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Intangible investment during the Global Financial Crisis in the EU*

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Abstract

In this paper, we identify a cyclical pattern for intangible to tangible economy during the the EU boom-bust cycle from 2000 to 2020. Specifically, the two ratios of intangible-to-tangible investment and hours worked fluctuate countercyclically with GVA. We show that in a frictionless RBC model augmented with an intangible sector a standard TFP shock can effectively replicate this cyclical pattern. Conversely, we show that in an RBC model augmented with financial frictions, a financial shock produces intangible-to-tangible investment ratio which is inconsistent with the observed EU data.

Keywords: Business Cycles, Intangible capital, European economy

JEL Classification: E22, E32, O52

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"That intangible capital investment financed and owned by firms is big has never been in dispute. A question is why intangible capital was not incorporated into quantitative aggregate theory."

Edward Prescott (Handbook of Macroeconomics, 2016)

1 Introduction

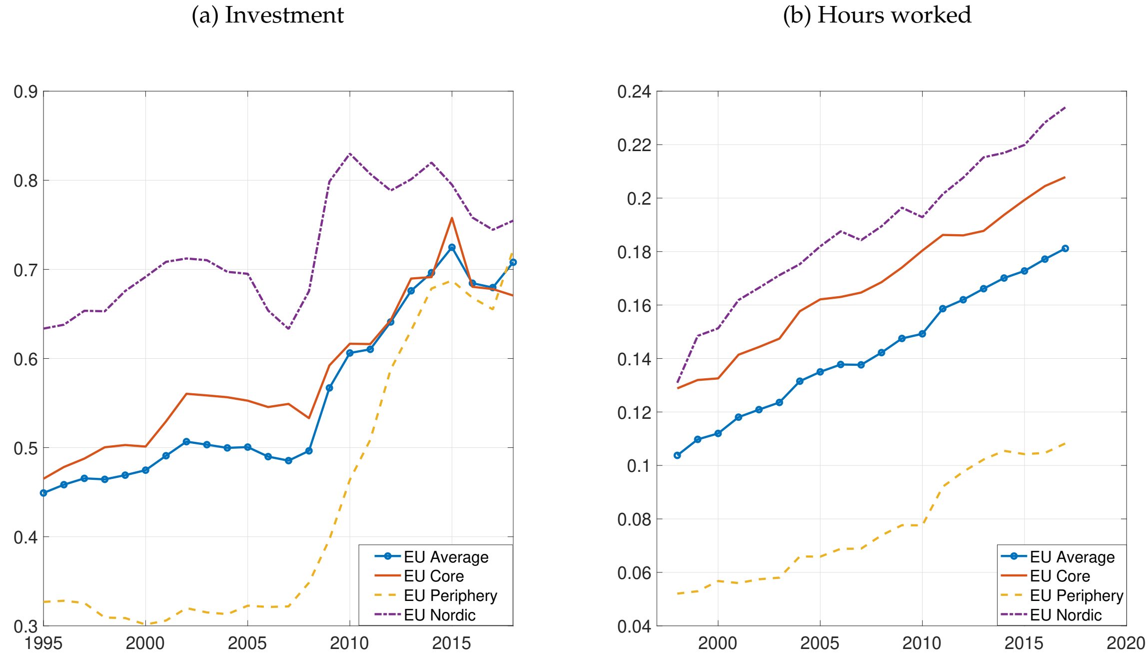
The importance of intangible production activities relative to tangible ones has steadily increased in modern economies. This shift has been documented for the US economy, see e.g., Corrado *et al.* (2022), and is clearly illustrated in Figure 1 for European countries (EU). Figure 1 plots two key ratios that represent the intangible intensity of the production in modern EU economies: the intangible-to-tangible investment ratio (left panel) and the ratio of hours worked in intangible-to-tangible occupations for EU average and selected country groups within EU. Both ratios exhibit an upward trend, indicating the relative expansion of intangible vis-à-vis tangible economy. Furthermore, there is a significant cross-country variation as well as over time variation in intangible intensity. The Nordic group is relatively more intangible intensive than Core and Periphery, whereas the Periphery followed by the Core, displays a notable acceleration in the aftermath of the Global Financial Crisis.

The purpose of this paper is to shed more light on business cycle fluctuations of the intangible economy and compare them to those in tangible economy. Our focus is on the EU during the period from 2000 to 2020. This timeframe is particularly suitable as it includes both a boom and a bust business cycle. During this period, the EU experienced a phase where economic activity, measured by gross value added (GVA), fluctuated above its trend, i.e., before the onset of the Global Financial Crisis, followed by a prolonged period where GVA remained below its trend for a significant subset of EU countries.

Focusing on the EU during this period, we aim to answer the following questions: How does the cyclicality of the intangible economy compare to that of the tangible economy during the recent EU boom-bust business cycle? Can the recent advances in Real Business Cycle (RBC) methodology, specifically the inclusion of an intangible sector, replicate the cyclical patterns observed in the data? Within such a model, which exogenous source is more likely to have triggered the EU boom-bust cycle: a standard Total Factor Productivity (TFP) shock or a financial shock?

To address these questions we work as follows. First, we identify the specific cyclical patterns in the data that describes how intangible economy fluctuates relative to the tangible economy. In section 2, we employ aggregate time series for the intangible and tangible economy, namely investment and hours worked, and examine their comovement with GVA. We use publicly available data from EUKLEMS&INTANProd database and survey data from EU Labour Force Survey for a

Figure 1: Intangible to tangible ratios of investment and hours worked



i. Source: EUKLEMS-INTANProd database and EU Labour Force Survey. Time series from the EU Labour Force Survey are available from the year 1998.
ii. EU Core group consists of Austria, Belgium, Germany, France, and the Netherlands; Periphery group consists of Greece, Italy, Portugal, and Spain; EU Nordic consists of Denmark, Finland, Sweden.
iii. The values reported for each group are the simple averages of country groups.

sample of 12 EU countries. Additionally, we categorize these countries into three distinct groups, the Periphery, the Core, the Nordic and compare them with the EU average.

Having identified the specific cyclical characteristics of intangible relative to tangible aggregate variables, our aim is to provide a theoretical rationale for these cyclical patterns using a general equilibrium model. Specifically, we employ a frictionless RBC model that incorporates an intangible sector, first developed by McGrattan and Prescott (2010b) for the US economy (for an overview see also McGrattan and Prescott (2014)). The model consists of households and firms. The household's decision problem is intentionally minimal and rather standard. The main departure from the traditional RBC model is the introduction of two sectors of production, i.e., tangible and intangible. Following McGrattan and Prescott (2010b), firms can allocate resources to two production activities, namely the production of a final tangible good and the production of an intangible investment good. Both goods are produced by using rivalry inputs, i.e., tangible capital and hours worked, and a non-rivalry input, i.e., intangible capital. Intangible capital is used in both production technologies, encompassing the notion that a new 'idea' can be used to develop both goods and new 'ideas'. To examine whether a financial shock, as opposed to a TFP shock, can generate the cyclical patterns observed in the data, we also extend the benchmark model by introducing financial frictions as in Jermann and Quadrini (2012). In this extended model, financial shocks may also generate real business cycle fluctuations.

We solve the model numerically and separately for each group of countries (in the Appendix we do this for the full sample of 12 individual EU countries). In our parameterization, we allow these groups to differ only in one structural parameter, namely the intangible capital share in the production function. To calibrate this parameter we employ data on intangible-to-tangible investment ratio for the three distinct country groups the Periphery, Core, Nordic and compare them with the EU average. This calibration process allows to obtain a measure of model-consistent intangible intensity for these countries.

We assess the performance of the model following the methodology outlined in McGrattan and Prescott (2010a), which states that a successful theory must satisfy two criteria. First, the *input justification criterion* necessitates that our exogenous shocks align with the empirical trends observed in the data. Second, the *prediction criterion* asserts that our model-based simulations should not produce counterfactual outcomes. In order to satisfy the *input justification criterion* we pin down a path for an exogenous shock (TFP or financial shock) to precisely match the cyclical component of GVA observed in the data with the cyclical component generated by the model. To test the *prediction criterion*, we compare model-based simulated endogenous variables with the cyclical component that we compute from the data. Specifically, we compare model-based ratios of intangible-to-tangible investment, and hours worked in the intangible-to-tangible sectors, with their counterparts in the data. We repeat this experiment for each country group and each individual country in our sample.

Our main findings are as follows. Initially, we characterize the cyclical properties of key intangible aggregates relative to tangible ones in the data. We identify a distinct cyclical pattern that connects the intangible with the tangible sector of the EU economies. Specifically, both intangible-to-tangible investment and hours worked ratios are countercyclical with respect to a measure of aggregate economic activity, such as GVA. This implies that during economic downturns, such as the GFC, productive resources tend to shift towards intangible-intensive activities. Conversely, tangible-intensive production activities seem to expand relative to intangible ones during economic booms, such as the period preceding the GFC. In other words, the intangible economy appears more resilient during recessions in the data. This countercyclical pattern of intangible-to-tangible ratios is more pronounced for Periphery countries which were more heavily impacted by the GFC.

Turning to the theoretical rationale for these patterns, we show that in a frictionless RBC model augmented with an intangible sector, a standard TFP shock can effectively replicate the observed cyclical pattern, particularly for the intangible-to-tangible investment ratio. This model satisfies the *input justification criterion*, meaning that the exogenous TFP shock generates the boom-bust cycle of GVA. Additionally, it meets the *prediction criteria*, i.e., it generates countercyclical intangible-to-tangible investment and hours worked ratios. Thus, it fulfils both necessary criteria for a successful theory as proposed by McGrattan and Prescott (2010b). Intuitively, during economic booms, firms optimally allocate productive inputs towards the production of final tangible goods. Thus, firms accumulate tangible capital relatively faster than intangible capital, and more hours worked are devoted to the tangible sector. Conversely, during economic downturns, the intangible sector expands relative to the tangible sector, indicating a shift in resource allocation towards intangible production. Firms optimally move resources away from the less productive tangible sector and redirect them within the firm to the intangible sector. As a result, intangible capital accumulates faster than tangible capital. Within the context of our model, the resilience of the intangible sector during recessions is attributed to the nature of intangible investments. These investments involve firm-specific expenditures and contribute to future profits by enhancing the intangible capital stock.

However, the benchmark model's performance varies across groups of countries and macroeconomic aggregates. The model captures the sectoral resource reallocation from tangible to intangible investment substantially better, during the crisis years for Periphery countries compared to Core and Nordic countries. Additionally, the model fits relatively well with the data for the Periphery and especially so during the bust period that followed the GFC. However, model's fit becomes less convincing when we examine the reallocation effect in hours worked intangible to tangible ratio for the Core and Nordic countries. Specifically, the model clearly overpredicts the reallocation of hours worked from the tangible to the intangible sector for the Core and the Nordic groups.

The extended model with financial frictions, where financial shocks are employed to generate the boom-bust cycle, does not satisfy both the necessary criteria for a successful theory. Specifically, this model may meet the *input justification criterion*, in the sense that an exogenous financial shock does generate the boom-bust cycle, however, it fails the *prediction criterion*. Specifically, in this model, a financial shock predicts a procyclical intangible-to-tangible investment ratio, which is inconsistent with the countercyclical pattern observed in the data. Although the model does predict a countercyclical number of hours worked in the intangible-to-tangible sector, this ratio is much more volatile compared to the respective ratio observed in the data. Our analysis implies that financial shocks are less likely to account for the cyclical patterns observed in the data regarding the intangible relative to tangible sector. Conversely, when standard TFP shocks are introduced into a rather standard RBC model augmented with an intangible sector, they can qualitatively, and to some extent quantitatively, explain the observed cyclical patterns.

