The Global Financial Resource Curse

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Abstract

Since the late 1990s, the United States has received large capital flows from developing countries - a phenomenon known as the global saving glut - and experienced a productivity growth slowdown. Motivated by these facts, we provide a model connecting international financial integration and global productivity growth. The key feature is that the tradable sector is the engine of growth of the economy. Capital flows from developing countries to the United States boost demand for U.S. non-tradable goods, inducing a reallocation of U.S. economic activity from the tradable sector to the non-tradable one. In turn, lower profits in the tradable sector lead firms to cut back investment in innovation. Since innovation in the United States determines the evolution of the world technological frontier, the result is a drop in global productivity growth. This effect, which we dub the global financial resource curse, can help explain why the global saving glut has been accompanied by subdued investment and growth, in spite of low global interest rates.

JEL Codes: E44, F21, F41, F43, F62, O24, O31.

Keywords: global saving glut, global productivity growth, international financial integration, capital flows, U.S. productivity growth slowdown, low global interest rates, Bretton Woods II, export-led growth.

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1 Introduction

There is a large literature in international macroeconomics studying the impact of productivity growth on the pattern of international capital flows. In this paper, we reverse this classic perspective by considering how international capital flows shape global productivity growth. We are motivated by the fact that since the late 1990s, the United States has received large capital flows from developing countries - mainly China and other Asian countries - a phenomenon known as the global saving glut (Figure 1a). Although much has been written about the causes and macroeconomic consequences of this saving glut, its implications for global productivity growth are yet poorly understood.

Conventional wisdom suggests that cheap capital inflows should, at least in part, help firms to finance investment and increase their productivity. One could then expect that the global saving glut coincided with a rise in U.S. investment and productivity growth. Since the early 2000s, however, in the United States firms' investment has been weak and productivity growth has slowed down (Figure 1b).[1] Moreover, the international evidence shows that episodes of large capital inflows are often associated with slowdowns in productivity growth, calling into question the conventional logic.[2] So could it be that capital flows from developing countries to the United States ended up not contributing much - or even depressing - U.S. productivity growth? If so, given the U.S. status as one of the world technological leaders, what would be the effect of the saving glut on global growth?

In this paper, we tackle these questions by providing two main contributions. First, we develop a novel endogenous growth model to study the impact of international financial integration on global productivity growth.[3] Second, we explore a channel through which a global saving glut originating from developing countries may, perhaps paradoxically, depress productivity growth in the United States, and eventually in the rest of world as well. For reasons that will become clear below, we dub this effect the global financial resource curse.

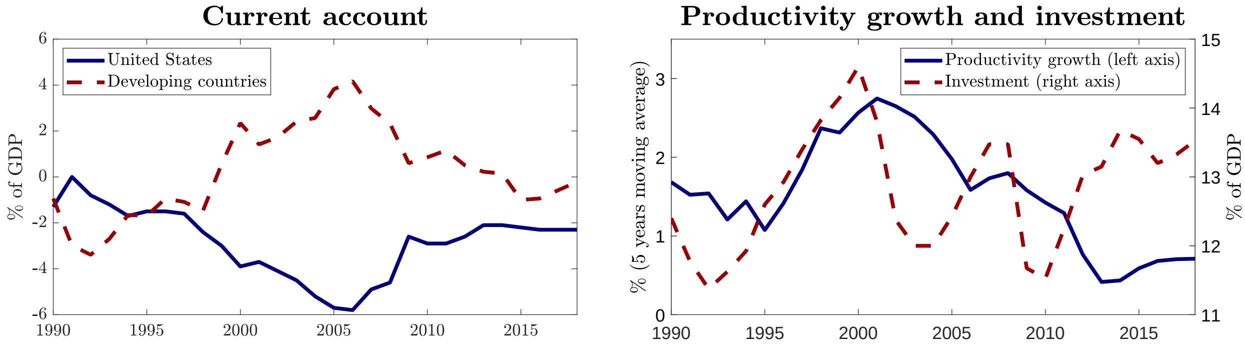
Our model is composed of two regions: the United States and developing countries. As in standard models of technology diffusion (Grossman and Helpman, 1991), innovation activities by the technological leader, i.e. the United States, determine the evolution of the world technological frontier. Developing countries, in contrast, grow by absorbing knowledge originating from the United States. Therefore, investments by firms in developing countries affect their proximity to the technological frontier.

