The Intangible Econonomy. Theory, Data and the Greek case.

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Outline

- Definitions
- Data trends for the Greek economy (and relative to the EU)
- A simple dynamic macro model that explains stylized facts about the intangible economy in Greece
- Results

Motivation

- European economies have shifted towards **intangible investment** over the last decades.
- The relative importance of **intangible vs. tangible capital** is steadily increasing.
- Most macroeconomic models for policy analysis **ignore intangible capital** as a factor of production.
- **Main challenge:** Measurement (see Corrado *et al.* (2022) and McGrattan (2020)).
  - The economic characteristics of intangible assets affect the transmission mechanism of shocks in a non-trivial way.

Intangible capital: definitions and measurement

- **Broad definition:** Accumulated know-how from investments in R&D, brands and building organizations (see McGrattan and Prescott (2010)).
- National accounts have been continuously expanded to better account for the role of intangibles.
- Only a limited range of intangible investment is measured in national accounts (see Corrado et al. 2016). Categories of intangibles
- EUKLEMS & INTANProd database.

Characteristics of intangible assets

- Intangible assets are different from tangible assets in a number of important ways.

- **Non-rivalry or scalability:** Intangible assets can be used in multiple production activities at the same time (just like in endogenous growth theories).

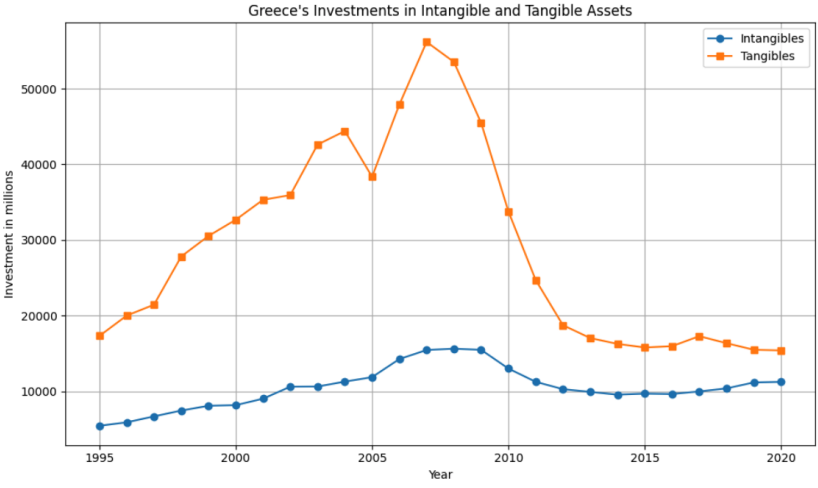
- The 4S:
  - **S**calability (e.g music/intellectual rights, computer codes)
  - **S**unkeness (intangible assets are harder to sell and more likely to be specific to the company that makes them/e.g a waste management system developed in a factory)
  - **S**pillovers (e.g social networks)
  - **S**ynergies (e.g Apple's licensing agreements with record labels and design skills created the iPod)

Key Trends and Stylized Facts for the Intangible Economy in Greece

- Before the 2009–10 crisis, both tangible and intangible investments were rising, but tangible investments grew faster.
- After the crisis, intangible investments rebounded more quickly, while tangible investments stagnated.
- Intangible investment shows a steady but slow upward trend.
- Tangible investment fell sharply after the crisis, whereas intangible investment partially recovered and eventually outperformed tangible assets.

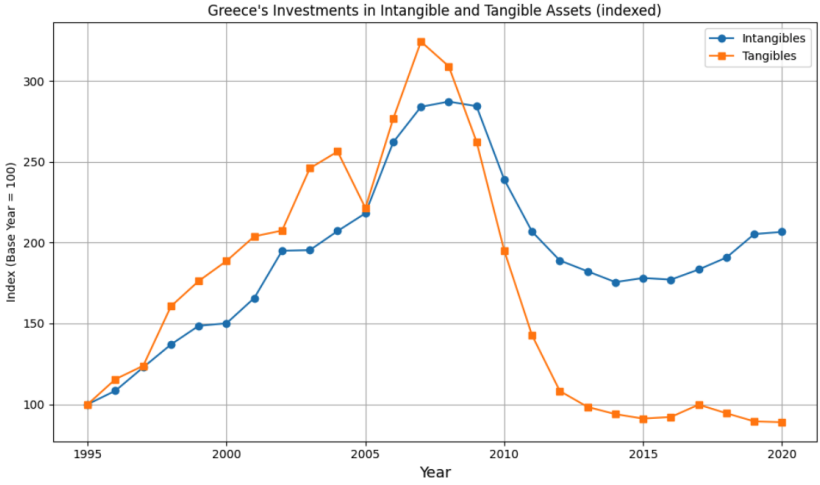
Investment Levels in Intangible and Tangible Assets

