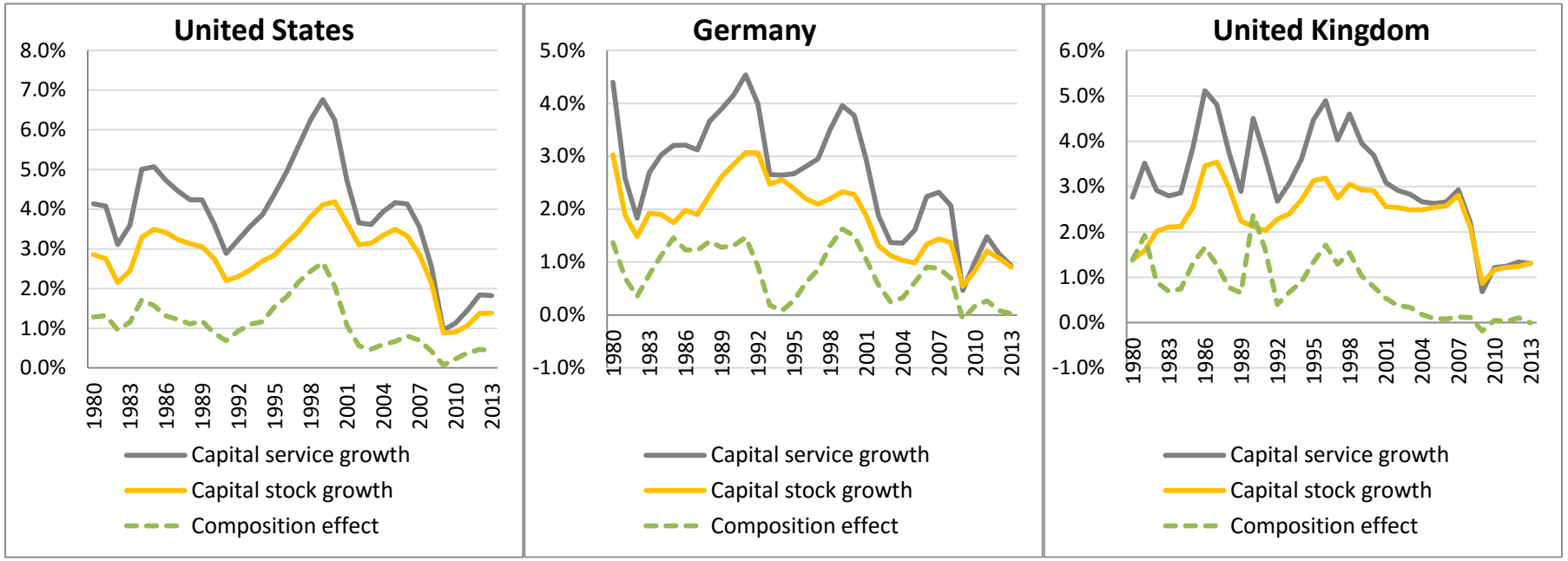


Consequently, ICT capital/output ratio has increased across regions until 2008, since then the speed has slowed