Compared to standard frameworks of technology diffusion, our model has two novel features.

[1] Of course, the literature has described several factors - independent of capital flows - that have contributed to the U.S. productivity growth slowdown. We discuss the relationship of our paper to this body of work in the literature review, at the end of the introduction.

[2] For instance, Gourinchas and Jeanne (2013) observe that among developing countries the fast growers are typically characterised by capital outflows, while slow growers tend to receive capital inflows. Benigno and Fornaro (2014) and Gopinath et al. (2017) discuss the case of euro area peripheral countries during the first ten years of the euro, in which large capital inflows have coincided with productivity growth slowdowns.

[3] To clarify, in this paper we are interested in isolating the impact of financial integration on global growth. We abstract, instead, from other forces commonly linked to globalization, most notably trade integration. Hence, throughout our analysis we hold the level of trade integration constant.



(a) Global saving glut. **(b) U.S. productivity growth slowdown.**

Figure 1: Motivating facts. Notes: The left panel shows the large current account deficits experienced by the United States since the late 1990s, accompanied by current account surpluses from developing countries. The right panel illustrates the productivity growth slowdown affecting the United States since the early 2000s, which was accompanied by a drop in the non-residential investment to GDP ratio. See Appendix F for the procedure used to construct these figures.

The first one is that sectors producing tradable goods are the engine of growth in our economy. That is, in both regions productivity growth is the result of investment by firms operating in the tradable sector. The non-tradable sector, instead, is characterized by stagnant productivity growth. As we explain in more detail below, this assumption captures the notion that sectors producing tradable goods, such as manufacturing, have more scope for productivity improvements compared to sectors producing non-tradables, for instance construction.[4] The second feature is that agents in developing countries have a higher propensity to save compared to U.S. ones. Again as we discuss below, the literature has highlighted a host of factors contributing to high saving rates in developing countries, such as demography, lack of insurance or government interventions.

Against this background, we consider a global economy moving from a regime of financial autarky to international financial integration. Due to the heterogeneity in propensities to save across the two regions, once financial integration occurs the United States receives capital inflows from developing countries. Capital inflows allow U.S. agents to finance an increase in consumption. Higher consumption of tradables is achieved by increasing imports of tradable goods from developing countries, and so the United States ends up running persistent trade deficits. But non-tradable consumption goods have to be produced domestically. Hence, in response to the rise in demand for non-tradable goods, factors of production migrate from the tradable sector toward the non-tradable one. As the share of global demand captured by tradable firms in the U.S. declines, their profits drop, reducing their incentives to invest in innovation.[5] The consequent drop in investment results in a slowdown in U.S. productivity growth. Therefore, in contrast with the conventional wisdom, cheap capital inflows depress investment and productivity growth, because they end up

[4] In Section 5.1 we explore a version of the model in which productivity grows endogenously also in the non-tradable sector. There we show that our key results hold, as long as the tradable sector is characterized by faster productivity growth than the non-tradable one. As we discuss in Section 2, this is the case in the data.

[5] Dorn et al. (2020) provide some evidence consistent with this transmission channel. In fact, they find that the rise in global market shares captured by Chinese firms - at the expenses of U.S. ones - lead to a decline in investment in R&D and innovation in the U.S. manufacturing sector.

financing a boom in the non-tradable sector.[6]

To some extent, developing countries experience symmetric dynamics compared to the United States. Financial integration leads developing countries to run persistent trade surpluses. This stimulates economic activity in the tradable sector, at the expense of the non-tradable one. In turn, higher profits in the tradable sector induce firms in developing countries to increase their investment in technology adoption. The proximity of developing countries to the technological frontier thus rises. But this does not necessarily mean that financial integration benefits productivity growth in developing countries. Following financial integration, indeed, productivity growth in developing countries initially accelerates, but then it slows down below its value under financial autarky. The explanation is that the drop in innovation activities in the U.S. reduces the productivity gains that developing countries can obtain by absorbing knowledge from the frontier. Therefore, in the long run the process of financial integration - and the associated saving glut - generates a fall in global productivity growth.[7]

