THREE ESSAYS ON

THE DYNAMICS OF GLOBAL FINANCIAL CONTAGION:

A MACROECONOMIC ANALYSIS OF INTANGIBLE CAPITAL

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Three Essays on the Dynamics of Global Financial Contagion:

A Macroeconomic Analysis of Intangible Capital

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Declaration of Originality

I, Çiğdem Ateş Saygılı, certify that

- I am the sole author of this thesis and that I have fully acknowledged and documented in my thesis all sources of ideas and words, including digital resources, which have been produced or published by another person or institution;
- this thesis contains no material that has been submitted or accepted for a degree or diploma in any other educational institution;
- this is a true copy of the thesis approved by my advisor and thesis committee at Boğaziçi University, including final revisions required by them.

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ABSTRACT

Three Essays on the Dynamics of Global Financial Contagion:

A Macroeconomic Analysis of Intangible Capital

The dissertation intricately explores the global economic responses to shocks with a nuanced focus on capital structures across different geographies. The first chapter examines the recovery patterns post-economic shocks, revealing how disparities in tangible and intangible capital ownership impact economic outcomes. A significant emphasis is placed on the distinction between core regions rich in intangible assets, such as R&D, and peripheries dependent on external capital and burdened with knowledge rent obligations.

Chapter two delves deeper into the mechanics of financial shocks within a globalized framework, employing a two-country macroeconomic model to distinguish between core and periphery economies. Our research indicates that intangible assets, serving as stable collateral, respond more robustly to economic shocks than traditional physical forms. Moreover, the study highlights the complex transmission mechanisms of productivity and leverage shocks, revealing that while the financial sector effectively assimilates the positive economic outcomes resulting from a productivity shock, leverage shocks, despite depleting capital, paradoxically stimulate overall economic output.

In the third chapter, empirical methods test theoretical models to scrutinize the transmission mechanisms of macroeconomic shocks and their impacts on advanced versus emerging economies. This analysis supports a profound relationship between the proportion of intangible to tangible capital and an economy's ability to withstand financial shocks. Economies with lower shares of intangible capital showcase increased susceptibility, particularly to monetary and leverage shocks, reinforcing the disproportionate effects experienced in peripheral regions.

ÖZET

Küresel Finansal Bulaşmanın Dinamikleri Üzerine Üç Makale:

Gayrimaddi Sermayenin Makroekonomik Analizi

Bu tez, farklı coğrafyalardaki sermaye yapılarına incelikli bir şekilde odaklanarak şoklara verilen küresel ekonomik tepkileri incelemektedir. İlk bölüm, ekonomik şoklar sonrası toparlanma eğilimlerini inceleyerek maddi ve gayrimaddi sermaye sahipliğindeki eşitsizliklerin ekonomik sonuçları nasıl etkilediğini ortaya koymaktadır. Ar-Ge gibi gayrimaddi varlıklar bakımından zengin merkez bölgeler ile dış sermayeye bağımlı ve bilgi rantı yükümlülükleri altında olan çevre ülkeler arasındaki ayrıma önemli bir vurgu yapılmaktadır.

İkinci bölüm, iki ülkeli bir makroekonomik model kullanarak küreselleşmiş bir çerçevede finansal şokların işleyişini daha derinlemesine incelemektedir. Araştırmamız, istikrarlı bir teminat işlevi gören gayrimaddi varlıkların ekonomik şoklara geleneksel fiziksel varlıklardan daha sağlıklı tepki verdiğini göstermektedir. Ayrıca çalışma, verimlilik ve kaldıraç şoklarının karmaşık aktarım mekanizmalarını vurgulayarak, kaldıraç şoklarının sermayeyi eritmesine rağmen, paradoksal olarak genel ekonomik çıktıyı teşvik ettiğini ortaya koymaktadır.

Üçüncü bölümde, ampirik yöntemler makroekonomik şokların aktarım mekanizmalarını ve bunların gelişmiş ve gelişmekte olan ekonomiler üzerindeki etkilerini incelemek için teorik modelleri test etmektedir. Bu analiz, gayrimaddi sermayenin maddi sermayeye oranı ile bir ekonominin finansal şoklara dayanma kabiliyeti arasında derin bir ilişki olduğunu desteklemektedir. Gayrimaddi sermaye payı daha düşük olan ekonomiler, özellikle parasal şoklara ve kaldıraç şoklarına karşı daha fazla duyarılık göstermekte ve bu durum çevre ülkelerde yaşanan orantısız etkileri pekiştirmektedir.

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HARVESTING KNOWLEDGE RENT: THE STRATEGIC ROLE OF INTANGIBLE CAPITAL

1.1 Introduction

The recovery trajectories following the Great Recession and the COVID-19 pandemic significantly shape the discourse of this paper. We argue that the responses to economic downturns exhibit substantial variation among countries with differing capital structures. With the emergence and growth of service economies, the importance of intangible capital and the accessibility thereof warrant comprehensive discussion. This paper delves into how disparities in the ownership of tangible versus intangible capital, as well as differences in the capital accumulation processes, impact both the core and the periphery during a global financial contagion. We emphasize the variations in total output, capital levels, labor, and consumption at their steady-state levels, both during and after productivity and financial shocks. Furthermore, we examine how the responses to such shocks fluctuate based on the capital structure of countries.

Our exploration begins with the acknowledgment that tangible and intangible capital ownership rates vary significantly between the core and the periphery. Notably, the core holds a greater proportion of intangible assets, encompassing both domestic and international research and development (R&D) capital. Moreover, it extends the usage rights of this capital to the periphery, creating a paradigm that distinctly benefits the core. This differential advantage arises not solely from the characteristics of the capital itself but also from the processes by which this capital accumulates. For instance, the licensing costs and terms associated with proprietary industrial software perpetuate the peripherys dependency on the core. Therefore, in the long term, when considered at their steady-state levels, regions in the periphery lag behind their potential development trajectory, constrained by insufficient access to necessary intangible capital for independent production processes. In light of these considerations, the first chapter delves into a comparative analysis of the capital structures and accumulation processes characteristic of both the core and the periphery.

1.2 Literature review

The neoclassical theory posits that rates of return on capital are lower in capital-abundant countries compared to those in capital-scarce countries (Chari & Rhee, 2020). This suggests that capital should flow from capital-abundant to capital-scarce countries. However, empirical studies challenge this notion, demonstrating that the marginal product of capital in the periphery is not inherently higher than in the core. Lucas (1990) elucidates that factors beyond physical capital, such as disparities in human capital and capital market imperfections, contribute to the lower marginal productivity observed in developing countries. Similarly, Parente and Prescott (1994) highlight that greater barriers to technology adoption and the absence of high returns from unmeasured investment in the periphery result in developmental disparities among nations. Further emphasizing the significance of human capital, Helpman (2009) points to the pivotal role of human capital externalities. Additionally, Reinhart and Rogoff (2004) identify the risk of serial default as a significant impediment for emerging economies, hindering their development. Caselli and Feyrer (2007) empirically substantiate that the lack of capital in capital-scarce countries can be attributed mainly to the inadequacy and inefficiency of factors complementary to physical capital.

In the framework of neoclassical investment theory, the primary emphasis was placed on physical capital due to the significant contribution of the manufacturing sector to the economy. However, with the advent of structural change, the technology-based service sector has markedly expanded its share, thereby enhancing the importance of non-physical assets such as "human capital, innovative products, brands, patents, software, customer relationships, databases, and distribution systems"

(Peters & Taylor, 2017, p. 1). McGrattan and Prescott (2010) argue that intangible capital has played a crucial role in the economic growth observed in the US since the 1990s. Coe et al. (2009) provide empirical evidence showing that both domestic and foreign R&D capital significantly influence total factor productivity (TFP) for OECD countries. Furthermore, van Ark et al. (2009) underline the necessity of including intangible capital in both the output and input sides of the GDP/GDI national accounts, indicating an aspect frequently overlooked in R&D literature.

Recent research increasingly underscores the prominent role of intangible assets. Thum-Thysen et al. (2017) ascertain that the contribution of intangibles to output growth is one to three times greater than that of tangible assets. Crouzet and Eberly (2019) highlights market power and productivity gains associated with intangibles. Further, Lim et al. (2020) elucidate the positive correlation between identifiable intangible assets and leverage ratios. Both McGrattan (2020) and Crouzet et al. (2022) stress the traditionally unmeasured productivity attributable to intangible capital.

Investment capital related to knowledge, such as R&D, software, and brands, lacks physical form and thus exhibits non-rival use and limited excludability characteristics (Crouzet et al., 2022). In our study, intangible capital pertains to excludable, privately owned intangible assets such as patents and proprietary and closed source software. In the domain of knowledge generation, patent data uniquely encapsulate the apex of innovative endeavors within the Schumpeterian paradigm, as delineated by Aghion et al. (2005) and Hatipoglu (2012). Displayed below is Figure 1 illustrating the average number of patents in selected countries.

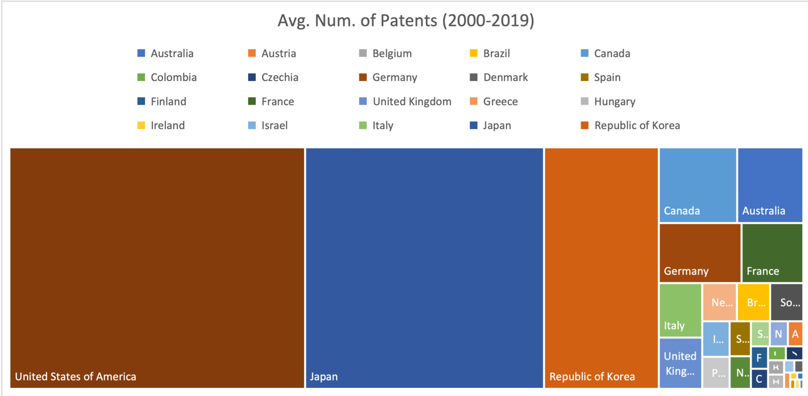

Figure 1. Average number of patents

Discussions on intangible capital also find resonance within heterodox economic schools. Veblen (1908, p. 105) differentiates tangible assets by identifying capital goods as "assets" whose value of "capitalizability" predominantly hinges on industrial serviceability. In contrast, intangible assets are characterized as "material items of wealth, immaterial facts owned, values, and capitalized based on an appraisal of the gain expected from their possession," with their capitalizable value being independent of material serviceability. Within the Veblenian framework, the ownership of physical capital entails owning buildings, machinery, and tools, while the ownership of intangible capital encompasses the laborers themselves. Consequently, the proprietor of intangible assets effectively holds the enterprise and its organizational structure indissolubly, endowing the owner with the capacity to regulate the supply of goods and services, thereby allowing capital to assume its form as vendible capital (Commons, 1936). A pivotal observation here is that, although workmanship can augment the supply, the ownership enables its withholding. Hence, a price must be paid to the owner for the authorization to pursue industrial activity.

In the Marxian analysis, when considering a fixed capital amount, the concept of differential advantage through ground rent arises from the varying productivity levels of land, with surplus value defined as the disparity between outputs generated on productive and unproductive land (Marx, 1993). The landowner possesses both the resource and the laborer's productivity. This differential advantage stems from the private ownership of more productive parcels of land and the capability to curtail the production process. Similarly, in the case of intangible assets, their development is confined to initial production processes; they do not undergo reproduction or value creation in the traditional Marxian sense. A critical observation here is that the possession of intangible assets confers a differential advantage, with such assets and capital functioning as mechanisms for transferring wealth from the renter to the owner, echoing principles found in Ricardo's rent theory. Our analysis delves into the production process and the concept of knowledge rent, furthering the discussion on the autonomization of capital as broached by Teixeira and Rotta (2012). Herein, we postulate and model how this differential advantage, or knowledge rent, generated in a labor-intensive production scheme within the periphery country, acts as surplus value extracted and transferred to the core country, which operates under a capital-intensive production model.

Given that the core possesses a larger proportion of intangible capital and extends its usage rights to the periphery, we contend that this arrangement establishes a differential advantage in favor of the core. The distinctive nature of capital in the core versus the periphery, attributable to both the type of capital and the processes through which it accumulates, necessitates a comparative analysis. Therefore, in the first chapter, we aim to juxtapose the capital accumulation processes of the core and the periphery. The prevalence of intangible capital in the core, contrasted with its scarcity in the periphery and the core's provision of a portion of its intangible capital to the periphery enables the latter to garner additional returns. As outlined in our model, there is a flow of returns from the core's intangible capital to the periphery. Concurrently, the core secures a rental payment, termed knowledge rent, by temporarily sharing the use rights of its accumulated knowledge. Our model illustrates that the disparity between the returns to intangible capital and the revenue derived from knowledge rent critically influences the divergences in the capital accumulation processes and the ultimate levels of accumulated capital.

1.3 Model

The inaugural chapter introduces an autarky equilibrium model, delineating distinct production schemes for a core and a periphery country. This model is predicated on the returns to the R&D framework, employing the primal approach pointed out by Hall et al. (2010, p. 5), which focuses on "estimating the production function with quantities as inputs." The model resonates with the two-country paradigms incorporating two sectors and facilitating trade between the North and the South, as utilized by Eaton and Kortum (2001) and Vural (2012). Within the framework of Vural (2012), vintage technologies are employed based on the empirical evidence from Navaretti et al. (2000), who posited that emerging economies import both obsolete and contemporary capital. Conversely, Lopez and Olivella (2018), drawing on Pérez-Orive (2016), construct a model that integrates intangible capital within the production function, in alignment with the R&D framework. Our model synergizes these approaches by concentrating on the transference of intangible capital across borders, from the core to the periphery. It depicts a one-sector economy devoid of other forms of international trade. Both countries incorporate tangible and intangible capital, alongside labor, into their production functions. Additionally, the periphery's production function includes rented intangible capital from the core, accompanied by a reciprocal rental payment. We introduce a financial wedge for the cost of rented intangible capital and suggest that knowledge rent functions as financial friction within our model. A positive shock in the rental payment is demonstrated to yield divergent outcomes for the core and the periphery, which we explicate through our analytical framework.

Within the chapter, we maintain the premise that the share of intangible capital in the core exceeds that of the periphery, with the core allocating a specific portion of its intangible capital to the periphery. Our model illustrates a flow of returns from the core's intangible capital to the periphery. At the same time, the core receives a rental payment, termed knowledge rent, by temporarily granting the usage rights of its accumulated knowledge to the periphery. Our analysis within the model reveals that the discrepancy between the returns on intangible capital and the knowledge rent is pivotal in shaping the divergences in the capital accumulation processes and the levels of capital accumulated. As our model demonstrates, this differential significantly influences the economic dynamics between the core and the periphery, impacting their respective capacities for capital accumulation and growth.

1.3.1 The core

Our model is founded on a bifurcated structure; it delineates two countries that epitomize the core and the periphery. The core country's economic framework encompasses domestic tangible capital, symbolized as $K_t^{H,T}$, and intangible capital, represented by $K_t^{H,I}$. The model further includes labor, denoted by L_t^H, which, in conjunction with the specified forms of capital, facilitates the production of the consumption good, expressed as C_t^H.

In the core, the production function is characterized by a constant returns-to-scale Cobb-Douglas formulation:

$$Y_t^H = A_t^H F(K_t^H L_t^H) = A_t^H \left(K_t^{H,T}\right)^{\alpha_H} \left(K_t^{H,I}\right)^{\gamma_H} \left(L_t^H\right)^{(1-\alpha_H-\gamma_H)} \tag{1.1}$$

wherein the firm selects capital, labor, and investment across infinite periods, represented as $\{K, L, I\}_{t=0}^{\infty}$. Here, $K_t^{H,T}$ signifies the tangible capital, $K_t^{H,I}$ represents the intangible capital, $0 < \alpha_H < 1$ indicates the share of tangible capital, and $0 < \gamma_H < 1$ illustrates the share of intangible capital in the production process.

The objective function of the firm, subject to the constraints imposed by the production function, is delineated as follows:

$$\max_{K_t^H, L_t^H \geq 0} \pi_t^H = \left[P_t^H \left(Y_t^H - w_t^H L_t^H - \left(r_t^{H,T} K_t^{H,T} + r_t^{H,I} K_t^{H,I}\right)\right)\right] \tag{1.2}$$

In the expression, P_t^H represents the price level, w_t^H denotes the marginal product of labor, $r_t^{H,T}$ indicates the marginal product of tangible capital, and $r_t^{H,I}$ signifies the marginal product of intangible capital. The initial capital stock, k_0, is a given constant, with the condition that $0 \leq k_t \leq k_{t+1}$ ensuring non-decreasing capital accumulation over time. The capital accumulation within the core is subsequently defined through the following relation:

$$K_{t+1}^{H} = I_t^H + (1 - \delta_H)K_t^{H,T} + (1 - \sigma_H)K_t^{H,I} + \kappa_t^H \tag{1.3}$$

In the model, the aggregate capital stock is denoted as $K_t^{H,T} + K_t^{H,I} = K_t^H$, where the sum of tangible and intangible capital constitutes the total capital stock of the core. Additionally, the transversality condition $\lim_{t\to\infty} \beta^t u'(f(k_t^H) - k_{t+1}^H)f'(k_t^H)k_t^H = 0$ must be met, ensuring the optimal path of capital accumulation does not result in an infinite accumulation of capital, aligning with the intertemporal budget constraint of the economy.

δ_H represents the depreciation rate of tangible capital, highlighting the portion that becomes obsolete or wears out over time. Similarly, σ_H denotes the depreciation rate for intangible capital, accounting for the loss in value or relevance of intangible assets over time.

Crucially, the core allocates a constant share η of its intangible capital for the use of the periphery. This arrangement implies that the periphery can utilize the allocated intangible capital without detracting from its usage within the core itself. The resulting exchange can be understood as a form of rent, where κ represents the income generated by the core through the periphery's rental payments for the use of foreign intangible capital. This dynamic introduces an additional dimension to the economic interactions between the core and the periphery, underpinning the flow of resources and returns between the two regions.

In the home country, individuals possess a utility function articulated as follows:

$$\max_{c_t, l_t, , i_t, k_{t+1}} U_t^H = \sum_{t=0}^{\infty} \beta_H^t u(C_t^H, 1 - L_t^H) \tag{1.4}$$

C_t^H represents the series of consumption over time, L_t^H denotes the series of labor provided over time, and $1 - L_t^H$ embodies the amount of leisure enjoyed. The term $\beta_H^t \in (0,1)$ is the discount factor, indicating the degree to which future utility is weighted relative to present utility in the individuals' preferences.

