Intangible Capital and Business Cycles in the EU

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CRETE 2023, Naxos

Overview

- Motivation and Definitions
- Literature
- Intangible capital data over the business cycle
- Model
- Experiments

Motivation

1. European economies have shifted towards intangible investment over the last decades.
2. The relative importance of intangible vis-a-vis tangible capital increases steadily.
3. Strong relocation from tangible to intangible documented during the Global Financial crisis of the previous decade.
4. Most macroeconomic models for business cycle and/or policy analysis ignore the role of intangible capital as a factor of production.
5. The economic characteristics of intangible assets affect the transmission mechanism of shocks in a non-trivial way.

In this paper

- We build a RBC model with tangible and intangible capital (McGrattan and Prescott; 2009, 2010
- Does an RBC model augmented with IC capture the cyclicality of the intangible economy relative to tangible economy in terms of two main macro-variables (i) investment (ii) hours worked?
- We focus on the recent Global Financial Crisis in selected EU economies.

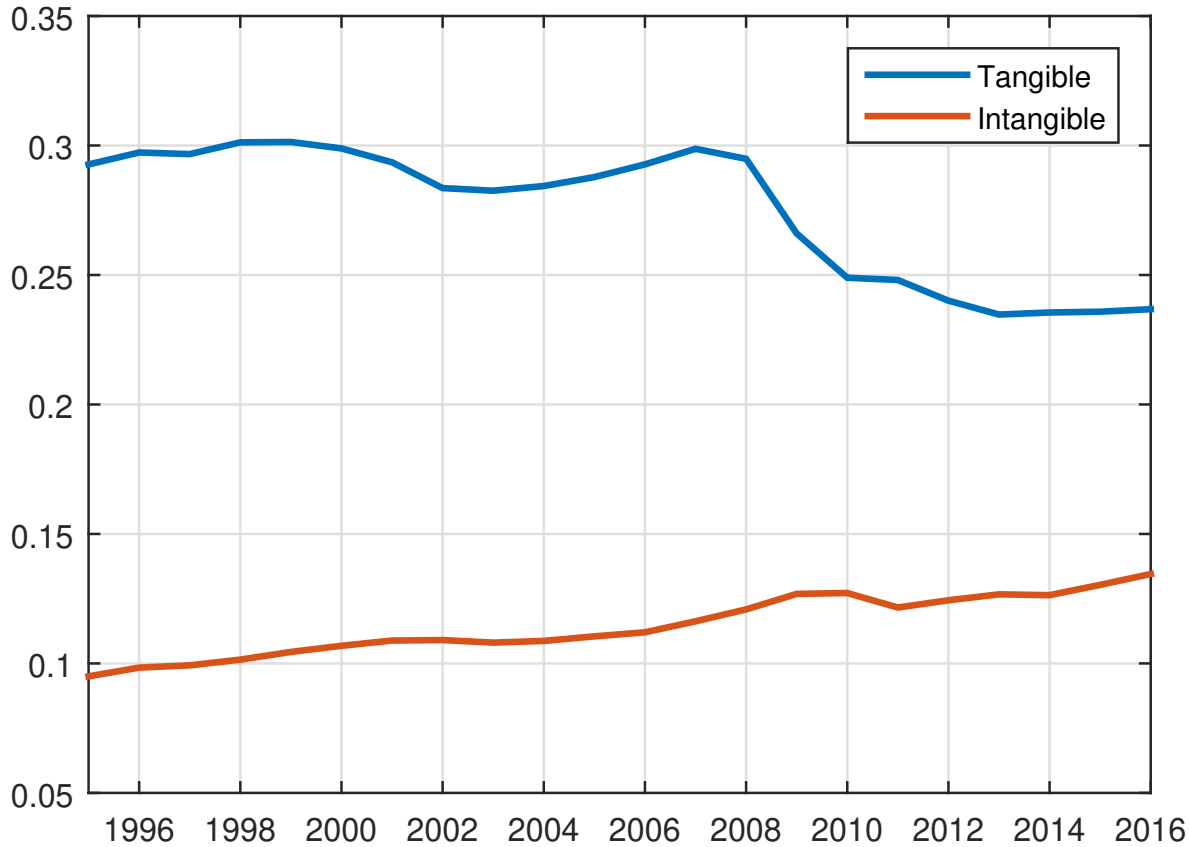
Intangible capital

- **Broad definition:** Accumulated know-how from investments in R&D, brands and building organizations (see McGrattan and Prescott (2010)).
- National accounts has been continuously expanded to better account for the role of intangibles.
- However, 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

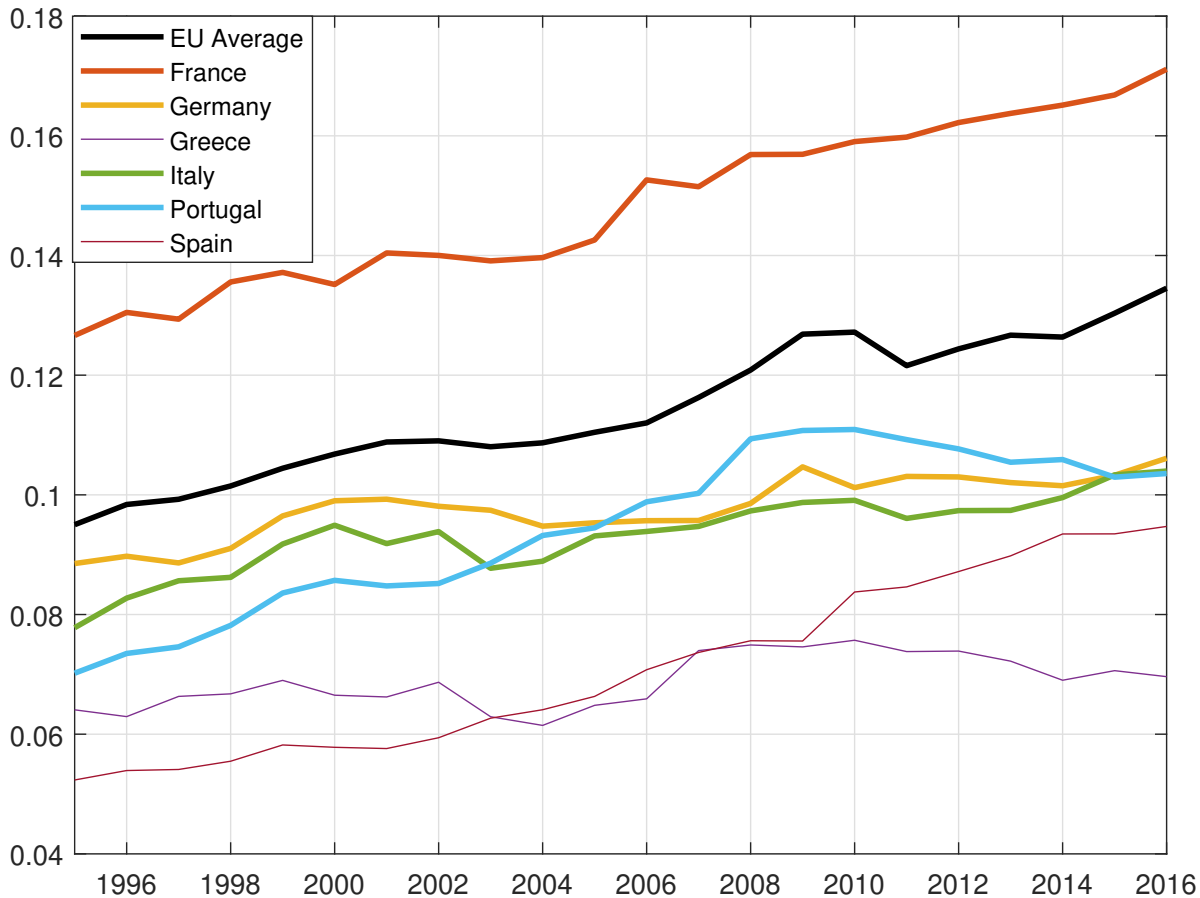
- **Non-Rivalry:** Intangible assets can be used in multiple production activities at the same time.
- **Sunkenness**: Intangible assets most of the times involve irrecoverable costs, thus, cannot be liquidated or sold.
- Other characteristics which are not incorporated in the current model include pledgeability, measurability, spillovers and synergies (Haskel and Westlake 2017).