Our paper belongs to an expanding strand of the literature that reassesses RBC theory by incorporating intangible capital to explain various puzzles in modern business cycle fluctuations, a non-exhaustive list includes McGrattan *et al.* (2005), McGrattan and Prescott (2010a), Gourio and Rudanko (2014), Mitra (2019). Prescott (2016) provides a comprehensive overview of this literature. We combine this theoretical framework with relatively new advancements in the measurement of intangible investment by Bontadini *et al.* (2023). Additionally, our work is related to studies that incorporate financial shocks as e.g., Lopez and Olivella (2018), Falato *et al.* (2022), Gareis and Mayer (2023).

The added value of our work is as follows. First, to the best of our knowledge our paper is the first that quantify the business cycle fluctuations of intangible economy in a sample of EU countries. Additionally, we offer new insights into the nature of EU business cycles during the boom-bust cycle occurred from 2000 to 2020. Our results contribute new evidence on the ongoing debate whether TFP or financial shock were the primary cause of the GFC. We analyse this question through the lenses of intangible versus tangible economy macroeconomic aggregates.

The rest of the paper is structured as follows. In section 2 we look into the cyclical characteristics of the intangible economy compared to the tangible economy across a sample of EU countries. The baseline model is developed in section 3. Section 4 presents parameter values and the calibration method used in the solutions. Section 5 presents the main findings. In turn, in section 6 we add financial constraints in the model and discuss its implications. Robustness checks and further sensitivity is discussed in 7, while Section 8 concludes the paper.

2 The cyclicality of intangible investment during the Global Financial Crisis across the EU

In this section, we discuss in more detail the cyclical characteristics of the intangible economy compared to the tangible economy across a sample of EU countries groups. To accomplish this, we employ annual data from the EUKLEMS-INTANProd database on intangible investment which contains harmonized estimates of investments and capital stocks in intangible assets, that are not included in national accounts (see Bontadini *et al.*, 2023). Figure 2 illustrates the cyclical component of key macroeconomic aggregates for the period 2000-2019 for selected EU groups of countries. Specifically, it depicts the GVA adjusted[1] to account for intangible investment not reported in national accounts (depicted by the lines in blue in each subplot of Figure 2). This adjusted GVA reflects the cyclical behavior of the total economy, i.e., both the tangible and intangible sectors.

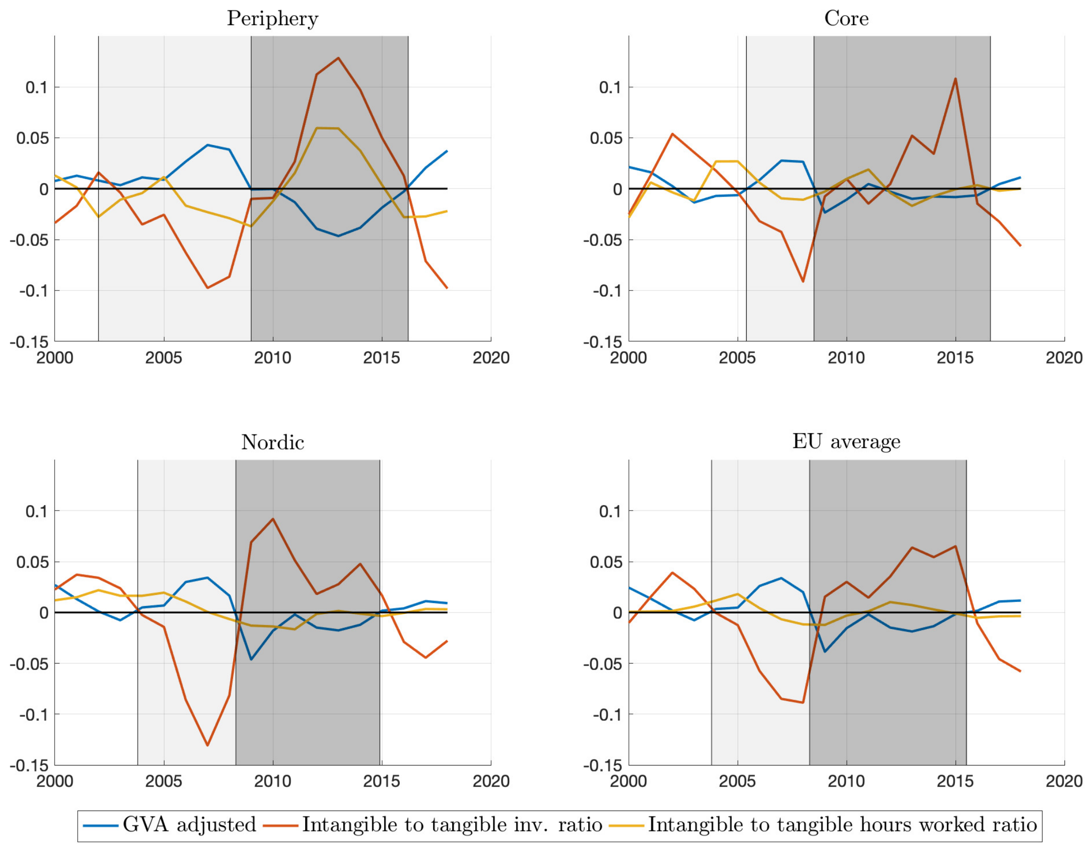
Then we identify the cyclical patterns for each of the EU countries group in terms of the intangible to tangible investment ratio (depicted by lines in red) and the intangible to tangible hours worked ratio (depicted by the lines in yellow). The light grey shaded areas represent boom periods, where the adjusted GVA exceeds its trend, while the dark grey shaded areas correspond to bust periods, where the adjusted GVA falls below its trend.[2]

[1]The gross value added adjusted is defined as the gross value added reported in national accounts plus additional intangible investment which are not reported in national accounts but are measured by Bontadini *et al.*, 2023.

[2]To derive the cyclical component, we utilize the raw time series of GVA from the EUKLEMS-INTANProd database. We then adjust it by the corresponding GVA deflator and working age population. Subsequently, we apply a standard HP filter and subtract the trend from the scaled GVA time series. Further details can be found in Appendix B.

In each of the countries group under consideration, we observe a countercyclical pattern in the respective ratios. This indicates that during economic downturns, productive resources such as investment and hours worked tend to reallocate towards intangible intensive activities, while tangible intensive activities appear to expand relatively more during periods of economic booms. Corrado *et al.* (2022) document a similar cyclical pattern in US data.[3] This cyclical trend suggests that the intangible sector demonstrates greater resilience than the tangible sector during recessions. However, this countercyclical behavior is more pronounced for the Periphery economies that experienced more severe economic crises (such as Greece, Spain, Portugal, and Italy), where both investment and hours ratios exhibit countercyclical movements. In other words stronger recessions come with stronger reallocation of investment from the tangible to the intangible sector. A similar pattern is observed in the Core and Nordic countries despite their experience of comparatively less severe recessions.[4]

Figure 2: Cyclical components at EU level and country groups, 2000-2018



Source: EUKLEMS-INTANProd database and EU Labour Force Survey

There are several economic reasons which might explain why intangibles are more resilient than tangibles during recessions. Intangible assets/goods, such as marketing and branding, customer

[3] Lopez and Olivella (2018) report a pro-cyclical behavior for the intangible to tangible capital ratio for the overall US economy. They utilize a different sample period from Corrado *et al.* (2022).

[4] Country specific figures can be found in the Appendix C.

relationships and firm specific business processes, can be produced within the same firm employing inputs that otherwise would remain unused during recessions. This within-firm reallocation of resources is usually less costly than the development and production of new tangible goods. During recessions where the demand of tangible goods is depressed, firms can quickly shift their production towards intangible assets since the latter type of assets are less sensitive to changes in interest rates than tangibles, reflecting their higher user costs.[5] In turn, the accumulated intangible capital stock can be used to generate higher profits in the future when the demand for final tangible goods/services would have recovered. This implies that intangibles could lead to potential higher returns in the future. Finally, one of the key economic characteristics that differentiate intangible from tangible capital as a factor of production is their nonrivalry. That is intangible capital can be used simultaneously in the production of final tangible goods as well as of new intangibles investment (see McGrattan and Prescott, 2014 and Crouzet *et al.*, 2022). In the next section we present a model that includes intangible capital as a factor of production à la McGrattan and Prescott (2010a) incorporating some of the features discussed above.

3 The augmented RBC model

In this section we present a Real Business Cycle general equilibrium model augmented with an intangible production sector. The model consists of households and firms. Household decision problem is rather standard. Firms can allocate resources to two production activities, namely the production of final tangible goods and the production of an intangible investment good. Both goods are produced by employing rivalry inputs, i.e., tangible capital and hours worked, and a non-rivalry input, i.e., intangible capital.

3.1 Firms

3.1.1 Technology

A representative firm in the corporate sector produces a final tangible good, y_t, using tangible capital, $k^1_{T,t}$, intangible capital, $k_{I,t}$, and labour, h^1_t:

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

where the parameters θ_1 and ϕ_1 measures the productivity shares of tangible and intangible capital in production of the final tangible good, respectively, and A^y_t follows an $AR(1)$ process. Also, the same firm produces an intangible investment good, $x_{I,t}$, using tangible capital, $k^2_{T,t}$, intangible capital, $k_{I,t}$, and labour, h^2_t:

[5] See Corrado *et al.* (2022) and the references therein.

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

We assume that intangible capital is a non-rivalrous productive input that enters both production technologies since it is not split between the production of the final good and the new intangible good (see McGrattan and Prescott, 2010a). The parameters θ_2 and ϕ_2 measure the productivity shares of tangible and intangible capital in production of intangible investment good, respectively, and A_t^x follows an $AR(1)$ process. The total GVA in the economy, y_t^{gva}, is defined as:

$$y_t^{gva} = y_t + \mu_t x_{I,t} \tag{3}$$

where μ_t is the shadow relative price of intangible GVA (which in our model is equal to the Lagrange multiplier associated with the law of motion of intangible capital defined in the next subsection). Thus, y_t^{gva} represents the model counterpart of GVA adjusted presented in section 2.

3.1.2 Profit maximization

The maximization problem of firms follows McGrattan and Prescott (2014) and Conesa and Domínguez (2013). Corporate profits, d_t, are given by:

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

where real profits are equal to measured output in real terms, y_t, less real wages, $w_t h_t$, and tangible investment, $x_{T,t}$. As in McGrattan and Prescott (2010a) and Mitra (2019), we assume that intangible investment is a within-firm input-output procedure, and hence, from an accounting point of view, it is not expensed from profits. However, total hours worked and tangible investment devoted to the production of the new intangible good are expensed. The law of motion of tangible and intangible capital stock, $k_{T,t}$ and $k_{I,t}$, are:

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

$$k_{I,t+1} = (1-\delta_I)\, k_{I,t} + x_{I,t} \tag{6}$$

where $0 \leq \delta_T \leq 1$ and $0 \leq \delta_I \leq 1$ are the capital depreciation rate of tangible and intangible capital respectively. The firm maximizes the discounted sum of net-of-tax dividends distributed to households:

$$\sum_{j=0}^{\infty} \Lambda_{t,t+j} d_{t+j} \tag{7}$$

subject to (5) and (6). Since firms are owned by households, we will ex post assume that $\Lambda_{t,t+j}$ equals households' marginal rate of substitution between consumption at t and $t+j$. That is, $\Lambda_{t,t} \equiv 1$ and $\Lambda_{t,t+j} \equiv \beta^j \frac{\lambda_{t+j}}{\lambda_t}$, for $j > 0$, where β is households' discount factor and λ_t is the Lagrange multiplier associated with households' budget constraint in equation (10). The first-order conditions of this problem are in Appendix A.3 .