The utility function of the representative agent in the core takes the following form:

$$U(C_t^H, 1 - L_t^H) = \theta^H \log(C_t^H) + (1 - \theta^H) \log(1 - L_t^H) \tag{1.5}$$

where $\theta^H \in (0,1)$ represents the weight of consumption on total income, indicating the significance of consumption relative to leisure. The household faces a decision-making process between consumption and leisure, with their utility being contingent on the consumption levels they achieve and the balance they strike between labor and leisure. $n_t + l_t = 1$ establishes the proportional distribution of labor and leisure.

The budget constraint specifies that the sum of total consumption and investment must equal the total income derived from wages earned through labor and rental income accrued from capital. This condition ensures that the household's expenditures on consumption and investment do not exceed their available financial resources, thereby maintaining financial equilibrium.

$$\sum_{t=0}^{\infty} P_t^H (C_t^H + I_t^H) = \sum_{t=0}^{\infty} P_t^H (w_t^H L_t^H + (r_t^{H,T} K_t^{H,T} + r_t^{H,I} K_t^{H,I})) \tag{1.6}$$

The household's Lagrangian in the core is framed as follows:

$$\begin{aligned} \mathcal{L} = \sum_{t=0}^{\infty} \beta_H^t \big[& U(C_t^H, 1 - L_t^H) \\ & + \lambda_t^H P_t^H \Big[w_t^H L_t^H + \Big(r_t^{H,T} K_t^{H,T} + r_t^{H,I} K_t^{H,I} \Big) \\ & - \Big(C_t^H + K_{t+1}^H - \Big((1 - \delta_H) K_t^{H,T} + (1 - \sigma_H) K_t^{H,I} + \kappa_t^H \Big) \Big) \Big] \Big] \end{aligned} \tag{1.7}$$

The characterization of the equilibrium, encompassing both intra-temporal and inter-temporal conditions, is delineated beginning with the derivation of the intra-temporal condition:

$$-\frac{u_l(C_t^H, 1 - L_t^H)}{u_c(C_t^H, 1 - L_t^H)} = w_t^H \tag{1.8}$$

The Euler equation is formulated as follows:

$$\frac{u_C(C_t^H, 1-L_t^H)}{\beta_H u_C(C_{t+1}^H, 1-L_{t+1}^H)} = r_{t+1}^{H,T} + (1-\delta_H) = r_{t+1}^{H,I} + (1-\sigma_H) \tag{1.9}$$

At the steady state, the following condition is obtained:

$$\begin{aligned}\frac{1}{\beta_H} &= \alpha_H A_{ss}^H (K_{ss}^{H,T})^{\alpha_H - 1} (K_{ss}^{H,I})^{\gamma_H} (L_{ss}^H)^{1-\alpha_H-\gamma_H} + (1-\delta_H) \\ &= \gamma_H A_{ss}^H (K_{ss}^{H,T})^{\alpha_H} (K_{ss}^{H,I})^{\gamma_H - 1} (L_{ss}^H)^{1-\alpha_H-\gamma_H} + (1-\sigma_H)\end{aligned} \tag{1.10}$$

1.3.2 The periphery

In the periphery, the consumption good C_t^P is produced. Although C_t^P and C_t^H are identical goods, the countries they are produced have been specified to distinguish them. In the production process, a share of foreign intangible capital is also utilized as an input in addition to domestic tangible and intangible capital. This inclusion of foreign intangible capital reflects the interconnectedness of global economies and the flow of intellectual assets across borders, influencing the production capabilities and outcomes of the periphery.

In the periphery country, the production function is defined as follows:

$$Y_t^P = A_t^P F(K_t^P, L_t^P) = A_t^P \left(K_t^{P,T}\right)^{\alpha_P} \left(K_t^{P,I}\right)^{\gamma_P} \left(K_t^{P,H}\right)^{\varphi} \left(L_t^P\right)^{1-\alpha_P-\gamma_P-\varphi} \tag{1.11}$$

The firm engages in decision-making regarding capital, labor, and investment across an infinite time horizon, symbolized by $\{K, L, I\}_{t=0}^{\infty}$. Within this framework, $K_t^{P,T}$ signifies the tangible capital, $K_t^{P,I}$ represents the domestically owned intangible capital, and $K_t^{P,H} = \eta K_t^{H,I}$ indicates the foreign-owned (by the core) intangible capital utilized within the periphery. The parameter $0 < \alpha_P < 1$ denotes the share of tangible capital in the production process, while $0 < \gamma_P < 1$ and $0 < \varphi < 1$ specify the shares of domestically and foreign-owned intangible capital, respectively. These parameters collectively delineate the composition of capital inputs contributing to the production function in the periphery.

The capital accumulation process in the periphery is delineated as follows:

$$K^P_{t+1} = I^P_t + (1-\delta_P)K^{P,T}_t + (1-\sigma_P)K^{P,I}_t + (1-\omega)K^{P,H}_t - \kappa^H_t \tag{1.12}$$

Above, the aggregate capital stock is defined as $K^{P,T}_t + K^{P,I}_t = K^P_t$, representing the summation of tangible and domestically owned intangible capital at time t. Furthermore, the transversality condition is articulated as $\lim_{t\to\infty} \beta^t u'(f(k^P_t) - k^P_{t+1})f'(k^P_t)k^P_t = 0$, ensuring the optimal path of capital accumulation over an infinite horizon is bounded and economically rational.

The variable δ_P denotes the depreciation rate for tangible capital, signifying the proportion of tangible capital that diminishes in value over time due to wear, tear, or obsolescence. Conversely, σ_P indicates the depreciation rate for domestically owned intangible capital, reflecting the rate at which the value of these assets decreases, potentially due to technological advancements or shifts in market demand. Lastly, ω represents the depreciation rate specifically for intangible capital that is owned by the foreign country.

Despite the differences in ownership and capital composition between the core and the periphery, the production process remains identical in both regions since the same type of consumption products is produced. However, since the periphery does not own the foreign intangible capital outright but merely has the rights to use it, a payment is made by the periphery to the core, conceptualized as rent. This rent, denoted as κ^H_t, represents the periphery's financial obligation for utilizing the core's foreign intangible capital in its production process.

The objective function of the firm is structured as follows:

$$\max_{K^P_t, L^P_t \geq 0} \pi^P_t = \left[Y^P_t - w^P_t L^P_t - \left(r^{P,T}_t K^{P,T}_t + r^{P,I}_t K^{P,I}_t + r^{P,H}_t K^{P,H}_t\right)\right] \tag{1.13}$$

The utility function and budget constraints mirror that of the core country in terms of their properties. The household's Lagrangian in the periphery is framed as follows:

$$\mathcal{L} = \sum_{t=0}^{\infty} \beta_P^t \Big[U(C_t^P, 1 - L_t^P)$$
$$+ \lambda_t^P P_t^P \Big[w_t^P L_t^P + \Big(r_t^{P,T} K_t^{P,T} + r_t^{P,I} K_t^{P,I} + r_t^{P,H} K_t^{P,H} \Big)$$
$$- \Big(C_t^P + K_{t+1}^P - \Big((1-\delta_P) K_t^{P,T} + (1-\sigma_P) K_t^{P,I} + (1-\omega) K_t^{P,H} - \kappa_t^H \Big) \Big) \Big] \Big] \tag{1.14}$$

The model incorporates lending and borrowing restrictions specifically pertaining to intangible capital. Owing to the necessity of a payment schedule for the rented capital, reputational complexities arise regarding these repayments by the periphery under certain circumstances. Drawing from the framework outlined by Obstfeld and Rogoff (1996), we establish a system where the periphery country is constrained from lending capital abroad and is only permitted to borrow for a single period. The obligation incurred from borrowing in one period must be addressed in the subsequent period.

Within this model, the core country adopts a risk-neutral stance. The payment and return scheme for the risk-neutral lender -namely, the core country- is depicted as follows:

$$\sum_{E_t} \pi(E_t) J_{t-1}^e(E_t) = \kappa_t^H \tag{1.15}$$

where $E_t \in [\underline{E}, \overline{E}]$ represents an independently and identically distributed (i.i.d.) mean-zero serially uncorrelated shock to the system. As a function of these shocks, $J(E_t) \geq 0$ outlines the repayment schedule from the periphery to the core, defining the financial obligations that must be met under varying economic conditions. The function $\pi(E_t)$ signifies the probability that E equals E_t, quantifying the likelihood of specific shock values occurring within the defined range. The condition $\sum_{t=1}^{N} \pi(E_t) = 1$ ensures that the sum of probabilities for all potential shock outcomes over the time horizon N equals 1, satisfying the requisite property of a complete probability distribution. This structure encapsulates the financial dynamics and implications of exogenous economic shocks on the repayment obligations between the periphery and the core countries.

Assumption 1: $J(E_t) \geq 0$, since the zero expected profit condition is $\sum_{i=1}^{N} \pi(E_i)J(E_i) = 0$.

Assumption 1 stipulates that $J(E_t) \geq 0$, underscoring that the repayment schedule amount must be non-negative for any given shock E_t. This is predicated upon the condition of zero expected profit, denoted as $\sum_{i=1}^{N} \pi(E_i)J(E_i) = 0$. Essentially, this equates to the expectation that, across all possible shocks, the aggregate repayment amounts will average to zero when weighted by their respective probabilities. This assumption ensures that, on expectation, the repayment schedule is designed such that the lender (core country) does not anticipate making a profit or loss from the variability of economic shocks affecting the borrower (periphery country).

The commitment of the periphery to a feasible debt servicing in period $t-1$ that aligns with a payment schedule in period t is denoted by $J_{t-1}(E_t)$. Consequently, the expected debt servicing, represented as $J^e_{t-1}(E_t)$, must equate to the actual debt servicing, $J_{t-1}(E_t)$. This equality ensures that the anticipations regarding debt repayments are accurately met, maintaining the integrity and feasibility of the financial arrangements between the periphery and the core. It essentially highlights the requirement for consistency between projected and real debt servicing obligations, making the arrangement predictable and manageable for both parties involved.

Assumption 2: E_t is stationary, so the peripherys choice of debt-servicing is time-invariant.

Assumption 2 posits that E_t is stationary, implying that the statistical properties of this variable, such as its mean, variance, and autocorrelation, do not change over time. Consequently, this assumption leads to the notion that the periphery's approach to debt servicing remains constant across time periods. This time-invariance suggests that the strategies and decisions regarding how the periphery manages and plans for its debt obligations do not fluctuate in response to the passage of time or the potential variability in E_t. Essentially, under this assumption, the periphery's financial behavior and obligations in relation to debt servicing demonstrate a level of consistency and predictability, unaffected by temporal dynamics.

The equilibrium within the model is characterized by both intra-temporal and inter-temporal conditions, as delineated below:

$$-\frac{u_l(C_t^P, 1 - L_t^P)}{u_c(C_t^P, 1 - L_t^P)} = w_t^P \tag{1.16}$$

The Euler equation is formulated as follows:

$$\frac{u_C(C_t^P, 1 - L_t^P)}{\beta_P u_C(C_{t+1}^P, 1 - L_{t+1}^P)} = r_{t+1}^{P,T} + (1 - \delta_P) = r_{t+1}^{P,I} + (1 - \sigma_P) = r_{t+1}^{P,H} + (1 - \omega) \tag{1.17}$$

Proposition 1: The ratio of intangible and tangible capital is determined by the shares and the depreciation rates of capital in the core and the periphery.

Proposition 1 posits that the ratio between intangible and tangible capital within both the core and the periphery is influenced by the respective shares of each form of capital and their corresponding depreciation rates. This proposition highlights the intrinsic relationship between the composition of capital assets and their degradation over time. In essence, the allocation between intangible and tangible capital is not only a reflection of the relative importance or productivity of these assets within each economy but also a function of how quickly these assets lose value or become obsolete. The depreciation rates reflecting the pace at which tangible and intangible assets diminish in value along with their proportional representation in the total capital stock, collectively dictate the equilibrium capital structure. This nuanced interplay ensures that strategic investment decisions, aimed at optimizing the capital mix, consider both the productive utility of the assets and their longevity within the economic landscape of the core and the periphery.

1.4 Calibration and results

1.4.1 Calibration of the parameters

Within the Dynamic Stochastic General Equilibrium (DSGE) framework, our model is constructed to elucidate the long-term dynamics between the ownership and rental of intangible capital and the subsequent repayment of knowledge rent. To effectively capture these relationships, carefully selecting parameters that define the long-run equilibrium state is imperative. Subsequently, with its targeted parameters, the model is also engineered to delineate the short-term interactions and adjustments following economic shocks.

In the context of our study, we identify and calibrate 17 targeted parameters. The household discount factors influence how future utility or consumption is valued relative to the present. The income shares of tangible, intangible, and rented capital determine how income is distributed across different types of capital assets. The depreciation rates of tangible, intangible, and rented capital account for the reduced value of these assets over time. The persistence of productivity shocks, which describes how long the effects of a productivity shock last within the economy. The constant relative risk aversion (CRRA) parameters for both the core and the periphery measure households' propensity to avoid risk, affecting their consumption and saving behavior.

The calibration of tangible and intangible capital depreciation rates is grounded in empirical data from the National Income and Product Accounts (NIPA) from 1947 to 2022. This approach ensures that the parameters reflect real-world economic conditions and trends. Specifically, we target a 5% intangible investment-to-output ratio, signifying that intangible investments (such as software, research and development, and patents) constitute 5% of the total economic output. Conversely, the tangible investment-to-output ratio is targeted at 12%, indicating that investments in physical assets (like machinery, buildings, and equipment) account for 12% of the total output.

Furthermore, the depreciation rate of rented capital is set to 1, which implies a complete depreciation within the period. This setting acknowledges the transient nature of rented capital, such as leased intangible assets, whose total value is assumed to be consumed within a single period.

In the absence of comprehensive data on the total income share of intangible capital across all countries, we establish these parameters by drawing upon the works of Corrado et al. (2009), Pérez-Orive (2016), and Lopez and Olivella (2018). For the core, $\gamma_H = 0.15$ For the periphery, we set $\gamma_P = 0.10$, reflecting a comparatively lower share of domestic intangible capital within its economic framework. The allocations of tangible capital, denoted by $\alpha_H = 0.25$ for the core and $\alpha_P = 0.20$ for the periphery, are selected to yield a labor income share of 0.60 in the core and in the periphery.

Total factor productivity is standardized to 1, aligning with the assumption of a baseline level of efficiency in the production process. The persistence of productivity shocks is adopted from Devereux and Yu (2020) and set at 0.912, indicating a high degree of autocorrelation and denoting that these shocks have lasting effects over time.

The inverse of the Frisch elasticity of labor supply is set to 0.5, consistent with empirical findings from Smets and Wouters (2007), Mendoza (2010), Christiano et al. (2014), Perri and Quadrini (2018), and Devereux and Yu (2020). This parameter choice reflects the sensitivity of labor supply to changes in real wages, suggesting a moderately elastic response.

Regarding household discount factors, we establish a rate of 0.99 for the core and 0.95 for the periphery. The lower discount factor for the periphery incorporates a risk premium, acknowledging the higher uncertainty and potential for economic volatility associated with these regions. This distinction underpins the differential time preferences and risk tolerances between households in the core versus those in the periphery, significantly influencing savings, investment, and consumption behaviors across these economic spheres. Displayed below is Table 1 demostrating the calibrated parameter values.

1.4.2 Computing the steady state

In the proposed model, the state variables include $K_t^{H,T}$ (tangible capital in the core), $K_t^{H,I}$ (intangible capital in the core), $K_t^{P,T}$ (tangible capital in the periphery), $K_t^{P,I}$

Table 1. Calibrated Parameter Values

Parameter	The Core	The Periphery
Household's Discount Factor	$\beta_H = 0.997$	$\beta_P = 0.95$
Income share of tangible capital	$\alpha_H = 0.25$	$\alpha_P = 0.20$
Income share of intangible capital	$\gamma_H = 0.15$	$\gamma_P = 0.10$
Income share of rented tangible capital		$\varphi = 0.10$
Depreciation of tangible capital	$\delta_H = 0.007$	$\delta_P = 0.007$
Depreciation of intangible capital	$\sigma_H = 0.017$	$\sigma_P = 0.017$
Depreciation of own tangible capital		$\omega = 1.00$
The Frisch elasticity of labor	$\xi_H = 0.50$	$\xi_P = 0.50$
Ratio of rented-to-intangible capital	$\eta = 0.10$	
Persistence of productivity shocks	$\rho_H = 0.912$	$\rho_P = 0.912$

(intangible capital in the periphery), $K_t^{P,H}$ (rented intangible capital from the core to the periphery), A_t^H (technology level in the core), and A_t^P (technology level in the periphery). These variables represent key components of the model's dynamics, reflecting the accumulation of different forms of capital and technological advancements over time in both the core and the periphery.

Co-state variables, on the other hand, include C_t^H (consumption in the core), C_t^P (consumption in the periphery), L_t^H (labor supply in the core), and L_t^P (labor supply in the periphery). These variables are crucial for understanding how the economic agents' decisions regarding consumption and labor supply respond to changes in the state variables, underpinning the intertemporal optimization problem faced by households in both regions.

Assuming the growth rates of $K_t^{H,T}$, $K_t^{H,I}$, $K_t^{P,T}$, $K_t^{P,I}$, and $K_t^{P,H}$ are constant in the steady state, we can express the equilibrium conditions for capital accumulation and technological progress. In this equilibrium, the economies of the core and the periphery have reached a state where all the variables grow at a constant rate, reflecting a balanced growth path.