Greece

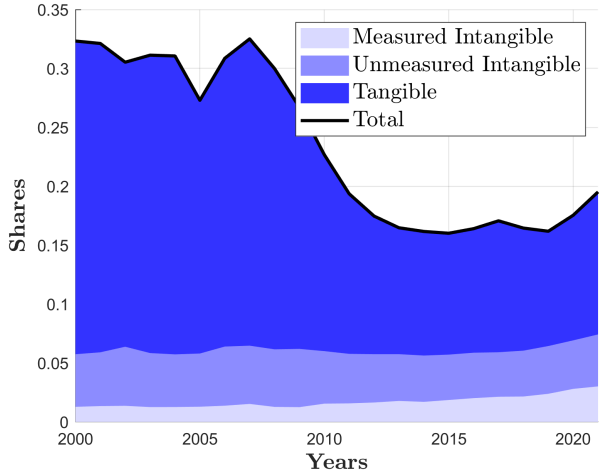


Normalized Investment in Intangible and Tangible Assets

Greece, 1995 = 100



Decomposition of total investment as share of Gross Value Added

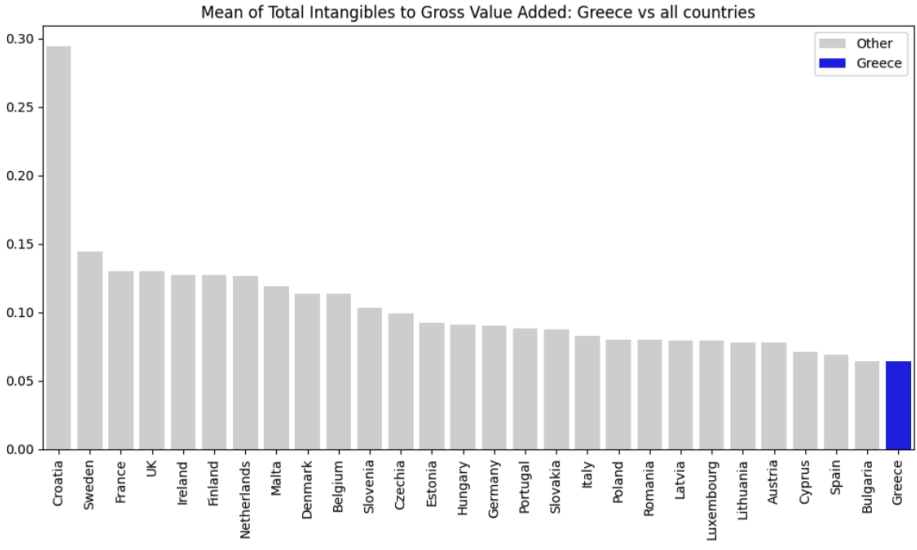


Notes: Gross Value Added is the sum of measured GVA and the unmeasured intangible investment. Measured intangible is taken from SNA and unmeasured intangible is taken from Intan-Invest.

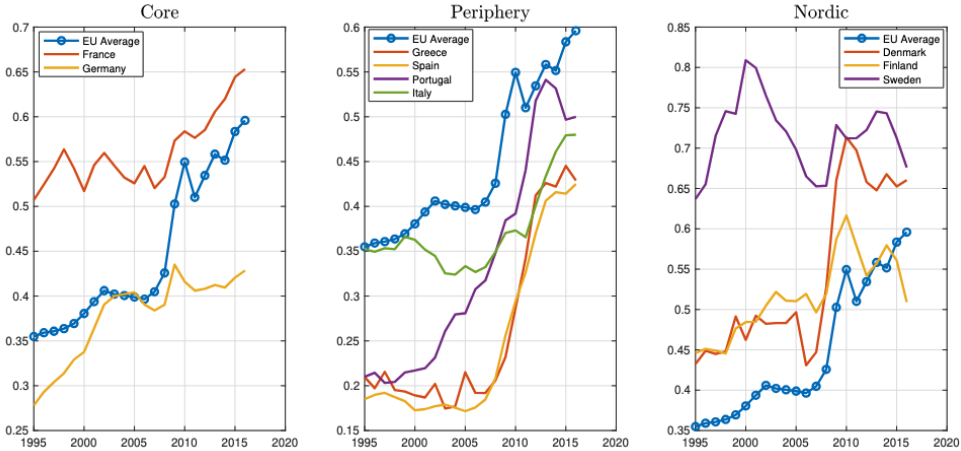
Greece's Position in the European Intangible Economy (base year 1995)

- Greece is an EU intangible laggard: intangible investment relative to GVA remains persistently lower than in most EU countries.
- The gap is widening, especially compared to Core and Nordic EU members.
- Greece consistently ranks below average in intangible intensity across reference groups.
- Tangible investment was relatively high pre-crisis but collapsed afterward; intangible investment proved more resilient.
- The gap is smaller vis-à-vis Periphery and Eastern European countries, but Greece still lags behind.