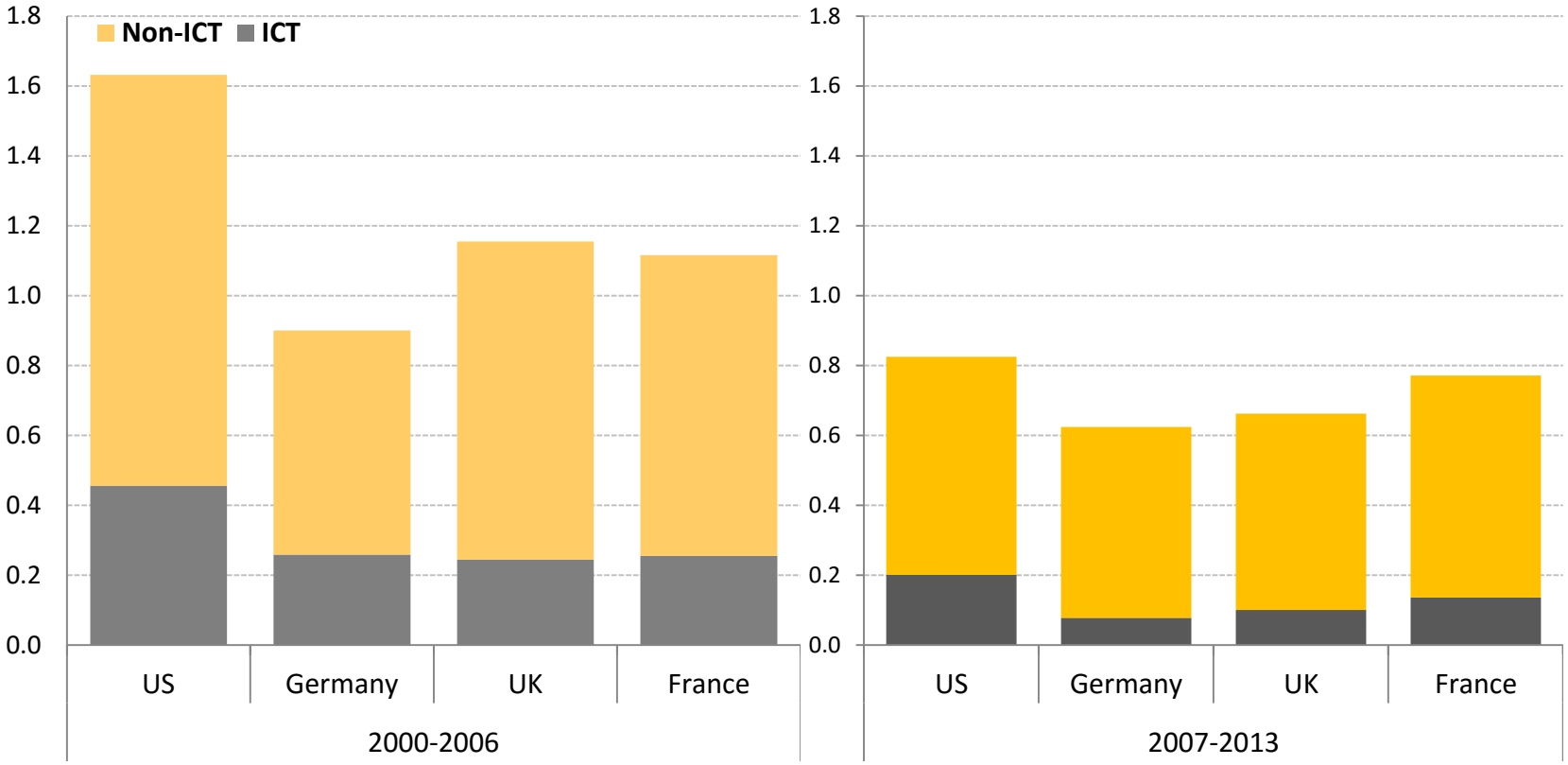


The compositional shift towards more productive assets has eroded in general in the recent years

