

Productivity, Technology and Intangible Assets

By Mas, Pérez & Pilat

Discussion at III Bank of Spain Conference on the Spanish Economy

July 2024

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Recap of the paper

- **This paper is a tour the force on data**

Recap of the paper

- This paper is *a tour the force* on data (EUKLEMS&INTANProd+).

K_I is large, and a must for many macro questions.

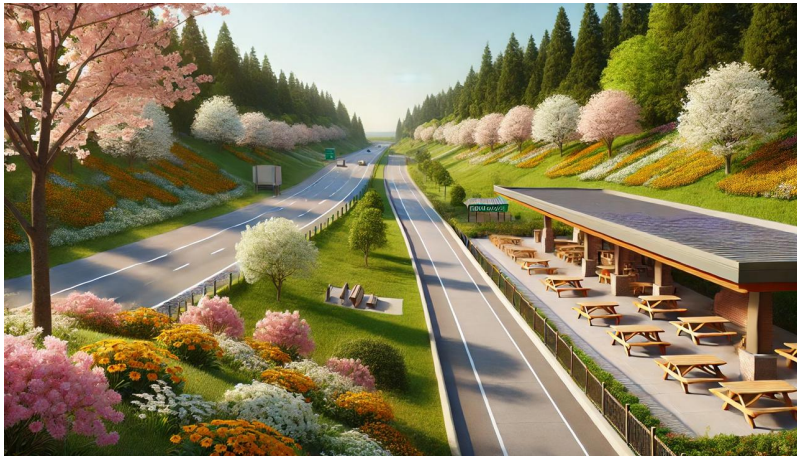
- The route is:

Productivity Slowdown \implies Intangibles \longrightarrow Digitalization \longrightarrow AI

Along the route, important differences in productivity and intangible assets **across countries**, and across *sectors* and time, are reported.

Recap of the paper

A route which is generally pleasant...



Recap of the paper

More precisely

- 1 Evolution of labor productivity, TFP & tang.-intang. investments
 - ICT as assets “like any other”.
 - *Digitalization based partition* into DP, MDIU and LDIU.
(25 sectors into 3 categories)

Key message: Top performing countries and categories. Policy: imitate?

- 2 International comparison through (extended) **growth accounting** (Spain, *Top* & EU-11).
 - Augmented with growth accounting at industry level (the 3 categories).
 - Then, on the potential role of AI (ICT A&U Survey, OECD).

So this can be taken somewhat as a pleasant route...

Recap of the paper

...but at the same time it is also **full of obstacles!**



1. Background

Productivity slowdown and intangibles

Background

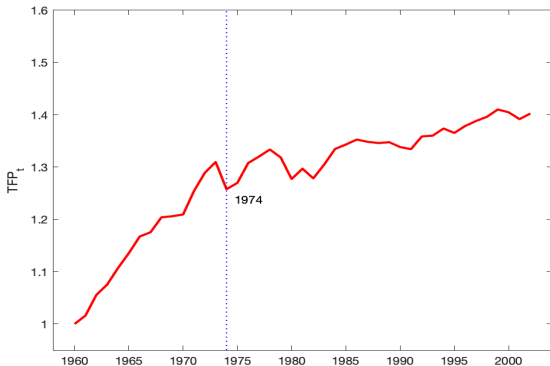
Obstacles I: productivity slowdown and intangibles

The evidence of the slowdown in productivity is often appalling, since long.

Background

Obstacles I: productivity slowdown and intangibles

Productivity slowdown 1.0: $TFP_t^{US} = \frac{Y_t}{K_t^{\bar{\theta}} (h_t E_t)^{1-\bar{\theta}}}$ before the 2000s.



Source: Own elaboration based on Greenwood and Jovanovic (1999)

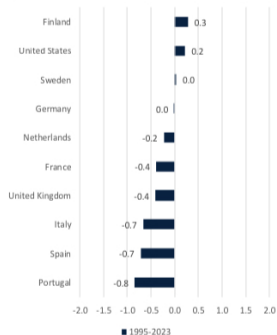
Background

Obstacles I: productivity slowdown and intangibles

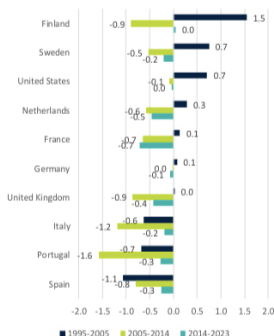
The evidence of the slowdown in productivity is appalling. *In Mas et al.:*

Figure 2. TFP growth rates. International comparison, 1995-2023
(in percentage)

a) 1995-2023



b) 1995-2005, 2005-2014 and 2014-2023



Source: The Conference Board (2024).