3.2 Households

The representative household own firms in the corporate sector and maximizes discounted lifetime utility:

$$\sum_{t=0}^{\infty} \beta^t U(c_t, h_t) \tag{8}$$

where c_t and h_t are respectively household's consumption and work hours, and $0 < \beta < 1$ is households' time discount factor. For our numerical solutions, and for algebraic simplicity, we assume Greenwood–Hercowitz–Huffman preferences:

$$U(c_t, h_t) = \frac{\left(c_t - \frac{h_t^{1-\omega}}{1-\omega}\right)^{1-\sigma}}{1-\sigma} \tag{9}$$

The period budget constraint of each household written in real terms is:

$$c_t = w_t h_t + d_t \tag{10}$$

where d_t are real profits rebated to the households from firms. The household chooses $\{c_t, h_t\}_{t=0}^{\infty}$ to maximize (8) subject to (10). The first-order conditions are in Appendix A.3.

3.3 Macroeconomic system

We solve for a dynamic competitive equilibrium (DCE) in which households maximize welfare, firms maximize profits, markets clear and all constraints are satisfied. The final macroeconomic system consists of 16 equations in 16 endogenous variables, $\{c_t, k^1_{T,t+1}, k^2_{t+1}, k_{T,t+1}, k_{I,t+1}, x_{T,t}, x_{I,t}, y_t, y^{gva}_t, h^1_t, h^2_t, h_t, d_t, \lambda_t, \mu_t, w_t\}_{t=0}^{\infty}$. This is given the paths of the exogenously set variables $\{A^y_t, A^x_t\}_{t=0}^{\infty}$ and initial conditions for the state variables, $k^1_{T,0}$, k^2_0, $k_{T,0}$, $k_{I,0}$. Algebraic details, market clearing conditions and the full DCE system are given in Appendix A.1 and A.3. In what follows we proceed with the quantitative analysis by calibrating and solving numerically this macroeconomic system.

4 Calibration

This section parameterizes the model. Some clarifications are important before discussing parameterization in more detail. First, for expositional reasons and to save space, we organize our sample of twelve EU countries into three distinct groups, i.e., the Core, Periphery and Nordic. Specifically, the Core consists of Austria, Belgium, Germany, France, and the Netherlands, the Periphery includes Greece, Italy, Portugal, and Spain while Denmark, Finland and Sweden is the Nordic group. [6] Second, we calibrate the model for each of these groups. Specifically, we allow these groups to differ only in one parameter, particularly, the intangible capital share in the production function. The rest of the structural parameters are set equal across groups.

The time unit is one year. Table 1 lists the values of the structural parameters that we set constant across country groups. We employ common parameter values within the usual ranges for the structural parameters of the model, β, ω, σ , δ_T, θ_1, θ_2. Regarding the depreciation of intangible capital, δ_I, we use a value of 0.3, that is higher than the depreciation rate of tangible capital. This value ranges inbetween several values reported in the literature regarding forms of capital belonging in the broader category of intangbile capital (e.g. organizational capital, information capital, knowledge capital etc) as reported by Falato *et al.* (2022) and Ewens *et al.* (2024). Regarding the structural parameters of the production function, namely tangible, θ_1 and θ_2, and intangible, ϕ_1 and ϕ_2, factor shares in the production of the final and investment goods respectively, we adopt the following calibration strategy.First, we assume that $\theta_1 = \theta_2 = \theta$, i.e., the tangible factor share is equal in the two production sectors, and equal to 0.25. Regarding the intangible factor shares, we assume that, $\phi_1 = \phi_2 = \phi$. We then internally calibrate ϕ for each country group to target the ratio of intangible to tangible investment, $\frac{\mu_t x_I}{x_T}$, as observed in the data 1995-2020 average.

Table 2 presents the resulting calibrated values of ϕ for each group in decreasing order. In fact, these values represent the model-based intangible intensities of each country. The calibrated values reveal that there is substantial cross-country variation in intangible intensities within the EU groups. Specifically, the Nordic countries exhibit the highest intangible intensity, followed by Core, while the lowest intangible intensity is identified in the Periphery.

Table 1: Baseline parameterization

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

[6]In Appendix C, we calibrate and the model numerically and separately for each country of the XX in our sample.

Table 2: Intangible factor shares across EU country groups (1995-2020)

Country	Value of ϕ	Targeted value $\frac{\mu_t x_I}{x_T}$
Nordic	0.134	0.722
Core	0.108	0.581
Periphery	0.076	0.410
EU Average	0.103	0.559

Note: Country specific calibrated values are reported in Appendix C.

5 Intangible economy over the boom-bust cycle

5.1 Numerical experiment

As has been discussed in section 2, intangible investment has exhibited a specific cyclical pattern during the boom period preceding the GFC of 2008 and the bust period that followed. In this section, we employ the RBC model augmented with intangible capital of section 3, to assess whether it can generate a similar cyclical boom-bust pattern for the intangible to tangible investment and hours worked ratios. We then use this model to explain the underlying mechanisms of the cyclical fluctuations related to the key endogenous variables that shape modern intangibles economies in section 5.3.

To assess whether our model successfully explains the cyclical pattern identified in section 2, we follow the methodology developed in McGrattan and Prescott (2010b) and McGrattan and Prescott (2010a) and employ their two criteria. First, the *input justification criterion*, that is, we require our exogenous shocks to be consistent with the empirical trends in the data. Second, the *prediction criterion*, which states that model based simulations should not be counterfactual. Finally, as a third stronger criterion, we compare model based simulations with empirical data for the endogenous variables of the model that has not been used to satisfy the justification criterion.

In order to satisfy the input justification criterion, we pin down an exogenous path for the TFP exogenous shock, $\{A_t^{data}\}_{t=0}^{T}$, in order to precisely match the cyclical component observed in the data (see Figure 9) and the cyclical component generated by the model, just for one specific variable. We choose this variable to be the total gross value added of the economy, y_t^{gva}, given by equation (3). We then feed back in the model the resulting path for TFP to simulate artificial model-based data for all the endogenous variables. Further details are provided in Appendix B.

To test the prediction criterion, we compare model-based simulated endogenous variables with the cyclical component that we compute from the data. Specifically, we compare the model-based ratios of intangible to tangible investment, $\frac{\mu_t x_{I,t}}{x_{T,t}}$, and hours worked in the intangible to tangible sectors, $\frac{h_t^2}{h_t^1}$, with their counterparts in the data.

5.2 Model fit

Figure 3 displays and compares the time series of cyclical components predicted by the model (see line in blue) to their analogs in the data (see line in red). This is done for the cyclical component of total gross value added, as well as the ratios of intangible to tangible investment and hours worked in the intangible to tangible sectors, respectively, for the period 2000-2018. As before, we present plots for EU country groups, Periphery, Core, Nordic, and the EU average.[7] As expected, the GVA generated by the model in the top panel of each subplot of Figure 3 perfectly matches the cyclical component of GVA in the data. By comparing the two ratios of productive inputs per activity, we can get a sense on how well the model captures the reallocation of resources between tangible and intangible production activities during boom and bust periods.

The model generates cyclical fluctuations for the variables of interest that mimic closely the fluctuations observed in the data and in particular the resource reallocation between the two production activities observed in EU data. This holds regardless of the specific country group under consideration. During a boom cycle (light grey shaded area), as measured by the cyclical component of GVA, the tangible goods sector enlarges relatively more compared to the intangible sector. Consequently, firms optimally reallocate productive inputs towards the production of tangible goods. This trend is evident upon visual inspection of the blue lines in the subplots of Figure 3. Conversely, during a bust period (dark grey shaded area), the intangible sector expands vis-à-vis the tangible sector. It's noteworthy that this does not necessarily imply an absolute increase in the intangible sector's output, but rather indicates a smaller reduction compared to the tangible sector. This dynamic is also reflected in the trajectories of the two ratios, signifying a reallocation of production resources towards the intangible sector.

Although the model performs well in general in capturing the reallocation effect, therefore the prediction criterion is satisfied, we observe interesting country group specific behaviors. The model appears to significantly better fit the sectoral investment reallocation effect during the bust years for the Periphery countries both quantitatively and qualitatively, relative to the rest of the Core and Nordic country groups presented in Figure 3.[8]

The economic rationale behind the latter result is as follows. A substantial portion of intangible investment inherently involves within-firm specific expenditures, such as marketing and clien-

[7] Country specific figures are reported in Appendix C.

[8] See Appendix C for country specific results. In summary for Core countries like Germany and the Netherlands, the model over-predicts and underpredicts, respectively, the cyclicality of the intangible to tangible investment ratio. It's important to note here that, according to the data presented in the beginning of the paper, Germany experienced no dramatic fluctuations in terms of intangible asset intensity over the years, unlike the Netherlands, which saw a steep increase after 2009. Similarly, upon inspecting the corresponding graphs for Nordic countries (Sweden, Denmark), the model relatively over-predicts the sectoral investment reallocation for Sweden and under-predicts it for Denmark. Analogous to Germany and the Netherlands, Sweden, despite being a highly intangible intensive economy, maintained a relatively stable intangible to tangible investments ratio, whereas Denmark documented a sharp increase in its intangible asset intensity after 2008, akin to the Netherlands.

tele development, organizational capital, and firm specific software, among other components (for further details, refer to Corrado *et al.*, 2022). Consequently, recessions triggered by negative TFP shocks imply that the production of the final tangible good becomes less efficient. Therefore, reallocating resources within the firm towards intangible investment appears to be a less costly utilization of the firm's productive inputs. Moreover, in our model, intangible investment augments future profits as it contributes to the accumulation of intangible capital stock, which in turn enhances the production of both intangible and tangible goods. During a recession, intangible investment appears to exhibit greater resilience as it becomes the last category that a firm would curtail or potentially increase, viewing it as an opportunity to capitalize on available productive inputs for higher future returns.

Regarding the reallocation effect in hours worked we observe the same pattern across EU countries. Intangible to tangible hours worked ratio is countercyclical at least for the Periphery countries where as can be seen in Figure 3 the model's predicted hours worked ratio fit quite well the time series obtained from the data. This is not the case regarding Core and Nordic countries where the model clearly overpredicts the reallocation of hours worked from the tangible to the intangible sector.

The above analysis suggests that the model's ability to capture cyclical trends regarding the ratio of intangible to tangible investment is stronger when the cyclical component is driven by strong and prolonged TFP shocks like the ones faced by Periphery economies.