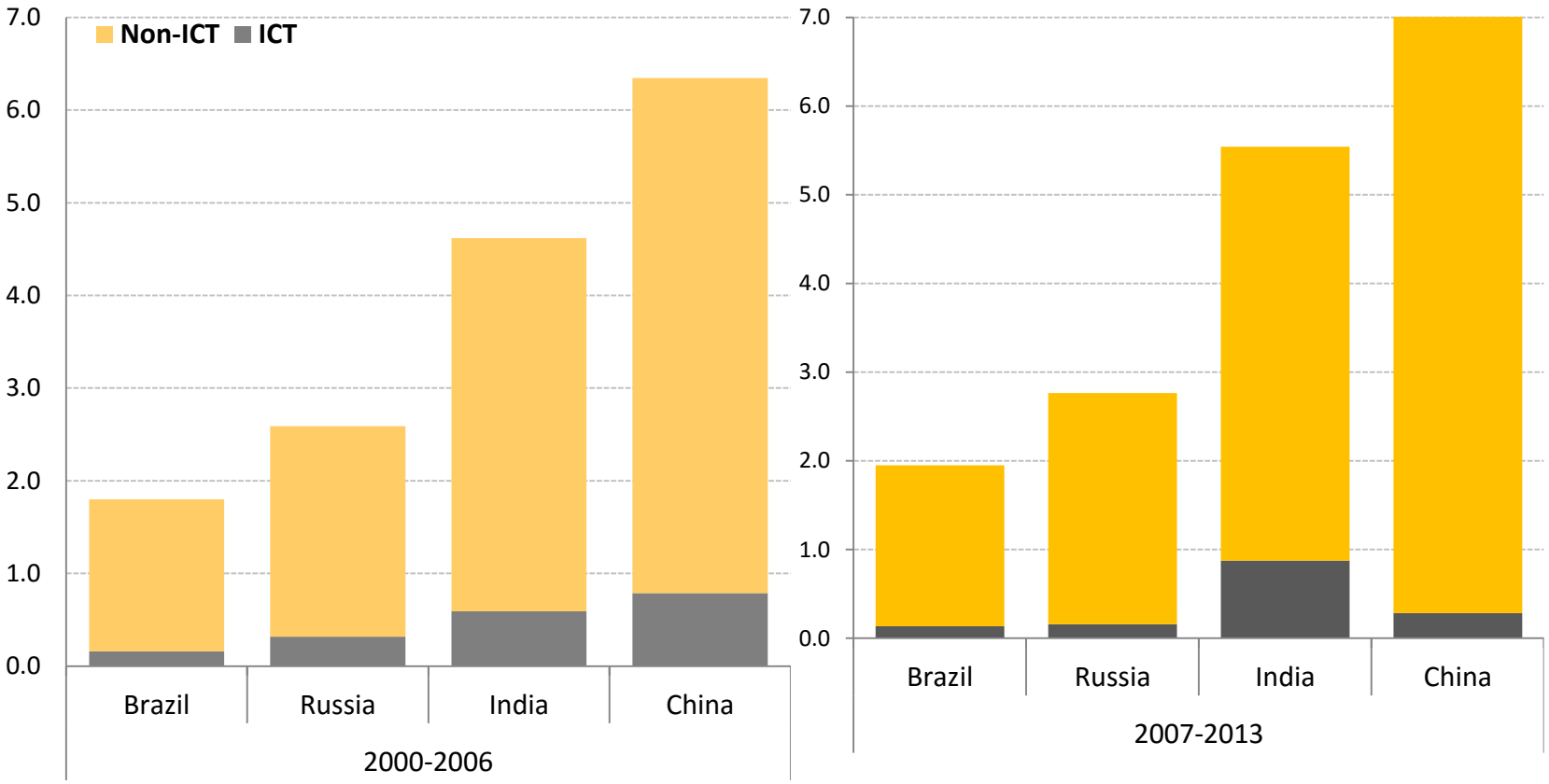
Growth rates of Capital Stock, Capital Service and Capital composition Effect



Contribution of capital, in general and ICT in particular, to GDP growth has declined in most advanced economies



While contribution of non-ICT capital as increased in almost all BRIC countries, ICT has declined except in India