The production functions for the core and the periphery, respectively, are structured to incorporate these state and co-state variables, detailing how inputs are transformed into outputs based on the available technologies, A_t^H and A_t^P, and the respective stocks of tangible and intangible capital. These functional forms capture the essence of the production process in both regions, highlighting differences in capital usage and technological efficiency that contribute to disparities in economic outputs and growth trajectories of the core and the periphery.

$$Y_t^H = A_t^H F(K_t^H, L_t^H) = A_t^H \left(K_t^{H,T}\right)^{\alpha_H} \left(K_t^{H,I}\right)^{\gamma_H} \left(L_t^H\right)^{1-\alpha_H-\gamma_H} \tag{1.18}$$

$$Y_t^P = A_t^P F(K_t^P, L_t^P) = A_t^P \left(K_t^{P,T}\right)^{\alpha_P} \left(K_t^{P,I}\right)^{\gamma_P} \left(K_t^{P,H}\right)^{\varphi} \left(L_t^P\right)^{1-\alpha_P-\gamma_P-\varphi} \tag{1.19}$$

Output per worker in the core country, denoted as N_t^H, can be computed through the following formulation:

$$N_t^H = \frac{Y_t^H}{L_t^H} = A_t^H \left(K_t^{H,T}\right)^{\alpha_H} \left(K_t^{H,I}\right)^{\gamma_H} \left(L_t^H\right)^{-\alpha_H-\gamma_H} \tag{1.20}$$

Output per worker in the periphery country, denoted as N_t^P, is given by:

$$N_t^P = \frac{Y_t^P}{L_t^P} = A_t^P \left(K_t^{P,T}\right)^{\alpha_P} \left(K_t^{P,I}\right)^{\gamma_P} \left(K_t^{P,H}\right)^{\varphi} \left(L_t^P\right)^{-\alpha_P-\gamma_P-\varphi} \tag{1.21}$$

In the steady state, the condition that both N_t^H (output per worker in the core country) and N_t^P (output per worker in the periphery country) grow at the same rate, denoted by ν_1, implies that the economies of the core and the periphery are achieving balanced growth in terms of labor productivity. Furthermore, the ratio of output per worker between the core and the periphery, $\frac{N_t^H}{N_t^P}$, stabilizes to a constant value in the steady state, represented as $\left(\frac{N_t^H}{N_t^P}\right)_{ss}$. This constancy indicates a persistent productivity differential between the core and the periphery that remains unchanged over time in proportional terms.

Given this framework, the growth rates of total output (Y_t^H) and consumption (C_t^H) in the core are both equal to ν_1, mirroring the steady growth rate of output per worker. This consistency underscores a situation where overall economic growth, as well as growth in consumption, aligns with the growth in labor productivity within the core.

Similarly, in the periphery, the growth rates of total output (Y_t^P) and consumption (C_t^P) also equate to the growth rate of output per worker (N_t^P), which is ν_1. This alignment suggests that, like the core, the periphery's overall economic growth and the growth in its consumption parallel the growth in labor productivity.

Such a scenario reflects a coordinated growth pattern between the core and the periphery where improvements in labor productivity drive proportional increases in output and consumption across both regions, maintaining a fixed relative productivity level between them in the long run.

For the consumption growth, recall the intra-temporal condition for the core and the periphery are:

$$-\frac{u_l(C_t^H, 1-L_t^H)}{u_c(C_t^H, 1-L_t^H)} = w_t^H \tag{1.22}$$

$$-\frac{u_l(C_t^P, 1-L_t^P)}{u_c(C_t^P, 1-L_t^P)} = w_t^P \tag{1.23}$$

Given that the preference parameter θ is identical in both countries and the growth rates of consumption in the core (C_t^H) and the periphery (C_t^P) are synchronized at the rate ν_1, a condition for steady-state equilibrium is that the rates of return in the two countries align. This equilibrium condition stems from the premise that, in the long run, identical preference parameters and harmonized consumption growth rates necessitate a convergence in the rates of return on investment across both regions.

This convergence is crucial for maintaining the steady-state, as differences in returns would incentivize capital to flow from the region with a lower return to the one with a higher return, disrupting the equilibrium. The equalization of rates of return ensures that there is no arbitrage opportunity between investing in one country over the other, thereby sustaining capital allocation and consumption growth at their steady-state levels.

Such a scenario reinforces the interconnectedness of global economies, where investment decisions are influenced not only by domestic factors but also by conditions in other economies. In this model, the alignment of rates of return across the core and the periphery underlines the mutual dependence and equilibrium dynamics that characterize international economic relations in the steady state.

$$\begin{aligned}&(1-\alpha_H-\gamma_H)A_t^H\left(K_t^{H,T}\right)^{\alpha_H}\left(K_t^{H,I}\right)^{\gamma_H}\left(L_t^H\right)^{-\alpha_H-\gamma_H}\\&\quad=(1-\alpha_P-\gamma_P-\varphi)A_t^P\left(K_t^{P,T}\right)^{\alpha_P}\left(K_t^{P,I}\right)^{\gamma_P}\left(K_t^{P,H}\right)^{\varphi}\left(L_t^P\right)^{-\alpha_P-\gamma_P-\varphi}\end{aligned}\tag{1.24}$$

The assertion that two countries with distinct capital markets can exhibit identical rates of return, facilitated by technological diffusion, underscores the complex interplay between technological transfer and capital market dynamics. In this scenario, even though the differential gains and losses from capital rental between the core and the periphery might not be explicitly captured within their intra-temporal conditions, the inclusion of rented intangible capital from the core, denoted as $K_t^{P,H}$, in the periphery's equation, and its allocated share, φ, plays a critical role.

Assuming $\alpha_H = \alpha_P$ and $\gamma_H = \gamma_P$ implies that both the core and the periphery allocate identical shares to their tangible and intangible capital, respectively. However, the labor share in the periphery, represented by $-\alpha_P - \gamma_P - \varphi$, is lesser compared to the share $-\alpha_P - \gamma_P$ in the core, given the constant growth of labor based on population growth. This condition necessitates that $(K_t^{P,H})^{\varphi}$ assumes a higher magnitude in the periphery's production function. Consequently, this representation amplifies the weight of rented intangible capital's impact on the periphery's economy.

The implication here is nuanced; it suggests that while the periphery does not close the gap with the core merely through equal shares of tangible and intangible capital, integrating a significant portion of rented intangible capital from the core contributes to a unique economic dynamic. The periphery, leveraging a higher rate of intangible capital originating from the core, may experience enhanced productivity or innovation capabilities, albeit without necessarily converging to the core's overall economic status. This delineation of the interrelation between technological diffusion through the vehicle of intangible capital renting and capital market equilibria adds a layer of complexity to understanding the trajectories of economic development and convergence in a globalized world.

Proposition 2: There is a divergence between the marginal productivity in the core and the periphery due to the returns to intangible capital in the core and the knowledge rent extracted.

Proposition 2 posits that a divergence exists between the marginal productivity levels in the core and the periphery, primarily instigated by the distinctive returns to intangible capital present in the core, in conjunction with the extracted knowledge rent. This divergence is rooted in the intrinsic dynamics of how intangible capital contributes to economic productivity and the structural interdependencies between the core and the periphery, particularly regarding the transfer and utilization of intangible capital.

Intangible capital, encompassing assets like technological know-how, patents, software, and organizational structures, fundamentally enhances productivity through improvements in efficiency, innovation, and the creation of new markets. In the core, where there is a higher accumulation of intangible capital, the returns on these assets significantly contribute to marginal productivity, thereby elevating economic output and growth.

However, the periphery, with relatively less accumulated intangible capital and consequently lower intrinsic returns, relies on rented intangible capital from the core. This reliance not only denotes a financial obligation in the form of knowledge rent but also introduces a dependency on external assets for productivity gains. The payment of knowledge rent from the periphery to the core stands as an extraction of economic value, which, while compensatory for the use of intangible assets, inherently represents a financial transfer that could otherwise be utilized locally in the periphery for further capital accumulation or consumption.

The process whereby the periphery pays knowledge rent to the core for accessing its intangible capital creates a dynamic wherein the core benefits from both its intrinsic returns on intangible assets and the additional income streams from leasing these assets. In contrast, the periphery, despite benefiting from the potential productivity gains associated with using intangible capital, faces a situation where the full economic benefits of utilizing these assets are not entirely retained locally.

This structural arrangement fosters a divergence in marginal productivity between the core and the periphery, underpinned by the differential access to, accumulation of, and returns from intangible capital. As such, the disparity in the economic exploitation of intangible assets -exacerbated by knowledge rent extraction- serves as a crucial mechanism through which the productivity gap between the core and the periphery is maintained and potentially widened over time.

1.4.3 Results

In the stochastic version of the model, the inclusion of three distinct types of shocks introduces variability and uncertainty into the system, affecting the dynamics between the core and the periphery. These shocks are:

- A TFP shock to the core: This type of shock directly impacts the efficiency with which all inputs (labor and capital, including tangible and intangible capital) are used in the production process within the core economy. A positive TFP shock could represent a sudden improvement in technology or a breakthrough innovation, enhancing the core's productivity and potentially widening the economic gap between the core and the periphery. Conversely, a negative TFP shock could indicate a downturn in efficiency, possibly due to economic or political turbulence, affecting the core's output negatively.

- A TFP shock to the periphery: Similar in nature to the TFP shock to the core, this shock affects the periphery's productivity. The implications of a TFP shock in the periphery are significant for its development prospects and the narrowing of the productivity and income gaps with the core. Positive shocks can accelerate growth and development in the periphery, while negative shocks can exacerbate existing vulnerabilities.

- A shock to the repayment schedule for the periphery to the core: Changes in the repayment obligations from the periphery to the core, concerning knowledge rent on rented intangible capital, can have substantial financial implications. Such a shock could reflect changes in interest rates, renegotiation of terms, or shifts in the intellectual property regime that alter the cost of accessing intangible capital. This could either relieve financial pressure on the periphery (if the shock reduces repayment burdens) or exacerbate it (if payments increase), impacting the periphery's capacity for investment and growth.

Each of these shocks introduces elements of unpredictability and real-time adaptation into the model's framework, allowing for the analysis of how sudden changes in economic fundamentals or policies impact the steady-state dynamics and long-term trajectories of the core and periphery. The responses to these shocks provide insight into the resilience and vulnerability of each economy to external and internal disturbances, highlighting pathways for policy intervention and adjustment in the face of stochastic events.

Below, we present plots illustrating the impacts of such shocks on total output, tangible capital, intangible capital, labor and consumption in both the core and the periphery.

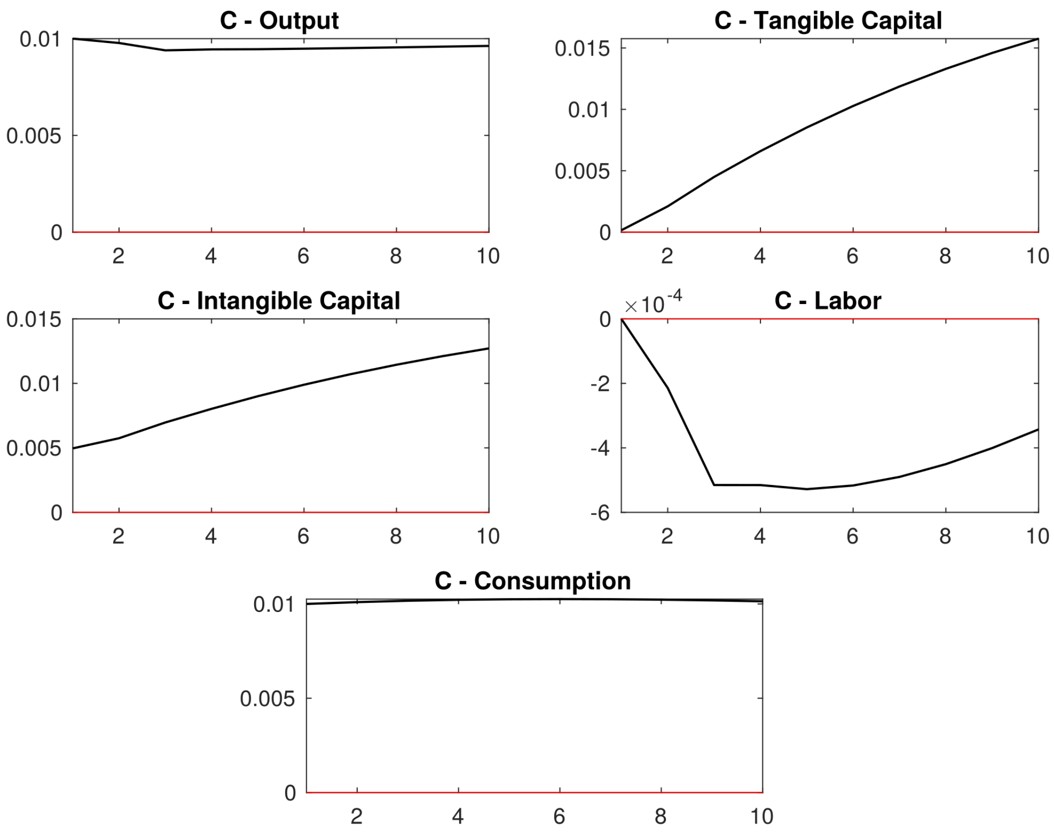

Figure 2. TFP shock to the core: responses of core variables

As illustrated in Figure 2, there are positive developments across most economic variables within the core, enhancing output, both forms of capital and consumption. However, the most pronounced and adverse impact is observed on labor in the short term, suggesting a paradoxical decrease that might reflect initial adjustments or displacement effects within the labor market.

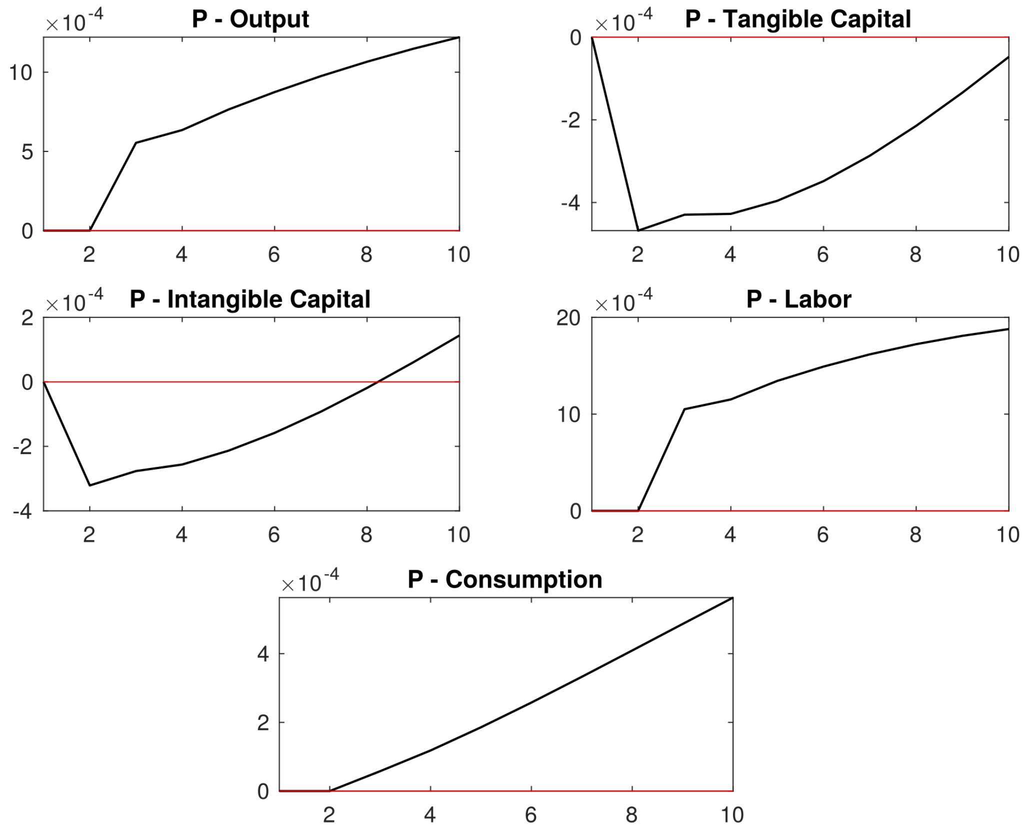

Figure 3. TFP shock to the core: responses of periphery variables

In Figure 3, output, labor, and consumption exhibit delayed but positive trends, indicating beneficial spillover effects, whereas both tangible and intangible forms of capital experience adverse impacts. This dichotomy underscores the complex financial and economic connections between the core and periphery, highlighting how enhancements in productivity in one region can inadvertently strain capital resources in another.

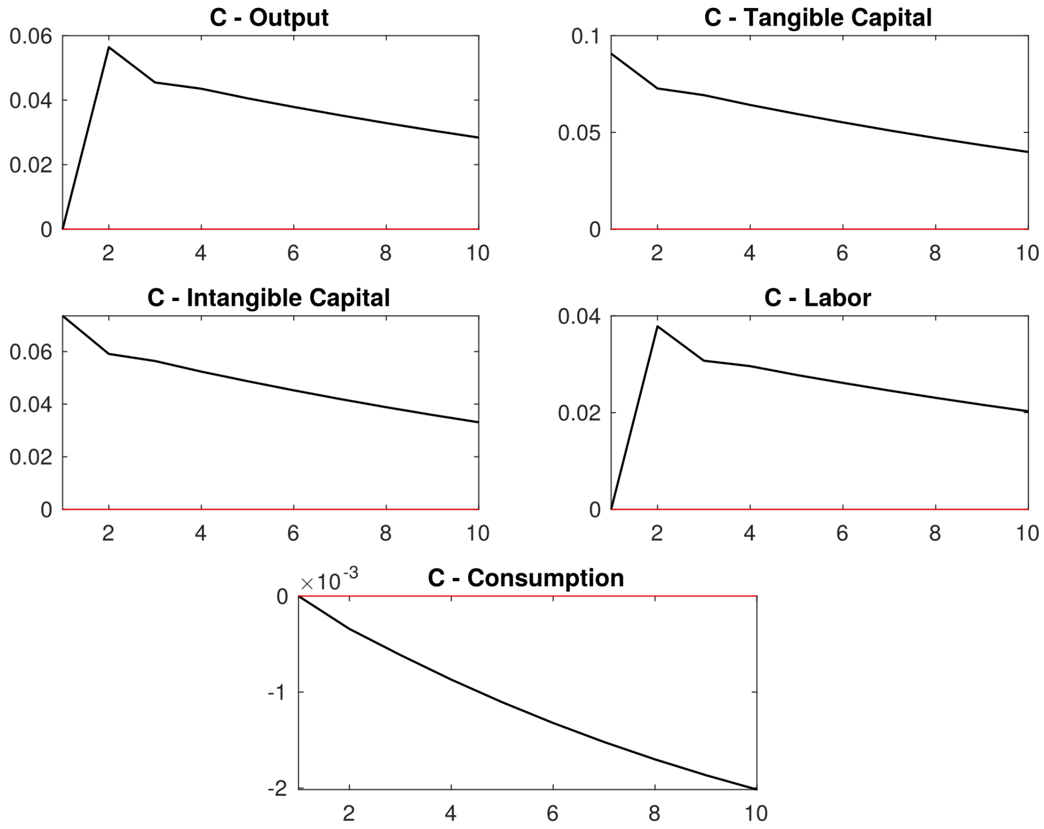

Figure 4. TFP shock to the periphery: responses of core variables

In Figure 4, output and labor exhibit positive responses, indicative of favorable spillover effects. Meanwhile, both forms of capital are subject to immediate impacts, highlighting the region's significant vulnerability to local productivity disturbances.