GVA shares of tangible/intangible investment for EU countries

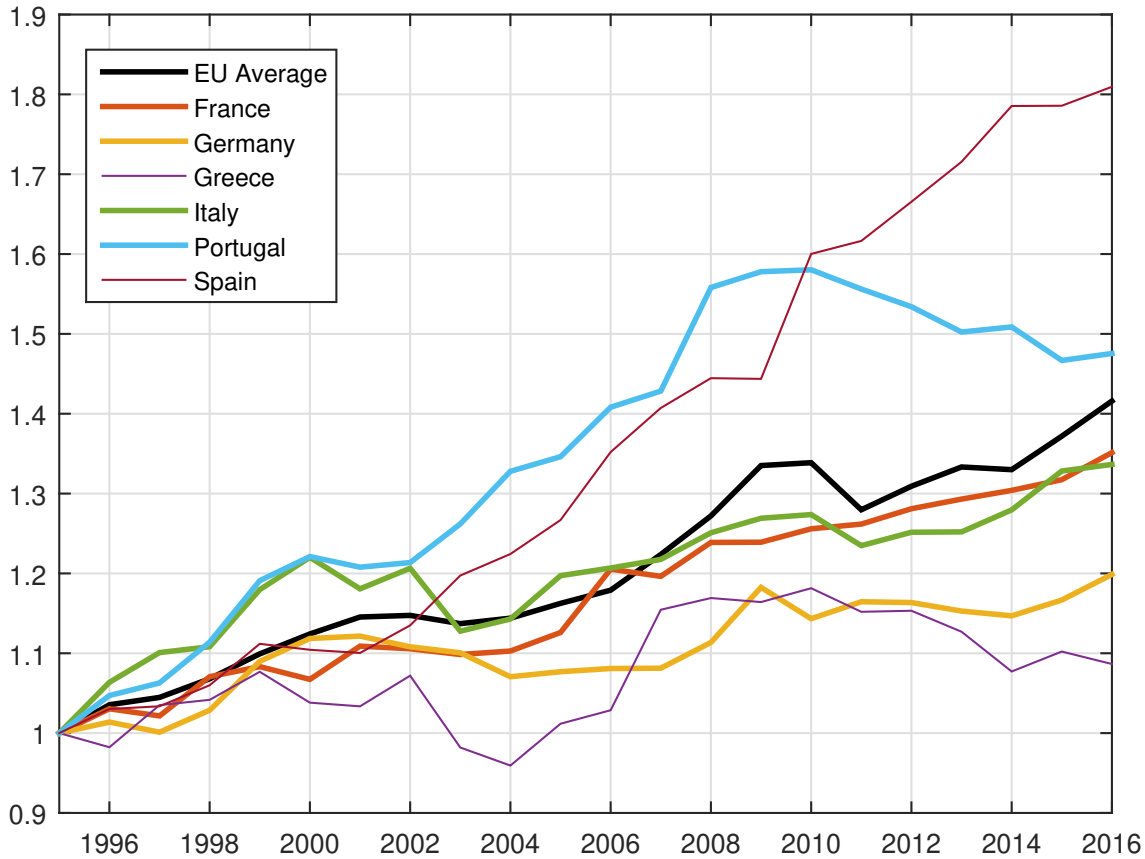


Sources: INTAN database and Eurostat; Note: GVA is adjusted to include unmeasured intangible assets.

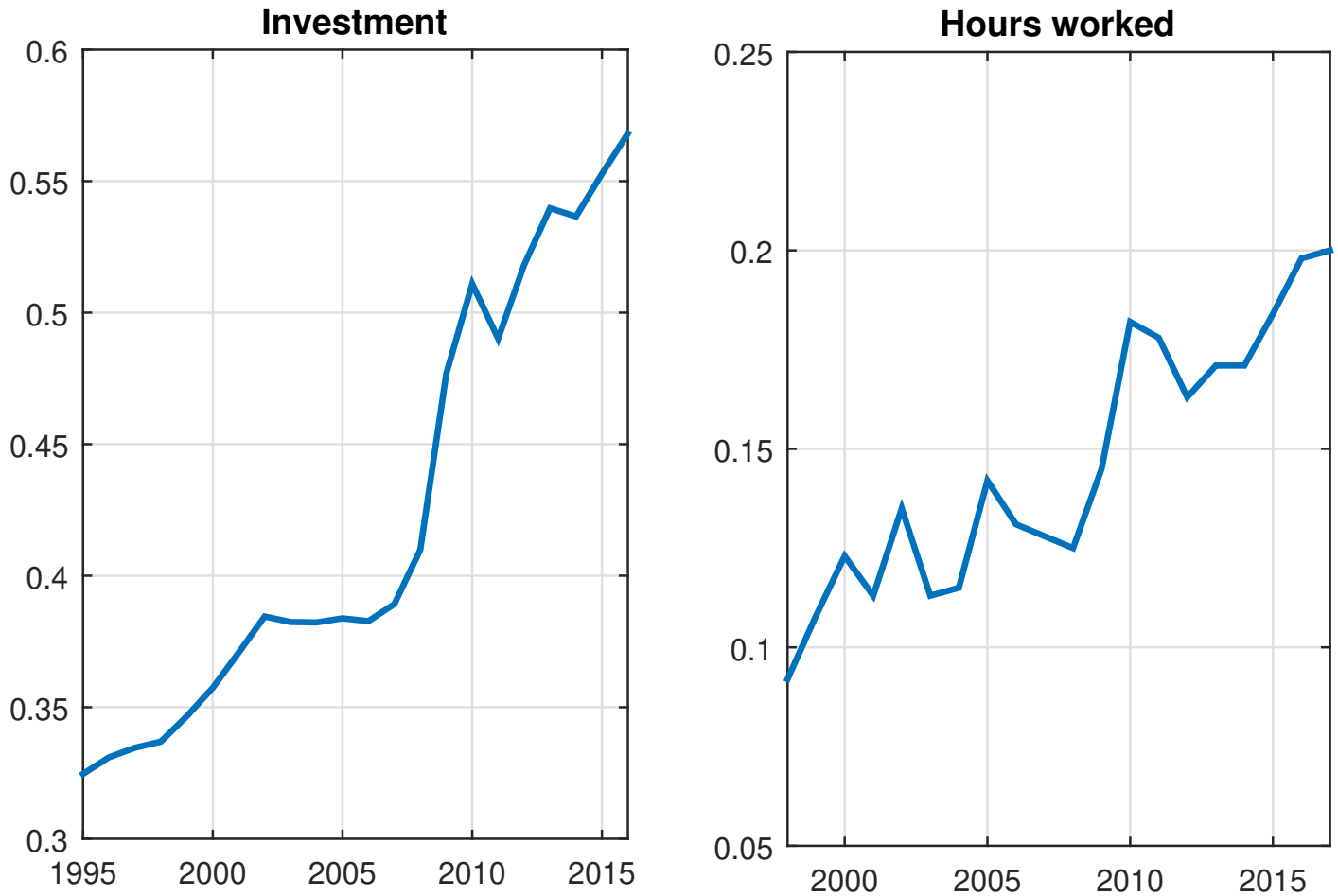
Intangible leaders and laggards in EU: Share of Intangibles