5.3 Impulse responses

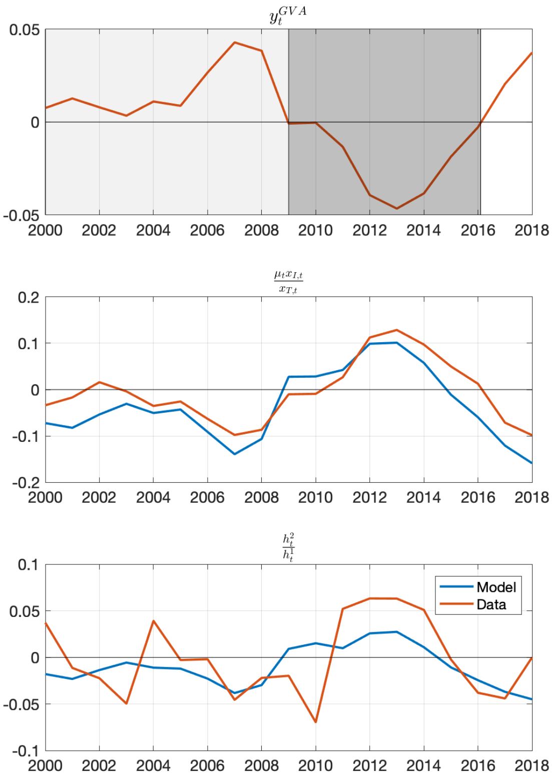
To shed more light on the propagation mechanism of our model, Figures 4 and 5 illustrate the impulse response functions of key endogenous variables in response to a negative TFP shock. The blue, red and yellow lines correspond to the calibrated value of ϕ, for the Periphery, Core and Nordic groups, respectively.

In the first row of Figure 4, we present the impulse responses of key standard macroeconomic aggregates, including total gross value added and hours worked, consumption, tangible and intangible investment, respectively. The second row shows hours worked in each sector, the shadow price of intangible investment and the two ratios which capture the relative importance of intangible production compared to tangible production. namely, the ratio of the intangible to tangible investment and hours worked allocated to the production of intangible goods relative to tangible goods. Additionally, Figure 5 displays marginal productivities of intangible and tangible capital in each sector.

A negative TFP shock induces a reduction in the gross value added of tangible goods, as well as a decrease in key macroeconomic aggregates such as hours worked, tangible and intangible in-

Figure 3: Model vs data

(a) Periphery



(b) Core

(c) Nordic

(d) EU Average

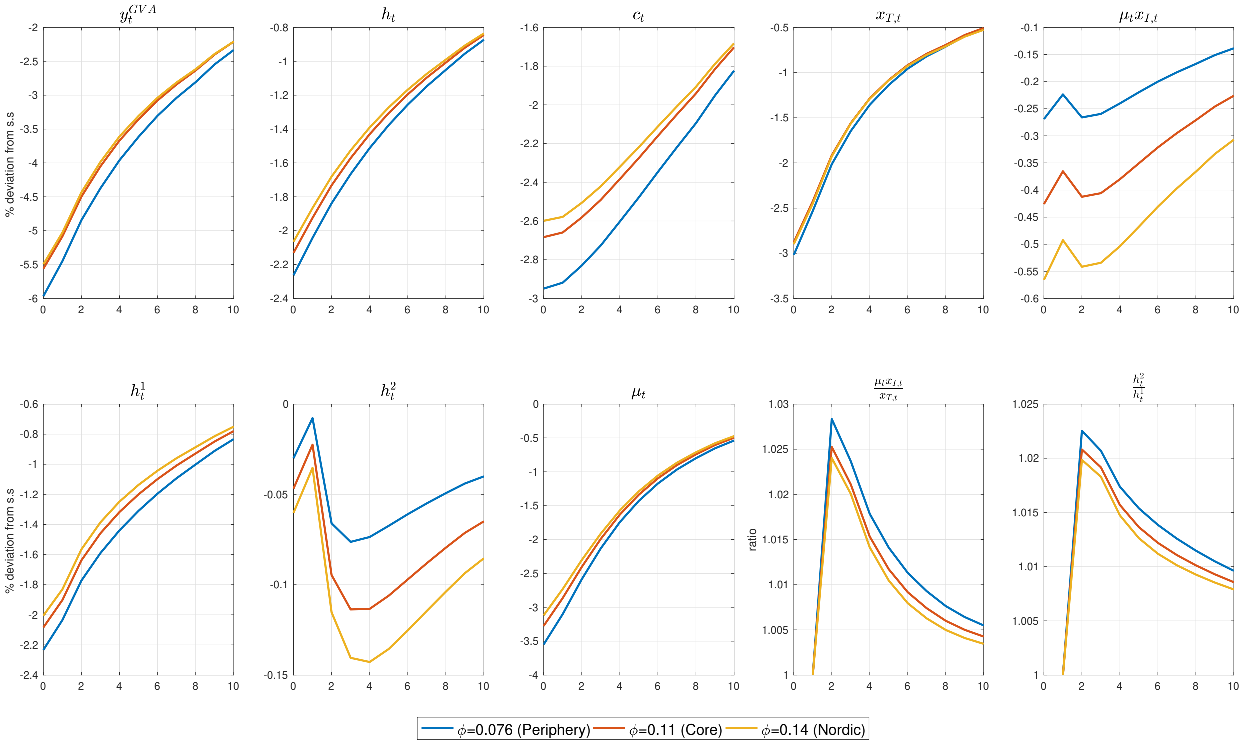
Note: (i) All variables are expressed as % deviations from the cyclical trend vestment with the reduction in tangible investment being more pronounced than that in intangible investment. The response of the relative ratio, $\frac{\mu_t x_{I,t}}{x_{T,t}}$, illustrates that a negative TFP shock, which generates a significant reduction in tangible output, would instead increase the relative size of intangible output and subsequently the associated productive inputs used in its production. This is primarily driven by the stronger decline of the marginal productivity of tangible capital, MPK_T^1 and intangible capital MPK_I^1 in the tangible sector (as shown in the first column of Figure 5) compared to the intangible sector (as shown in the second column of Figure 5).[9] Consequently, this relaxation of the constraint associated with the accumulation of intangible capital is depicted by the declining μ_t in Figure 4. Regarding the reallocation of hours worked between the two sectors bear in mind that since this standard RBC model does not include any type of labour market frictions this result is mainly driven by the change in intangible investment as a share of output.[10]

Lastly, as said previously and shown from the impulse responses, during a recession, intangible investment appears to exhibit greater resilience. However, the higher the intangible capital share ϕ is, the lower the reallocation of productive resources from the tangible to the intangible sector. This is evident from the comparison of the impulses responses of the intangible to tangible investment and hours worked ratios in Figure 4. When $\phi = 0.076$, i.e., which is the calibrated value for the less intangible intensive Periphery countries, the ratio of intangible to tangible investment and hours worked increases more after an adverse TFP shock compared to when $\phi = 0.11$ or $\phi = 0.14$, which are the calibrated values for the more intangible intensive Core and Nordic countries, respectively. This is driven by the fact that while the decrease in tangible investment, x_T, does not exhibit substantial differences for different values of ϕ, the decline in intangible investment $\mu_t x_{I,t}$, although much smaller than the respective of $x_{T,t}$, is almost double in magnitude when ϕ is high. The same holds when comparing hours worked between the two sectors, h_1 and h_2. In other words, countries with high intangible capital intensity (e.g., Nordic) tend to reallocate towards intangible intensive activities relatively less during a typical economic recession caused by a TFP shock. The economic logic is that intangible intensive countries have already built a significant intangible capital stock by the time of the recession, and thus, the benefits from relocating sources are relatively smaller compared to countries with less intangible intensity.

[9]The marginal productivities of tangible and intangible capital in each sector are defined as: $MPK_{T,t}^1 \equiv \frac{\partial y_t}{\partial k_{T,t}^1}$, $MPK_{T,t}^2 \equiv \frac{\partial y_t}{\partial K_{T,t}^2}$, $MPK_{I,t}^1 \equiv \frac{\partial x_{I,t}}{\partial k_{I,t}^1}$, $MPK_{I,t}^2 \equiv \frac{\partial x_{I,t}}{\partial k_{I,t}^2}$

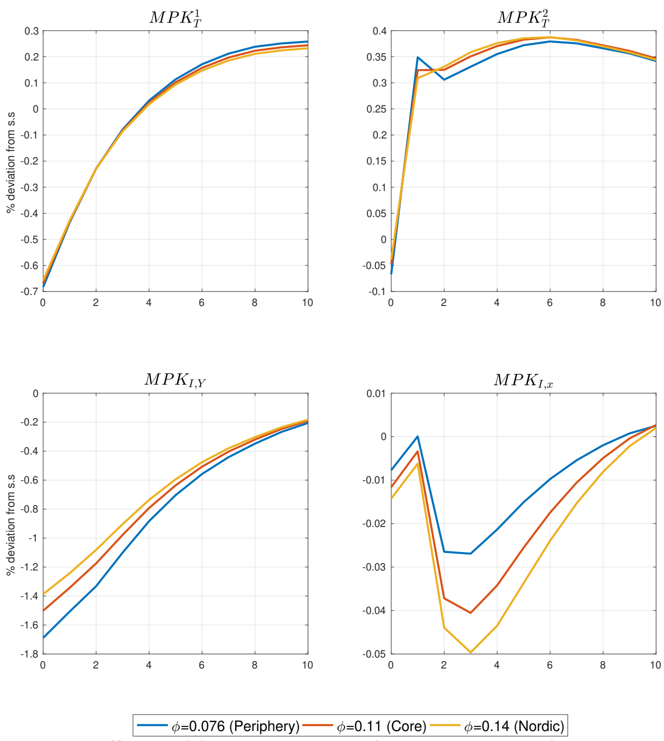
[10]This is straightforward: Assuming that $\theta_1 = \theta_2$ and $\phi_1 = \phi_2$ from the equilibrium system we have that $(1-\theta_1-\phi_1)\frac{y_t}{h_t^1} = (1-\theta_2-\phi_2)\frac{\mu_t x_{I,t}}{h_t^2}$ which implies that the intangible to tangible hours worked ratio is given so that $\frac{h_t^2}{h_t^1} = \frac{\mu_t x_{I,t}}{y_t}$. Hours worked ratio is a linear function of the share of intangible investment to output. Higher shares imply a widening ratio. Next, substitute $y_t = A_t^y \left(k_{T,t}^1\right)^{\theta_1} \left(k_{I,t}\right)^{\phi_1} \left(h_t^1\right)^{1-\theta_1-\phi_1}$ and differentiate with respect to A_t^y to get $\frac{\partial\left(\frac{h_t^2}{h_t^1}\right)}{\partial\left(A_t^y\right)} = -\frac{1}{\left(A_t^y\right)^2}\frac{\mu_t x_{I,t}}{\left(k_{T,t}^1\right)^{\theta_1}\left(k_{I,t}\right)^{\phi_1}\left(h_t^1\right)^{1-\theta_1-\phi_1}} < 0$. This implies that the positive (negative) TFP shocks will decrease (increase) the hours worked ratio. Therefore in our model we should expect stronger relocation of hours worked to intangible after stronger negative TFP shocks.

Figure 4: Impulse response functions of key macroeconomic variables



Note: All variables are expressed in percentage deviations from the initial steady state

Figure 5: Impulse response functions of marginal productivities of capital



Note: All variables are expressed in percentage deviations from the initial steady state

6 Adding financial frictions and shocks

Since the onset of the GFC, an ongoing debate has emerged about whether financial shocks generate real business cycles fluctuations. Specifically, the GFC spurred a strand of literature that incorporated financial frictions into general equilibrium models. This body of literature, see e.g., Christiano *et al.* (2010), Gertler and Karadi (2011), Jermann and Quadrini (2012), and Del Negro *et al.* (2017) among others, identifies financial shocks as a significant source of real business cycles fluctuations. In this section we offer new insights into this debate. Specifically, we revisit the question of whether the boom-bust cycle observed over the 2000-2018 period in EU countries could be better explained by a productivity or a financial shock. We address this question using the model developed in section 3 and the cyclical pattern for intangible relative to tangible economy identified in section 2. To do this, we extend the frictionless model from section 3 by incorporating financial frictions as in Jermann and Quadrini (2012). Additionally, our setup differs in that only tangible capital can be used as a collateral, while intangible capital is not pledgeable as in McGrattan (2020). In what follows, we present this extended model, focusing solely on the differences from the benchmark model.