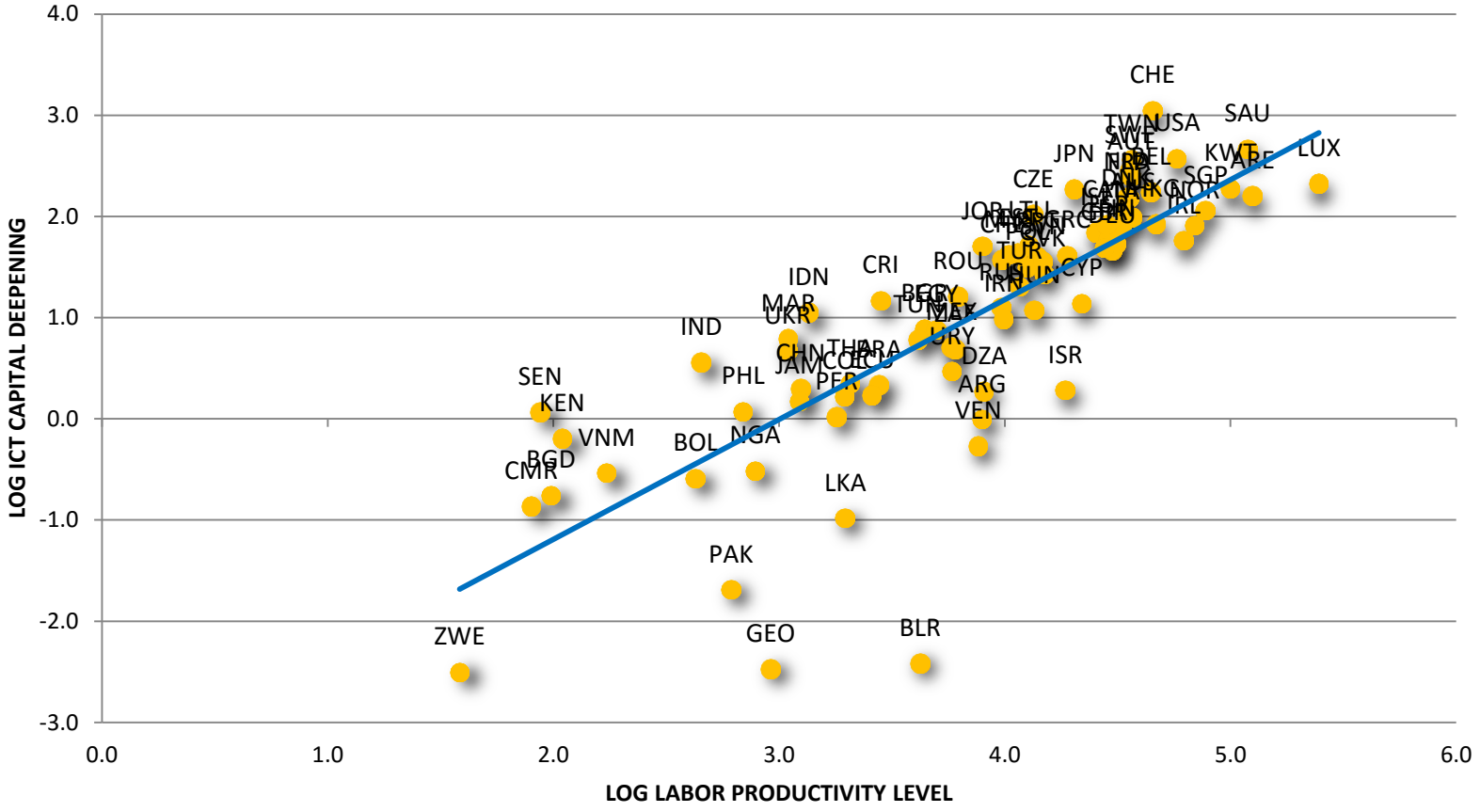
Summary

Remaining issues

- Investment price deflators
  - ✓ We ignore non-produced assets, such as land and subsoil assets (World Bank 2006, Caselli and Feyrer, 2007) and inventories
  - ✓ Intangible assets (Corrado et al., 2009); IPP are included in machinery, software in ICT
- No data on most indicators after 2013 (in some cases 2014)
  - ✓ Imputations for 2015, 2016 and 2017
- No ICT price data for the U.S beyond 2014

Countries with higher labor productivity level also have higher level of ICT capital per worker