Leaders and laggards in EU: Shares of Intangibles (normalized)

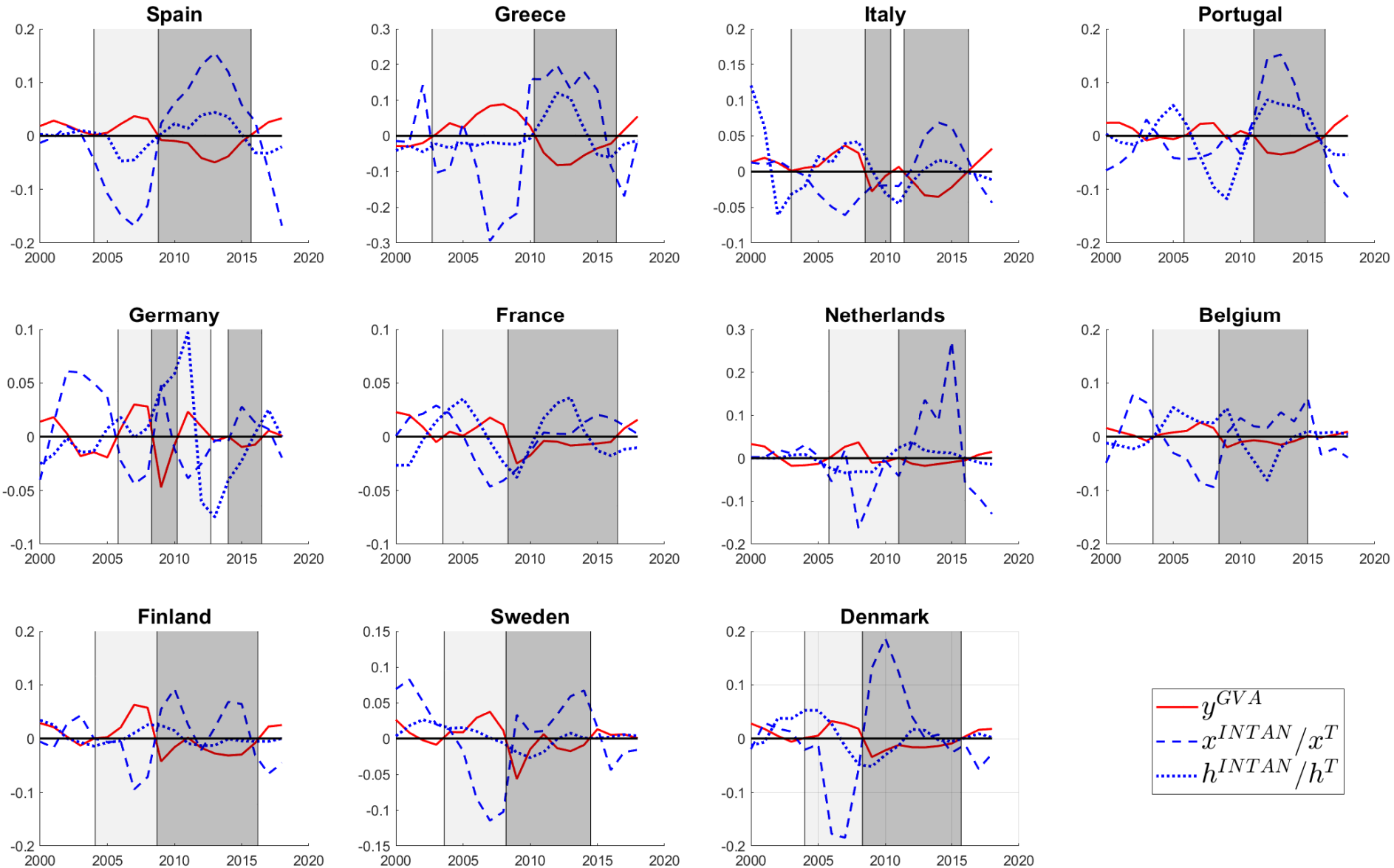


Ratio of intangible to tangible investment and hours worked



Source: EUKLEMS and INTAprod; EU LFS (isco)

Cyclical component



Patterns in the data

1. Focusing on the boom period that preceded the GFC and the bust period of the GFC/European Debt Crisis we see that most in European countries, the respective ratios are countercyclical.

2. Productive resources, like investment and hours, relocate towards the intangible intensive activities during busts, while tangible intensive activities seem to expand relatively more during booms.

3. This cyclical pattern implies that intangible sector is relatively more resilient than tangible sector during recessions.
    a. More evident in countries that faced more severe crisis (Greece, Spain, Portugal, Italy). Both inv. and hours ratios are countercyclical.
    b. Also evident in Germany, France, the Netherlands but less pronounced or with irregularities, lags
    c. Hours worked ratio not countercyclical in Belgium, Finland, Sweden, Denmark

Related Literature

- **Real Business Cycle Theory:** A strand that reassesses RBC theory, e.g. McGrattan and Prescott (2005, 2009, 2010, 2014), Gurio and Rudanko (2014), Mitra (2019), McGrattan (2020).
- **Measurement and Growth Accounting:** Corrado et al. (2006,2016) construct measures of intangible capital by NACE sector. Similarly, Niebel et al. (2017) and Thum-Thysen et al. (2017).
- **Financial frictions:** Lopez and Olivella (2018).
- **Optimal capital taxation:** Conesa and Dominguez (2013, 2020) study optimal fiscal policy under the presence of both intangible and tangible capital.

Model

- A simple RBC model.
- Rivalrousness:
  - Tangible capital is a rivalrous input.
  - Intangible capital is a non-rivalrous input: can be used simultaneously in producing consumer goods and services and in creating new ideas.
- The economies differ only with respect to the intangible capital share in the production function.

Model

- Corporate firms
- Households

Technology

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

$$x_{I,t} = A_t^I \left(k_{T,t}^2\right)^{\theta_2} \left(k_{I,t}\right)^{\phi_2} \left(h_t^2\right)^{1-\theta_2-\phi_2} \tag{2}$$

$$k_{I,t+1} = (1-\delta_I)\, k_{I,t} + x_{I,t} \tag{3}$$

- 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".

Profit maximization

- Corporate profits in real terms are given (McGrattan, 2017; Conesa and Dominguez, 2013):

$$d_t = y_t - w_t h_t - x_{T,t} \tag{4}$$

- 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.