Perhaps paradoxically, in our framework cheap access to foreign capital by the world technological leader depresses global productivity growth in the long term. The reason is that capital inflows lead to a contraction in economic activity in tradable sectors, which are the engine of growth in our economies. In this respect, our model is connected to the idea of natural resource curse (Van der Ploeg, 2011). However, our mechanism is based on financial - rather than natural - resources. Moreover, the forces that we emphasize are global in nature. In fact, lower innovation by the technological leader drives down productivity growth also in the rest of the world, including in those countries experiencing capital outflows and an expansion of their tradable sectors. For these reasons, we refer to the link between capital flows toward the world technological leader and weak global growth as the *global financial resource curse.*

Relatedly, it has been argued that the U.S. enjoys an exorbitant privilege, because it issues the world's dominant currency and is thus able to borrow cheaply from the rest of the world (Gopinath and Stein, 2018; Gourinchas et al., 2019). But in our model the exorbitant privilege carries an exorbitant burden, since capital inflows generate a growth slowdown in the country issuing the dominant currency.[8] Moreover, given that the U.S. represents the world's technological leader, this exorbitant burden spreads to the rest of the world as well. To the best of our knowledge, we are the first to emphasize this connection between the central role played by the United States in the international monetary and technological system.

Our model also helps to rationalize the sharp decline in global rates observed over the last three decades. Some commentators have claimed that the integration of high-saving developing countries

[6]In the model, a second force is at work. Capital inflows lower firms' cost of funds, thus fostering their incentives to invest. However, as we will show, this effect is dominated by the fall in the return to investment caused by lower economic activity and profits in the tradable sector.

[7]This pattern is not inconsistent with the data. Indeed, in Appendix G.1 we show that productivity growth in a sample of developing countries accelerated in the early phases of the global saving glut, but later experienced a mild slowdown.

[8]Our concept of exorbitant burden is related to the view put forward by Pettis (2011), that the exorbitant privilege hurts the U.S. manufacturing sector. In Gourinchas et al. (2010), the exorbitant privilege carries an exorbitant duty in the form of abnormally low returns on the U.S. foreign asset position during times of global financial stress.

in global credit markets has contributed to depress interest rates around the world, by triggering a global saving glut (Bernanke, 2005). This effect is also present in our framework, but in a magnified form. In standard models, after two regions integrate financially, the equilibrium interest rate lies somewhere between the two autarky rates. In our model, instead, financial integration induces a drop in the equilibrium interest rate below both autarky rates. In fact, lower global growth leads agents to increase their saving supply, exerting downward pressure on interest rates. Because of this effect, financial integration and the global saving glut lead to a regime of superlow global rates, in which investment and productivity growth are depressed.

In the last part of the paper, we revisit some prominent debates in international macroeconomics. First, we consider the impact of capital inflows from developing countries to the U.S. on the dollar (Obstfeld and Rogoff, 2005). We show that the response may be non-monotonic, and characterized by an initial appreciation of the dollar, giving way to a depreciation in the medium to long run. We then consider export-led growth by developing countries, that is the idea that technology adoption can be fostered by policies that stimulate trade balance surpluses and capital outflows (Dooley et al., 2004). We show that export-led growth might be successful at raising productivity growth in developing countries in the medium run. However, this comes at the expenses of a fall in innovation activities in the United States, which eventually produces a drop in global productivity growth. We finally turn to innovation policies. We show that policies that sustain innovation activities can play a crucial role in insulating U.S. - and more broadly global - productivity growth from the adverse impact of the global saving glut.[9]

Related literature. This paper unifies two strands of the literature that have been traditionally separated. First, there is a literature studying the macroeconomic consequences of financial globalization, and in particular of the integration of high-saving developing countries in the international financial markets. For instance, Caballero et al. (2008) and Mendoza et al. (2009) provide models in which the integration of developing countries in global credit markets leads to an increase in the global supply of savings and a fall in global rates. Caballero et al. (2015), Eggertsson et al. (2016) and Fornaro and Romei (2019) show that in a world characterized by deficient demand financial integration can lead to a fall in global output. This paper contributes to this literature by studying the impact of the global saving glut on global productivity growth.

Second, there is a vast literature on the impact of globalization on productivity growth. One part of this literature has argued that globalization increases global productivity growth by facilitating the flow of ideas across countries (Howitt, 2000). Another body of work has focused on the impact of trade globalization on productivity (Grossman and Helpman, 1991; Rivera-Batiz and Romer, 1991; Atkeson and Burstein, 2010; Akcigit et al., 2018; Cuñat and Zymek, 2019). We complement this literature by studying the impact of *financial globalization* on productivity growth.