LOG LABOR PRODUCTIVITY LEVEL AND LOG ICT CAPITAL DEEPENING, 2013



To build historical data series on investment by asset types we depend on multiple sources

National Accounts based data (106 countries)

Country coverage	Source	Availability*
Global	UN National Accounts Statistics, main aggregates and detailed tables, pt.1 (CD-ROM)	80 countries; 1950-1997
	UN National Accounts Statistics – Main aggregates database (Total GFCF only)	211 countries; 1970-2014
	UN National Accounts Statistics – Official estimates (Total GFCF only)	211 countries; 1950-2014
High-income	OECD National Accounts Statistics	40 countries; 1950-2015
Europe	Eurostat	43 countries; 1950-2015
	Annual Macro-Economic Database (European Commission)	42 countries; 1960-2017
Latin America	Economic Commission for Latin America and the Caribbean (ECLAC CEPALstat)	32 countries; 1950-2015
Other	National Statistical Institutes	65 countries; 1950-2015

Commodity Flow Method

Country coverage	Source	Availability*
Global	World Bank's International Comparison Program	168 countries; 1970-2011
	UNIDO INDSTAT ISIC rev.2	180 countries; 1963-2003
	UN COMTRADE	196 countries; 1962-2011

** Data availability is a rough indication, and can vary between countries. For instance, ECLAC national accounts provides estimates for 1950 for only half of the countries; as for other countries data series start in later years (e.g. 1977, 1978 etc.).*

Data on ICT assets are obtained from a variety of sources and using alternate approaches

1. National Accounts based data
   - Available for about 50 countries
   - Sources: Eurostat, OECD, country-specific sources

2. Non-official data
   - Databases constructed by researchers often working together with national statistical agencies or national policy institutes
   - KLEMS (EU KLEMS, Asia KLEMS) and related databases
   - Commodity flow approach (using input-output tables) – e.g. India

3. ICT spending data from WITSA (see next slide)

Deriving investment data from WITSA ICT spending data

- Discontinued WITSA reports on ICT spending for around 70 countries until 2013
- Business and consumer spending need to be separated manually
  - ✓ Previously we used 'Kuznets' database (Jorgenson and Vu, 2013):
    - Constant spending/investment ratio derived from United States data applied to all countries
  - ✓ New approach:
    - Compile investment spending ratio using national accounts or other sources (steps 1&2 in the previous slide) and WITSA (using step 3) for all countries for which both WiTSA and NAS data available
    - Use regional averages of spending/investment ratio, based on newly collected actual investment data
    - 5-year moving averages used instead of assuming constant investment/spending ratio to allow for intertemporal variation

Non-ICT assets: investment in structures

- National Accounts data whenever available
  - ✓ Split of residential and non-residential not always available
- For countries where NAS is not available, actual investment in structures is obtained from at least one ICP benchmark year
  - ✓ Data for other years are extrapolated using the trend in value added in the construction industry provided by UN national accounts

- In the past we did NOT include residential construction for countries where we could obtain that data separately in TED
  - ✓ This choice has a major implication for capital/output ratios
  - ✓ Data on this split is lacking for many countries
  - ✓ Output measure includes imputed rents,
    - perhaps it is more appropriate to include residential construction in this database, also from an international comparability perspective

Non-ICT assets: investment in machinery and transport equipment

- National Accounts based data used whenever available
  - ✓ Split into transport equipment and other machinery not always available

- For remaining countries and years, we rely on data derived from the Commodity Flow Method (next slide)
  - ✓ The trend in the CFM derived availability of assets are used to extrapolate the benchmark estimates of investment in these assets from ICP
    - The distribution of this estimates (i.e. the share of each asset in the sum of structures, machinery and transport) is considered as the final asset distribution.
    - This asset distribution is applied to the total GFCF obtained in the first step, to derive consistent series of asset wise investment.