GVA share of Intangible Investment across EU

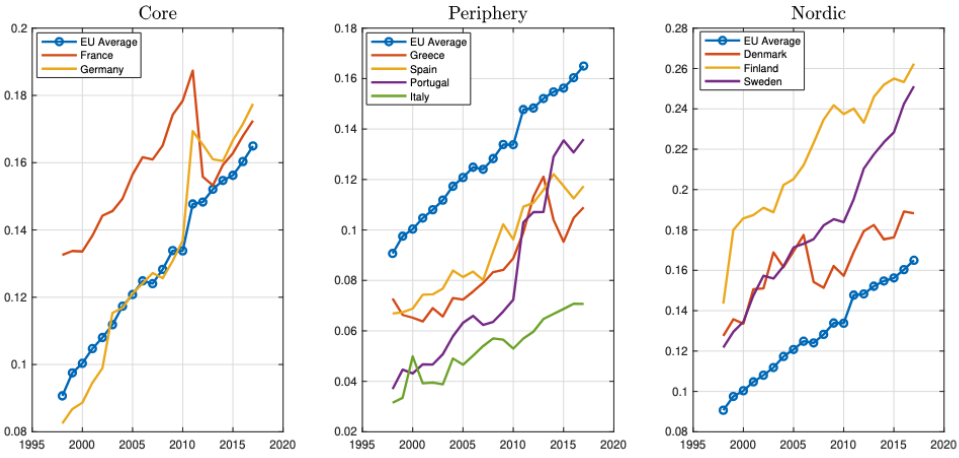


Ratio of Intangible to Tangible Investment (GFCF)



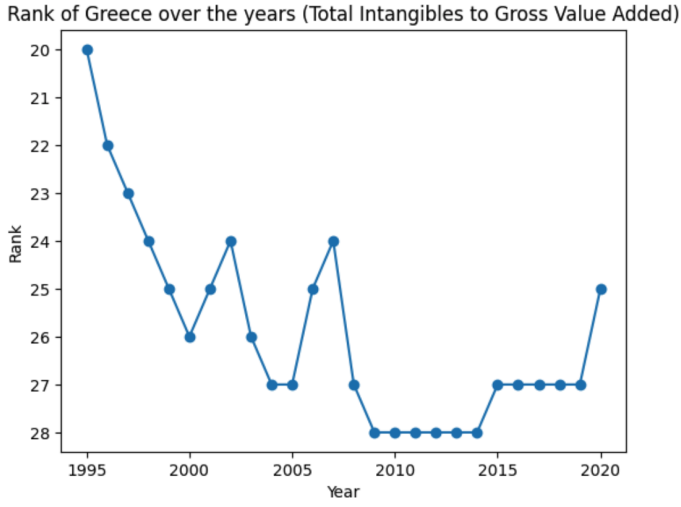
Source: EUKLEMS-INTAN-prod database and EU-labor Force Survey

Ratio of Intangible to Tangible Investment (hours worked)



Source: EUKLEMS-INTAN-prod database and EU-labor Force Survey

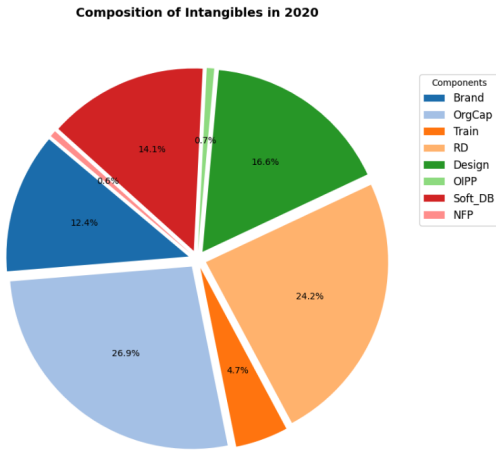
Relative Position of Greece in Intangible Intensity



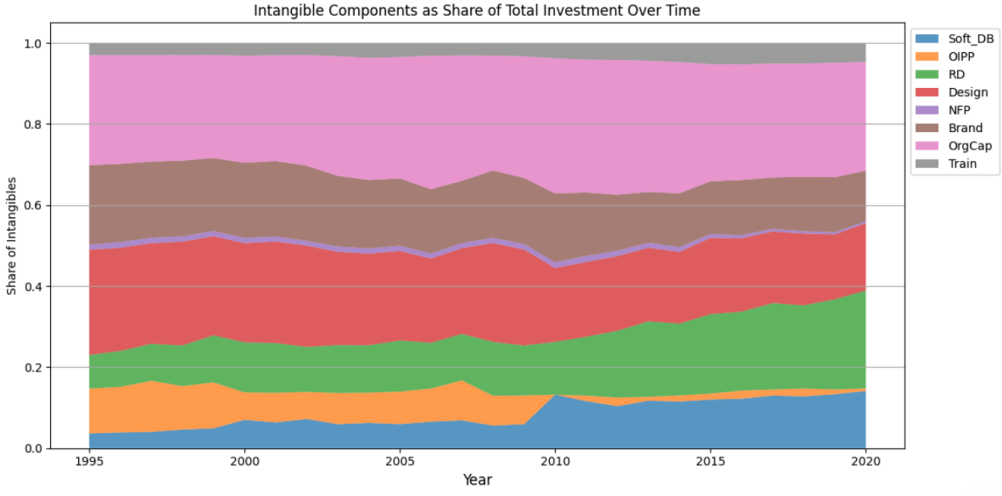
Decomposition of Intangible Investment in Greece