The paper is also related to a third literature, which connects capital flows to productivity. In

[9] In the appendix, we consider a few other policy scenarios. In particular, we study the impact of a sudden stop in capital inflows hitting the United States on global growth, and the global implications of restriction on capital inflows imposed by the United States.

Ates and Saffie (2016), Benigno et al. (2021) and Queralto (2019) sudden stops in capital inflows depress productivity growth. In Gopinath et al. (2017) and Cingano and Hassan (2019) capital flows affect productivity by changing the allocation of capital across heterogeneous firms. Studying an episode of capital account liberalization in Hungary, Varela (2018) finds that better access to credit helped financially constrained firms to increase their investment in technology adoption and their productivity.[10] Rodrik (2008), Benigno et al. (2021); Benigno and Fornaro (2014) and Brunnermeier et al. (2018) study single small open economies and show that capital inflows might negatively affect productivity by reducing innovation activities in the tradable sector.[11] Rodrik and Subramanian (2009) argue that this effect explains why the integration of developing countries in the international financial markets has been associated with disappointing growth performances. Our paper builds on this insight, but takes a global perspective. In particular, due to their impact on the world technological frontier, in our model capital flows out of developing countries can induce a drop in global productivity growth. Coeurdacier et al. (2020) study the impact of financial integration on global growth, using a two-country neoclassical growth model. Their framework focuses on capital accumulation and takes productivity growth as an exogenous force, while in our model the endogenous response of productivity growth to financial integration is crucial.

Finally, this paper contributes to the recent literature exploring the causes of the U.S. productivity growth slowdown. This literature has focused on different possibilities, such as rising costs from discovering new ideas (Bloom et al., 2020), slower technology diffusion from frontier to laggard firms (Akcigit and Ates, 2020), rising firms' entry costs (Aghion et al., 2019), falling interest rates leading to low competition (Liu et al., 2019) or discouraging intangible investment financed through internal savings (Caggese and Pérez-Orive, 2020), and weak aggregate demand leading to low profits from investing in innovation (Anzoategui et al., 2019; Benigno and Fornaro, 2018). Our paper provides a complementary explanation, based on the interaction of capital flows and the sectoral allocation of production. Our paper is also different from this literature because it shows how cheap access to capital - which the conventional wisdom would associate with higher investment and faster growth - may surprisingly end up depressing productivity growth.

The rest of the paper is structured as follows. Section 2 discusses the empirical underpinnings

[10] Notice that this finding is consistent with our framework. In our model, keeping everything else constant, better access to credit fosters firms' investment in innovation. The negative relationship between capital inflows and productivity growth arises because - through a general equilibrium effect - capital inflows depress the return from investing in innovation in the tradable sector.

[11] The notion of financial resource curse, defined as the joint occurrence of large capital inflows and weak productivity growth, was introduced in Benigno and Fornaro (2014) by a subset of the authors of this paper. There are, however, stark differences between this paper and Benigno and Fornaro (2014). Benigno and Fornaro (2014) focus on a single small open economy, receiving an exogenous inflow of foreign capital. Instead, here we take a global perspective, and study the impact on the global economy of capital flows from developing countries to the technological leader. We show that in this case also those countries experiencing capital outflows, which should grow faster according to the logic of Benigno and Fornaro (2014), will eventually see their productivity growth slowing down. Moreover, in the current framework we consider the implications for global interest rates, which were taken as exogenous in Benigno and Fornaro (2014), and study the global impact of export-led growth by developing countries, of a sudden stop hitting the U.S., and of restrictions on capital inflows by the United States. Another difference is that in Benigno and Fornaro (2014) growth was the unintentional byproduct of learning by doing. Here, as in the modern endogenous growth literature, productivity growth is the result of investment in innovation by profit-maximizing firms.

behind the key elements of our theory. Section 3 introduces the model. Section 4 presents our main results, by studying the impact of financial integration on global growth. Section 5 discusses some extensions to the baseline model, and considers different policy scenarios. Section 6 concludes. The proofs to all the propositions are collected in the Appendix.