6.1 Entrepreneurs

To introduce financial frictions, we assume that firms are owned by entrepreneurs who are relative more impatient than households, as in e.g., Lopez and Olivella (2018).[11] Entrepreneurs consume, own capital and produce final goods, combining the capital with labor. They maximize their expected discounted flow of utility, derived from consumption, c_t^e, by choosing labor, investment in tangible and intangible capital, and the amount of borrowing in form of one period households' loans, b_{t+1}, at an interest rate r_t,. The period budget constraint is:

$$c_t^e + b_t + x_{T,t} + w_t h_t = y_t + \frac{b_{t+1}}{(1+r_t)} \tag{11}$$

Furthermore, entrepreneurs are borrowing constrained, as in Jermann and Quadrini (2012), meaning they must raise interest-free intraperiod loans to finance their working capital, and these loans can be diverted. Under the assumption that only tangible capital can be liquidated in the case of default, and thus used as a collateral, entrepreneurs borrowing constraint takes the form:[12]

$$\chi_t \left(k_{T,t+1} - \frac{b_{t+1}}{(1+r_t)} \right) \geq l_t \tag{12}$$

[11] The assumption of two types of agents with different discount factors implies a differential between lending and borrowing interest rates, which in turns allows for binding financial constraints. Similar interest rate differentials could also arise in a set up where firms face additional adjustments costs or tax benefits (see e.g. McGrattan, 2020).

[12] Nonpledgeability, is a characteristic, along with nonrivalry, that differentiates intangible from tangible capital as a factor of production.

where l_t is the amount of loan to entrepreneurs, and χ_t is the probability the lender can recover that loan. Equation (12) implies that the maximum amount of the intratemporal borrowing by the entrepreneur is tied to the value of tangible capital net of intertemporal debt. An adverse financial shock, interpreted as a decrease in χ_t, would lower the amount that entrepreneurs could borrow, and in turn their resources for labor and investment. Then, if we assume, as Jermann and Quadrini (2012) do, that the size of the loan is equal to the current-period tangible output, y_t, and that the borrowing constraint is always satisfied with equality, then equation (12) could be rewritten as:[13]

$$\chi_t \left(k_{T,t+1} - \frac{b_{t+1}}{(1+r_t)} \right) = y_t \tag{13}$$

The optimization problem of an entrepreneur is thus summarized as:

$$\sum_{t=0}^{\infty} \gamma^t log \left(c_t^e \right) \tag{14}$$

where γ is entrepreneurs' discount factor. As entrepreneurs are relatively impatient, γ is smaller than households' discount factor, denoted by β. Each entrepreneur chooses $\{c_t^e, k_{T,t+1}^1, k_{T,t+1}^2, h_t^1, h_t^2, b_{t+1}\}_{t=0}^{\infty}$ to maximize (14) subject to the production functions of tangible and intangible capital, equations (1) and (2) respectively, the laws of motion of the two types of capital, equations (5) and (6) respectively, the borrowing constraint, equation (13) and the budget constraint, equation (11). The first-order conditions are presented in Appendix (A.4).

6.2 Households

The representative household chooses consumption, c_t^h, labor, h_t, and one-period loans to entrepreneurs, b_{t+1}, to maximize discounted lifetime utility as defined by equations (8) and (9). The period budget constraint of each household is:

$$c_t^h + \frac{b_{t+1}}{(1+r_t)} = w_t h_t + b_t \tag{15}$$

The first-order conditions are presented in Appendix (A.4).

6.3 Model fit with financial frictions

To assess the performance of the extended model with financial frictions, we repeat the same numerical experiment developed in section 5. However now, to satisfy the *input justification criterion*, instead of using TFP shocks, we use financial shocks, χ_t. Specifically, we pin down an exogenous path for the financial shocks, $\{\chi_t^{data}\}_{t=0}^{T}$, in order to exactly match the cyclical component in the

[13] McGrattan (2020) uses a similar type of collateral constraint but tie the working capital loans to the total value of tangible goods and intangible investment goods; this assumption would not affect our main qualitative results.

data with the cyclical component generated by the model, for the gross value added adjusted. Then, we feed back in the model the resulting path of financial shocks to simulate model-based data for all endogenous variables of the model. Figure 6 compares the time series for the intangible to tangible investment ratio and hours worked ratio in the model (see blue lines) with their analogs in the data (see red lines). Panels (a), (b), (c) and (d) corresponds to Periphery, Core, Nordic and EU average, respectively.

Financial shocks can indeed generate significant endogenous cyclical fluctuations for our variables of interest, namely intangible-to-tangible investment and hours worked ratios. However, and more importantly, the cyclical pattern generated by financial shocks is not consistent with the analogous fluctuations observed in the data. Specifically, a financial shock in the model predicts a procyclical fluctuation of intangible to tangible investment ratio whereas in the data this ratio is countercyclical. This inconsistency between the model and the data is evident across all country groups. Interestingly, the extended model with financial frictions still generates a countercyclical movement of this hours worked ratio, however it is quite more volatile compared with the analogous time series in the data. Thus, the implementation of a financial shock to the extended model does not satisfy the second of our criteria, i.e., the *prediction criterion*.

Therefore, in the context of our model, it seems that financial shocks produce a cyclical pattern of intangible-to-tangible investment ratios which are inconsistent both in qualitative and quantitative terms with the actual cyclical pattern that we observe in the data.

6.4 Impulse responses

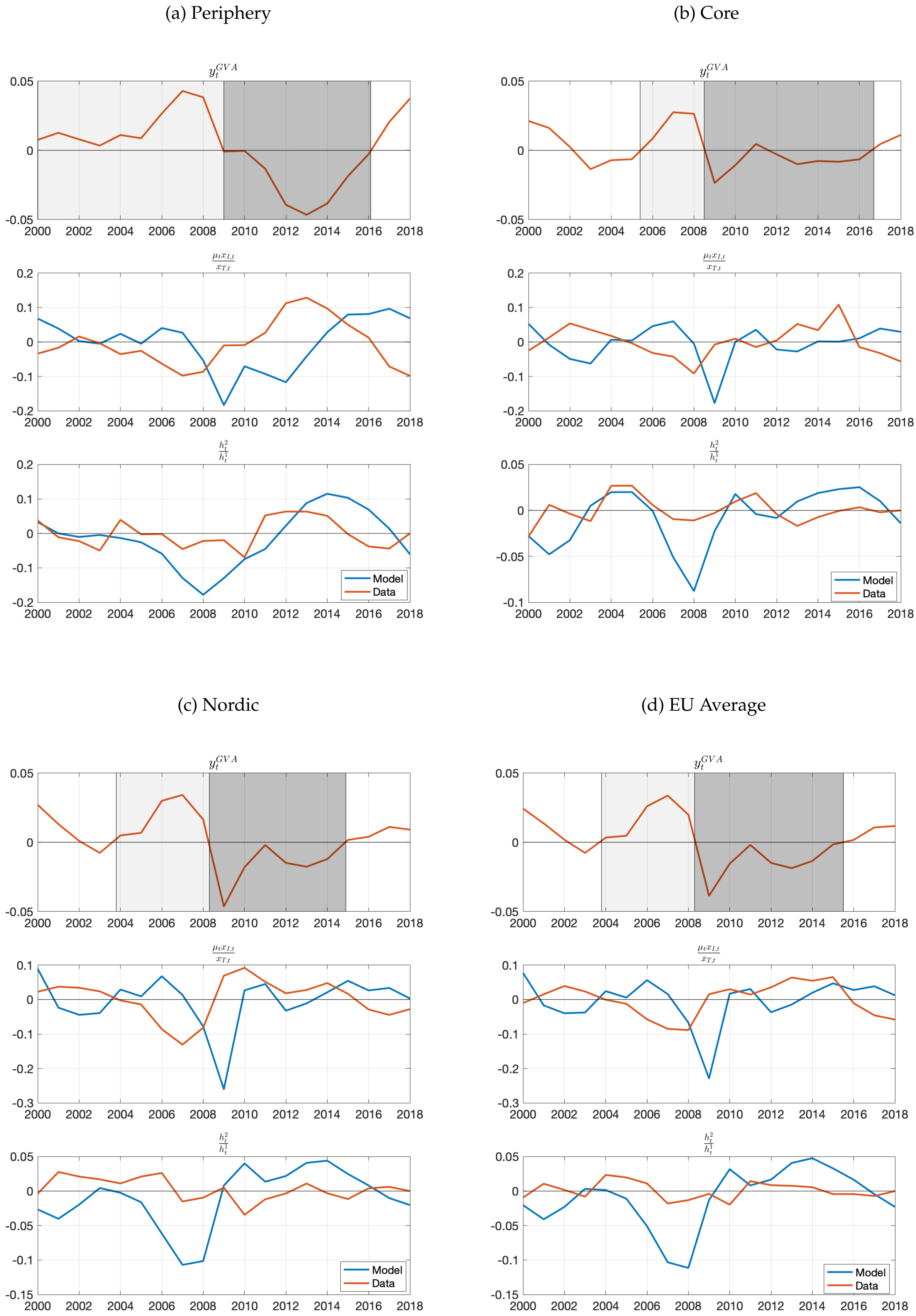
To better understand the propagation mechanisms of TFP compared to financial shocks in our model, in this section we depict the impulse response functions from three cases. Specifically, Figures 7 to 8 illustrate the impulse response functions of a negative TFP shock in the models benchmark model (see blue lines) and the extended model with financial frictions (see red line). Then, in the same figures, we compare them to the impulse response functions of a negative financial shock in the model with financial frictions (see yellow lines).[14]

As discussed in subsection 5.3, in response to a negative TFP shock, firms and households reallocate capital and hours worked towards the intangible goods sector, as the production of the final tangible good becomes less efficient. Impulse responses show that firms reduce both tangible x_T and intangible investment μx_I, but the latter declines by less than tangible investment does. The same holds for hours worked in the intangible versus the tangible goods sectors.

When we introduce financial frictions the reallocation effect between tangible and intangible investment in a negative TFP shock is more pronounced, as the drop in tangible output and capital

[14]Obviously, a negative financial shock in the benchmark model is nonexistent.

Figure 6: Model with financial frictions vs data



Note: (i) All variables are expressed as % deviations from the cyclical trend, (ii) Country specific predictions becomes more persistent. The reason behind the latter are the feedback effects among tangible investment, output and debt, induced by the collateral constraint, which make distortions to persist and volatility to increase.[15] The intuition behind the mechanism is that a lower value of tangible capital makes firms to cut investment in response to their inability to borrow, which reduces tangible output and tightens further the collateral constraint, generating a downward spiral between investment and debt.