Constraints

$$y_t = A_t \left(k_{T,t}^1\right)^{\theta_1} \left(k_{I,t}\right)^{\phi_1} \left(h_t^1\right)^{1-\theta_1-\phi_1} \tag{5}$$

$$x_{I,t} = A_{I,t} \left(k_{T,t}^2\right)^{\theta_2} \left(k_{I,t}\right)^{\phi_2} \left(h_t^2\right)^{1-\theta_2-\phi_2} \tag{6}$$

$$k_{T,t+1} = (1-\delta_T)\, k_{T,t} + x_{T,t} \tag{7}$$

$$k_{I,t+1} = (1-\delta_I)\, k_{I,t} + x_{I,t} \tag{8}$$

$$k_{T,t} = k_{T,t}^1 + k_{T,t}^2 \tag{9}$$

$$h_t = h_t^1 + h_t^2 \tag{10}$$

First order condition w.r.t intangible capital

$$\mu_t = \underbrace{\Lambda_{t,t+1}\left(\phi_1 \frac{y_{t+1}}{k_{I,t+1}}\right)}_{\text{increase in future output}} + \underbrace{\mu_{t+1}\left((1-\delta_I) + \phi_2 \frac{x_{I,t+1}}{k_{I,t+1}}\right)}_{\text{increase in intangible added value}} \tag{11}$$

- 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.
  - The first is IC's contribution to an increase in output of final goods discounted by the amount of its marginal productivity.
  - The second is the change in the expected shadow value of the IC constraint due to an increase in IC investment, discounted by the amount of its marginal productivity in the IC sector, along with the un-depreciated amount of IC.

Households

GHH preferences:

$$\max U\left(c_t, h_t\right) = \frac{\left(c_t - \frac{h_t^{1-\omega}}{1-\omega}\right)^{1-\sigma}}{1-\sigma} \tag{12}$$

subject to:

$$c_t = w_t h_t + d_t \tag{13}$$

FOCS:

$$\left(c_t - \frac{h_t^{1-\omega}}{1-\omega}\right)^{-\sigma} = \lambda_t \tag{14}$$

$$h_t^{\omega-1} = w_t \tag{15}$$

Decentralized Equilibrium

The DE is a system of 19 processes $k^1_{T,t+1}$, k^2_{t+1}, $k_{T,t+1}$, $k_{I,t+1}$, $x_{T,t}$, $x_{I,t}$, y_t, y^{gva}_t, b_{t+1}, h_t, h^1_t, h^2_t, c_t, τ^l_t, $\frac{D^f_t}{P_t}$, w_t, r_t, λ_t, μ_t in 19 equations, given initial conditions for the state variables, economic policy and exogenous shocks.

Numerical steady state and calibration

- We use common parameter values for most of the parameters.
- The intangible capital share parameter $\phi = \phi_1 = \phi_2$ is calibrated for each country to match the steady state value of the intangible-to-tangible investment ratio to the data.

Calibration

Parameter	Description	Value
β	discount rate	0.96
ω	labour supply elasticity	2.5
σ	elasticity of intertemporal subs.	2
δ_I	depreciation rate of intangible	0.3
δ_T	depreciation rate of tangible	0.1
θ_1, θ_2	tangible capital shares	0.25

Calibration: intangible capital share in EU (1995-2019)

Country	Value of ϕ	Targeted value $\frac{\mu_I x_I}{x_T}$
Sweden	0.158	0.85
Ireland	0.150	0.81
France	0.139	0.75
Netherlands	0.139	0.75
Denmark	0.121	0.65
Finland	0.124	0.67
Belgium	0.108	0.58
Greece	0.091	0.49
Italy	0.089	0.48
Portugal	0.085	0.46
Austria	0.069	0.37
Germany	0.063	0.34
Spain	0.063	0.34

Numerical experiments

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Model assessment: We compare model-based simulations with actual data for the endogenous variables of interest (investment and hours worked ratio.) We impose two criteria following McGrattan and Prescott (2010).

1. the **input justification criterion**, i.e., we require our exogenous shocks to be consistent with the empirical trends in the data.

2. the **prediction criterion**, which states that our model-based simulations should not be counterfactual.

Numerical experiments: justification criterion

1 We calculate the cyclical component of output from raw data, $y_t^{data,c}$:

$$y_t^{data} \equiv \log\left(\frac{Y_t^{data}}{P_t^{GVA} N_t}\right), \qquad y_t^{data,c} = y_t^{data} - y_t^{hp\_trend}$$

2 We would like to bring the cyclical component y_t^m produced by the model close to the data. Thus, we pin down the time path of $\left\{A_t^{data}\right\}_{t=1995}^{2018}$ such that it holds with equality.

$$\log\left(\frac{y_t^m}{y^{ss}}\right)^{m,cycle} = y_t^{data,c}$$

3 Then we test this for the variable y_t^{simul} simulated by the model:

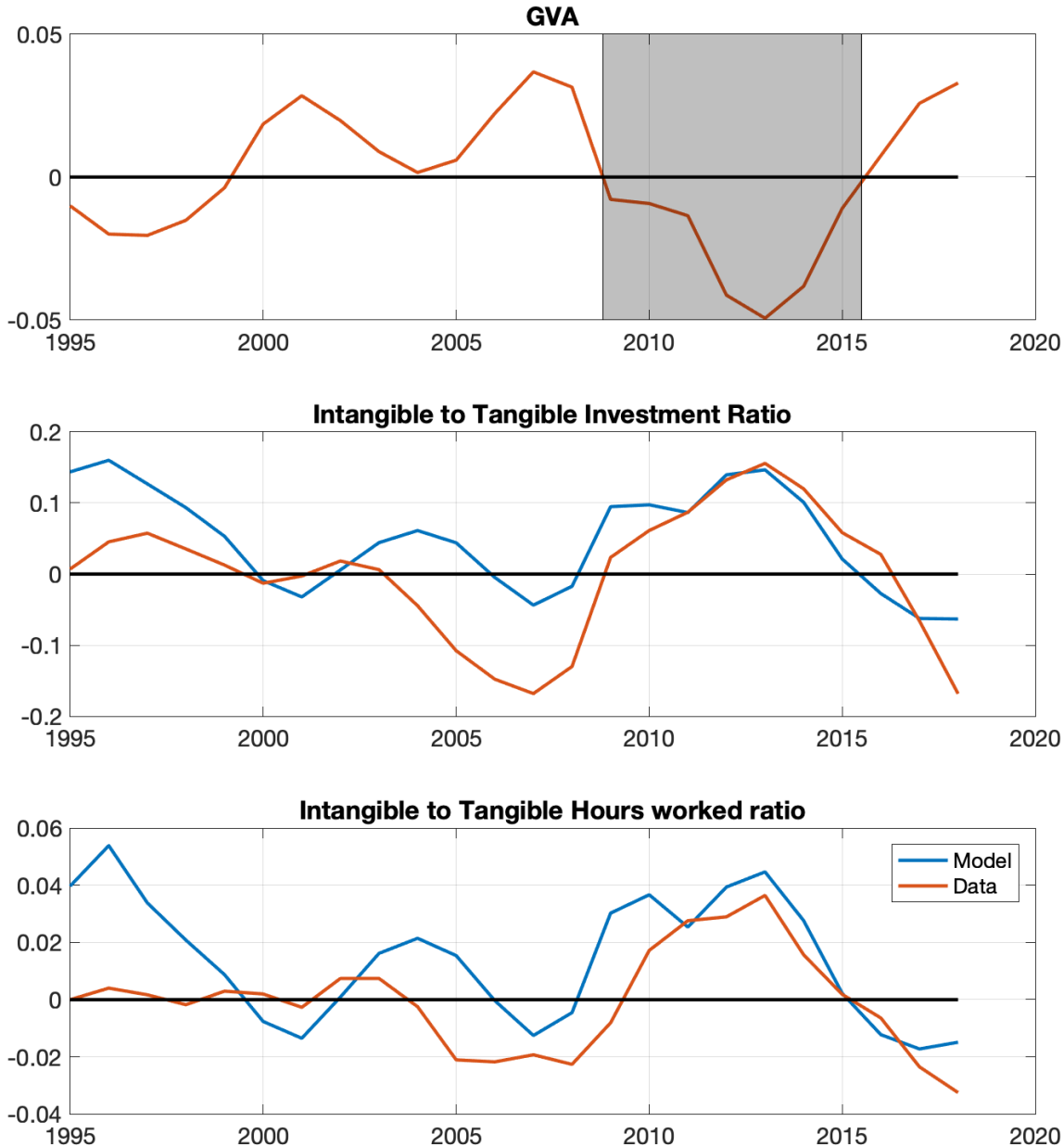
$$\log\left(\frac{y_t^{simul}}{y^{ss}}\right) - \log\left(\frac{y_t^{data,c}}{y^{ss}}\right) = 0$$