- In 2020, organizational capital was the largest intangible asset (27% of total intangible investment) followed by:
  - R&D: 24%
  - Industrial design: 16.6%
  - Software & databases: 14%
  - Branding: 12%
- Smallest categories: entertainment, artistic/literary originals, and new financial products.
- Fastest-growing category: software & databases ($\approx$800% since 1995), followed by R&D ($\approx$600% growth).
- Growth in organizational capital, industrial design, and branding slowed after the crisis.

Decomposition of Intangibles in Greece (2020)

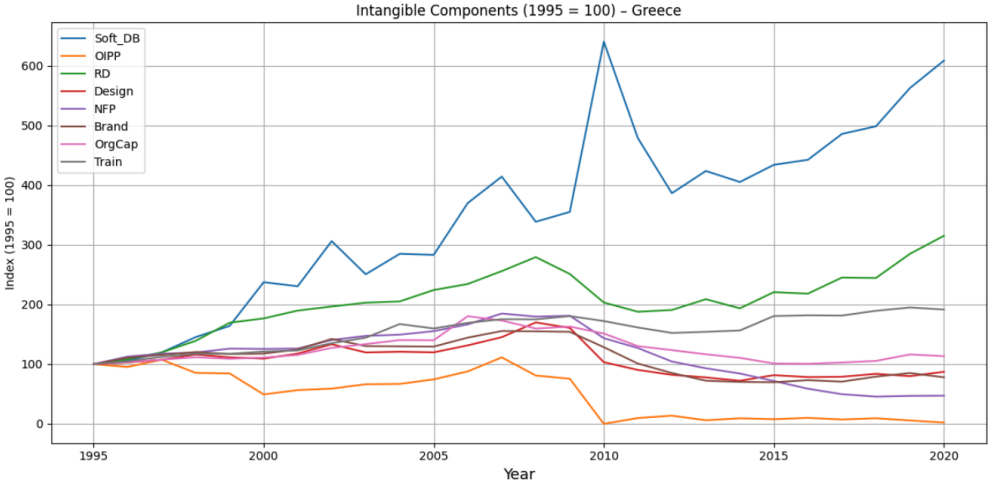


Intangible Components as Share of Total Intangibles



Intangible Components over Time

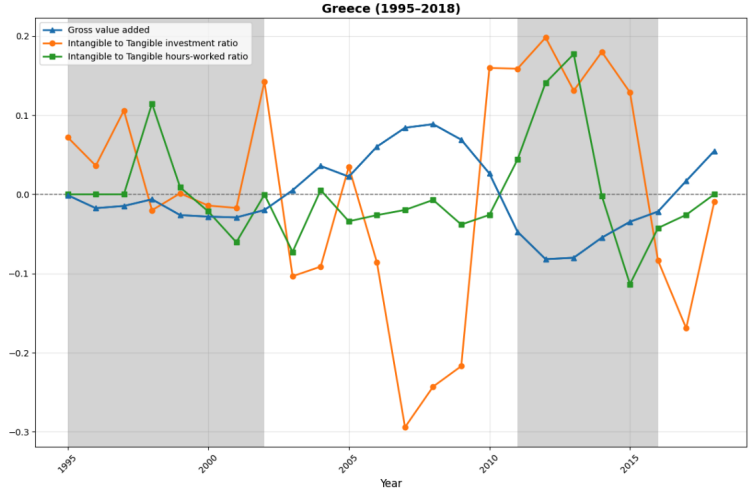
Index (1995 = 100), Greece



Time series of individual intangible asset categories.

Cyclical Behaviour of Intangibles and Tangibles

Greece, 1995–2018



A model-based assessment of the intangible economy in Greece

- We construct model-based estimates of the Greek intangible economy:
  1. Intangible value added (investment) and capital stock.
  2. Tangible capital and hours worked associated with the production of intangible value added.
  3. An estimate of productivity in the Greek intangible sector.
- Cross-validation: Compare data, i.e.,EUKLEMS-INTANProd, and model-based estimates.

A model-based assessment of the intangible economy in Greece

- To do this, we need a theoretical macroeconomic model.

- Specifically, we use a a closed economy RBC model augmented with an intangible sector following closely Dimakopoulou *et al.* (2025) (which builds on McGrattan and Prescott (2010)).

The Model

An RBC model augmented with an intangible sector (see Dimakopoulou *et al.* (2025)).

→ Corporate firms

- Final tangible good.
- Intangible investment good.