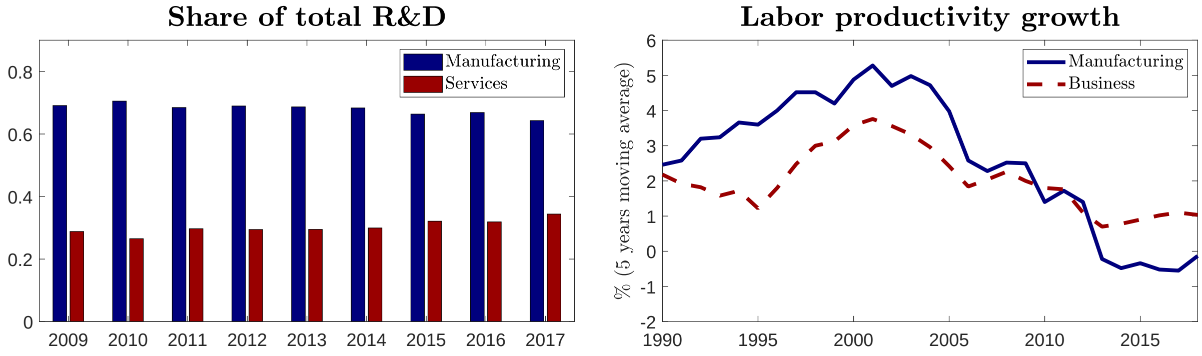
2 Discussion of key elements

Our theory rests on two key elements: the special role of sectors producing tradable goods in the growth process, and the impact of capital flows on the sectoral allocation of productive resources. Here we discuss the empirical evidence that underpins these notions.

We study an economy in which the tradable sector is the engine of growth. Empirically, tradable sectors are characterized by higher productivity growth compared to sectors producing non-tradable goods. For instance, Duarte and Restuccia (2010) study productivity growth at the sectoral level, using data from 29 OECD and developing countries over the period 1956-2004. They find that productivity grows faster in manufacturing and agriculture - two sectors traditionally associated with production of traded goods - compared to services, the sector producing the bulk of non-traded goods. Hlatshwayo and Spence (2014) reach the same conclusion using U.S. data for the period 1990-2013, even after accounting for the fact that some services can be traded. In our baseline model, we capture this asymmetry by assuming that productivity growth is fully concentrated in the tradable sector. In Section 5.1, however, we introduce investment in innovation and endogenous growth in the non-tradable sector as well. There we show that our main results hold as long as non-tradable sectors are characterized by a smaller scope for productivity improvements compared to tradable ones.

Figure 2 provides two additional pieces of evidence consistent with our focus on the tradable sector as driver of productivity dynamics in the United States. First, the left panel shows that the manufacturing sector, which represents about 10% of value added, accounts for about 70% of total R&D spending done by U.S. firms. This fact points toward the central role played by manufacturing in U.S. innovation activities. Second, the right panel shows that the U.S. productivity growth slowdown has coincided with a sharp drop in productivity growth in the manufacturing sector. This suggests that, in order to understand the U.S. productivity growth slowdown, one should place particular attention on the behavior of manufacturing, and so of sectors producing tradable goods.

In our model the tradable sector also represents the source of knowledge spillovers from advanced to developing countries. Grossman and Helpman (1991) provide an early theoretical treatment of knowledge flows across countries, while Klenow and Rodriguez-Clare (2005) show that international knowledge spillovers are necessary in order to account for the cross-countries growth patterns observed in the data. Several empirical studies point toward the importance of trade in facilitating technology transmission from advanced to developing countries. Just to cite a few examples, Coe et al. (1997), Keller (2004) and Amiti and Konings (2007) highlight the importance



(a) Spending on R&D. **(b) Productivity growth.**

Figure 2: U.S. labor productivity growth and R&D, by sector. Notes: The left panel shows firms' R&D spending as a share of total spending in the U.S. contrasting manufacturing and services. The right panel shows annual U.S. labor productivity growth in manufacturing and private business, respectively. See Appendix F for the procedure used to construct these figures.

of imports as a source of knowledge transmission, while Blalock and Gertler (2004), Park et al. (2010) and Bustos (2011) provide evidence in favor of exports as a source of productivity growth. Rodrik (2012) considers cross-country convergence in productivity at the industry level and finds that this is restricted to the manufacturing sector. This finding lends support to our assumption that knowledge spillovers are concentrated in sectors producing tradable goods.