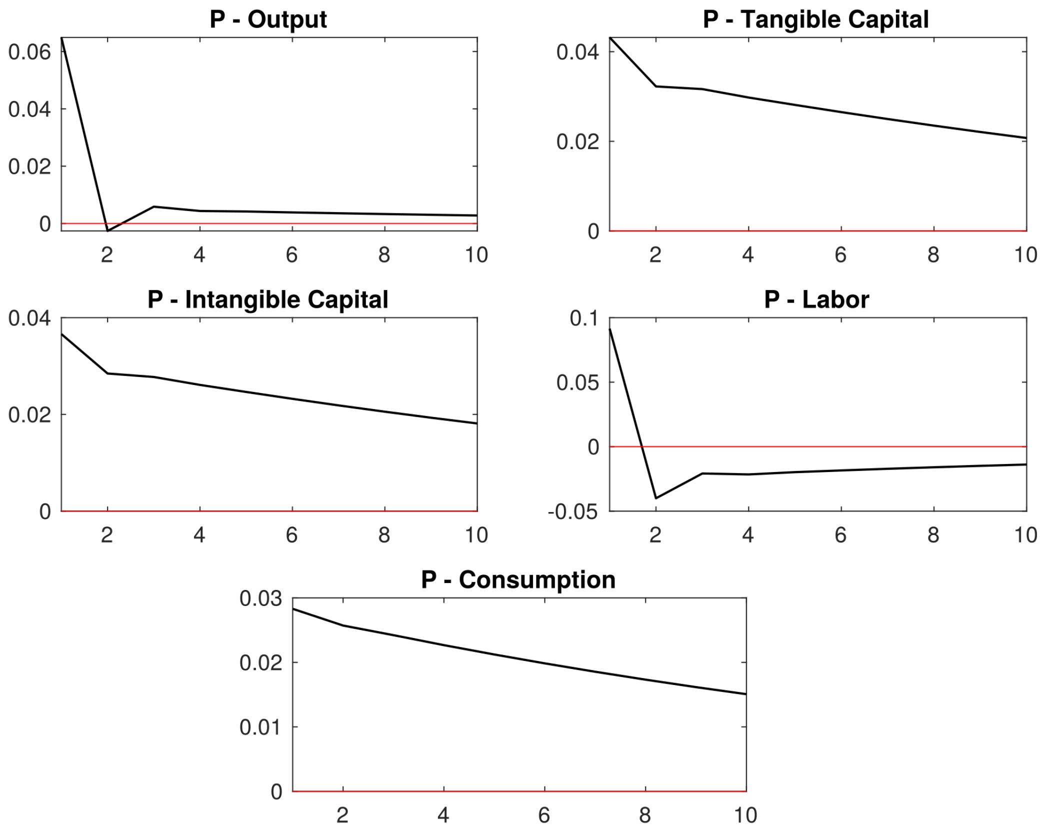

Figure 5. TFP shock to the periphery: responses of periphery variables

In Figure 5, the results stand in stark contrast to those from a core-initiated shock. There is an overarching impact on all considered variables in the periphery, suggesting significant interdependence and a fragile balance within the global economic framework.

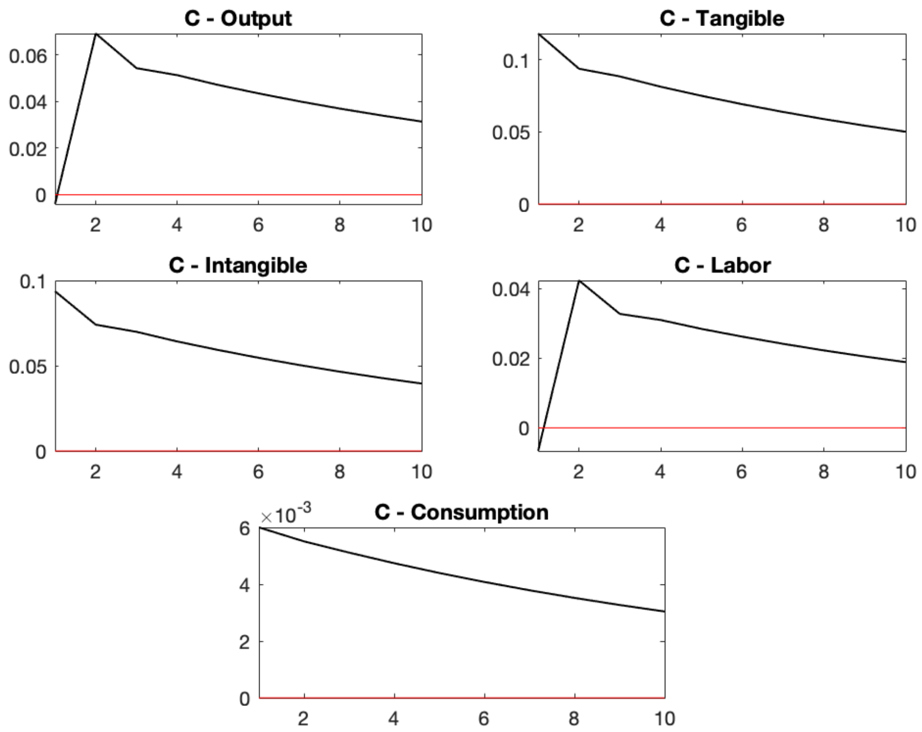

Figure 6. Repayment schedule shock: impact on core variables

In Figure 6, a positive shock to the repayment schedule yields beneficial effects on the core, likely driven by shifts in anticipated income from knowledge rents. This shock also results in slightly positive impacts on both tangible and intangible capital.

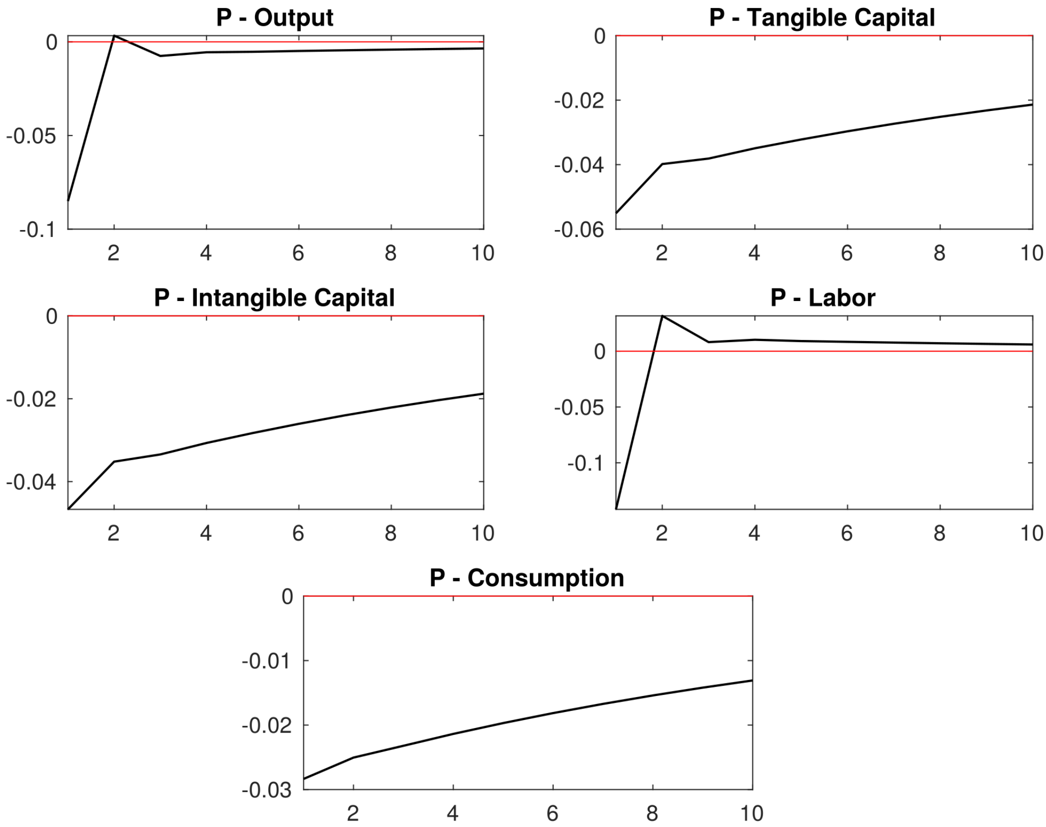

Figure 7. Repayment schedule shock: impact on periphery variables

In Figure 7, the periphery suffers from these shocks, potentially exacerbating financial pressures and diverting resources from productive investments or consumption. These outcomes are consistent with theoretical predictions and initial expectations.

1.5 Conclusion

In the modern global economy, the distribution and type of capital that countries possess significantly influence their stability and resilience during economic shocks. Intangible capital, including technology, brand value, and intellectual property, is crucial in determining how well a nation can withstand productivity fluctuations and financial crises. Countries with a higher ratio of intangible to tangible capital typically have a robust mechanism to handle such economic disruptions better.

On the other hand, peripheral nations, which often rely heavily on core countries for their supply of intangible capital, find themselves in a precarious position. This dependency creates a dynamic where peripheral countries must incur additional costs, referred to as knowledge rents, to access essential intangible resources. These rents represent a financial burden that can drain the limited economic resources of these countries, putting them at a disadvantage.

Moreover, this reliance on external sources of intangible capital ties the economic fortunes of peripheral countries closely with those of the core countries. During periods of global financial contagion, this interdependence becomes a liability. As core nations focus on stabilizing their own economies, the flow of intangible capital to peripheral countries may be reduced or become more costly, exacerbating economic challenges in these nations.

Furthermore, countries that predominantly rely on tangible assets such as physical machinery, equipment, and natural resources while paying knowledge rents for rented intangible capital are doubly vulnerable. Not only do these nations face the intrinsic volatility associated with tangible assets, which may fluctuate wildly during crises, but they also bear the brunt of costly access to vital intangible resources.

In conclusion, the economic outcomes of nations during global financial crises are heavily influenced by the composition of their capital assets. Countries with more intangible capital are generally better positioned to navigate economic shocks, while those dependent on tangible assets and external intangible resources are more vulnerable to adverse effects. This underscores the importance of developing internal capacities for generating and sustaining intangible capital to reduce dependency and improve economic resilience.

CHAPTER 2

RESILIENT FORCES: THE ROLE OF INTANGIBLE CAPITAL IN MITIGATING FINANCIAL CONTAGION DYNAMICS

2.1 Introduction

Since the 1980s, economic crises have emerged across nearly every continent, with notable instances including the 1994 Mexican Tequila Crisis, the 1997 Asian crisis, and the 1998 Russian crisis, underscoring the international contagion of financial turmoil. The concept of contagion describes the regional or global spread of the effects of speculative attacks or crises to other countries (Eichengreen et al., 1996). In early studies, Gerlach and Smets (1995) demonstrate that speculative attacks on one currency (the Finnish markka) could lead to speculation against another (the Swedish krona), emphasizing the role of trade and competitiveness. Focusing on the financial aspects, Kaminsky and Reinhart (2000) argue that trade alone cannot account for the Latin American exchange rate crises or the Asian crises. More recently, the Great Recession of 2008 highlighted how global economic integration facilitates the spread of financial crises from central economies to the periphery, transmitting financial crises on a global scale. The transmission mechanism of the global recession has been the subject of empirical investigation in more recent research by authors such as Campello et al. (2010), Reinhart and Rogoff (2011), Pérez-Orive (2016), Guerrieri and Lorenzoni (2017), Epstein et al. (2019), Devereux and Yu (2020), Cesa-Bianchi and Sokol (2022), Miranda-Agrippino and Nenova (2022), and Obstfeld and Zhou (2023).

This chapter strives to enrich the literature on global policy spillovers and the mechanisms through which such spillovers are transmitted between core and peripheral economies. To achieve this, we develop a two-country macroeconomic model that encapsulates both advanced and emerging economies. From the firm side of the model, these countries are distinguished by their capital structures. To facilitate an analysis of the variances in capital structure between the two types of economies, we incorporate intangible capital into the production function. The model meticulously examines both productivity shocks and, more crucially, exogenous stochastic financial leverage shocks affecting each country, placing a deliberate focus on elucidating the financial transmission channel.

2.2 Literature review

In the existing literature, it is recognized that there are two principal channels through which macroeconomic disturbances are transmitted: exogenous global shocks and endogenous country-specific shocks. In their studies, Devereux and Yetman (2010) posited that leverage constraints activate a financial transmission channel, resulting in a co-movement among countries in response to an exogenous technological shock. Additionally, Dedola and Lombardo (2012) contend that cross-country co-movements arising from financial shocks become more pronounced with increased global integration. They further elaborate that domestic policy measures aimed at supporting "constrained investors" can effectively reduce borrowing costs (Dedola & Lombardo, 2012, p. 326). Lopez and Olivella (2018) examine intangible capital's significant role in transmitting financial shocks and the consequent volatility in the labor market due to these shocks. Our research highlights the financial channel as the pivotal transmission mechanism of shocks between core economies and the periphery. However, a key element that our study introduces is the consideration of collateral in both core and periphery economies, which comprises both tangible and intangible assets, thereby underlining the important role of intangible capital in this context.

Caggese and Pérez-Orive (2022) explore the dynamics between intangible capital and changes in interest rates, concluding that lower interest rates do not necessarily boost investments in intangible assets. This is attributed to the diminished collateral value of intangibles, which consequently leads to reduced financing options through debt. Echoing these findings, Döttling and Ratnovski (2023) delve deeper into the subject, examining three economic mechanisms that could explain the non-stimulative effects of monetary policy on intangible investments: the lower collateral value, higher depreciation rates, and higher adjustment costs of intangibles. Their research highlights that among these factors, the lowered collateral value coupled with a weakened credit channel stands out as the most substantial evidence, indicating a critical area of consideration for monetary policy's impact on investments in intangible assets.

As highlighted in the first chapter, there is significant variation in the amount and utility of intangible capital across different nations in their production processes. Relying predominantly on tangible assets and leveraging the credit channel, countries with limited access to intangible capital find themselves at a greater risk of being affected by the repercussions of global financial contagion. Our study takes a novel approach to the issues identified and discussed by Caggese and Pérez-Orive (2022) and Döttling and Ratnovski (2023), investigating the scenario from an alternative perspective. We propose that a higher accumulation of intangible capital in core economies, contrasted with a scarcity of intangible capital in the periphery, leads to a disparity in their steady states post-financial contagion. This divergence in the steady states between core and peripheral economies underscores the pivotal role of intangible capital in the distribution of global financial contagion outcomes.

2.3 Model

In our model, individuals act as firm investors within both core and periphery regions, allocating their investments solely into domestic equities characterized by tangible and intangible capital assets. Financing for these investments is sourced from an external third-party creditor, herein referred to as the global banker. Both tangible and intangible capital assets within each country serve as collateral for borrowing purposes. Additionally, these firm investors also participate in the labor market, thereby earning labor income. Our model synthesizes two distinct frameworks for analyzing the preferences of firm investors: Corsetti et al. (2010), which examines optimal policy in a setting of diverse investor preferences, and Devereux and Yu

(2020), which delves into the effects of international financial integration. This amalgamation allows for a nuanced exploration of how tangible and intangible assets influence investment decisions and labor income in a globalized financial landscape.

This model's foundational premise is to explore how the incorporation of both tangible and intangible assets as collateral influences the borrowing dynamics of firms and investors, reflecting a more comprehensive understanding of collateral's role in the credit market. Through this, we aim to shed light on the nuanced mechanisms of credit cycles and international financial integration, particularly focusing on the differential impact that tangible and intangible capital have on the financial system's stability and the broader economy.

2.3.1 Firm investors

Individual j has a utility function of the following form:

$$V^S = E_0 \left\{ \sum_{t=0}^{\infty} \beta_t^S [u(C_t^S) + v(1 - L_t^S)] \right\} \tag{2.1}$$

In the given framework, $S = H, P$ represents the core and the periphery, while V_j^S denotes the utility, C_t^S refers to consumption, and $1 - L_t^S$ captures leisure. Furthermore, β^t lies within the interval $(0, 1)$ and signifies the discount factor. The functional forms for consumption and labor are adapted and refined based on the CES model, following examples from Clarida et al. (2002), Benigno and Benigno (2006), and Corsetti et al. (2010).

$$u(C_t^S) = \frac{(C_t^S)^{1-\sigma} - 1}{1 - \sigma} \tag{2.2}$$

$$v(1 - L_t^S) = \frac{(1 - L_t^S)^{1+\eta}}{1 + \eta} \tag{2.3}$$

The budget constraint for the firm-investor is presented as follows:

$$\begin{aligned} &\left\{ C_t^S + q_{1,t}^S k_{t+1}^{S,T} + q_{2,t}^S k_{t+1}^{S,I} - \frac{d_{t+1}^S}{R_{t+1}} \right\} \\ &= \left\{ (w_t^S L_t^S) + (q_{1,t}^S + R_{1,t}^S) k_t^{S,T} + (q_{2,t}^S + R_{2,t}^S) k_t^{S,I} - d_t^S \right\} \end{aligned} \tag{2.4}$$

The budget constraint for the firm-investor includes the portfolio decisions $k_{t+1}^{S,T}$ and $k_{t+1}^{S,I}$, and the debt holdings denoted by d_t^S; R_{t+1} represents the global interest rate. The components $(q_{1,t}^S + R_{1,t}^S)k_t^{S,T}$ and $(q_{2,t}^S + R_{2,t}^S)k_t^{S,I}$ refer to the gross returns on equities based on tangible and intangible capital, respectively.

Building upon the insights from Loumioti (2012) and Lopez and Olivella (2018), our model integrates both tangible and intangible capital as collateral for loans secured from bankers. This methodology aligns closely with the approaches employed in the seminal works by Kiyotaki and Moore (1997) and Devereux and Yu (2020). Consequently, we have developed a model that incorporates a binding collateral constraint on borrowing, as outlined below:

$$w_t^S L_t^S + \frac{d_{t+1}^S}{R_{t+1}} \leq \kappa_t^S E\left\{q_{1,t+1}^S k_{t+1}^{S,T} + q_{2,t+1}^S k_{t+1}^{S,I}\right\} \tag{2.5}$$

κ_t^S represents an exogenous stochastic financial leverage shock. This concept is integral to the dynamic constraints of the model, influencing the borrowing conditions by varying the degree of financial leverage available to firms at different times.