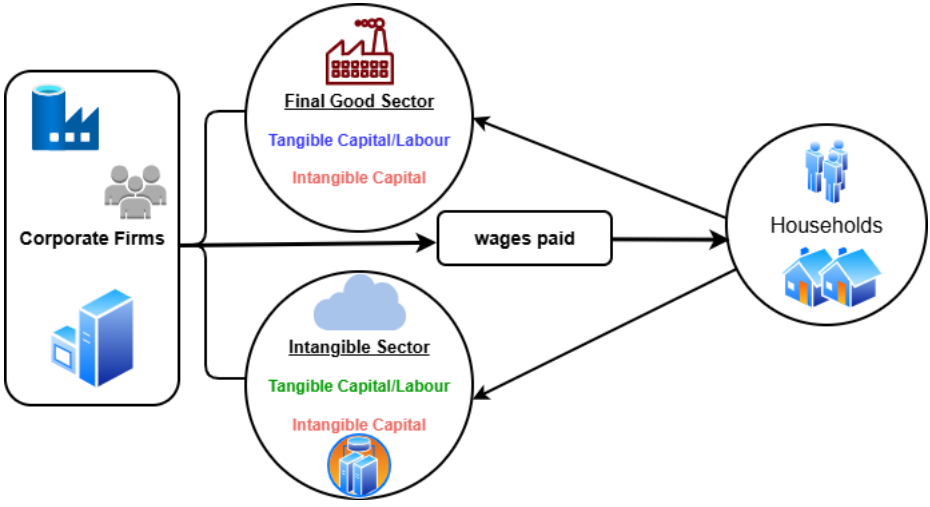
  → Tangible capital and hours worked are rivalrous inputs.

  → Intangible capital is a non-rivalrous input: can be used simultaneously in producing consumer goods and services and in creating new ideas.

- Details for technology in the next slide.

→ Households

→ The model consists of 17 endogenous variables in 17 dynamic equations.


Final Good Sector
Tangible Capital/Labour
Intangible Capital
Corporate Firms
wages paid
Households
Intangible Sector
Tangible Capital/Labour
Intangible Capital

Technology

- Tangible sector:

$$y_t = A_t \left(k^1_{T,t}\right)^{\theta_1} \left(k_{I,t}\right)^{\phi_1} \left(h^1_t\right)^{1-\theta_1-\phi_1} \tag{1}$$

- Intangible sector:

$$x_{I,t} = A^I_t \left(k^2_{T,t}\right)^{\theta_2} \left(k_{I,t}\right)^{\phi_2} \left(h^2_t\right)^{1-\theta_2-\phi_2} \tag{2}$$

- where,

$$k_{I,t+1} = (1-\delta_I)\, k_{I,t} + x_{I,t}.$$

$$k_{T,t+1} = (1-\delta_T)\, k_{T,t} + I_t.$$

$$k_T = k^1_{T,t} + k^2_{T,t}$$

Intangible capital

- Intangible capital is a non-rivalrous productive input that enters both production technologies (see McGrattan and Prescott (2010)).

- **Intuition:** A new "idea" can be used to develop both goods and new "ideas".

Notation

- Gross Value Added (final good/measured): y_t.
- Intangible Gross Value Added (unmeasured): $\mu_t x_{I,t}$.
  (where μ_t is the relative price of the intangible investment good)
- Total Gross Value Added: $y_t + \mu_t x_{I,t}$.
- Productivity in the final-good sector (aka TFP): A_t.
- Productivity in the intangible sector: A_t^I.

Methodology

1. We calibrate the model to match some key observable ratios of the Greek economy over 1995-2000 (see Calibration).

2. Hence, the point of departure is 2000. To generate model-based time series, we feed the model with one (or more) exogenous process(es).

3. We start with TFP in the final good sector, A_t.

4. We then use both TFP in the final good sector, A_t, and productivity in the intangible sector, A_t^I.

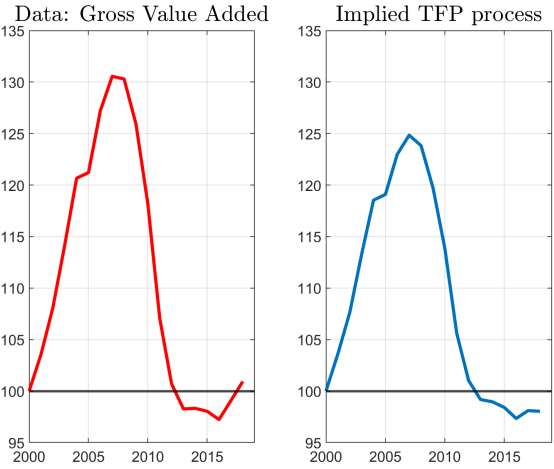
Methodology: Backing out the implied TFP process

- Conditional on the model and calibration, the time path of $\{A_t\}_{t=2000}^{2018}$ is chosen such as:

$$\underbrace{\{y_t\}_{t=2000}^{2018}}_{\text{model-generated}} = \underbrace{\{\text{GVA}_t\}_{t=2000}^{2018}}_{\text{data}}$$

- where GVA_t is the real measured Gross Value Added (excl. measured intangible investment) from the data.