A crucial aspect of our framework is that capital inflows, and the associated credit booms, induce a shift of productive resources out of tradable sectors and toward non-tradable ones. Benigno et al. (2015) study 155 episodes of large capital inflows occurring in a sample of 70 middle- and high-income countries during the period 1975-2010. They find that these episodes are characterized by a shift of labor and capital out of the manufacturing sector.[12] Pierce and Schott (2016) document a sharp drop in U.S. employment in manufacturing starting from the early 2000s, and thus coinciding with the surge in capital inflows from developing countries.[13] Interestingly, over the same period, productivity growth in manufacturing fell sharply (Syverson, 2016). More broadly, Mian et al. (2019) show that increases in credit supply tend to boost employment in non-tradable sectors at the expenses of tradable ones.[14] In a very interesting recent paper, Müller and Verner (2021) document how credit booms geared toward the non-tradable sector are typically followed by slowdowns in productivity growth, lending empirical support to one of the key mechanisms of

[12]Relatedly, Broner et al. (2019) find that exogenous rises in capital inflows in developing countries are associated with lower profits earned by firms operating in the tradable sector. And Saffie et al. (2020) find that capital inflows following the financial liberalization in Hungary in 2001 led to lower value added and employment in the manufacturing sector, but to higher value added and employment in the service sector.

[13]Of course, due to structural transformation, since the end of WWII in the United States there has been a secular decline in the manufacturing share of employment. The literature on structural transformation usually interprets the decline in manufacturing employment as the outcome of faster productivity growth in manufacturing compared to other sectors (Ngai and Pissarides, 2007). Therefore, the models developed by this literature cannot explain why manufacturing has experienced a fall in both employment and productivity growth during the global saving glut. For simplicity, our analysis abstracts from structural transformation. So the variables in our model can be interpreted as deviations from the path dictated by the forces linked to structural transformation.

[14]As an example, they document that the deregulation of financial markets taking place in the United States during the 1980s lead to a credit boom and a shift of employment from tradable to non-tradable sectors.

the model. Furthermore, Richter and Diebold (2021) find that credit booms financed by foreign capital flows are particularly likely to be followed by drops in output growth in the medium run. All this evidence is consistent with the predictions of our model.

Lastly, in our framework financial integration triggers capital flows out of developing countries and toward the United States. This feature of the model captures the direction of capital flows observed in the data from the late 1990s (see Figure 1a). The literature has proposed several explanations for this fact. In Caballero et al. (2008) developing countries export capital to the U.S. because they are unable to produce enough stores of value to satisfy local demand, due to the underdevelopment of their financial markets. Mendoza et al. (2009) argue that lack of insurance against idiosyncratic shocks contributes to the high saving rates observed in several developing countries. Gourinchas and Jeanne (2013) and Alfaro et al. (2014) show that policy interventions by governments in developing countries - aiming at fostering national savings - explain an important part of the capital outflows toward the United States. For our results we do not need to take a stance on the precise source of high saving rates in developing countries. Our model is thus consistent with all these possible explanations.

3 Baseline model

Consider a world composed of two regions: the United States and a group of developing countries.[15] The two regions are symmetric except for two aspects. First, developing countries have a higher propensity to save compared to the United States. Second, innovation in the U.S. determines the evolution of the world technological frontier. Developing countries, instead, experience productivity growth by adopting discoveries originating from the United States. In what follows, we will refer to the U.S. as region u and to developing countries as region d. For simplicity, we will focus on a perfect-foresight economy. Time is discrete and indexed by $t \in \{0, 1, ...\}$.

3.1 Households

Each region is inhabited by a measure one of identical households. The lifetime utility of the representative household in region i is

$$\sum_{t=0}^{\infty} \beta^t \log(C_{i,t}), \tag{1}$$

where $C_{i,t}$ denotes consumption and $0 < \beta < 1$ is the subjective discount factor. Consumption is a Cobb-Douglas aggregate of a tradable good $C_{i,t}^T$ and a non-tradable good $C_{i,t}^N$, so that $C_{i,t} = (C_{i,t}^T)^\omega (C_{i,t}^N)^{1-\omega}$ where $0 < \omega < 1$. Each household is endowed with $\bar{L}$ units of labor, and there is no disutility from working.

[15]There is no need to specify the number of developing countries. For instance, our results apply to the case of a single large developing country, or to a setting in which there is a continuum of measure one of small open developing countries.