Background

Obstacles I: productivity slowdown and intangibles

The evidence of the slowdown in productivity is appalling. The drivers are many:

Productivity Slowdown \implies Intangibles



Measurement

Background

Obstacles I: productivity slowdown and intangibles

Productivity Slowdown \implies Intangibles



Measurement (& ICT revolution: both quantities and prices)

Background

Obstacles I: productivity slowdown and intangibles

Productivity Slowdown \implies Intangibles



Measurement (& ICT revolution: both quantities and prices)



Adoption and diffusion of new technologies \leftarrow

Business dynamics, globalization,...

Energy transition(s): choice of energy intensity w/ Oil+ISTC shocks

Background

Obstacles II: Intangibles

Productivity Slowdown \implies **Intangibles** (chosen explanation)



but, ...too less, or in excess? (wait!)

Background

Obstacles II: Intangibles

Productivity Slowdown \implies **Intangibles**



Measurement (measured vs unmeasured intangibles)

In Mas et al.: $P^Q Q = P^Y Y + P^N N = P^C C + P^I I + P^N N$,

where N is *commercialised knowledge* (not in Nat. Accs.). Note the importance of deflators. Then, growth accounting over Q (**expanded**), and with inputs K_T, K_I, L and TFP . Shares at industry level are also in EUKLEMS&INTANprod.

Background

Obstacles II: Intangibles

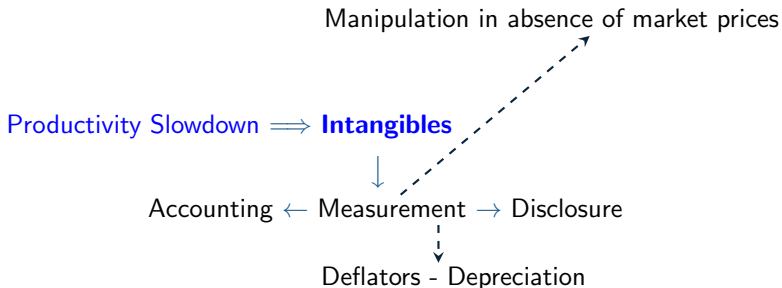
Productivity Slowdown \implies **Intangibles**



Accounting \leftarrow Measurement \rightarrow Disclosure

Background

Obstacles II: Intangibles



Capitalization (rules/strategies) of IPP: consequences for measured factor shares.
 (cf. Santaaulalia and coauthors, various works)

Background

Obstacles III: Digitalization and AI

Productivity Slowdown \implies Intangibles \longrightarrow **Digitalization** \longrightarrow **AI**



Data & Software
Internal & External R&D

Secular trends since 2005:

- Software/Knowledge \uparrow ;
 - Software price \downarrow ;
 - Knowledge Diffusion \downarrow + Knowledge gap (P90 to P50 productive) \uparrow
- (cf. Akgicit and coauthors, various works)

Background

Obstacles III: Digitalization and AI

Productivity Slowdown \implies Intangibles \longrightarrow **Digitalization** \longrightarrow **AI**



Data & Software

Internal & External R&D



Europe is not an AI producer

AI as a General Purpose Technology:

- Similarities between epochs (Electricity, ICT, AI now,...), can guide us?
- Technological change and its effects (targeting key sectors/bottlenecks).

(cf. Jovanovic/Acemoglu and coauthors, various works)

2. Some comments

Obstacles, Microevidence and Relative Prices

Some comments

- 1 **A need:** Expanded growth accounting at industry level needs to tackle (some of) the aforementioned obstacles (for some purposes/in the discussion).
- 2 **A difficulty:** Huge sectoral heterogeneity within and across countries (so as to rely in “categories”).
- 3 **A key issue:** How to maintain appropriate price indices to deflate past investment expenditures in intangibles.

Some comments (1)

What are the biggest obstacles to an effective productivity policy?

Some examples:

- Data and Software usage is now a key intangible asset for innovation activity. Main property: easier to internally develop \implies then, ideas harder to diffuse. Akgicit and Ates (2021) ; Xu and Zhang (2024)

R&D subsidies less effective when barriers to diffusion higher.

- Related, complementarity between intangibles and firm span (non-rivalry in use), and generation of spillovers (limits to excludability), also negative (wide dissemination brings obsolescence), as discussed in Crouzet et al. (2022).

Positive, but also negative effects.