Similarly, the increase in hours worked in the intangible to tangible sectors after a negative TFP shock occurs with a delay but is more persistent in the model with financial frictions. In the frictionless RBC model, the relative hours worked in each sector seem to be driven solely by the relative output of each sector (see equations (A.3.13) and (A.3.14) in Appendix A.3). On the other hand, when we add financial frictions, the fact that entrepreneurs finance with intra-period loans only tangible output (i.e. only tangible output is included in the collateral constraint) generates a wedge between the marginal product of labor in the two sectors (compare equation (A.4.17) vs equation (A.4.18) in Appendix A.4). When the adverse TFP shock hits the economy, the positive shadow cost of relaxing the collateral constraint, ζ_t, decreases on impact as the demand of tangible goods and borrowing needs for tangible investment are depressed, which makes h_t^1, initially more resilient to the negative TFP shock. However, as tangible output recovers, the increase in ζ_t, makes the drop in h_t^1, to last longer.

The sectoral investment reallocation effect is reversed when we feed the model with an adverse financial shock. The latter limits entrepreneurs' borrowing capacity, who in turn find it optimal to tilt investment in favor of pleadgable tangible capital to mitigate the tightening financial conditions.[16] In particular, entrepreneurs cut tangible capital used in the tangible goods sector, $k_{T,t}^1$, by less relative to the scenario where a negative TFP shock hits the economy, whereas they increase tangible capital used in the intangible goods sector, $k_{T,t}^2$. The latter coupled with higher labour help intangible output to recover shortly after the adverse financial shock.

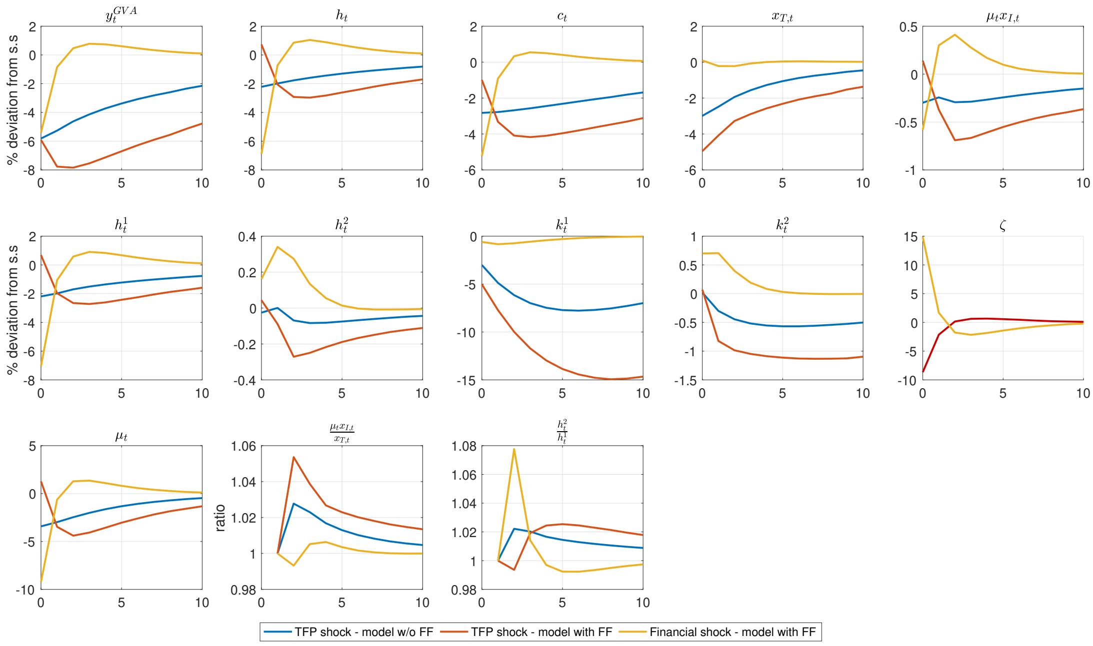
7 Robustness

In this section, we conduct a sensitivity analysis with respect to key structural parameters of the model, such as the tangible capital, θ_1, θ_2, and labor shares, $1 - \theta_1 - \phi_1$, $1 - \theta_2 - \phi_2$, including the case of asymmetric productivity shares across sectors and the depreciation rate of intangible capital

[15] The feedback effects induced by these types of financial frictions have been described properly by Fisher's "debt deflation mechanism". See, also, the financial accelerator mechanism of Kiyotaki and Moore (1997) and Bernanke *et al.* (1999).

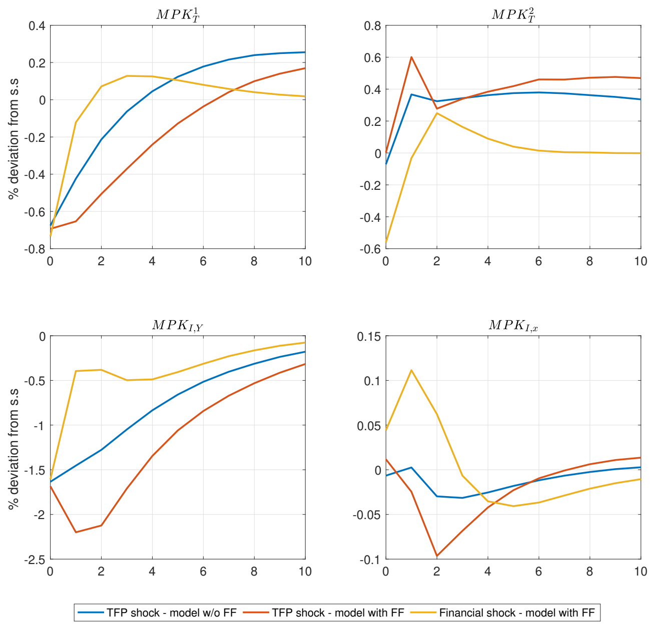
[16] The procyclicality of the intangible to tangible investment ratio has been documented in the literature, see e.g. Lopez and Olivella (2018) and Gareis and Mayer (2023). The latter, show that considering additional adjustment costs for intangible investment in conjunction with a higher depreciation rate of intangible capital and limited pleadgability of the latter, can alter the firm's incentives such that the intangible to tangible investment ratio to increase in response to a negative financial shock

Figure 7: Impulse response functions of key macroeconomic variables



Note: All variables are expressed in percentage deviations from the initial steady state

Figure 8: Impulse response functions of key macroeconomic variables



Note: All variables are expressed in percentage deviations from the initial steady state

δ_I. We have also considered modifications of the benchmark model an empirically relevant feature, such as capital adjustment costs. We report that our main results hold. All results are available upon request.

8 Conclusions

This paper identifies an interesting cyclical pattern of intangible relative to tangible macroeconomic aggregates in European countries during the period from 2000-2020. Specifically, the intangible-to-tangible investment and hours worked ratios fluctuate countercyclically with GVA. To rationalize this result and incorporate it in a coherent macroeconomic narrative, we employ a frictionless RBC model augmented with an intangible sector. We show that a standard TFP shock within this model can effectively replicate the observed cyclical pattern for intangible economy relative to tangible economy. Our work can be extended in several ways. For instance, we could extend this setup to a multi-country model with a rich fiscal block to study the macroeconomic implications of tax reforms across countries and sectors. Another, possible avenue is to allow for some complementarity between intangible capital and specific skills. We leave these extensions for future work.

References

BERNANKE, B., GERTLER, M. and GILCHRIST, S. (1999). The financial accelerator in a quantitative business cycle framework. *Handbook of macroeconomics*, **1**, 1341–1393.

BONTADINI, F., CORRADO, C., HASKEL, J., IOMMI, M. and JONA-LASINIO, C. (2023). Euklems & intanprod: industry productivity accounts with intangibles. *Sources of growth and productivity trends: methods and main measurement challenges, Luiss Lab of European Economics, Rome*.

CHRISTIANO, L., MOTTO, R. and ROSTAGNO, M. (2010). *Financial factors in economic fluctuations*. Working paper series, European Central Bank.

CONESA, J. C. and DOMÍNGUEZ, B. (2013). Intangible investment and ramsey capital taxation. *Journal of Monetary Economics*, **60** (8), 983–995.

CORRADO, C., HASKEL, J., JONA-LASINIO, C. and IOMMI, M. (2022). Intangible capital and modern economies. *Journal of Economic Perspectives*, **36** (3), 3–28.

CROUZET, N., EBERLY, J. C., EISFELDT, A. L. and PAPANIKOLAOU, D. (2022). The economics of intangible capital. *Journal of Economic Perspectives*, **36** (3), 29–52.

DEL NEGRO, M., EGGERTSSON, G., FERRERO, A. and KIYOTAKI, N. (2017). The great escape? a quantitative evaluation of the fed's liquidity facilities. *American Economic Review*, **107** (3), 824–57.

EWENS, M., PETERS, R. H. and WANG, S. (2024). Measuring intangible capital with market prices. *Management Science*.

FALATO, A., KADYRZHANOVA, D., SIM, J. and STERI, R. (2022). Rising intangible capital, shrinking debt capacity, and the us corporate savings glut. *The Journal of Finance*, **77** (5), 2799–2852.

GAREIS, J. and MAYER, E. (2023). Financial shocks and the relative dynamics of tangible and intangible investment: Evidence from the euro area. *Macroeconomic Dynamics*, **27** (5), 1455–1480.

GERTLER, M. and KARADI, P. (2011). A model of unconventional monetary policy. *Journal of Monetary Economics*, **58** (1), 17–34, carnegie-Rochester Conference Series on Public Policy: The Future of Central Banking April 16-17, 2010.

GOURIO, F. and RUDANKO, L. (2014). Customer capital. *Review of Economic Studies*, **81** (3), 1102–1136.

JERMANN, U. and QUADRINI, V. (2012). Macroeconomic effects of financial shocks. *Amrican Economic Review*, **102** (1), 238–271.

KIYOTAKI, N. and MOORE, J. (1997). Credit cycles. *Journal of Political Economy*, **105** (2), 211–248.

LOPEZ, J. I. and OLIVELLA, V. (2018). The importance of intangible capital for the transmission of financial shocks. *Review of Economic Dynamics*, **30**, 223–238.

MCGRATTAN, E. R. (2020). Intangible capital and measured productivity. *Review of Economic Dynamics*, **37**, 147–166.

— and PRESCOTT, E. C. (2010a). Technology capital and the us current account. *American Economic Review*, **100** (4), 1493–1522.

— and — (2010b). Unmeasured investment and the puzzling us boom in the 1990s. *American Economic Journal: Macroeconomics*, **2** (4), 88–123.

— and — (2014). A reassessment of real business cycle theory. *American Economic Review*, **104** (5), 177–182.

—, — *et al.* (2005). Expensed and sweat equity. *Federal Reserve Bank of Minneapolis, Working Paper*, **636**.

MITRA, S. (2019). Intangible capital and the rise in wage and hours volatility. *Journal of Economic Dynamics and Control*, **100**, 70–85.

PRESCOTT, E. (2016). Chapter 22 - rbc methodology and the development of aggregate economic theory. *Handbook of Macroeconomics*, vol. 2, Elsevier, pp. 1759–1787.