To ensure the existence of an equilibrium within our model, we incorporate a penalty function related to the binding collateral constraint on borrowing. This approach is consistent with methodologies presented by Judd et al. (2002) and Devereux and Yu (2020), which employ a penalty function to manage the complexities associated with binding constraints. The specific form of the penalty function is articulated as follows:

$$\Phi^S\left(k_{1,\ t}^l, k_{2,\ t}^l\right) = \kappa_1 \min\left(0, k_{1,\ t}^l - k_1^l\right)^4 + \kappa_2 \min\left(0, k_{2,\ t}^l - k_2^l\right)^4 \tag{2.6}$$

Here, k_i^l, where $i = 1,\ 2$, represents the lower bound for holding equity i by investor l, and $\kappa_i > 0$ is a penalty parameter. A penalty is imposed on investors when equity holdings fall below this lower bound, reflecting the punitive measures for not maintaining minimum required levels. In contrast, the upper bound of the collateral constraints limits the maximum permissible level of borrowing, thereby defining the ceiling for investors leverage.

This penalty function serves to mathematically model the repercussions faced by firm investors when the collateral constraint becomes binding, thereby preventing unbounded borrowing against future income or asset values. Implementing such a function within the model allows for a more realistic simulation of credit markets, ensuring that the equilibrium achieved is consistent with real-world financial conditions and behaviors. However, in the simulations of the baseline model, we adjust parameters for the lower bound to ensure that discrepancies do not exceed zero.

In the context of competitive equilibrium, the intratemporal condition stipulates that:

$$-\frac{V_l(C_t^S, 1 - L_t^S)}{V_c(C_t^S, 1 - L_t^S)} = w_t^S \tag{2.7}$$

For the intertemporal conditions for portfolio choices, we observe the following:

$$q_{1,t}^S = \frac{\beta^S V_c(C_{t+1}^S, 1 - L_{t+1}^S)}{V_c(C_t^S, 1 - L_t^S)}(q_{1,t+1}^S + R_{1,t+1}^S) + \frac{\mu_t^S \kappa_t^S E_t q_{1,t+1}^S}{V_c(C_t^S, 1 - L_t^S)} \tag{2.8}$$

$$q_{2,t}^S = \frac{\beta^S V_c(C_{t+1}^S, 1 - L_{t+1}^S)}{V_c(C_t^S, 1 - L_t^S)}(q_{2,t+1}^S + R_{2,t+1}^S) + \frac{\mu_t^S \kappa_t^S E_t q_{2,t+1}^S}{V_c(C_t^S, 1 - L_t^S)} \tag{2.9}$$

After a series of manipulations, we arrive at the following conclusion:

$$\beta^S \frac{E_t V_c(C_{t+1}^S, 1 - L_{t+1}^S)}{V_c(C_t^S, 1 - L_t^S)} + \frac{\mu_t^S}{V_c(C_t^S, 1 - L_t^S)} = \frac{1}{R_{t+1}} \tag{2.10}$$

2.3.2 The global bankers

In our theoretical framework, both in the core and periphery, formally employed savers in the production sector derive their income from labor and channel their savings into the financial system, extending loans to investors. These labor participants face vulnerabilities related to variances in wage rates and capital prices, which considerably influence their income and consumption decisions. Such dynamics are especially pertinent in examining the effects of monetary shocks.

In the model, using a two-country paradigm, savers from both the core and the periphery engage in risk-sharing activities and collectively function akin to a global banker entity, a concept inspired by the framework established by Devereux and Yu (2020). Within each respective nation, a localized branch of this global banking entity processes deposits from savers and directs them toward subsequent investment and lending activities. Consequently, the optimization process that traditionally involves separate calculations for savers within each jurisdiction is consolidated into a singular problem managed by the global banker. This amalgamation significantly reduces the complexity of managing distinct financial strategies across borders.

This unified approach not only simplifies economic modeling but is also reflective of a more interconnected global financial system. Such a system underscores the importance of cross-border financial activities and robust risk-sharing mechanisms, essential in mitigating localized economic impacts and fostering global economic stability. This model provides vital insights into how global financial integrations can distribute financial stresses and sustain economic equilibrium across different territories.

The production functions for the two countries, namely the core and the periphery, are presented as follows:

$$Y_t^S = A_t^S F(K_t^S, L_t^S) = A_t^S (K_t^{S,T})^{\alpha_S} (K_t^{S,I})^{\gamma_S} (L_t^S)^{1-\alpha_S-\gamma_S} \tag{2.11}$$

In both the core ($S = H$) and the periphery ($S = P$), firms repeatedly choose capital, labor, and investment, denoted by $\{K, L, I\}_{t=0}^{\infty}$. The variable $K_t^{S,T}$ represents tangible capital, while $K_t^{S,I}$ stands for intangible capital. The parameter $0 < \alpha_S < 1$ indicates the share of tangible capital, and $0 < \gamma_S < 1$ represents the share of intangible capital. This production function is considered to exhibit constant returns to scale. In the periphery, similarly, the firm makes choices regarding capital, labor, and investment for each period, denoted by $\{K, L, I\}_{t=0}^{\infty}$.

The expression for capital accumulation is defined as:

$$K_{t+1}^{S} = I_t^S + (1-\delta_S)K_t^{S,T} + (1-\sigma_S)K_t^{S,I} \tag{2.12}$$

where $K_{t+1}^{S} = K_{t+1}^{S,T} + K_{t+1}^{S,I}$.

The utility function of the representative banker is given by the following form:

$$V^B(C_t^B, 1-L_t^B) = E_0 \left\{ \frac{1}{2} \sum_{t=0}^{\infty} \beta_t^B \left[V^H(C_t^H, (1-L_t^H)) + V^P(C_t^P, (1-L_t^P)) \right] \right\} \tag{2.13}$$

where B represents the global banker. $\{C_t^B\}_{t=0}^{\infty}$ denotes consumption, $1-L_t^B$ represents leisure, and $\beta_t^B \in (0,1)$ is the discount factor.

In the work undertaken by global bankers, we establish a penalty function associated with the binding collateral constraints on borrowing. Following the approach in Devereux and Yu (2020), we introduce a penalty function represented as:

$$\Phi^B\left(k_{1,t}^B, k_{2,t}^B, d_t^B\right) = \kappa_1 \min\left(0, k_{1,t}^B - k_1^B\right)^4 + \kappa_2 \min\left(0, k_{2,t}^B - k_2^B\right)^4 + 2\kappa_B \min\left(0, \overline{d^B} - d_t^B\right)^4 \tag{2.14}$$

This equation encapsulates the penalty structure for violations of predefined collateral limits. Each term in the function is configured to impose a steep penalty (quartic in nature) whenever the respective collateral (assets $k_{1,t}^B$ and $k_{2,t}^B$ or the debt amount d_t^B) falls below or exceeds its designated threshold (k_1^B, k_2^B, or $\overline{d^B}$ respectively). Here, κ_1, κ_2, and κ_B represent the penalty coefficients corresponding to each type of collateral and debt constraint. The inclusion of the quadratic exponent magnifies the penalty incurred, emphasizing the severe disincentive for breaching the set limits, which reinforces fiscal discipline and stability within the financial system. Nonetheless, in the simulations of the baseline model, we fine-tune parameters for the lower bound to guarantee that discrepancies do not surpass zero.

In the context of competitive equilibrium, the intra-temporal condition is described as follows:

$$-\frac{V_l(C_t^B, 1 - L_t^B)}{V_c(C_t^B, 1 - L_t^B)} = w_t^B \tag{2.15}$$

The intertemporal condition is given by:

$$\frac{\beta^S E_t V_c(C_{t+1}^B, 1 - L_{t+1}^B)}{V_c(C_t^B, 1 - L_t^B)} = \frac{1}{R_{t+1}} \tag{2.16}$$

Assumption 1: The number of firm investors and savers is equal both in the core and the periphery.

Assumption 1 posits that the number of firm investors and savers is equal in both the model's core and periphery regions. This establishes a balanced financial environment within each region, where the supply of funds from savers matches the demand for funds from investors. This symmetry simplifies the economic analysis by ensuring no inherent imbalances between those who provide capital and those who seek it, facilitating a smoother examination of capital flows and financial dynamics within each area.

2.4 Calibration and results

2.4.1 Calibration of the parameters

In our model, calibration is critical to ensure that the theoretical framework aligns with real-world data and behaviors. To achieve this, we have identified 14 targeted parameters requiring calibration. These parameters are crucial for accurately reflecting the economic conditions of both the core and the periphery regions. They include household discount factors, income shares of tangible and intangible capital, depreciation of tangible and intangible capital, the persistence of productivity shocks, and the constant relative risk aversion for both the core and the periphery. Calibrating these parameters requires careful consideration of empirical data and existing literature, ensuring that the model's outcomes are robust and reflect differing economic dynamics across the core and periphery. This process is fundamental in constructing a realistic macroeconomic model that analyzes monetary policy spillovers and their transmission mechanisms.

For calibration, we closely align with the methodology outlined in the first chapter. The depreciation rates for both tangible and intangible capital are determined using data from the National Income and Product Accounts (NIPA) spanning from 1947 to 2022. We aim for an intangible investment-to-output ratio of 5% and a tangible investment-to-output ratio of 12%. Given the paucity of comprehensive data on the total income share of intangible capital across all countries, we adopt a value of $\gamma_H = 0.15$, guided by Corrado et al. (2009) and Pérez-Orive (2016). For economies in the periphery, we reduce this to $\gamma_P = 0.10$, reflecting a more modest contribution of intangible capital within these regions. The allocation for tangible capital shares, $\alpha_H = 0.20$ for the core and $\alpha_P = 0.15$ for the periphery, is chosen to mirror the respective labor shares 0.60 in the core and 0.70 in the periphery.

We standardize total factor productivity at 1, and select a persistence rate for productivity shocks of 0.912, in line with Devereux and Yu (2020). The constant relative risk aversion (CRRA) parameter is set at 4, following the precedent established by Neumeyer and Perri (2005). Discount factors for households are differentiated between core and periphery to account for the inherent risk premium associated with the latter; 0.99 for the core, and 0.95 for the periphery. This calibrated model structure allows us to examine the differential impact of policies, accounting for the unique economic compositions and conditions in core and peripheral economies. Displayed below is Table 2 demonstrating the calibrated parameter values.

2.4.2 Results

In the stochastic version of the model, incorporating four distinct types of shocks introduces variability and uncertainty into the system, significantly influencing the dynamics between the core and the periphery. The specific shocks introduced are as follows:

- A TFP shock to the core: This refers to a sudden change in the efficiency with

Table 2. Calibrated Parameter Values

Parameter	The Core	The Periphery
Household's Discount Factor	$\beta_H = 0.99$	$\beta_P = 0.95$
Income share of tangible capital	$\alpha_H = 0.25$	$\alpha_P = 0.20$
Income share of intangible capital	$\gamma_H = 0.15$	$\gamma_P = 0.10$
Depreciation of tangible capital	$\delta_H = 0.007$	$\delta_P = 0.007$
Depreciation of intangible capital	$\sigma_H = 0.017$	$\sigma_P = 0.017$
Constant relative risk aversion	$\varphi_H = 4$	$\varphi_P = 4$
Persistence of productivity shocks	$\rho_H = 0.912$	$\rho_P = 0.912$

which all inputs (labor and capital) are used in the production processes in the core region. A positive shock implies an increase in productivity without an increase in the amount of inputs, potentially leading to higher output and economic growth. Conversely, a negative shock could reduce output and slow economic activity.

- A TFP shock to the periphery: This involves a sudden change in the productivity of all inputs in the periphery region. The effects mirror those in the core region, with positive shocks potentially boosting economic performance and adverse shocks potentially hindering it. The impact might differ based on the periphery's economic structure and reliance on different industries compared to the core.

- A leverage shock in the core: This type of shock involves a sudden change in the borrowing capacity or financial leverage of economic agents in the core. An increase in leverage allows firms and individuals to borrow more, potentially increasing investment and consumption but also increasing financial risk. A decrease in leverage could lead to reduced investment and spending, tightening economic conditions.

- A leverage shock in the periphery: This shock affects the borrowing capabilities in the periphery. The consequences are similar to those in the core but might be amplified or mitigated by the periphery's specific financial and regulatory environment. Increased leverage could stimulate economic expansion, whereas decreased leverage could constrain growth and expenditure.

The subsequent sections present plots that illustrate the impacts of these shocks on total output, tangible capital, intangible capital, labor, consumption, and total investment within both the core and periphery regions.

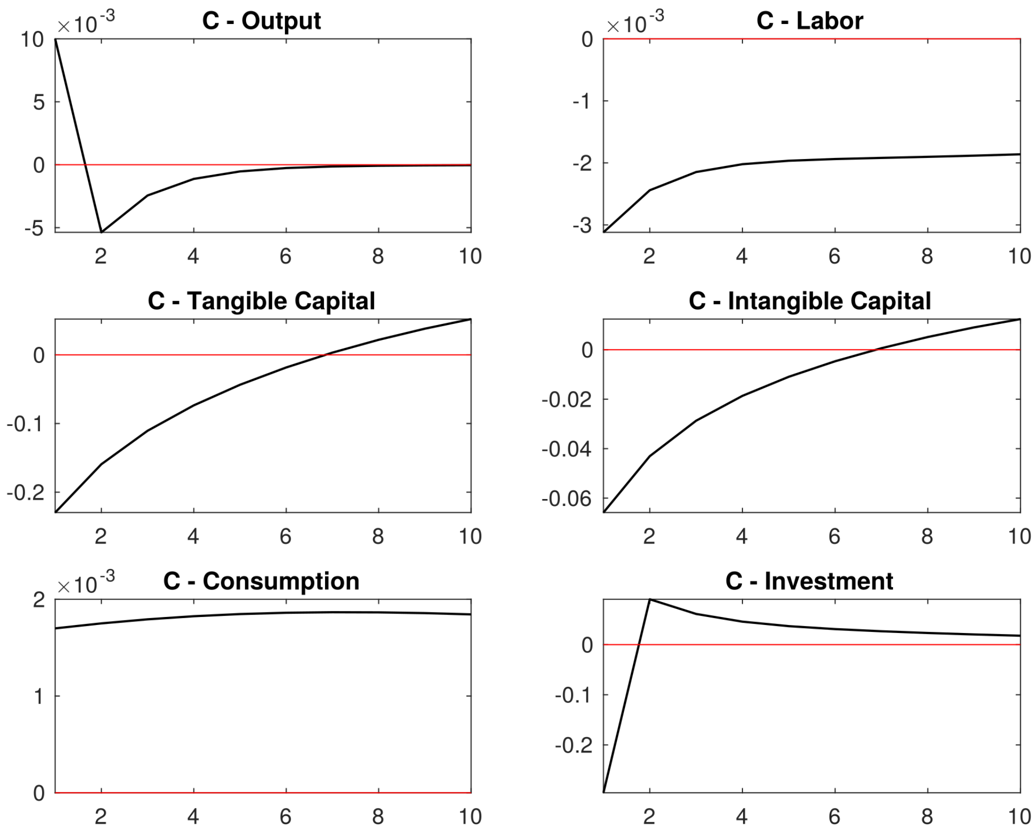

Figure 8. TFP shock in the core: impact on core country

As depicted in Figure 8, the shock depresses total output in the short term after an initial positive response while both forms of capital adjust gradually, suggesting the dominance of financial interactions over production processes. Intangible capital demonstrates a smoother response compared to tangible capital.

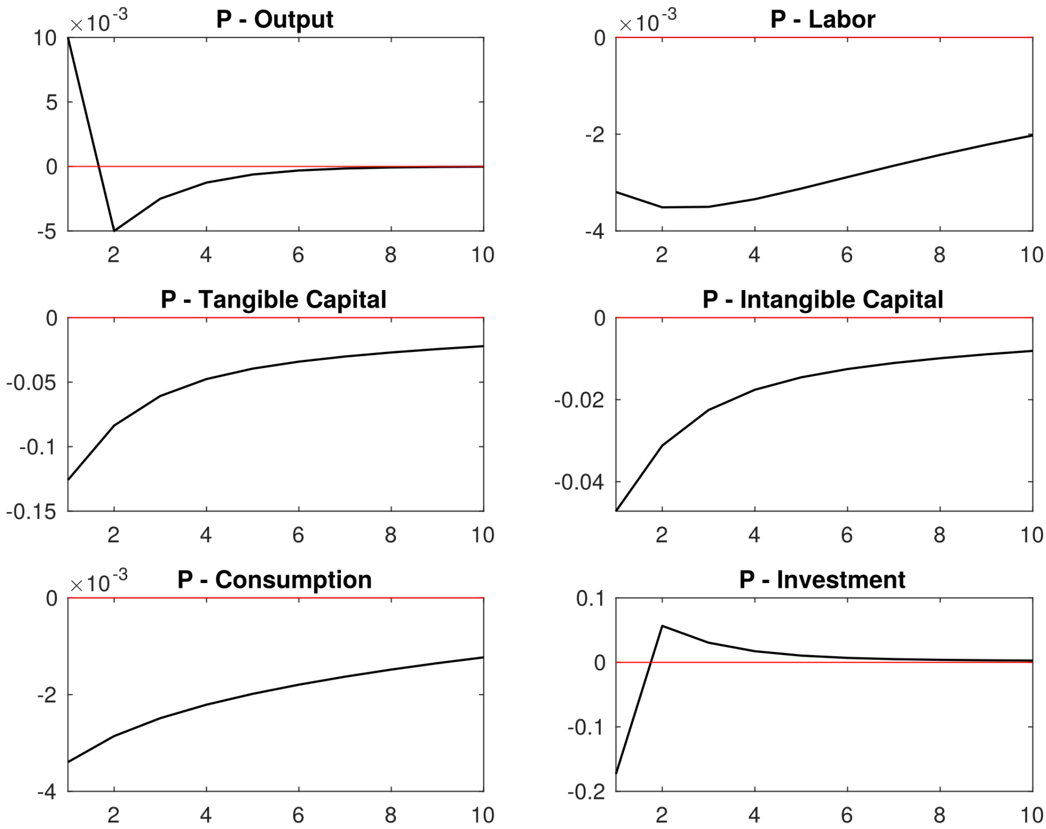

Figure 9. TFP shock in the periphery: impact on periphery country

In Figure 9, Similar to the core, total output initially responds positively but quickly declines, while other variables exhibit a gradual recovery. Intangible capital displays a smoother response compared to tangible capital. The fundamental drivers of growth, innovation and efficient production, are overshadowed by financial concerns.