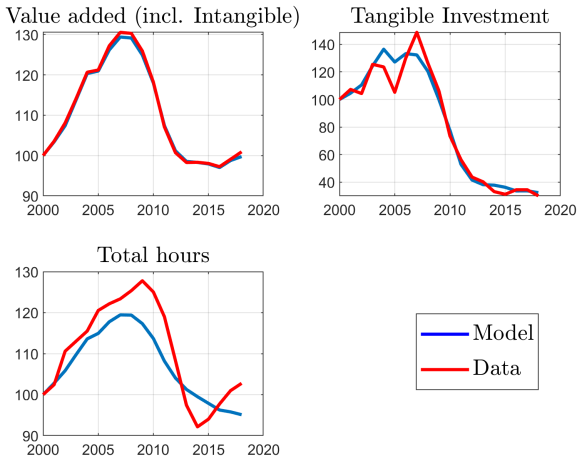
The implied TFP process



Notes: Both time series are normalized to 2000.

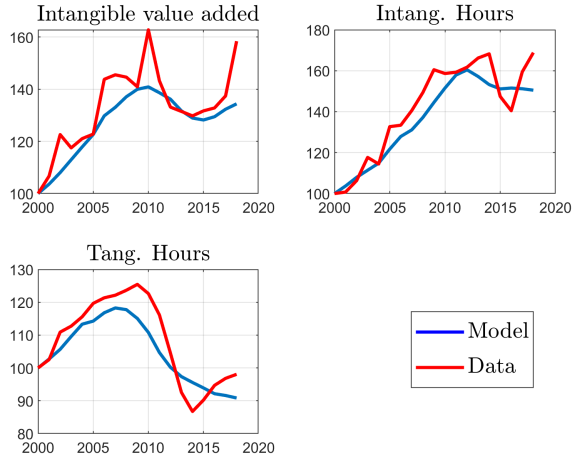
- We feed the A_t path back into the model.
- We examine whether the model performs well vis-á-vis the data at hand.
- Then, we can use the model to generate time series for the intangible variables.

Tangible economy: endogenous variables



Notes: All time series are normalized to 2000.

Intangible economy: endogenous variables



Notes: All time series are normalized to 2000.
Data for intangible related series are taken from EUKLEMS-IntanProd database.

Methodology: Backing out both implied productivity processes

- Conditional on the model and calibration, the time path of $\{A_t\}_{t=2000}^{2018}$ is chosen such as:

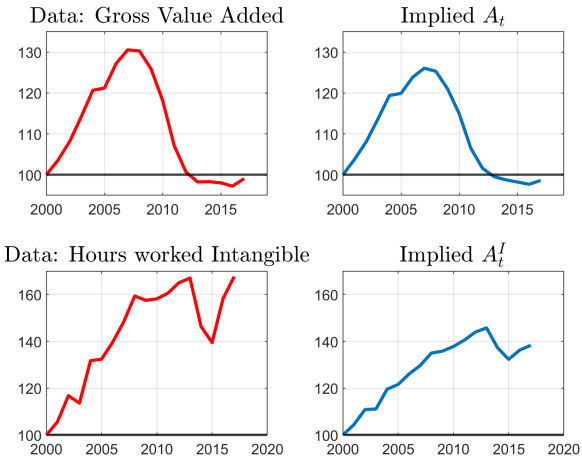
$$\underbrace{\{y_t\}_{t=2000}^{2018}}_{\text{model-generated}} = \underbrace{\{\text{GVA}_t\}_{t=2000}^{2018}}_{\text{data}}$$

- Similarly, the time path of $\left\{A_t^I\right\}_{t=2000}^{2018}$ is chosen such as:

$$\underbrace{\left\{h_t^2\right\}_{t=2000}^{2018}}_{\text{model-generated}} = \underbrace{\left\{\text{hours}_t^{intang}\right\}_{t=2000}^{2018}}_{\text{data}}$$

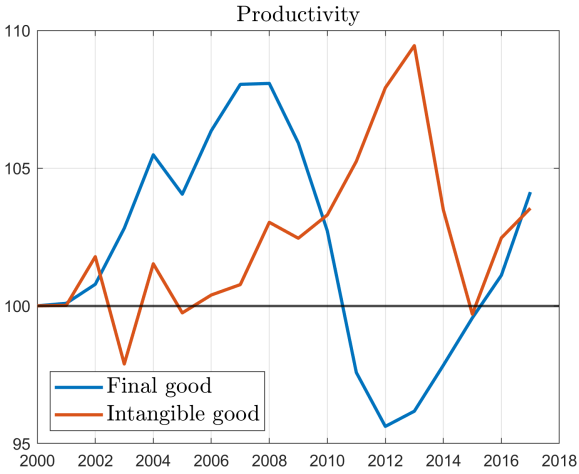
- where hours_t^{intang} are hours worked associated with intangible related occupations (constructed from LFS data).