4 Then, we feed back in the model the resulting path for TFP so as to simulate artificial model-based data for all the endogenous variables of the model.

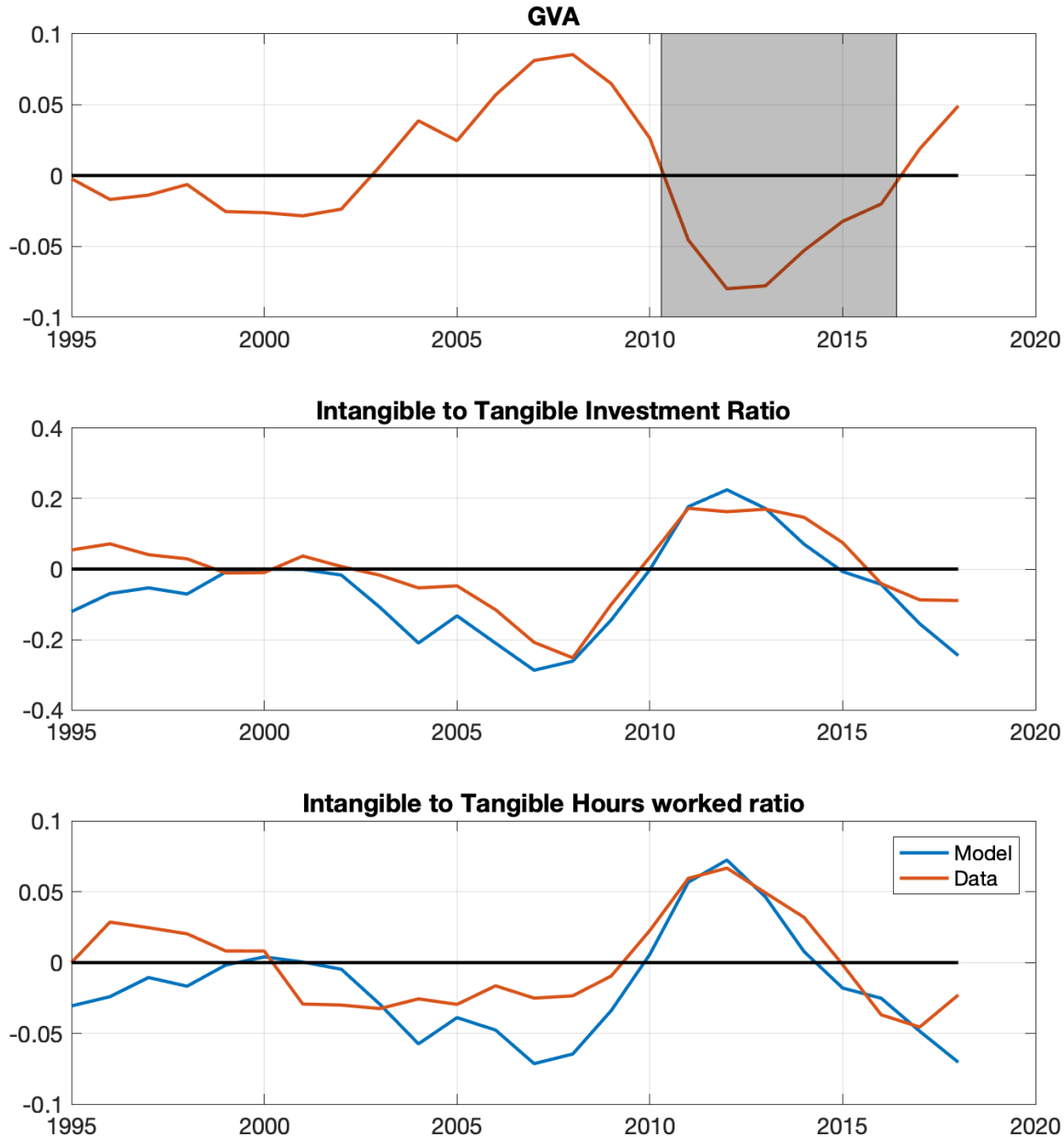
Numerical experiments: prediction criterion

- Suppose x_t^{simul} any endogenous variable simulated with the model after implementing the abovementioned exogenous path, i.e., $\left\{A_t^{data}\right\}_{t=1995}^{2018}$.
- We compare model-based variable, i.e., $\log\left(\frac{x_t^{simul}}{x^{ss}}\right)$, with the associated data $x_t^{data,c}$ which are computed as above.
- Specifically, we compare model-based ratios of intangible to tangible investment, $\frac{\mu_{I,t}x_{I,t}}{x_{T,t}}$, and hours worked in the intangible to tangible sectors, $\frac{h_t^2}{h_t^1}$, with their counterparts in the data. We repeat the same experiment for each country in our sample.