Appendix

A Market clearing, equilibrium and the macroeconomic system

A.1 Market clearing conditions

The labour market clears:

$$h_t = h_t^1 + h_t^2 \tag{A.1.1}$$

The final good market clears (or measured output):

$$c_t + x_{T,t} = y_t \tag{A.1.2}$$

Total GVA in the economy is:

$$y_t^{gva} = y_t + \mu_t x_{I,t} \tag{A.1.3}$$

A.2 Equilibrium

The macroeconomic equilibrium is defined to be a sequence of 16 endogenous variables $\{c_t, k_{T,t+1}^1, k_{t+1}^2, k_{T,t+1}, k_{I,t+1}, x_{T,t}, x_{I,t}, y_t, y_t^{gva}, h_t^1, h_t^2, h_t, d_t, \lambda_t, \mu_t, w_t\}_{t=0}^{\infty}$ in 16 non-linear equations given the process of the exogenous variables $\left\{A_t, A_t^I\right\}_{t=0}^{\infty}$ and initial conditions for the state variables such that: (i) households maximize utility; (ii) firms maximize profits; (iii) all constraints are satisfied and all markets clear.

A.3 Macroeconomic system

Optimality condition for c_t:

$$\left(c_t - \frac{h_t^{1-\omega}}{1-\omega}\right)^{-\sigma} = \lambda_t \tag{A.3.1}$$

Labour supply:

$$h_t^{\omega-1} = w_t \tag{A.3.2}$$

Real profits:

$$d = y_t - w_t h_t - x_{T,t} \tag{A.3.3}$$

Production function of Tangibles:

$$y_t = A_t^y \left(k_{T,t}^1\right)^{\theta_1} (k_{I,t})^{\phi_1} \left(h_t^1\right)^{1-\theta_1-\phi_1} \tag{A.3.4}$$

Intangible investment:

$$x_{I,t} = A_t^x \left(k_{T,t}^2\right)^{\theta_2} (k_{I,t})^{\phi_2} \left(h_t^2\right)^{1-\theta_2-\phi_2} \tag{A.3.5}$$

Law motion of tangible Capital:

$$k_{T,t+1} = (1 - \delta_T)\, k_{T,t} + x_{T,t} \tag{A.3.6}$$

Law motion of Intangible Capital:

$$k_{I,t+1} = (1 - \delta_I)\, k_{I,t} + x_{I,t} \tag{A.3.7}$$

Aggregate tangible capital:

$$k_{T,t} = k^1_{T,t} + k^2_{T,t} \tag{A.3.8}$$

Aggregate hours worked:

$$h_t = h^1_t + h^2_t \tag{A.3.9}$$

Euler equation of tangible capital:

$$1 = \Lambda_{t,t+1} \left(\theta_1 \frac{y_{t+1}}{k^1_{t+1}} + (1 - \delta_T) \right) \tag{A.3.10}$$

Euler equation of intangible capital:

$$1 = \Lambda_{t,t+1} (1 - \delta_T) + \mu_{t+1} \theta_2 \frac{x_{I,t+1}}{k^2_{t+1}} \tag{A.3.11}$$

Return to capital:

$$\mu_t = \Lambda_{t,t+1} \phi_1 \frac{y_{t+1}}{k_{I,t+1}} + \mu_{t+1} \left((1 - \delta_I) + \phi_2 \frac{x_{I,t+1}}{k_{I,t+1}} \right) \tag{A.3.12}$$

Marginal productivity of labour in the tangible sector:

$$w_t = (1 - \theta_1 - \phi_1) \frac{y_t}{h^1_t} \tag{A.3.13}$$

Marginal productivity of labour in the intangible sector:

$$w_t = (1 - \theta_2 - \phi_2) \frac{\mu_t x_{I,t}}{h^2_t} \tag{A.3.14}$$

Total output:

$$c_t + x_{T,t} = y_t \tag{A.3.15}$$

GVA:

$$y^{gva}_t = y_t + \mu_t x_{I,t} \tag{A.3.16}$$

Endogenous and exogenous variables

We therefore have a dynamic system of equations, (16)-(16) endogenous variables. The latter are the time-paths of $\{c_t, k^1_{T,t+1}, k^2_{t+1}, k_{T,t+1}, k_{I,t+1}, x_{T,t}, x_{I,t}, y_t, y^{gva}_t, h^1_t, h^2_t, h_t, d_t\}^{\infty}_{t=0}$, the Langange multipliers $\{\lambda_t, \mu_t\}^{\infty}_{t=0}$ associated with the household budget constraint and the production of intangible goods respectively and prices $\{w_t\}^{\infty}_{t=0}$. The processes for the exogenous variables $\left\{A_t, A^I_t\right\}^{\infty}_{t=0}$ are:

$$A_t = \rho^y A_{t-1} + \varepsilon^y_t \tag{A.17}$$

$$A^I_t = \rho^I A^I_{t-1} + \varepsilon^I_t \tag{A.18}$$

A.4 Macroeconomic system with financial frictions

Market clearing conditions

The labour market clears:

$$h_t = h^1_t + h^2_t \tag{A.4a}$$

The final good market clears (or measured output):

$$c^h_t + c^e_t + x_{T,t} = y_t \tag{A.4b}$$

Total GVA in the economy is:

$$y^{gva}_t = y_t + \mu_t x_{I,t} \tag{A.4c}$$

Macroeconomic system

Optimality condition for c^h_t:

$$\left(c^h_t - \frac{h^{1-\omega}_t}{1-\omega}\right)^{-\sigma} = \lambda^h_t \tag{A.4.1}$$

Labour supply:

$$h^{\omega-1}_t = w_t \tag{A.4.2}$$

Loan supply:

$$1 = \frac{\beta \lambda^h_{t+1}}{\lambda^h_t} (1 + r_t) \tag{A.4.3}$$

Budget constraint of entrepreneurs:

$$c^e_t + b_t + x_{T,t} + w_t h_t = y_t + \frac{b_{t+1}}{(1 + r_t)} \tag{A.4.4}$$

Optimality condition for c_t^e:

$$\frac{1}{c_t^e} = \lambda_t^e \tag{A.4.5}$$

Borrowing constraint of entrepreneurs:

$$\chi_t \left(k_{T,t+1} - \frac{b_{t+1}}{(1+r_t)} \right) = y_t \tag{A.4.6}$$

Production function of Tangibles:

$$y_t = A_t^y \left(\xi_t k_{T,t}^1 \right)^{\theta_1} (k_{I,t})^{\phi_1} \left(h_t^1 \right)^{1-\theta_1-\phi_1} \tag{A.4.7}$$

Intangible investment:

$$x_{I,t} = A_t^x \left(\xi_t k_{T,t}^2 \right)^{\theta_2} (k_{I,t})^{\phi_2} \left(h_t^2 \right)^{1-\theta_2-\phi_2} \tag{A.4.8}$$

Law motion of tangible Capital:

$$k_{T,t+1} = \xi_t \left(1 - \delta_T\right) k_{T,t} + x_{T,t} \tag{A.4.9}$$

Law motion of Intangible Capital:

$$k_{I,t+1} = \left(1 - \delta_I\right) k_{I,t} + x_{I,t} \tag{A.4.10}$$

Aggregate tangible capital:

$$k_{T,t} = k_{T,t}^1 + k_{T,t}^2 \tag{A.4.11}$$

Aggregate hours worked:

$$h_t = h_t^1 + h_t^2 \tag{A.4.12}$$

Euler equation of loans:

$$1 - \chi_t \zeta_t = \frac{\gamma \lambda_{t+1}^e}{\lambda_t^e} \left(1 + r_t\right) \tag{A.4.13}$$

Euler equation of k_{t+1}^1:

$$1 - \chi_t \zeta_t = \frac{\gamma \lambda_{t+1}^e}{\lambda_t^e} \left(\left(1 - \zeta_{t+1}\right) \theta_1 \frac{y_{t+1}}{k_{t+1}^1} + \xi_{t+1} \left(1 - \delta_T\right) \right) \tag{A.4.14}$$

Euler equation of k_{t+1}^2:

$$1 - \chi_t \zeta_t = \frac{\gamma \lambda_{t+1}^e}{\lambda_t^e} \left(\mu_{t+1} \theta_2 \frac{x_{I,t+1}}{k_{t+1}^2} + \xi_{t+1} \left(1 - \delta_T\right) \right) \tag{A.4.15}$$

Euler equation of intangible capital:

$$\mu_t = \frac{\gamma \lambda^e_{t+1}}{\lambda^e_t} \left[(1 - \zeta_{t+1}) \phi_1 \frac{y_{t+1}}{k_{I,t+1}} + \mu_{t+1} \left((1 - \delta_I) + \phi_2 \frac{x_{I,t+1}}{k_{I,t+1}} \right) \right] \tag{A.4.16}$$

Marginal productivity of labour in the tangible sector:

$$w_t = (1 - \zeta_t)(1 - \theta_1 - \phi_1) \frac{y_t}{h^1_t} \tag{A.4.17}$$

Marginal productivity of labour in the intangible sector:

$$w_t = (1 - \theta_2 - \phi_2) \frac{\mu_t x_{I,t}}{h^2_t} \tag{A.4.18}$$

Total output:

$$c^h_t + c^e_t + x_{T,t} = y_t \tag{A.4.19}$$

GVA:

$$y^{gva}_t = y_t + \mu_t x_{I,t} \tag{A.4.20}$$

Endogenous and exogenous variables

We therefore have a dynamic system of equations, (20)-(20) endogenous variables. The latter are the time-paths of $\{c^h_t,\, c^e_t,\, k^1_{T,t+1},\, k^2_{t+1},\, k_{T,t+1},\, k_{I,t+1},\, b_{t+1},\, x_{T,t},\, x_{I,t},\, y_t,\, y^{gva}_t,\, h^1_t,\, h^2_t,\, h_t\}_{t=0}^{\infty}$, the Lagraange multipliers $\{\lambda^h_t,\, \lambda^e_t,\, \mu_t,\, \zeta_t\}_{t=0}^{\infty}$ and prices $\{w_t,\, r_t\}_{t=0}^{\infty}$. The processes for the exogenous variables $\left\{A_t, A^I_t, \chi_t, \xi_t\right\}_{t=0}^{\infty}$ are:

$$A_t = \rho^y A_{t-1} + \varepsilon^y_t \tag{A.4.21}$$

$$A^I_t = \rho^I A^I_{t-1} + \varepsilon^I_t \tag{A.4.22}$$

$$\chi_t = (1 - \rho^\chi) \chi + \rho^\chi \chi^I_{t-1} + \varepsilon^\chi_t \tag{A.4.23}$$

$$\xi_t = \left(1 - \rho^\xi\right) \xi + \rho^\xi \xi^I_{t-1} + \varepsilon^\xi_t \tag{A.4.24}$$

where variables without time subscripts denotes steady state values.

B Data vs model

This section provides details on how we process the data used in order to compare the with model predicted time series.

B.1 Output, investment and labour market data

We use aggregate data for GVA, GDP deflators, and working age populations from the national accounts of Eurostat and AMECO databases. Investment specific data on the intangible and tangible sectors are obtained from the EUKLEMS-INTANProd databases, (see Bontadini *et al.*, 2023 for further details).

Hours worked of intangible capital occupations are calculated using data from the EU Labor Force Survey (EU-LFS). We follow the International Standard Classification of Occupations 2008 (ISCO-08) to regroup occupations in tangible and intangible ones. 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.