- Even alternative measures of productivity (profits, ACs and capacity utilization), as in Comín and Quintana (2023)

Some comments (2)

Huge sectoral heterogeneity within and across countries

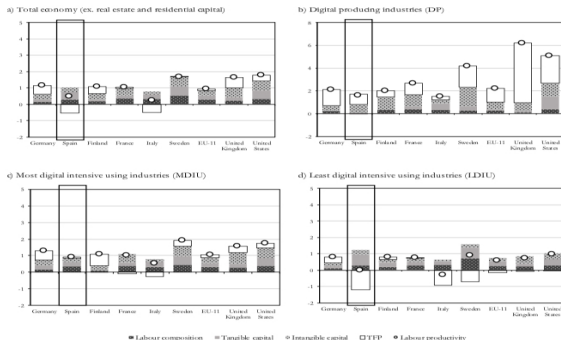
- Paper main strategy is splitting sectors into DP, MDIU and LDIU.
- However, we know that “intangible-intensive industries produce a lot of intermediate inputs, implying that they can indirectly affect less-intangible-intensive industries, further complicating the analysis of sectoral productivities”. (McGrattan and Prescott, *AER* 2014).
 - Needed: improve our understanding of the Input-Output linkages.
 - Notwithstanding, aggregate growth accounting at the industry level can inform on the construction of structural models.

Some comments (2)

Huge sectoral heterogeneity within and across countries

For instance, inform structural model with clusters of sectoral differences in productivity across countries (with expanded accounts):

Figure 11. Contribution of factor inputs to labour productivity growth. International comparison, 2000-2020 (percentage)



Some comments (2)

Huge sectoral heterogeneity within and across countries

Next, a simple illustration on this heterogeneity and the limits to aggregation with selected EUKLEMS & INTANProd data.

Some comments (2)

Huge sectoral heterogeneity within and across countries

A motivation for my approach is in Crouzet et al. (2022), when looking to Intangible to Tangible Assets (again, productivity slowdown):

Figure 1

Ratio of Intangible Assets to Tangible Assets for US Public Firms, 1975–2021



Source: Authors' calculations (Crouzet et al. 2022a).

Note: Intangible assets are constructed by applying the perpetual inventory method to 30 percent of firms' Selling and General Administrative expenses following Eisfeldt and Papanikolaou (2013, 2014) and Eisfeldt, Kim, and Papanikolaou (2022). Tangible assets are property, plant, and equipment.

Some comments (2)

Huge sectoral heterogeneity within and across countries

If I look to this data under Hayashi & Prescott (2002) growth accounting:

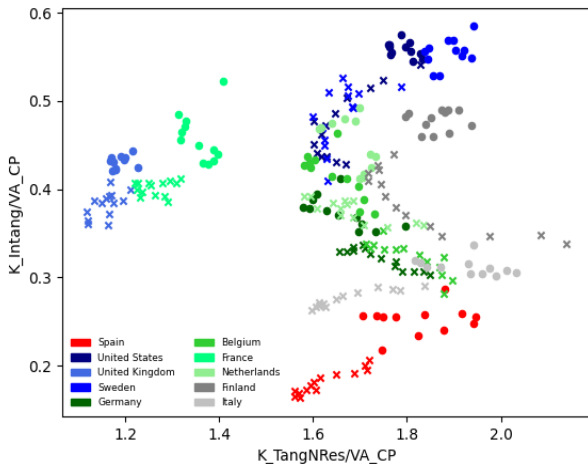
$$\frac{Y_t}{N_t} = TFP_t^{1-\theta} \times \left(\frac{K_t}{Y_t} \right)^{\frac{\theta}{1-\theta}} \times \frac{E_t}{N_t} \times h_t$$

In the long-run where K_t/Y_t is constant, (and employment rate and hours per employed person too), the trend in output per worker is given by adjusted TFP.

Remark: This is one sector without intangibles, but the argument \sim follows for multisector with intangible capital extension: use $q_t^x K_t^x / Y_t$, for q_t^x units of output.

Intangible Capital over Output

Selected countries, 1995-2008(×) & 2009-2020(●) – current prices, total industries.

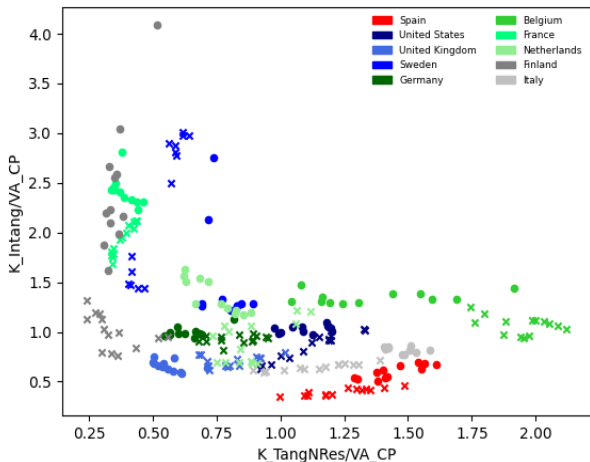


- $K_t^{\text{TangNRes}}/Y_t \sim$ at a constant (per country).
- Cyclicality. UK & FR apart.
- Sp & It K_I more complement to K_e .
- Mostly ordered, but pooled: (slow) convergence.