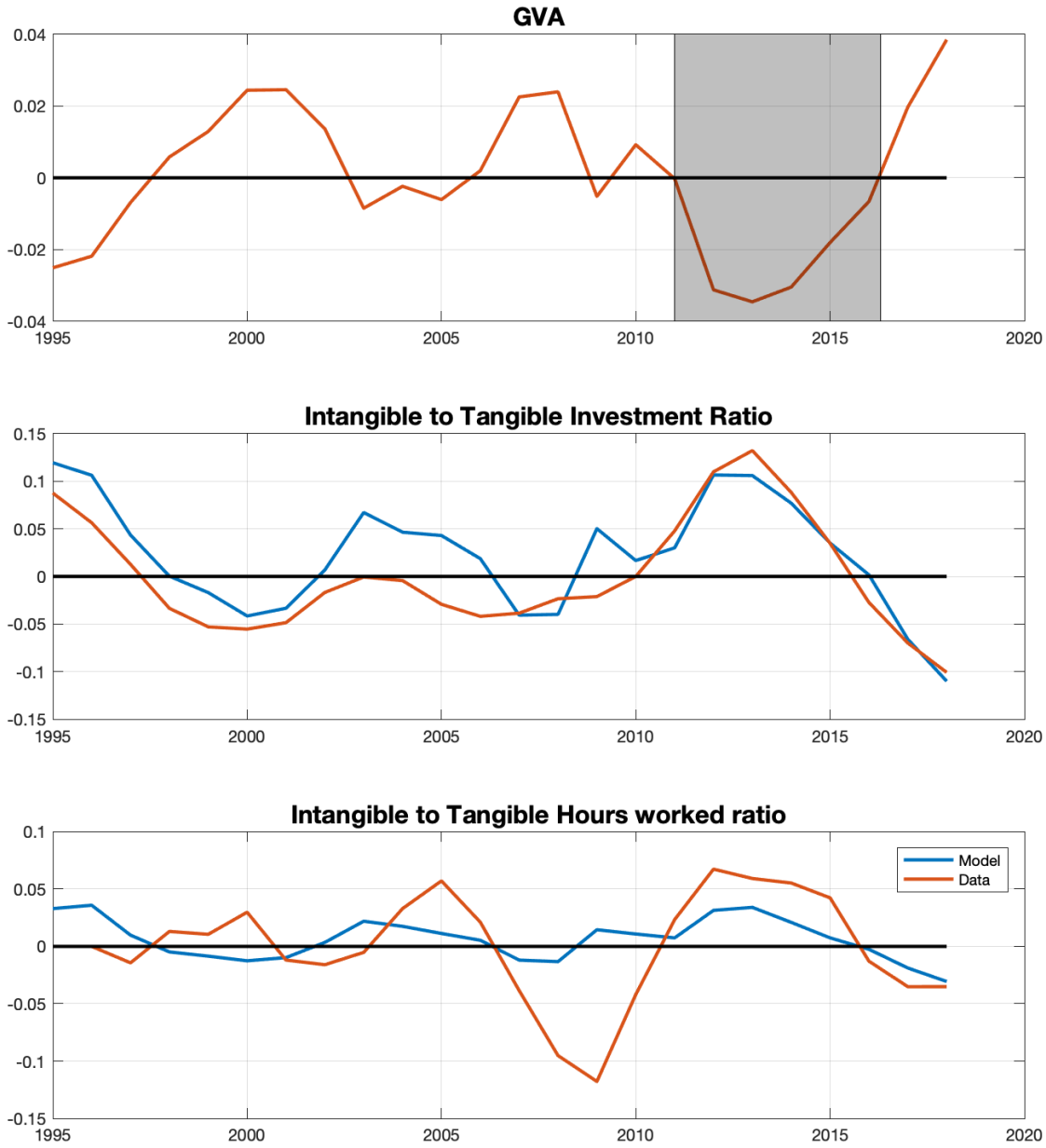
Cyclical patterns comparisons: model/data - Spain



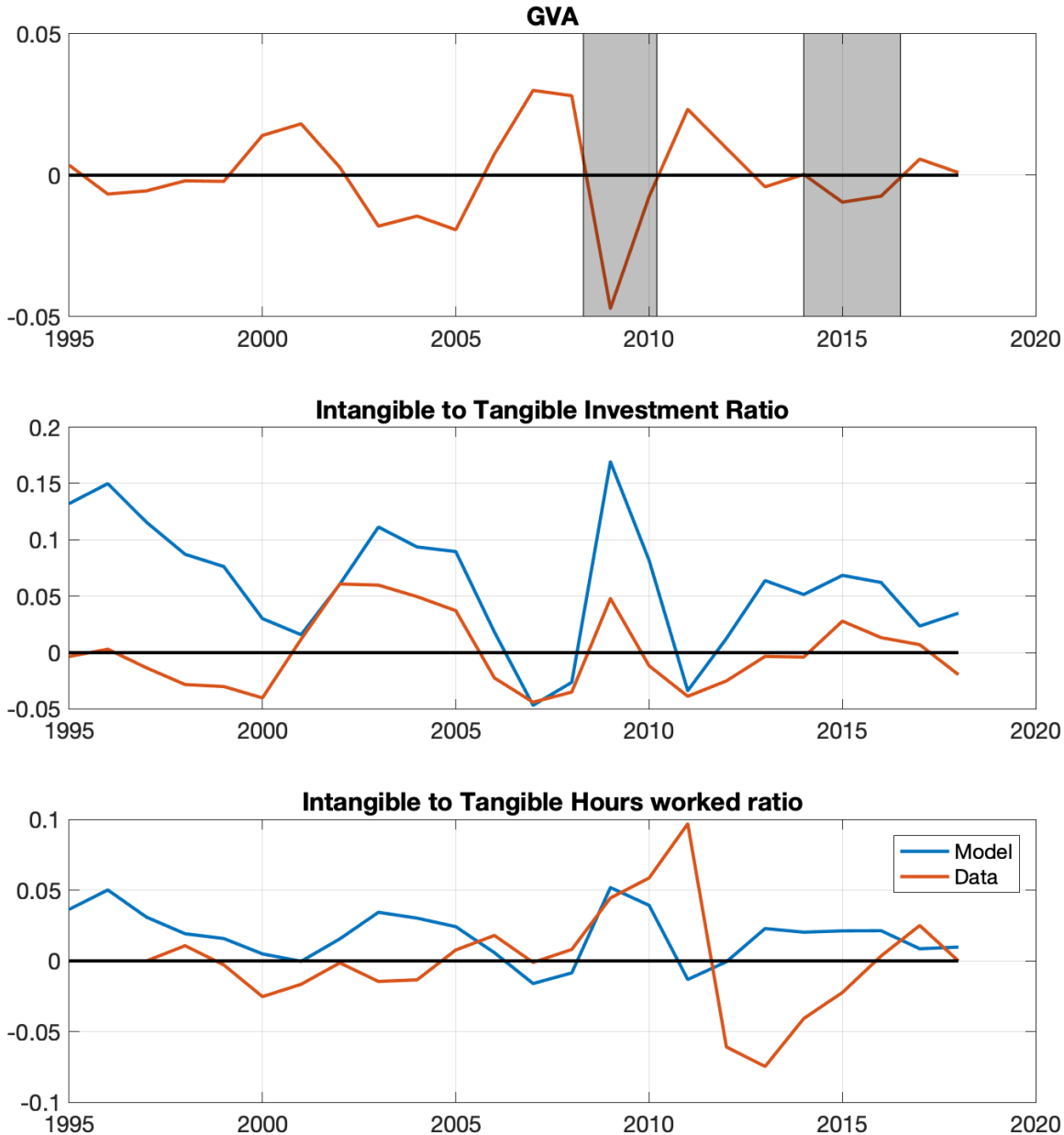
Cyclical patterns comparisons: model/data - Greece