Table 3: Description of variables and data sources

Variables	Description	Frequency	Period	Source
x^I	Intangible investment	annual	1995-2018	EUKLEMS-INTAN PROD
x^I	Tangible investment	annual	1995-2018	EUKLEMS-INTAN PROD
y^{gva}	GVA consistent with new intangible GFCF	annual	1995-2018	EUKLEMS-INTAN PROD
h	Hours worked (employed persons)	annual	1995-2018	EUKLEMS-INTAN PROD
K_I	Intangible capital stock (current prices)	annual	1995-2018	EUKLEMS-INTAN PROD
K_T	Tangible capital stock (current prices)	annual	1995-2018	EUKLEMS-INTAN PROD
$\frac{y^{gva}}{P_t}$	GVA from national accounts, 2015 ref. prices	annual	1995-2018	National accounts
N	Total Employment, in thousands	annual	1995-2018	AMECO
C	Total Consumption (public and private)	annual	1995-2018	AMECO
h_1	Hours worked tangible occupations	annual	1998-2017	EU-Labor Force Survey
h_2	Hours worked intangible occupations	annual	1998-2017	EU-Labor Force Survey

B.2 How we process the data

Denote Y_t^{data} is the raw time series, first we scale it with GVA deflator and working age population and we take logs, i.e., :

$$y_t^{data} \equiv \log\left(\frac{Y_t^{data}}{P_t^{GVA} N_t}\right) \tag{B.1}$$

Second we apply the HP filter with smoothing parameter $\lambda = 100$, and we subtract the HP trend, $y_t^{hp\_trend}$, to estimate the cyclical component, $y_t^{data,c}$,

$$y_t^{data,c} = y_t^{data} - y_t^{hp\_trend} \tag{B.2}$$

B.3 How we compare the model generated time series with time series from the data

Denote y_t^m as the model based level of output in period t and y^{ss} is the steady state value, we would like to bring the cyclical component of variable y_t^m produced by the model close to the data which means,

$$\log\left(\frac{y_t^m}{y^{ss}}\right)^{m,cycle} = y_t^{data,c} \tag{B.3}$$

Thus, we pin down the time path of A_t such that B.3 holds with equality, let's call this time path as $\{A_t^{data}\}_{t=1995}^{2018}$. Then we test this for the variable y_t^{simul} simulated by the model, that is we check:

$$\log\left(\frac{y_t^{simul}}{y^{ss}}\right) - \log\left(\frac{y_t^{data,c}}{y^{ss}}\right) = 0 \tag{B.4}$$

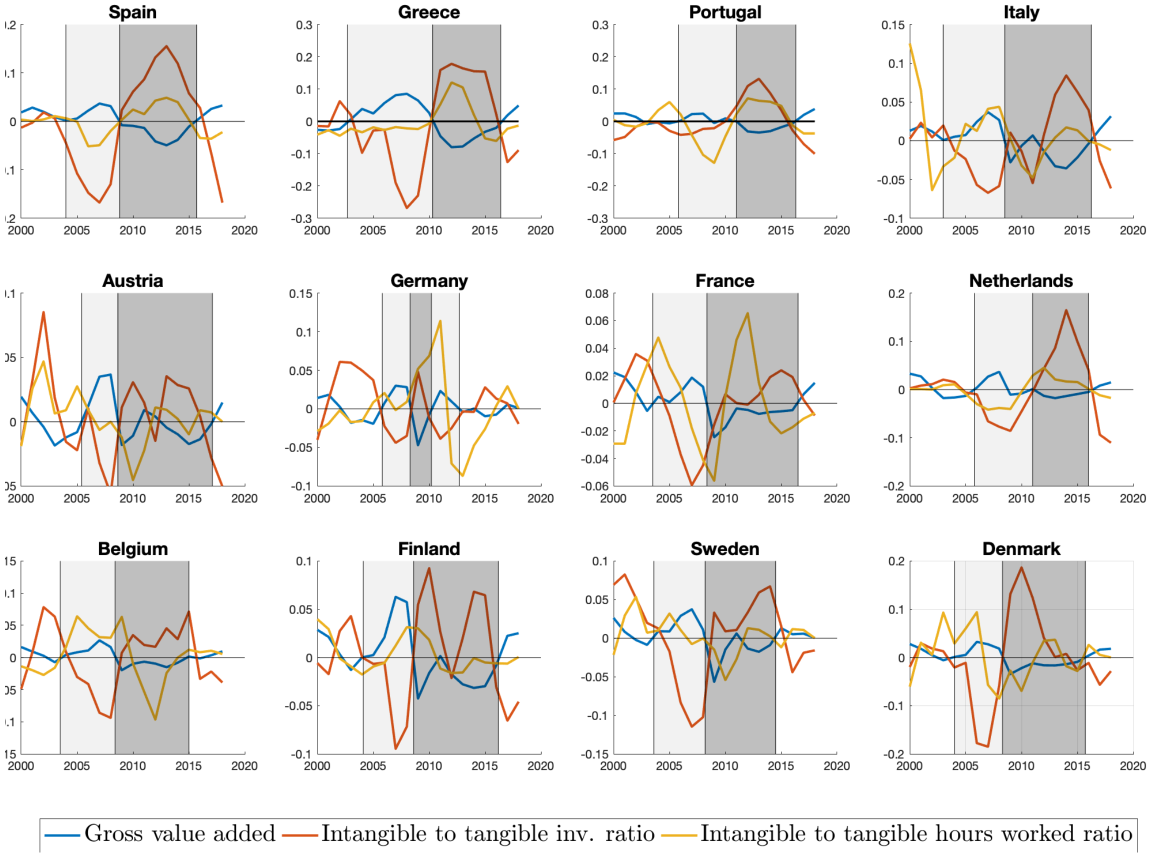
In turn, assume x_t^{simul} any endogenous variable simulated with the model after implementing the aforementioned exogenous path, i.e., $\{A_t^{data}\}_{t=1995}^{2018}$. We compare model based variable, i.e., $\log\left(\frac{x_t^{simul}}{x^{ss}}\right)$, with the associated data $x_t^{data,c}$ which are computed as above. In our simulations we compute a perfect-foresight equilibrium path for this model, assuming households take as given time paths for TFP.

C Additional figures

Table 4: Intangible factor shares across EU countries

Country	Value of ϕ	Targeted value $\frac{\mu_t x_I}{x_T}$
Sweden	0.158	0.85
Netherlands	0.139	0.75
France	0.139	0.74
Finland	0.124	0.67
Denmark	0.121	0.65
Belgium	0.108	0.58
Germany	0.091	0.49
Greece	0.091	0.49
Italy	0.089	0.47
Portugal	0.085	0.45
Austria	0.069	0.37
Spain	0.063	0.33

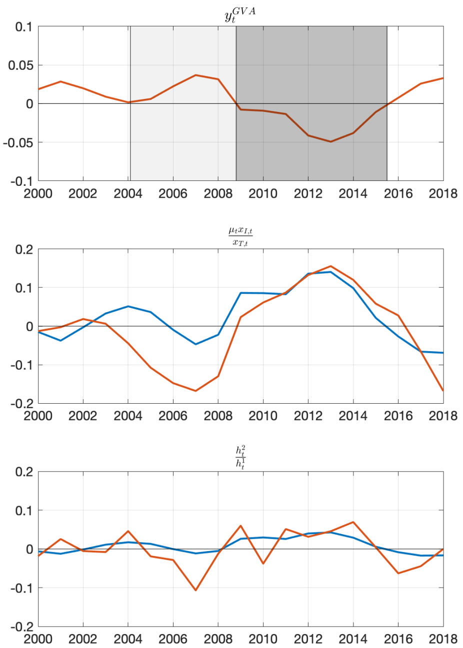
Figure 9: Cyclical components, 2000-2018



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

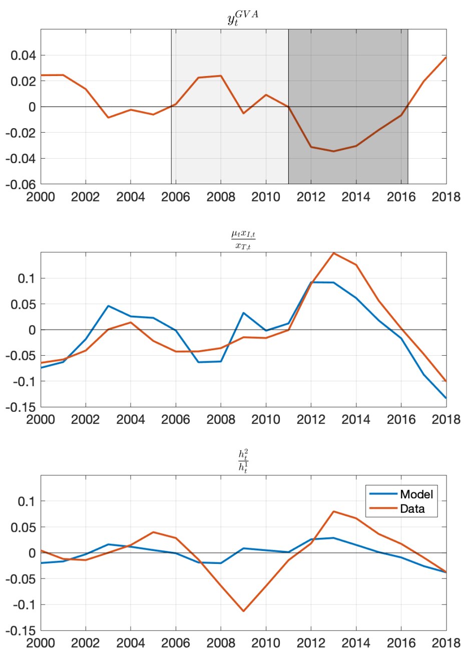
Figure 10: Cyclical patterns - model vs data

(a) Spain



(b) Greece

(c) Portugal

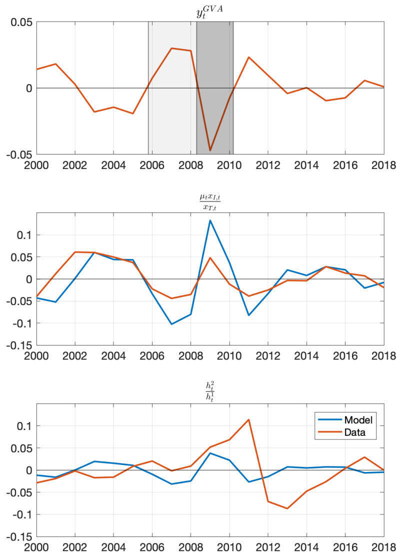


(d) Italy

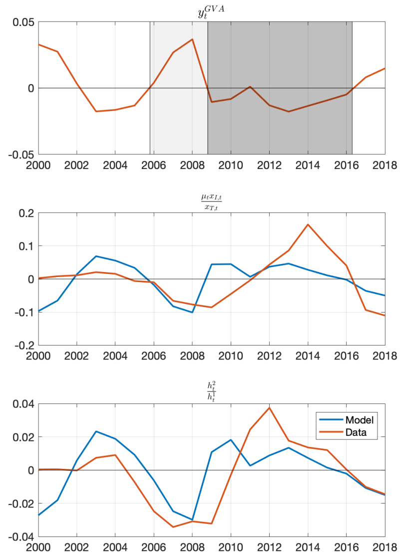
Note: (i) All variables are expressed as % deviations from the cyclical trend. (ii) We set the persistence parameter to 0.625.

Figure 11: Cyclical patterns (Core) - model vs data

(a) Germany



(b) Netherlands



(c) France

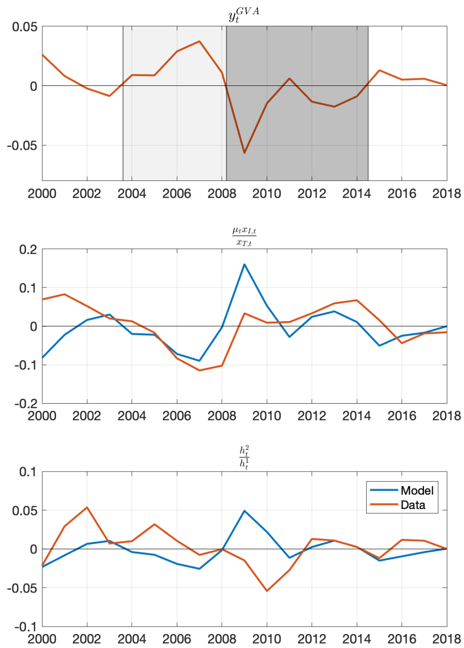
(d) Austria

(e) Belgium

Note: (i) All variables are expressed as % deviations from the cyclical trend. (ii) We set the persistence parameter to 0.625.

Figure 12: Cyclical patterns (Nordic) - model vs data

(a) Sweden



(b) Denmark

(c) Finland

Note: (i) All variables are expressed as % deviations from the cyclical trend. (ii) We set the persistence parameter to 0.625.

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