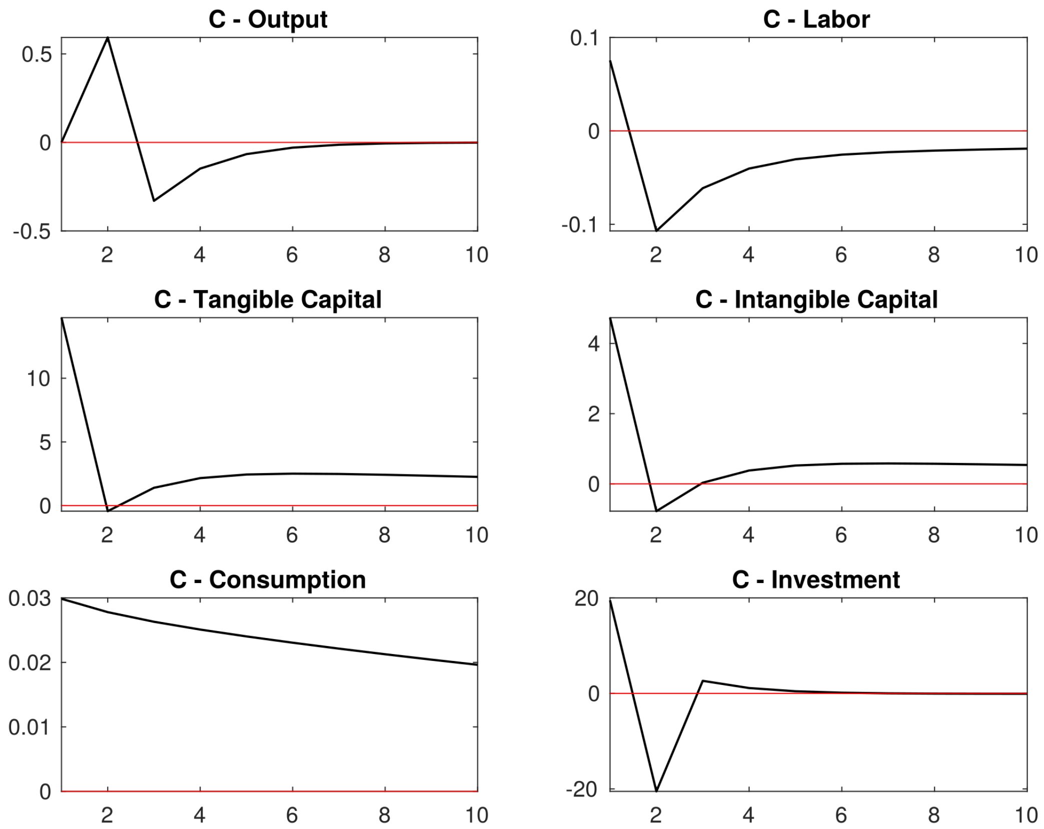

Figure 10. Leverage shock in the core: responses of core variables

In Figure 10, an uplift in total output is observed, alongside sharp but rapidly diminishing responses in both types of capital, labor, and investment activities. This outcome underscores a nuanced response mechanism to financial shocks, highlighting the complex interplay among various economic determinants in shaping the core's financial stability.

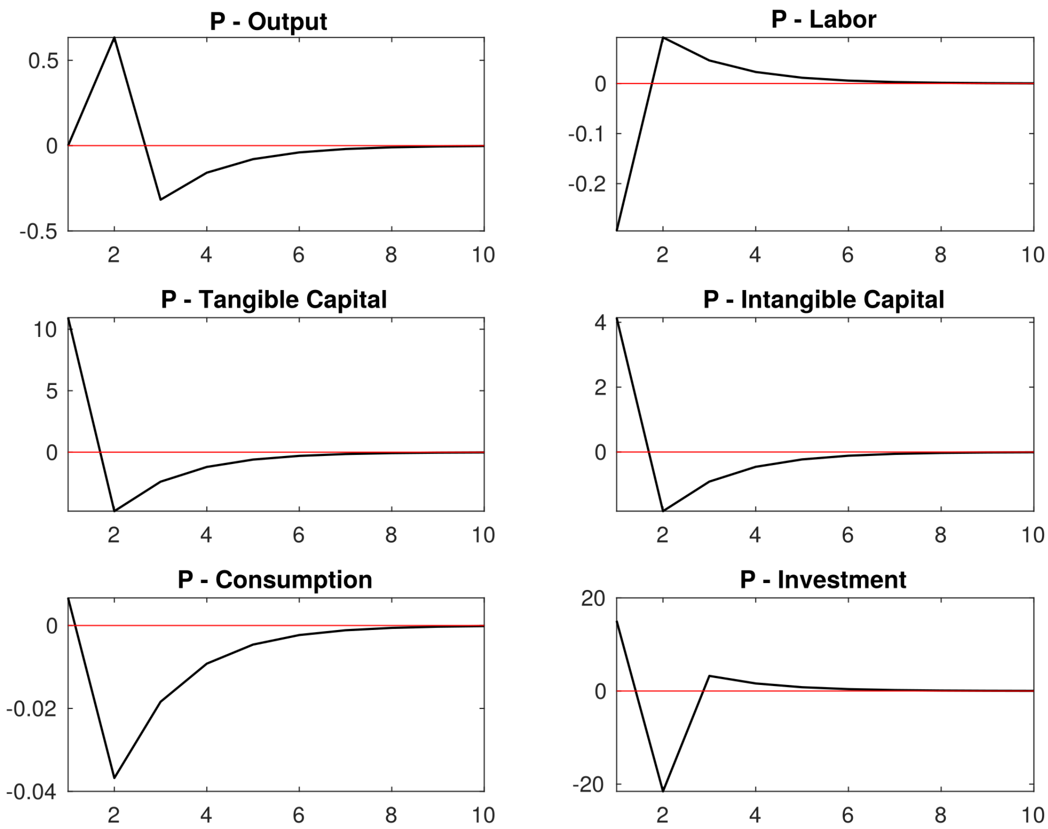

Figure 11. Leverage shock in the periphery: responses of periphery variables

In Figure 11, sharp effects are evident on all measured variables in the short term, aligning with our theoretical expectations. Initially, total output exhibits positive responses; however, in subsequent periods, both types of capital, along with consumption and investment, encounter negative repercussions. This pattern suggests a redistribution of capital toward more immediately productive or essential uses, potentially at the expense of long-term investment.

2.5 Conclusion

Our research delves into the complex interplay between economic policy, the type of capital, and resilience during financial crises. The study posits a novel perspective, suggesting that economies with lower stimulative capacity in economic policies might exhibit enhanced protection against economic contagion. This counterintuitive finding becomes particularly relevant in contexts where intangible capital is accessible.

Intangible capital plays a pivotal role in distinguishing the economic resilience of core economies from peripheral ones. In core economies, greater access to intangible capital fortifies the economic structure and imbues these economies with enhanced resilience during financial disturbances. On the contrary, peripheral economies, often less endowed with intangible resources, face greater vulnerability and weaker economic performance under similar conditions.

Moreover, our research underscores the role of intangible capital as a more stable form of collateral than traditional physical assets. It effectively responds to economic shocks with the flexibility and robustness that tangible assets often lack. This attribute of intangible capital is significant, highlighting its potential as a buffer against the adversities of economic downturns.

The study further elucidates the mechanisms of shock transmission across countries, mainly focusing on productivity and leverage shocks, thereby highlighting the global interconnectedness of economies. We find that while productivity shocks are generally well assimilated by the financial sectors of advanced economies, leveraging shocks, although depleting both tangible and intangible forms of capital, paradoxically stimulate total output. This phenomenon reflects a complex dynamic, where the initial negative impacts of such shocks are offset by subsequent adaptive economic responses, potentially after the stimulative aspects of leveraged investments or crisis-driven innovations.

In summary, our investigation reveals a comprehensive picture of how different types of capital and the nature of economic policies interact to shape the resilience of economies during financial crises. The endowed flexibility and potential of intangible capital as effective collateral make a compelling case for policies that foster the development of these assets, especially in peripheral economies. This strategic focus could allow these regions to dampen the adverse effects of global economic shocks and enhance their participatory role in the global economy. Thus, the study advances our understanding of economic resilience and offers practical insights for economic strategizing and policy-making in an interconnected world.

CHAPTER 3

QUANTIFYING THE IMPACT: EMPIRICAL INSIGHTS INTO THE ROLE OF INTANGIBLE CAPITAL

3.1 Introduction

In this essay, we employ empirical methods and tools to test the hypotheses formulated in the preceding chapters. Our overarching objective is to scrutinize the relationship and transmission mechanisms between the macroeconomic policies of advanced and emerging economies. The core focus of our inquiry resides in exploring how developed and developing economies react to macroeconomic shocks and examining the role of tangible and intangible capital within these economic contexts.

In the first chapter, we introduce a two-country framework characterized by autarky, where a peripheral country rents intangible capital from a core country, compensating with knowledge rent, yet maintains no other economic relations. Our model simulations reveal distinct responses to productivity shocks and changes in rent repayment schedules in the core versus the periphery.

In the second chapter, we expand the scenario to another two-country setting that allows for limited economic integration. Here, the core and periphery borrow from a global banker at a global interest rate. Our simulations suggest that financial integration corroborates the findings from the initial chapter.

This essay proceeds to discuss the empirical model and puts to test the hypotheses derived from the modeling exercises and simulations discussed in earlier chapters. We aim to empirically validate the theoretical constructs and insights from our analytical exploration of these economic interactions.

3.2 Literature review

Extensive empirical research has examined the impact of international integration and macroeconomic policies on core and peripheral economies. Backus et al. (1992)

suggest that there is an international co-movement of shocks affecting domestic real variables such as output and consumption. Calvo et al. (1993) demonstrate that US monetary policy significantly impacts the flow of capital to emerging economies. Utilizing data from 2002 to 2012, Ahmed and Zlate (2014) find that the unconventional monetary policy in the US has a notable effect on capital flows to emerging economies. Dahlhaus and Vasishtha (2014) conduct a VAR analysis using data from 2004 to 2014, showing that the normalization of monetary policy and increasing interest rates in the US have substantial effects on capital flows to the periphery since the summer of 2013, a period known as the taper tantrum. Dahlhaus and Vasishtha (2021) reveal that countries most affected by a monetary policy news shock were those that received the most capital inflows before 2013 and experienced capital outflows after 2013. Bacchetta and van Wincoop (2016) identify that international integration facilitates the transmission of financial crises, with the Great Recession serving as a recent example of this phenomenon. Bhattarai et al. (2020) analyze the significant adverse effects of US monetary policy on emerging markets. Using a panel VAR model, they demonstrate that an uncertainty shock in the US is correlated with changes in financial and real outcomes. They also show that the spillover effect of US uncertainty varies based on the monetary policy responses in each emerging economy.

Perri and Quadrini (2018) suggest that the global economic outcomes of the 2008 recession are correlated with the economic conditions in the G8 countries before and during the crisis. They emphasize the credit channel, constructing their model based on the endogeneity of credit shocks and demonstrating the existence of multiple self-fulfilling equilibria. Additionally, they conclude that a higher level of global integration leads to less frequent but more profound economic crises. Döttling and Ratnovski (2023) demonstrate that the response of intangible investment to monetary policy is significantly weaker compared to that of tangible investment. Consequently, stock prices and total investment in firms with a higher share of intangible assets respond less to a monetary policy shock. In this regard, we argue that such differentiation in terms of intangible capital between core and periphery might impact the level of deterioration of both real and financial variables in the latter. Bates et al. (2009), Brown et al. (2009), and Falato et al. (2022) demonstrate that firms with higher shares of intangible assets tend to be less indebted and rely less on external sources of finance.

3.3 Data and methodology

Optimization of consumption through maximizing the intertemporal utility function, subject to constraints, delineates an individual's consumption scheme via the optimal path of savings, investment, and capital (Weitzman, 1976). Investments that lower current consumption in favor of higher future levels should be treated symmetrically, as suggested by Hulten (1979) and Corrado et al. (2009). Motivated by this conclusion, we posit that intangible capital possesses a distinct presence characterized by its unique attributes.

Following Corrado et al. (2005), Corrado et al. (2009), and Roth and Thum (2013), intangible capital has been classified into three groups: computerized information, innovative property, and economic competencies. The first group encompasses knowledge in the form of (i) computer software. The second group comprises scientific knowledge including (ii) scientific R&D, (iii) new product development in the financial services industry, (iv) new architectural and engineering designs, and (v) mineral exploration, along with copyright and license costs (Roth & Thum, 2013, p. 490).

As a proxy for intangible capital, several alternatives can be utilized in empirical analysis, including R&D expenditure, patent application and renewal data, and patent data (Lanjouw et al., 1998, p. 490). The relationship between investment in R&D and economic growth has been explored by researchers such as Griliches and Lichtenberg (1984), Hall (1996), Aghion et al. (1998), Wakelin (2001), Zachariadis (2003), with R&D expenditure being employed as an indicator of the measure of the level of innovation by Rabiei (2011) and Bayarçelik and Tasel (2012). However, in the realm of knowledge creation, patent data distinctively represent the culmination of innovative activities within the Schumpeterian framework, as identified by Aghion et al. (2005) and Hatipoglu (2012).

Table 3. Sample of Countries

Australia	France	Latvia
Austria	Greece	Netherlands
Belgium	United Kingdom	Norway
Brazil	Hungary	New Zealand
Canada	Ireland	Poland
Colombia	Israel	Portugal
Czechia	Italy	Slovakia
Germany	Japan	Sweden
Denmark	Republic of Korea	Switzerland
Spain	Lithuania	United States of America
Finland	Luxembourg	South Africa

We address the co-movement of international shocks and the relatively lower responsiveness of intangible capital. We hypothesize that, on a global scale, countries with economies predominantly dependent on tangible capital are more vulnerable to such disturbances than those with substantial investments in intangible capital. To substantiate this hypothesis, we analyze and compare the reactions of tangible and intangible capital across various datasets.

Table 3 outlines the countries that are the focus of our analysis. The dataset employed spans from 2000 to 2019 and incorporates 33 advanced and emerging OECD countries for which data is accessible. This range allows for a comprehensive examination of economic patterns and trends across both developed and developing economies within the OECD framework during the specified period.

3.4 Model

Following Bond (2002), Lütkepohl (2005), and Kilian and Lütkepohl (2017), we construct Panel Structural Vector Autoregression Models and apply the Generalized Method of Moments (GMM). We conduct a structural analysis, generate generalized impulse response functions, and create bootstrapped confidence intervals for impulse response functions, as demonstrated by Sigmund and Ferstl (2021). We test the following three hypotheses, which emerged from the first and second chapters:

Hypothesis 1: Intangible capital is less responsive to significant disruption following a monetary (interest rate) shock, relative to tangible capital, assuming all other factors remain constant.

Hypothesis 2: Intangible capital is less responsive to significant disruption following a leverage (credit supply) shock, relative to tangible capital, assuming all other factors remain constant.

Hypothesis 3: Intangible capital is less responsive to significant disruption following a total factor productivity (TFP) shock, relative to tangible capital, assuming all other factors remain constant.

3.4.1 Monetary shock case

We examine the relationship between interest rates, tangible capital, and intangible capital. We employ long-term interest rates from the OECD, patent data from WIPO, and capital stock figures, as well as output-side real GDP data obtained from the Penn World Table. The ordering of the endogenous variables is determined via the correlation matrix, enabling us to estimate the following Structural Vector Autoregression Model in order to test our first hypothesis. Additionally, we provide the Vector Moving Average (VMA) representation as follows:

$$By_{i,t} = A\left(L\right) y_{i,t} + \varepsilon_{i,t} \tag{3.1}$$

where $i = [1, \ldots, 33]'$ denotes the number of countries and $t = [1, \ldots, 20]'$ denotes the time dimensions of the panel. $y_{i,t} \equiv \begin{bmatrix} k^T_{i,t} & k^I_{i,t} & r_{i,t} \end{bmatrix}'$ is a bidimensional vector consisting of $k^T_{i,t}$, tangible capital to GDP, $k^I_{i,t}$, intangible capital to GDP, and $r_{i,t}$, interest rates. $A(L) = \sum_{j=0}^{p} A_j L^j$ is a polynomial of lagged coefficients where A_j stands for a matrix of coefficients. $\varepsilon_{i,t}$ is vector of stacked residuals and B is matrix of contemporaneous coefficients.

Results

As hypothesized in our initial proposition, we anticipate that intangible capital exhibits less responsiveness compared to tangible capital, and a lower intangible/tangible capital ratio correlates with an elevated risk of financial crisis in the wake of a monetary (interest rate) shock, assuming all other conditions remain constant. The Impulse Response Functions generated from our preliminary analysis provide empirical support for this theory. The data reveals that the impact of an interest rate shock on intangible capital is less pronounced than on tangible capital. Moreover, our estimations highlight a marked negative impact on tangible capital, contrasting with a more gradual effect on intangible capital.

This observation aligns with our hypothesis, reinforcing our expectations regarding the differential responses of tangible and intangible capital to monetary shocks. This distinction underscores the nuanced behaviors of different capital types under economic stress and highlights the importance of considering the composition of capital in financial risk assessments.