The implied productivity by sector



Notes: Normalized to 2000=100.

Productivity in the final good and intangible sectors

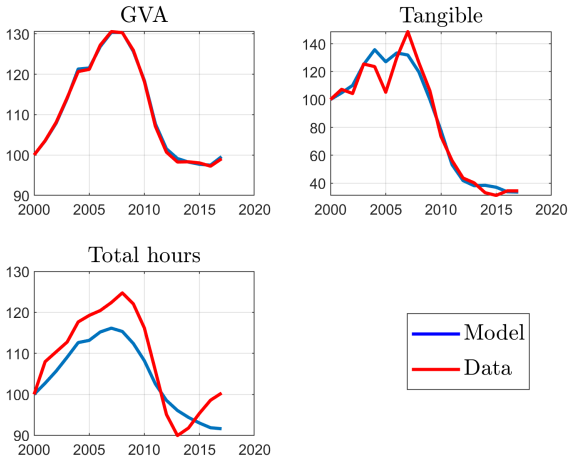


Notes: Normalized to 2000=100. Compared to Figure in slide 19 these time series are detrended.

Productivity by sector

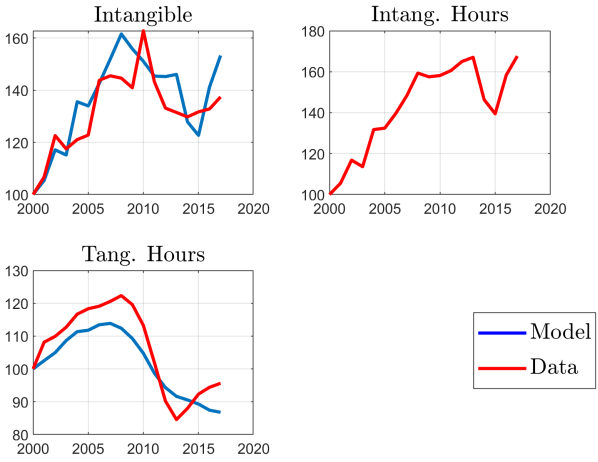
- The productivity in the final good and intangible sector do not necessarily comove, in fact during this crisis move countercyclically.
- Over time the productivity in the intangible sector grows steadily (with a notable drop in 2013).
- Is the intangible sector less sensitive to business cycles (or more resilient during economic crises)?
- TFP was the main driving force until 2010, when it experience a substantial decline.

Tangible economy: endogenous variables



Notes: Normalized to 2000=100.

Intangible economy: endogenous variables



Notes: Normalized to 2000=100.

How to construct better estimates and match the data?

- Introduce wedges for investment, labour etc
- A wedge is a gap between what the model predicts and what we observe in the data.
- Think of a wedge as an invisible distortion or friction. Examples include taxes, regulations, market power, financial frictions, or measurement errors that the basic model does not explicitly include.

What wedges help us understand when matching models to data

- **They tell us where the model fails.**
  - By looking at which equilibrium condition needs a wedge (labor supply, investment, productivity, etc.), we learn which part of the economy is not well captured.
- **They help decompose fluctuations.**
  - Instead of saying "GDP fell," wedges let us say whether it was mainly due to labor distortions, investment frictions, productivity problems, or demand-like forces.
- **They guide model improvement.**
  - A large labor wedge suggests missing labor market institutions; a large investment wedge suggests financial frictions; a productivity wedge may reflect misallocation or technology issues.

Appendix

Technology

- Tangible sector:

$$y_t = A_t \left(k^1_{T,t}\right)^{\theta_1} \left(k_{I,t}\right)^{\phi_1} \left(h^1_t\right)^{1-\theta_1-\phi_1} \tag{3}$$

- Intangible sector:

$$x_{I,t} = A^I_t \left(k^2_{T,t}\right)^{\theta_2} \left(k_{I,t}\right)^{\phi_2} \left(h^2_t\right)^{1-\theta_2-\phi_2} \tag{4}$$

$$k_{I,t+1} = (1-\delta_I)\, k_{I,t} + x_{I,t} \tag{5}$$

Profit maximization

- Corporate firm maximizes real profits:

$$\max E_t \sum_{t=0}^{\infty} \Lambda_{t,t+1} \left(y_t - w_t h_t - x_{T,t} \right) \tag{6}$$

where $\Lambda_{t,t+1}$ is a stochastic discount factor

- Intangible investment is not directly measured as such it is not expensed as a separate expenditure per se (McGrattan and Prescott, 2010; Mitra, 2019).
- Hours worked and tangible investment devoted to the production of the new intangible good are expensed.