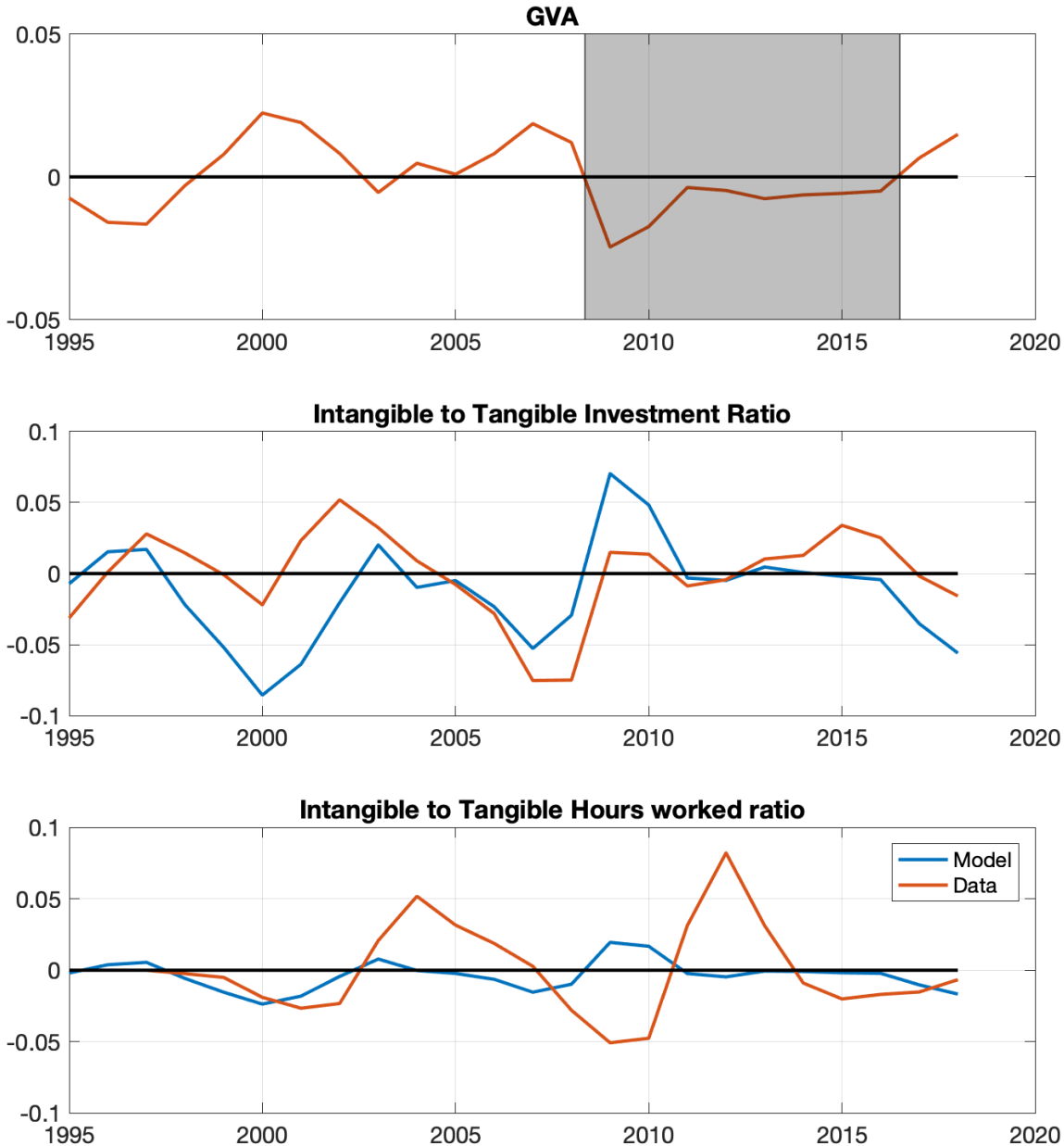
Cyclical patterns comparisons: model/data - Portugal



Cyclical patterns comparisons: model/data - Germany



Cyclical patterns comparisons: model/data - France



Comparison of the cyclical pattern in the model and data

- The model accurately replicates the resource relocation observed in Eurozone during the Global Financial Crisis (which seems that can be replicated via negative TFP shock in our model) between the tangible goods sector and the intangible sector during boom and bust cycles.

- During a boom cycle, the tangible goods sector experiences relatively more growth compared to the intangible sector, leading firms to relocate resources towards the production of tangible goods.

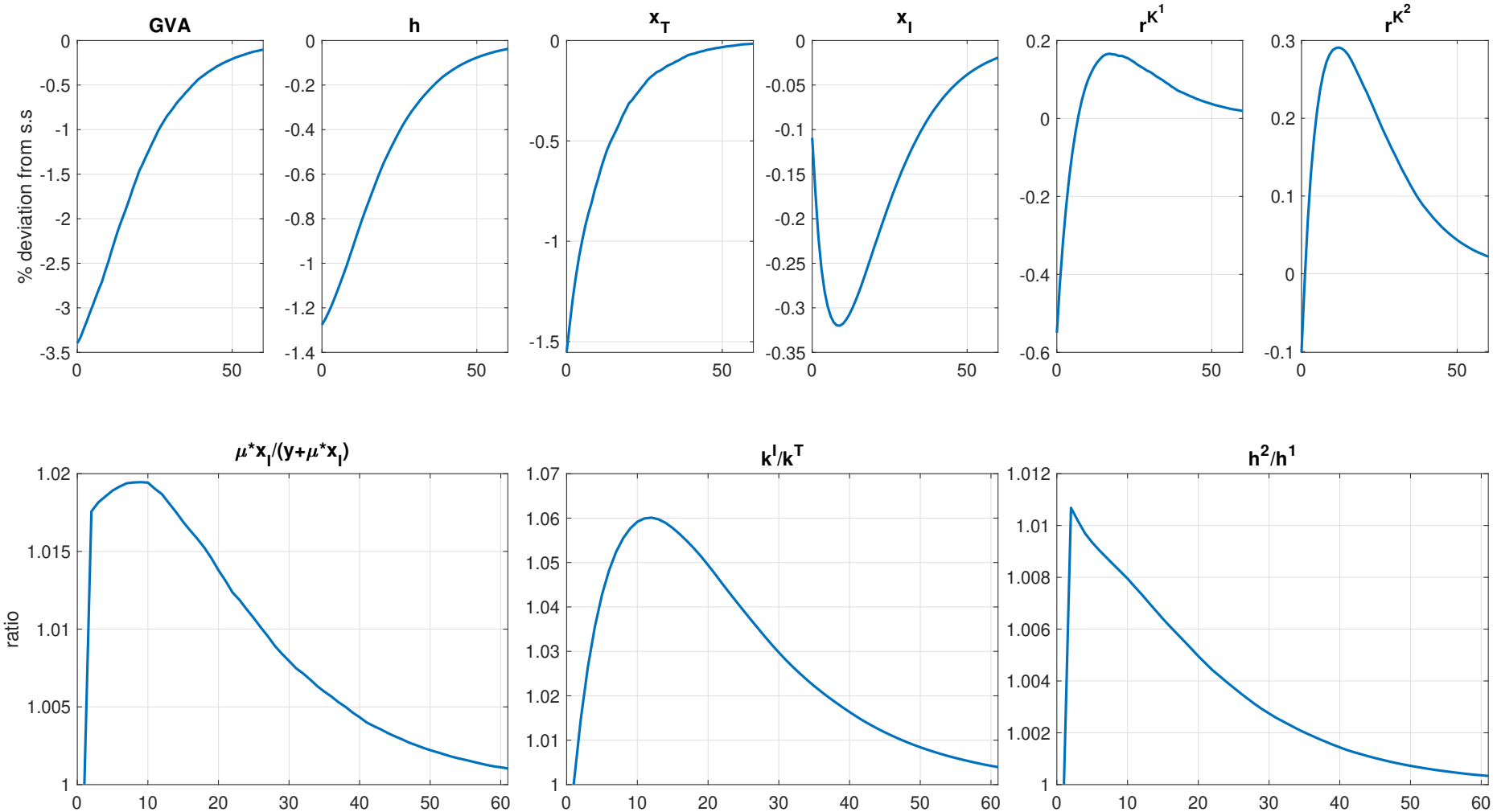
- In contrast, during a bust period, the intangible sector grows in comparison to the tangible sector, indicating that resources are being reallocated towards the intangible sector.