Intangible Capital over Output (“DP1”: C26-27)

Selected countries, 1995-2008(×) & 2009-2020(●) – current prices, Manuf. CEO.

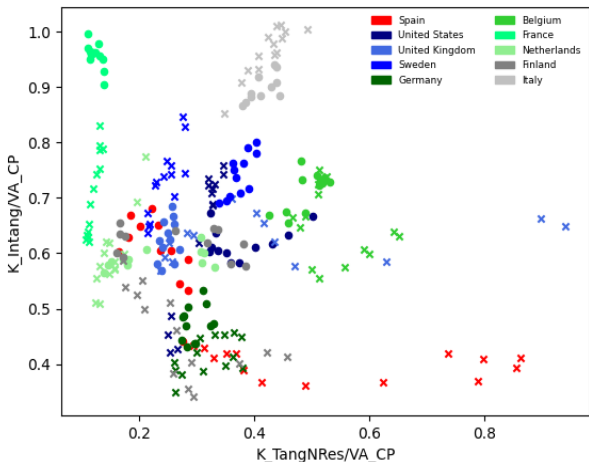
- US & SW now, different models
- Used to rely on tangibles
- It & Sp, wrong direction?
- **All this reflects a transition** (or, sthg at 4 digit? (so, TFP at this level)



Intangible Capital over Output (“DP2b”: J62-J63)

Selected countries, 1995-2008(×) & 2009-2020(●) – current prices, Serv. CEO.

- More to intangibles
Fr & It apart. Sp,
from where?
- Lots of clustering
- Yes, complement to
domestic services
- **All this leads to
IO networks**



Some comments (3)

The price of capital (The Cambridge controversy strikes back)

A closed loop in standard capital theory:

K^i aggregation \leftarrow prices \leftarrow returns \leftarrow rates $\leftarrow K$

- Solow (1960) vintage capital model can provide a route to compute the user cost of intangible capital (vs Schreyer, 2002).
- Price of capital is recursive, so interest rates underlie. Instead, measures of ISTC for different types of investment.

Concluding Remarks

- Huge amount of relevant data. Lots of useful measurement and findings.
- Growth accounting at industry level can be used to inform **structural models** of innovation and the **Input-Output network**.
- There is a lot to be learnt from **the microevidence** on tangible and intangible investments at times of changing investment like these we are living.

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Annex: On growth accounting

Hayashi & Prescott (2002) meets McGrattan & Prescott (2014)

$$y_{st} = a_{st}^{\frac{1}{1-\theta_s-\phi_s-\gamma_s}} \left(\frac{k_{T,st}^1}{y_{st}} \right)^{\frac{\theta_s}{1-\theta_s-\phi_s-\gamma_s}} \left(\frac{k_{I,st}}{y_{st}} \right)^{\frac{\phi_s}{1-\theta_s-\phi_s-\gamma_s}} \left(\frac{m_{st}^1}{y_{st}} \right)^{\frac{\gamma_s}{1-\theta_s-\phi_s-\gamma_s}} h_{st}^1,$$

where y_{st} is output of a firm in sector s at t , h is labor input, m a composite of intermediates, and k_T and k_I are Tangible and Intangible capital.

{1} refers to new output production, while {2} (omitted) is new intangible investment production. Notice k_I does not have a superscript.

A growth accounting such that, in the long-run where $\left(\frac{k_{T,st}^1}{y_{st}} \right)$ is constant, (and the employment rate and hours too), the trend in output per worker is given by adjusted TFP and Intangibles intensity.

La Tabla

Asset	Intang included in Nat Accounts?	Capitalization Factor	Depreciation rate
<i>Computerised Information</i>			
Purchased Software	Yes	1	0.315
Own-Account Software	Yes	1	0.315
Databases	See note	1	0.315
<i>Innovative property</i>			
R&D	Yes	1	0.15
Design	No	0.5	0.2
Mineral Exploration	Yes	1	0.075
Financial Innovation	No	1	0.2
Artistic originals	Yes	asset-specific	asset-specific
<i>Economic Competencies</i>			
Advertising	No	0.6	0.55
Marketing research	No	0.6	0.55
Own-Account Organisational Capital	No	1	0.4
Purchased Organisational Capital	No	0.8	0.4
Training	No	1	0.4