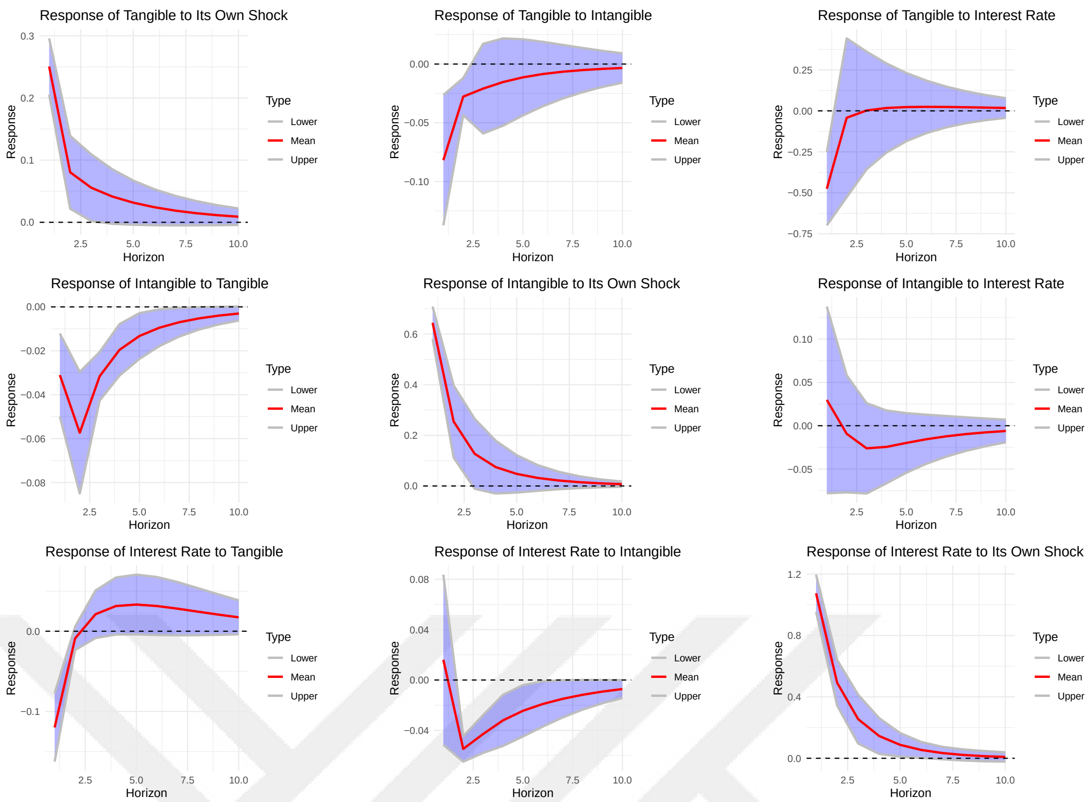

Figure 12. IRFs for a monetary shock in a one-lag panel SVAR

3.4.2 Credit supply shock case

For our second hypothesis, we adopt a methodology similar to the one used for the first. We draw on domestic credit to the private sector as a percentage of GDP data from the World Bank, alongside patent data from WIPO, capital stock, and output-side real GDP from the Penn World Table. To establish the ordering of the endogenous variables, we utilize the correlation matrix. This setup allows us to estimate the Structural Vector Autoregression Model specifically designed to test our second hypothesis. We present the Vector Moving Average (VMA) representation, as outlined below:

$$By_{i,t} = A\left(L\right)y_{i,t} + \varepsilon_{i,t} \tag{3.2}$$

where $i = [1, \ldots, 33]'$ denotes the number of countries and $t = [1, \ldots, 20]'$ denotes the time dimensions of the panel. $y_{i,t} \equiv \begin{bmatrix} k_{i,t}^T & k_{i,t}^I & c_{i,t} \end{bmatrix}'$ is a bidimensional vector consisting of $k_{i,t}^T$, tangible capital to GDP, $k_{i,t}^I$, intangible capital to GDP, and $c_{i,t}$, domestic credit to private sector as a percentage of GDP. Accordingly, we empirically assess the relationship between credit supply and tangible and intangible capital. This analysis aims to unpack the intricate dynamics that these variables exert on each other and their combined influence on the broader economic landscape.

Results

As stated in our second hypothesis, we anticipate that intangible capital exhibits less responsiveness than tangible capital. Accordingly, we propose that countries with a lower ratio of intangible to tangible capital are at an increased risk of financial crises following a leverage (credit supply) shock, provided all other conditions remain constant. This hypothesis underscores the importance of the composition of capital in determining economic vulnerability to financial disturbances. The Impulse Response Functions derived from our analysis present a nuanced view that supports this conjecture. They indicate that while the initial impact on tangible capital from a credit supply shock is more severe, its recovery period is also more prolonged compared to intangible capital.

Consistent with our expectations, our findings reveal a sustained effect on tangible capital, confirming the relatively longer-lasting impact on intangible capital as hypothesized. This analysis underscores the vulnerability of economies with lesser intangible assets when confronted with financial disturbances.

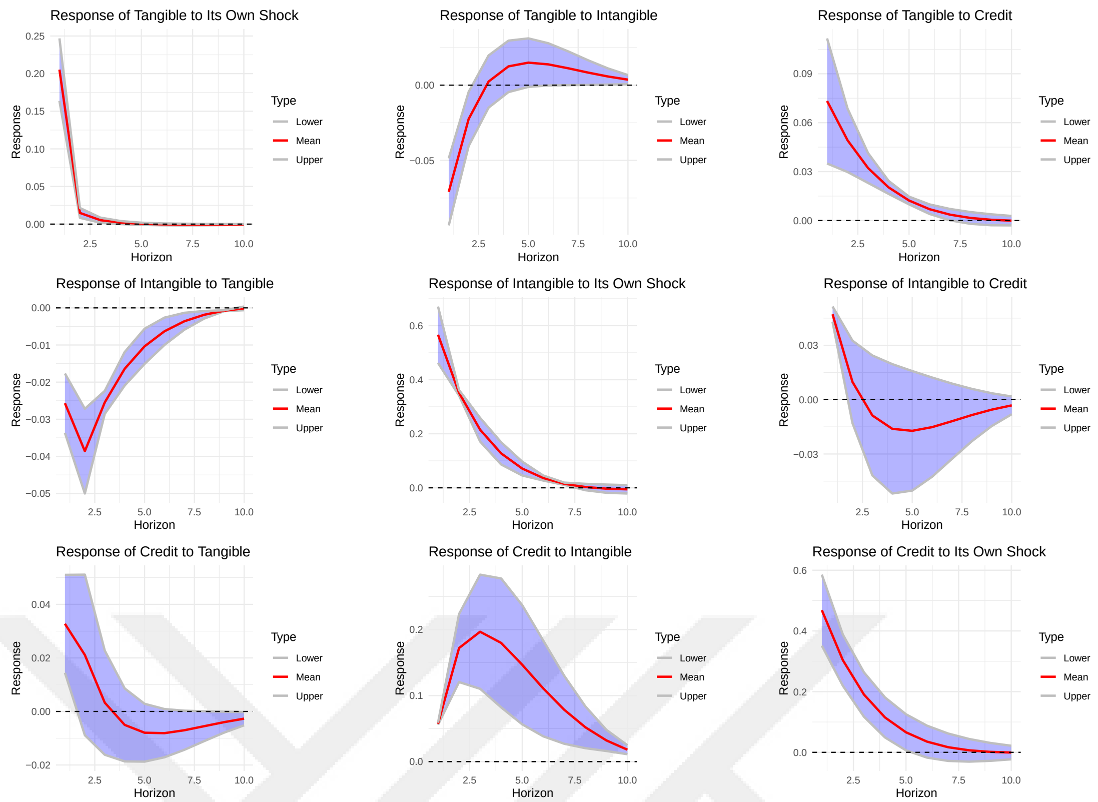

Figure 13. IRFs for a leverage shock in a one-lag panel SVAR

3.4.3 Total factor productivity shock case

For our third hypothesis, we apply the same methodology utilized in previous analyses. We employ total factor productivity at current PPPs data sourced from the Penn World Table, alongside patent data from WIPO, capital stock figures, and output-side real GDP from the Penn World Table. We rely on the correlation matrix to determine the sequencing of the endogenous variables. This preparation allows us to use the Structural Vector Autoregression Model designed to examine our third hypothesis. Following this, we will delineate the Vector Moving Average (VMA) representation, as indicated below:

$$By_{i,t} = A\left(L\right)y_{i,t} + \varepsilon_{i,t} \tag{3.3}$$

where $i = [1, \ldots, 33]'$ denotes the number of countries and $t = [1, \ldots, 20]'$ denotes the time dimensions of the panel. $y_{i,t} \equiv \begin{bmatrix} k^T_{i,t} & k^I_{i,t} & tfp_{i,t} \end{bmatrix}'$ is a bidimensional vector consisting of $k^T_{i,t}$, tangible capital to GDP, $k^I_{i,t}$, intangible capital to GDP, and $tfp_{i,t}$, total factor productivity at current PPPs. Hence, we examine the relationship among total factor productivity, tangible capital, and intangible capital. This analysis aims to elucidate the interconnected influences these elements exert on one another and to explore their collective impact on economic performance.

Results

As articulated in our third hypothesis, we anticipate that intangible capital is less responsive than tangible capital to a total factor productivity (TFP) shock. Consequently, a country exhibiting a lower ratio of intangible to tangible capital faces an increased risk of financial crisis following a TFP shock, assuming all other conditions remain constant. This hypothesis emphasizes the differential impact of productivity shocks on the two types of capital, highlighting the broader economic implications of capital composition in the face of productivity variations. The Impulse Response Functions from our third analysis reveal that the impact of a TFP shock on intangible capital is notably positive. Furthermore, our estimation uncovers a prolonged effect on intangible capital, which bolsters our hypothesis. This outcome indicates that intangible capital may possess a distinctive resilience or growth potential in the face of TFP shocks, aligning with our theoretical expectations and providing valuable insights into the dynamics between capital structure and productivity shocks.

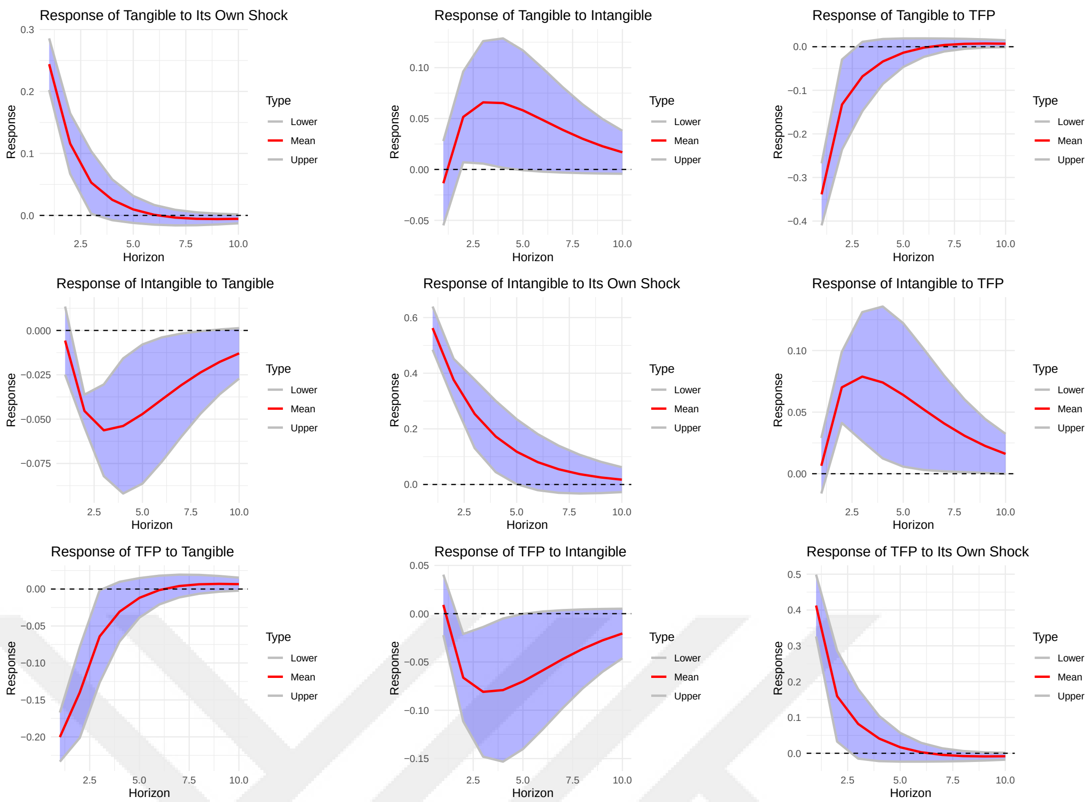

Figure 14. IRFs for a TFP shock in a one-lag panel SVAR

3.4.4 Shocks in the core and in the periphery

In the final section, we delve into the origins of the TFP shock outcomes. We categorize countries based on the ownership level of intangible capital as a percentage of their GDPs, using a dummy variable to distinguish between core and periphery countries. Subsequently, influenced by the approach of Angrist and Pischke (2009), we introduce an interaction term to our model, detailed as follows:

$$By_{i,t} = A\left(L\right)y_{i,t} + \varepsilon_{i,t} \tag{3.4}$$

Here, $y_{i,t} \equiv \begin{bmatrix} k^T_{i,t} & k^I_{i,t} & (dummy * x_{i,t}) \end{bmatrix}'$ represents a bidimensional vector. This vector is comprised of $k^T_{i,t}$ (tangible capital to GDP), $k^I_{i,t}$ (intangible capital to GDP), and $(dummy * x_{i,t})$ (the interaction term).

TFP shocks in the core only

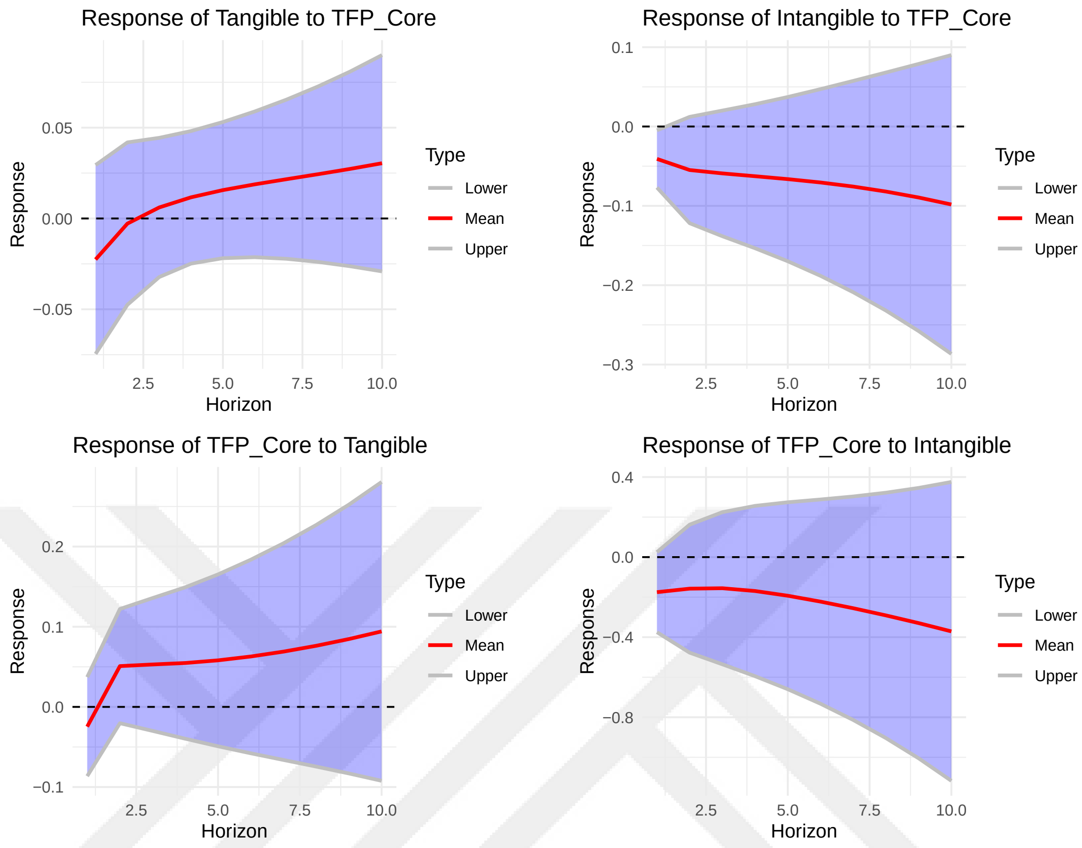

Figure 15. IRFs from a one-lag panel SVAR after a TFP shock in the core

TFP shocks in the periphery only

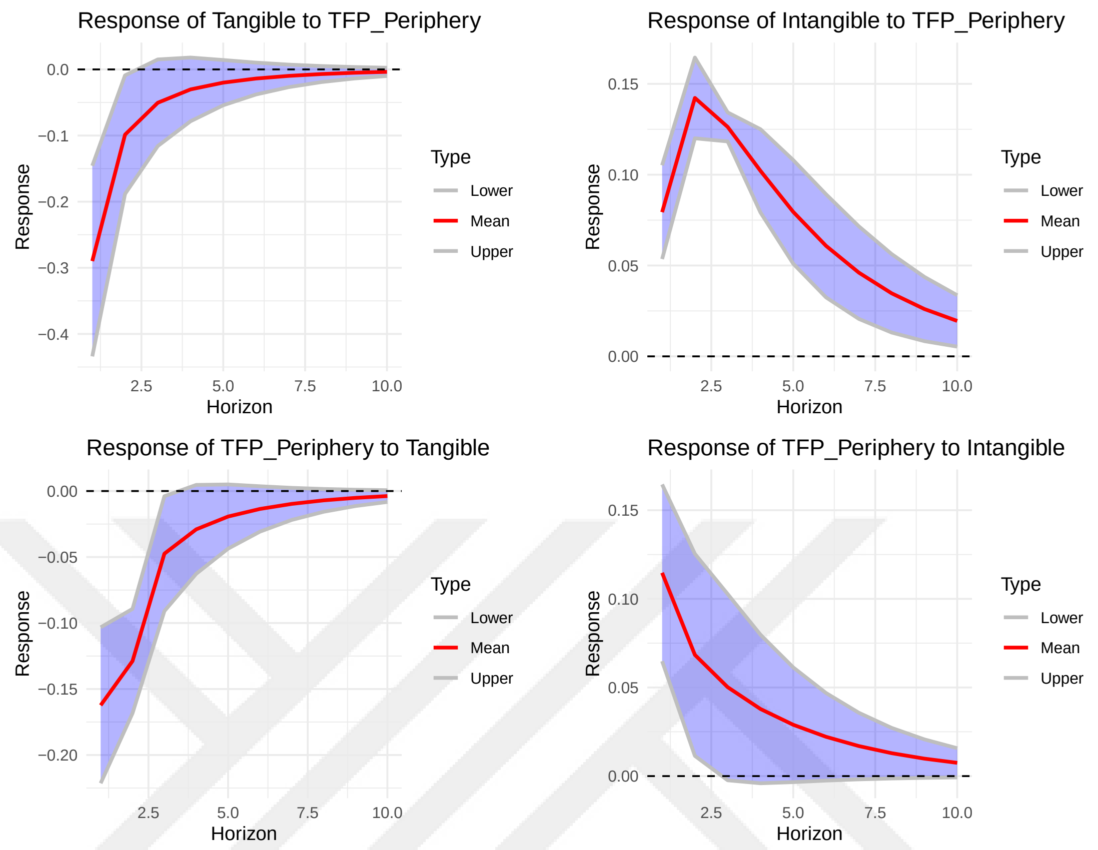

Figure 16. IRFs from a one-lag panel SVAR after a TFP shock in the periphery

Results

Our analysis reveals that the impact of a TFP shock on tangible and intangible capital in the periphery is considerably more severe than a similar shock in the core. This finding highlights the varying levels of vulnerability to productivity shocks between core and periphery countries, particularly with respect to intangible capital.