Cyclical patterns comparisons: model vs data

Correlation of predicted values with actual

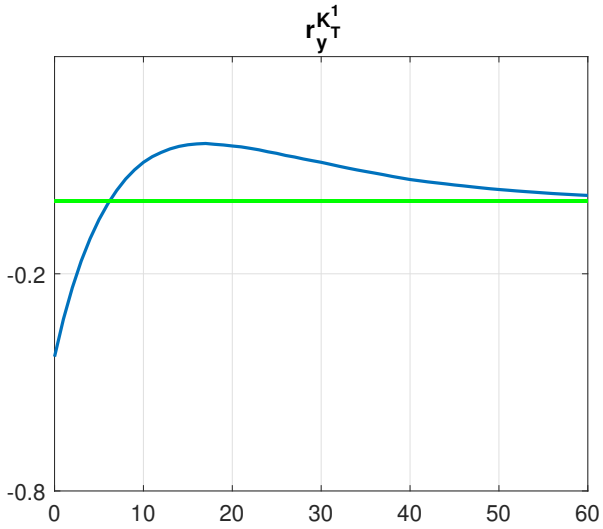
Country	$\frac{\mu_I x_I}{x_T}$	$\frac{h_2}{h_1}$
Portugal	0.8825	0.341
Greece	0.8178	0.5959
Spain	0.7647	0.6146
Netherlands	0.3678	0.2462
Belgium	0.6325	0.0315
France	0.4137	0.0289
Germany	0.7938	-0.0020
Italy	0.678	-0.1697
Sweden	0.3549	-0.1232
Finland	0.8657	-0.2032
Denmark	0.7748	-0.0846
Austria	0.6365	-0.0878

A negative TFP shock

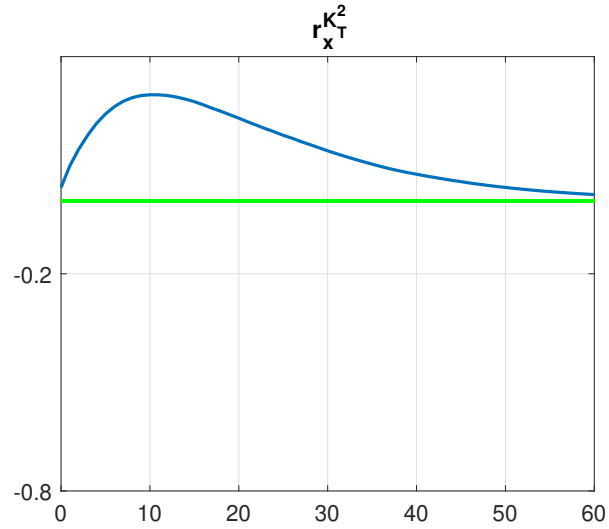


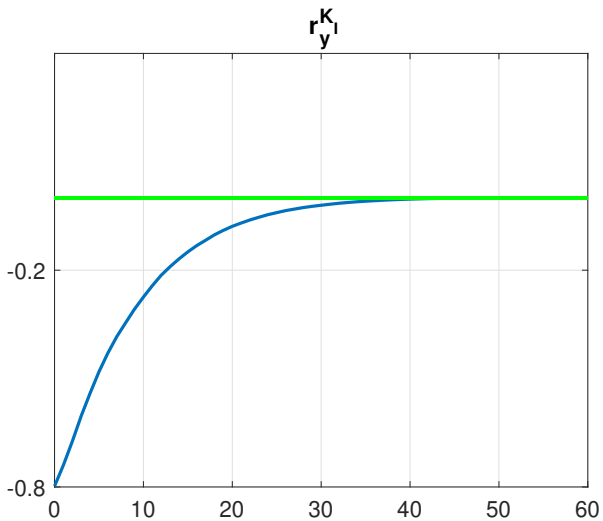
MPKs

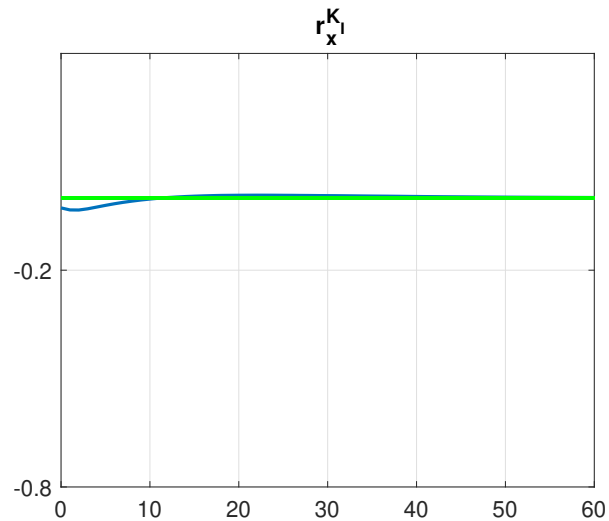
Tangible sector



Intangible sector







Mechanism

- A negative TFP shock induces a reduction in tangible goods gross value added. It also leads to a reduction in the key macroeconomic aggregates of the economy, i.e., hours worked, tangible and intangible investment.

- However, the reduction in tangible investment is more profound than the reduction in intangible investment. The relative ratio illustrates that a negative TFP shock which generates a significant reduction in tangible output would instead increase the relative size of the intangible output and subsequently the associated productive inputs used to its production.

- During recessions caused by negative TFP shocks, the production of tangible goods becomes less productive than intangible (see marginal productivities). Thus, reallocating resources towards intangible investment is a less costly usage of productive inputs for firms.

- In the model, intangible investment increases future profits by accumulating in intangible capital stock, which enhances the production of both intangible and tangible production activities.

Sensitivity and robustness

- Complementarities betweeen tangible and intangible capital (Corrado et al, 2017)
- Higher/lower ϕ.
- Larger factor share of intangible capital in the intangible production activity $\phi_2 > \phi_1$

Extensions

- Redistribution and inequality considerations
- Intangible capital and monetary policy
- Financial frictions

Thank you!

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Categories of intangible assets

Corrado et al. (2005) categorize intangible assets into three broad groups:

- Computer related, i.e. software and databases.
- Innovative properties, i.e. R&D, design and artistic originals.
- Company competencies, i.e. marketing and branding, firm-specific training, business process engineering, management consulting services, advertising

National accounts only include software, artistic originals and R&D.

▸ Intangibles