Back to Model

Constraints

$$y_t = A_t \left(k^1_{T,t}\right)^{\theta_1} \left(k_{I,t}\right)^{\phi_1} \left(h^1_t\right)^{1-\theta_1-\phi_1} \tag{7}$$

$$x_{I,t} = A_{I,t} \left(k^2_{T,t}\right)^{\theta_2} \left(k_{I,t}\right)^{\phi_2} \left(h^2_t\right)^{1-\theta_2-\phi_2} \tag{8}$$

$$k_{T,t+1} = (1-\delta_T)\, k_{T,t} + x_{T,t} \tag{9}$$

$$k_{I,t+1} = (1-\delta_I)\, k_{I,t} + x_{I,t} \tag{10}$$

$$k_{T,t} = k^1_{T,t} + k^2_{T,t} \tag{11}$$

$$h_t = h^1_t + h^2_t \tag{12}$$

Euler equation for intangible capital

FOC wrt $k_{I,t+1}$:

$$\mu_t = \underbrace{\Lambda_{t,t+1}\left(\phi_1 \frac{y_{t+1}}{k_{I,t+1}}\right)}_{\text{increase in future output}} + \underbrace{\mu_{t+1}\left((1-\delta_I) + \phi_2 \frac{x_{I,t+1}}{k_{I,t+1}}\right)}_{\text{increase in intangible added value}} \tag{13}$$

- μ_t measures the "shadow value" of the IC constraint to the firm and equals the expected discounted value of the marginal benefit from having an extra unit of intangible which is the sum of two components.

Euler equation for sectoral tangible capital

- FOC wrt $k^1_{T,t+1}$:

$$1 = \Lambda_{t,t+1} \left((1-\delta_T) + \underbrace{\theta_1 \frac{y_{t+1}}{k^1_{T,t+1}}}_{MPK^1_T} \right) \tag{14}$$

- FOC wrt $k^2_{T,t+1}$

$$1 = \Lambda_{t,t+1} (1-\delta_T) + \mu_{t+1} \underbrace{\theta_2 \frac{x_{I,t+1}}{k^2_{T,t+1}}}_{MPK^2_T} \tag{15}$$

- the marginal product of additional physical capital investment in intangibles relaxes the future IC constraint of the firm and is therefore weighted by the value to the firm next period (in utility terms) of a change in this constraint

MPL and hours worked ratio

We assume that wage is the same across two sectors as well as the elasticities $\theta_1 = \theta_2$ and $\phi_1 = \phi_2$. From the equilibrium system we have that

$$w_t = (1 - \theta_1 - \phi_1) \frac{y_t}{h_t^1} \tag{16}$$

$$w_t = (1 - \theta_2 - \phi_2) \frac{\mu_t x_{I,t}}{h_t^2} \tag{17}$$

which implies

$$\frac{h_t^2}{h_t^1} = \frac{\mu_t x_{I,t}}{y_t} \tag{18}$$

Households

GHH preferences:

$$\max U(c_t, h_t) = \frac{\left(c_t - \frac{h_t^{1-\omega}}{1-\omega}\right)^{1-\sigma}}{1-\sigma} \tag{19}$$

subject to:

$$c_t = w_t h_t + d_t \tag{20}$$

FOCs:

$$\left(c_t - \frac{h_t^{1-\omega}}{1-\omega}\right)^{-\sigma} = \lambda_t \tag{21}$$

$$h_t^{\omega-1} = w_t \tag{22}$$

Hours worked in the intangible and tangible sectors

- Assumption: We classify occupations as intangible if their core function is primarily related to the creation, management, or application of knowledge, data, and organizational processes.

- Methodologically, this in the same logic with studies that reclassify occupations based on the skill content of the tasks performed in the occupation (see e.g. in Jaimovich and Siu (2020) they delineate occupations along “cognitive” versus “manual” and “routine” versus “nonroutine” occupations

Hours worked in the intangible and tangible sectors

- Specifically, when assessing the raw survey data we follow the International Standard Classification of Occupations 2008 (ISCO-08) to identify occupations at the 2-digit level. Then we assume that the following 2-digit occupational groups belong to the intangible group: 11-Chief executives, senior officials and legislators, 12-Administrative and commercial managers, 21- Science and engineering professionals, 24-Business and administration professionals, 25-Information and communications technology professionals, 26- Legal, social and cultural professionals.

- Caveats: We acknowledge that some of these occupations — notably managers (ISCO 11–12) and ICT professionals (ISCO 25) — may combine intangible tasks with operational or routine activities. However, in line with prior literature (Corrado et al., 2012; OECD, 2013), we assign these occupations to the intangible group based on their dominant function within the firm and their contribution to knowledge-based capital. Back to Methodology.

Calibration

Parameter	Description	Value	Target
β	discount rate	0.96	Real rate
ω	labour supply elasticity	2.5	Total hours worked
σ	elasticity of intertemporal subs.	2	Standard
δ_I	depreciation rate of intangible	0.3	Corrado et al. (2022)
δ_T	depreciation rate of tangible	0.1	Standard
$\theta_1 = \theta_2$	tangible capital shares	0.25	$\frac{\mu x_I}{x_T}$
$\phi_1 = \phi_2$	intangible capital shares	0.05	$\frac{\mu x_I}{y + \mu x_I}$

Back to Methodology.