$$I_{it} = S_{it} * GFCF^{NA}$$

Filling the gaps: imputing missing investment data using Commodity Flow Method (CFM)

- Caselli and Wilson (2004), Feenstra, Inklaar and Timmer (2015):

$$\hat{I}_{it} = Y_{it} - X_{it} + M_{it}$$

  Y = gross output; X = exports; M = imports

- Implied assumption: change in investment is proportional to change in total availability of these assets in the economy
  - Gross output from UNIDO INDSTAT
  - Exports and imports from either United Nations Comtrade database or Feenstra's World Trade Flows (only when Comtrade is not available)
  - A better approach would be to combine it with IO tables, benchmark year investment to total availability ratios (and interpolate it between benchmark years), but that is cumbersome and data demanding at a global scale
- Approximately 10% of total observations had no trade or output data; in those cases a linear interpolation was applied:

$$X = X_a + (X_b - X_a)\frac{(t-t_a)}{(t_b-t_a)}; \qquad M = M_a + (M_b - M_a)\frac{(t-t_a)}{(t_b-t_a)}$$

  ✓ Missing trade data for earlier years are obtained by extrapolating the trend in total GFCF

Investment price deflators

- Aggregate and asset-wise investment deflators from NAS whenever available
- Asset wise investment deflators from: EU KLEMS, India KLEMS, OECD National Accounts, ECLAC
- Missing countries: for non-ICT assets, aggregate deflators are used
- For ICT assets: US hedonic deflators, corrected for domestic investment price inflation are used (Schreyer, 2002)

$$\Delta lnP_{t,i}^{ICT} = \Delta lnP_{t,i}^{nonICT} + \Delta lnP_{t,US}^{ICT} - \Delta lnP_{t,US}^{nonICT}$$

Depreciation rates differ across assets

Asset	Depreciation rate
Structures (residential and non-residential)	2.0 (1.1 & 3.1)
Transport equipment	18.9
Computers	31.5
Communication equipment	11.5
Software	31.5
Other machinery and assets	12.6

Source: depreciation rates are based on official BEA deprecation rates of Fraumeni (1997).

Investment by Assets – what is aimed for?

- PWT
  1. Investment by broadly defined asset groups (SNA 2008)
     a) Current and constant prices
     b) ICT and non-ICT assets and ICT hedonic deflators
  2. Capital stock by broadly defined asset groups
- TED (in addition to 1 & 2 above)
  1. Capital services by ICT and non-ICT
  2. Contribution of ICT and non-ICT capital to GDP and labor productivity growth
  3. Total Factor Productivity growth

Overview of current approaches….

- TED uses non-ICT investment distribution underlying the PWT 6 capital stock data, along with national accounts total GFCF
  - ✓ For countries where the national accounts data was unavailable, asset distribution in PWT 6 was created using a linear interpolation
    - – In some cases negative investment data (Erumban, 2008)
- For ICT assets, TED relied on Jorgenson and Vu (2013) – Kuznet's dataset based on WITSA ICT spending data, and EU KLEMS.
  - ✓ In addition to limited country coverage, EU KLEMS is not up-to-date
  - ✓ Methodological issues: use of a constant United States' investment to spending ratio from WITSA to all countries is less appropriate (de Vries … Erumban, 2016)

Improvement to past approach of combining different sources and methods

- Better availability of data, especially on ICT investment
  - ✓ More data for several advanced economies
- Improved use of WITSA data to derive investment from spending data
- More transparent methodology to construct asset distribution for countries where the data is not available.

Broad step-by-step overview of our approach – investment data by assets

1. Total GFCF in national currency in current and constant prices are collected from UN national accounts
2. Price deflators are constructed
3. GFCF/GDP rates (investment rates) are computed
4. In TED these are applied to PPP converted GDP, to obtain consistent total GFCF in PPP terms
   - ✓ In PWT annual PPPs are used.
5. These totals are considered sacred, and the remaining estimation procedures are used to distribute the total across assets