3.5 Conclusion

In economic research, understanding how financial shocks impact different types of capital is critical for predicting and mitigating economic crises. Our study explores the nuanced effects of monetary shocks on the intangible-to-tangible capital ratio, revealing critical vulnerabilities. Specifically, we find that a lower ratio heightens a country's susceptibility to financial crises induced by such shocks. Our results demonstrate that while tangible capital tends to suffer immediate, significant adverse effects due to its fixed and depreciating nature in volatile monetary conditions, intangible capital shows a more tempered response. This result suggests that intangible capital's inherent flexibility allows it to withstand fluctuations in monetary policy more effectively than its tangible counterpart, playing a crucial role in economic resilience.

The dynamics become more intricate when examining the repercussions of leverage shocks. In these scenarios, tangible capital sustains a more immediate impact and experiences a more prolonged recovery process. This extended vulnerability can undermine economic stability and growth, particularly in sectors that rely heavily on physical assets. In contrast, intangible capital exhibits a notably lower vulnerability, recovering from shocks more swiftly. This disparity highlights the importance of intangible assets in building economic resilience. It underscores the need to explore how different forms of capital can bolster economic resilience against leverage-induced upheavals.

Furthermore, the response of both capital types to total factor productivity (TFP) shocks accentuates intangible capital's remarkable resilience or growth capability. Our findings indicate that the adverse impacts of TFP shocks are disproportionately felt in peripheral regions compared to core economic areas, thereby highlighting significant geographical disparities in shock susceptibility. This insight is pivotal for policymakers, suggesting that invigorating the intangible capital framework in less resilient regions could substantially enhance their economic stability and capacity to manage productivity shocks effectively. Overall, our study indicates that a strategic focus on strengthening intangible capital, particularly in more vulnerable areas, could provide a buffer against various economic shocks, promoting more stable and resilient growth across different regions.

REFERENCES

Aghion, P., Bloom, N., Blundell, R., Griffith, R., & Howitt, P. (2005). Competition and innovation: An inverted-u relationship. *The Quarterly Journal of Economics*, *120*(2), 701–728. https://doi.org/10.1093/qje/120.2.701

Aghion, P., Howitt, P., Brant-Collett, M., & García-Peñalosa, C. (1998). *Endogenous growth theory*. MIT press.

Ahmed, S., & Zlate, A. (2014). Capital flows to emerging market economies: A brave new world? *Journal of International Money and Finance*, *48*, 221–248. https://doi.org/10.1016/j.jimonfin.2014.05.015

Angrist, J. D., & Pischke, J.-S. (2009). *Mostly harmless econometrics: An empiricist's companion*. Princeton university press.

Bacchetta, P., & van Wincoop, E. (2016). The great recession: A self-fulfilling global panic. *American Economic Journal: Macroeconomics*, *8*(4), 177–98. https://doi.org/10.1257/mac.20140092

Backus, D. K., Kehoe, P. J., & Kydland, F. E. (1992). International real business cycles. *Journal of Political Economy*, *100*(4), 745–775. https://doi.org/10.1086/261838

Bates, T. W., Kahle, K. M., & Stulz, R. M. (2009). Why do U.S. firms hold so much more cash than they used to? *The Journal of Finance*, *64*(5), 1985–2021. https://doi.org/10.1111/j.1540-6261.2009.01492.x

Bayarçelik, E. B., & Tasel, F. (2012). Research and development: Source of economic growth. *Procedia - Social and Behavioral Sciences*, *58*, 744–753. https://doi.org/10.1016/j.sbspro.2012.09.1052

Benigno, G., & Benigno, P. (2006). Designing targeting rules for international monetary policy cooperation. *Journal of Monetary Economics*, *53*(3), 473–506. https://doi.org/10.1016/j.jmoneco.2005.03.009

Bhattarai, S., Chatterjee, A., & Park, W. Y. (2020). Global spillover effects of US uncertainty. *Journal of Monetary Economics*, *114*, 71–89. https://doi.org/10.1016/j.jmoneco.2019.05.008

Bond, S. R. (2002). Dynamic panel data models: A guide to micro data methods and practice. *Portuguese Economic Journal*, *1*(2), 141–162. https://doi.org/10.1007/s10258-002-0009-9

Brown, J. R., Fazzari, S. M., & Petersen, B. C. (2009). Financing innovation and growth: Cash flow, external equity, and the 1990s R&D boom. *The Journal of Finance*, *64*(1), 151–185. https://doi.org/10.1111/j.1540-6261.2008.01431.x

Caggese, A., & Pérez-Orive, A. (2022). How stimulative are low real interest rates for intangible capital? *European Economic Review*, *142*, 103987. https://doi.org/10.1016/j.euroecorev.2021.103987

Calvo, G. A., Leiderman, L., & Reinhart, C. M. (1993). Capital inflows and real exchange rate appreciation in Latin America: The role of external factors. *Staff Papers - International Monetary Fund*, *40*(1), 108. https://doi.org/10.2307/3867379

Campello, M., Graham, J. R., & Harvey, C. R. (2010). The real effects of financial constraints: Evidence from a financial crisis. *Journal of Financial Economics*, *97*(3), 470–487. https://doi.org/10.1016/j.jfineco.2010.02.009

Caselli, F., & Feyrer, J. (2007). The marginal product of capital. *The Quarterly Journal of Economics*, *122*(2), 535–568. https://doi.org/10.1162/qjec.122.2.535

Cesa-Bianchi, A., & Sokol, A. (2022). Financial shocks, credit spreads, and the international credit channel. *Journal of International Economics*, *135*, 103543.

Chari, A., & Rhee, J. S. (2020, August). *The return to capital in capital-scarce countries* (Working Paper No. 27675). National Bureau of Economic Research. http://www.nber.org/papers/w27675

Christiano, L. J., Motto, R., & Rostagno, M. (2014). Risk shocks. *American Economic Review*, *104*(1), 27–65. https://doi.org/10.1257/aer.104.1.27

Clarida, R., Galí, J., & Gertler, M. (2002). A simple framework for international monetary policy analysis. *Journal of Monetary Economics*, *49*(5), 879–904. https://doi.org/10.1016/S0304-3932(02)00128-9

Coe, D. T., Helpman, E., & Hoffmaister, A. W. (2009). International R&D spillovers and institutions. *European Economic Review*, *53*(7), 723–741. https://doi.org/10.1016/j.euroecorev.2009.02.005

Commons, J. R. (1936). Institutional economics. *The American Economic Review*, *26*(1), 237–249.

Corrado, C., Haltiwanger, J., & Sichel, D. (2005). *Measuring capital in the new economy*. University of Chicago Press. https://doi.org/10.7208/chicago/9780226116174.001.0001

Corrado, C., Hulten, C., & Sichel, D. (2009). Intangible capital and U.S. economic growth. *Review of Income and Wealth*, *55*(3), 661–685. https://doi.org/10.1111/j.1475-4991.2009.00343.x

Corsetti, G., Dedola, L., & Leduc, S. (2010). Optimal monetary policy in open economies. In *Handbook of monetary economics* (pp. 861–933, Vol. 3). Elsevier.

Crouzet, N., & Eberly, J. (2019, May). *Understanding weak capital investment: The role of market concentration and intangibles* (w25869). National Bureau of Economic Research. Cambridge, MA. https://doi.org/10.3386/w25869

Crouzet, N., Eberly, J. C., Eisfeldt, A. L., & Papanikolaou, D. (2022). The economics of intangible capital. *Journal of Economic Perspectives*, *36*(3), 29–52. https://doi.org/10.1257/jep.36.3.29

Dahlhaus, T., & Vasishtha, G. (2014). *The impact of U.S. monetary policy normalization on capital flows to emerging-market economies* (Bank of Canada Working Paper No. 2014-53). Bank of Canada. Ottawa. https://hdl.handle.net/10419/123742

Dahlhaus, T., & Vasishtha, G. (2021). Reprint: Monetary policy news in the US: Effects on emerging market capital flows. *Journal of International Money and Finance*, *114*, 102403. https://doi.org/10.1016/j.jimonfin.2021.102403

Dedola, L., & Lombardo, G. (2012). Financial frictions, financial integration and the international propagation of shocks: Financial Frictions. *Economic Policy*, *27*(70), 319–359. https://doi.org/10.1111/j.1468-0327.2012.00286.x

Devereux, M. B., & Yetman, J. (2010). Leverage constraints and the international transmission of shocks. *Journal of Money, Credit and Banking*, *42*, 71–105.

Devereux, M. B., & Yu, C. (2020). International financial integration and crisis contagion. *The Review of Economic Studies*, *87*(3), 1174–1212. https://doi.org/10.1093/restud/rdz054

Döttling, R., & Ratnovski, L. (2023). Monetary policy and intangible investment. *Journal of Monetary Economics*, *134*, 53–72. https://doi.org/10.1016/j.jmoneco.2022.11.001

Eaton, J., & Kortum, S. (2001). Trade in capital goods. *European Economic Review*, *45*(7), 1195–1235. https://doi.org/10.1016/S0014-2921(00)00103-3

Eichengreen, B., Rose, A. K., & Wyplosz, C. (1996, July). *Contagious currency crises* (Working Paper No. 5681). National Bureau of Economic Research. https://doi.org/10.3386/w5681

Epstein, B., Shapiro, A. F., & Gómez, A. G. (2019). Global financial risk, aggregate fluctuations, and unemployment dynamics. *Journal of International Economics*, *118*, 351–418.

Ewens, M., Peters, R., & Wang, S. (2019). *Measuring intangible capital with market prices* (SocArXiv No. kvp2f). Center for Open Science. https://EconPapers.repec.org/RePEc:osf:socarx:kvp2f

Falato, A., Kadyrzhanova, D., Sim, J., & Steri, R. (2022). Rising intangible capital, shrinking debt capacity, and the U.S. corporate savings glut. *The Journal of Finance*, *77*(5), 2799–2852. https://doi.org/10.1111/jofi.13174

Friedman, B. M., & Woodford, M. (2011). *Handbook of monetary economics: Texte imprimé*. North-Holland.

Gerlach, S., & Smets, F. (1995). Contagious speculative attacks. *European Journal of Political Economy*, *11*(1), 45–63. https://doi.org/10.1016/0176-2680(94)00055-O

Griliches, Z. (1984). Introduction to R&D, patents, and productivity. In *R&D, patents, and productivity* (pp. 1–20). University of Chicago Press.

Griliches, Z., & Lichtenberg, F. R. (1984). R&D and productivity growth at the industry level: Is there still a relationship? In *R&D, patents, and productivity* (pp. 465–502). University of Chicago Press.

Guerrieri, V., & Lorenzoni, G. (2017). Credit crises, precautionary savings, and the liquidity trap. *The Quarterly Journal of Economics*, *132*(3), 1427–1467.

Hall, B. H. (1996). The private and social returns to research and development. *NBER Working Paper*, (R2092).

Hall, B. H., Mairesse, J., & Mohnen, P. (2010). Measuring the returns to R&D. In *Handbook of the economics of innovation* (pp. 1033–1082, Vol. 2). Elsevier.

Hatipoglu, O. (2012). The relationship between inequality and innovative activity: A Schumpeterian theory and evidence from cross-country data. *Scottish Journal of Political Economy*, *59*(2), 224–248. https://doi.org/10.1111/j.1467-9485.2011.00577.x

Helpman, E. (2009). *The mystery of economic growth*. Harvard University Press.

Hulten, C. R. (1979). On the "importance" of productivity change. *The American Economic Review*, *69*(1), 126–136. Retrieved April 29, 2024, from http://www.jstor.org/stable/1802503

Judd, K. L., Kubler, F., & Schmedders, K. (2002). A solution method for incomplete asset markets with heterogeneous agents. *Unpublished manusript, Standford University*, *36*.

Kaminsky, G. L., & Reinhart, C. M. (2000). On crises, contagion, and confusion. *Journal of International Economics*, *51*(1), 145–168. https://doi.org/10.1016/S0022-1996(99)00040-9

Kilian, L., & Lütkepohl, H. (2017, November 23). *Structural vector autoregressive analysis* (1st ed.). Cambridge University Press. https://doi.org/10.1017/9781108164818

Kiyotaki, N., & Moore, J. (1997). Credit cycles. *Journal of Political Economy*, *105*(2), 211–248. https://doi.org/10.1086/262072

Lanjouw, J. O., Pakes, A., & Putnam, J. (1998). How to count patents and value intellectual property: The uses of patent renewal and application data. *The journal of industrial economics*, *46*(4), 405–432.

Lim, S. C., Macias, A. J., & Moeller, T. (2020). Intangible assets and capital structure. *Journal of Banking & Finance*, *118*, 105873. https://doi.org/10.1016/j.jbankfin.2020.105873

Lopez, J. I., & Olivella, V. (2018). The importance of intangible capital for the transmission of financial shocks. *Review of Economic Dynamics*, *30*, 223–238. https://doi.org/10.1016/j.red.2018.04.004

Loumioti, M. (2012). The use of intangible assets as loan collateral. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1748675

Lucas, R. E. (1990). Why doesn't capital flow from rich to poor countries? *The American Economic Review*, *80*(2), 92–96. Retrieved March 1, 2024, from http://www.jstor.org/stable/2006549

Lütkepohl, H. (2005). *New introduction to multiple time series analysis*. New York : Springer.

Marx, K. (1993). *Capital: A critique of political economy, volume 3* (Vol. 3). Penguin UK.

McGrattan, E. R. (2020). Intangible capital and measured productivity. *Review of Economic Dynamics*, *37*, S147–S166. https://doi.org/10.1016/j.red.2020.06.007

McGrattan, E. R., & Prescott, E. C. (2010). Technology capital and the US current account. *American Economic Review*, *100*(4), 1493–1522. https://doi.org/10.1257/aer.100.4.1493

Mendoza, E. G. (2010). Sudden stops, financial crises, and leverage. *American Economic Review*, *100*(5), 1941–66. https://doi.org/10.1257/aer.100.5.1941

Miranda-Agrippino, S., & Nenova, T. (2022). A tale of two global monetary policies. *Journal of International Economics*, *136*, 103606.

Navaretti, G. B., Soloaga, I., & Takacs, W. (2000). Vintage technologies and skill constraints: Evidence from U.S. exports of new and used machines. *The World Bank Economic Review*, *14*(1), 91–109. https://doi.org/10.1093/wber/14.1.91

Neumeyer, P. A., & Perri, F. (2005). Business cycles in emerging economies: The role of interest rates. *Journal of Monetary Economics*, *52*(2), 345–380. https://doi.org/10.1016/j.jmoneco.2004.04.011

Obstfeld, M., & Rogoff, K. (1996). *Foundations of international macroeconomics*. MIT press.

Obstfeld, M., & Zhou, H. (2023). *The global dollar cycle*. National Bureau of Economic Research.

Parente, S. L., & Prescott, E. C. (1994). Barriers to technology adoption and development. *Journal of Political Economy*, *102*(2), 298–321. http://www.jstor.org/stable/2138663

Pérez-Orive, A. (2016). Credit constraints, firms precautionary investment, and the business cycle. *Journal of Monetary Economics*, *78*, 112–131. https://doi.org/10.1016/j.jmoneco.2016.01.006

Perri, F., & Quadrini, V. (2018). International recessions. *American Economic Review*, *108*(4-5), 935–984. https://doi.org/10.1257/aer.20140412

Peters, R. H., & Taylor, L. A. (2017). Intangible capital and the investment-q relation. *Journal of Financial Economics*, *123*(2), 251–272. https://doi.org/10.1016/j.jfineco.2016.03.011

Rabiei, M. (2011). An empirical research on the relationship between entrepreneurship and economic growth. *Australian Journal of Basic and Applied Sciences*, *5*(8), 1060–1065.

Reinhart, C. M., & Rogoff, K. S. (2004). Serial default and the "paradox" of rich-to-poor capital flows. *American Economic Review*, *94*(2), 53–58. https://doi.org/10.1257/0002828041302370

Reinhart, C. M., & Rogoff, K. S. (2011). From financial crash to debt crisis. *American Economic Review*, *101*(5), 1676–1706. https://doi.org/10.1257/aer.101.5.1676

Rey, H. (2015, May). *Dilemma not trilemma: The global financial cycle and monetary policy independence* (Working Paper No. 21162). National Bureau of Economic Research. http://www.nber.org/papers/w21162

Roth, F., & Thum, A.-E. (2013). Intangible capital and labor productivity growth: Panel evidence for the EU from 19982005. *Review of Income and Wealth*, *59*(3), 486–508. https://doi.org/10.1111/roiw.12009

Sigmund, M., & Ferstl, R. (2021). Panel vector autoregression in R with the package panelvar. *The Quarterly Review of Economics and Finance*, *80*, 693–720. https://doi.org/10.1016/j.qref.2019.01.001

Smets, F., & Wouters, R. (2007). Shocks and frictions in US business cycles: A bayesian DSGE approach. *American Economic Review*, *97*(3), 586–606. https://doi.org/10.1257/aer.97.3.586

Teixeira, R. A., & Rotta, T. N. (2012). Valueless knowledge-commodities and financialization: Productive and financial dimensions of capital autonomization. *Review of Radical Political Economics*, *44*(4), 448–467. https://doi.org/10.1177/0486613411434387

Thum-Thysen, A., Voigt, P., Bilbao-Osorio, B., Maier, C., & Ognyanova, D. (2017, May). *Unlocking investment in intangible assets* (European Economy - Discussion Papers No. 047). Directorate General Economic and Financial Affairs (DG ECFIN), European Commission. https://ideas.repec.org/p/euf/dispap/047.html

van Ark, B., Hao, J. X., Corrado, C., & Hulten, C. (2009). Measuring intangible capital and its contribution to economic growth in Europe. *EIB Papers*, *14*(1), 62–93. https://hdl.handle.net/10419/44905

Veblen, T. (1908). On the nature of capital: Investment, intangible assets, and the pecuniary magnate. *The Quarterly Journal of Economics*, *23*(1), 104–136.

Vural, G. (2012). A two-country two-sector model with vintage technologies. *Öneri Dergisi*, *10*(38), 125–128.

Wakelin, K. (2001). Productivity growth and R&D expenditure in UK manufacturing firms. *Research Policy*, *30*(7), 1079–1090. https://doi.org/10.1016/S0048-7333(00)00136-0

Weitzman, M. L. (1976). On the welfare significance of national product in a dynamic economy. *The Quarterly Journal of Economics*, *90*(1), 156–162. https://doi.org/10.2307/1886092

Zachariadis, M. (2003). R&D, innovation, and technological progress: A test of the Schumpeterian framework without scale effects. *Canadian Journal of Economics/Revue canadienne d'économique*, *36*(3), 566–586. https://doi.org/10.1111/1540-5982.t01-2-00003