Households can trade in one-period riskless bonds. Bonds are denominated in units of the tradable consumption good and pay the gross interest rate $R_{i,t}$. Moreover, investment in bonds is subject to a subsidy $\tau_{i,t}$. This subsidy is meant to capture a variety of factors, such as demography or policy-induced distortions, affecting households' propensity to save. This feature of the model allows us to generate, in a stylized but simple way, heterogeneity in saving rates across the two regions. In particular, we are interested in a scenario in which developing countries have a higher propensity to save compared to the United States. We thus normalize $\tau_{u,t} = 0$ and assume that $\tau_{d,t} = \tau > 0$.

The household budget constraint in terms of the tradable good is

$$C_{i,t}^T + P_{i,t}^N C_{i,t}^N + \frac{B_{i,t+1}}{R_{i,t}(1+\tau_{i,t})} = W_{i,t}\bar{L} + \Pi_{i,t} - T_{i,t} + B_{i,t}. \tag{2}$$

The left-hand side of this expression represents the household's expenditure. $P_{i,t}^N$ denotes the price of a unit of the non-tradable good in terms of the tradable one. Hence, $C_{i,t}^T + P_{i,t}^N C_{i,t}^N$ is the total expenditure in consumption. $B_{i,t+1}$ denotes the purchase of bonds made by the household at time t. If $B_{i,t+1} < 0$ the household is holding a debt.

The right-hand side captures the household's income. $W_{i,t}$ denotes the wage, and hence $W_{i,t}\bar{L}$ is the household's labor income. Labor is immobile across regions and so wages are region-specific. Firms are fully owned by domestic agents, and $\Pi_{i,t}$ denotes the profits that households receive from the ownership of firms. $T_{i,t}$ is a tax paid to the domestic government. We assume that governments run balanced budgets and so $T_{i,t} = \tau_{i,t}B_{i,t+1}/(R_{i,t}(1+\tau_{i,t}))$. Finally, $B_{i,t}$ represents the gross return on investment in bonds made at time $t-1$.

There is a limit to the amount of debt that a household can take. In particular, the end-of-period bond position has to satisfy

$$B_{i,t+1} \geq -\kappa_{i,t}, \tag{3}$$

where $\kappa_{i,t} \geq 0$. This constraint captures in a simple form a case in which a household cannot credibly commit in period t to repay more than $\kappa_{i,t}$ units of the tradable good to its creditors in period $t+1$.

The household's optimization problem consists in choosing a sequence $\{C_{i,t}^T, C_{i,t}^N, B_{i,t+1}\}_t$ to maximize lifetime utility (1), subject to the budget constraint (2) and the borrowing limit (3), taking initial wealth $B_{i,0}$, a sequence for income $\{W_{i,t}\bar{L} + \Pi_{i,t} - T_{i,t}\}_t$, and prices $\{R_{i,t}(1+\tau_{i,t}), P_{i,t}^N\}_t$ as given. The household's optimality conditions can be written as

$$\frac{\omega}{C_{i,t}^T} = R_{i,t}(1+\tau_{i,t})\left(\frac{\beta\omega}{C_{i,t+1}^T} + \mu_{i,t}\right) \tag{4}$$

$$B_{i,t+1} \geq -\kappa_{i,t} \quad \text{with equality if} \quad \mu_{i,t} > 0 \tag{5}$$

$$\lim_{k\to\infty} \frac{B_{i,t+1+k}}{R_{i,t}(1+\tau_{i,t})...R_{i,t+k}(1+\tau_{i,t+k})} \leq 0 \tag{6}$$

$$C_{i,t}^{N} = \frac{1-\omega}{\omega} \frac{C_{i,t}^{T}}{P_{i,t}^{N}}, \tag{7}$$

where $\mu_{i,t}$ is the nonnegative Lagrange multiplier associated with the borrowing constraint. Equation (4) is the Euler equations for bonds. Equation (5) is the complementary slackness condition associated with the borrowing constraint. Equation (6) is the terminal condition for bond holdings, ensuring that the household consumes asymptotically all its income.[16] Equation (7) determines the optimal allocation of consumption expenditure between tradable and non-tradable goods. Naturally, demand for non-tradables is decreasing in their relative price $P_{i,t}^{N}$. Moreover, demand for non-tradables is increasing in $C_{i,t}^{T}$, due to households' desire to consume a balanced basket between tradable and non-tradable goods.

3.2 Non-tradable good production

The non-tradable sector represents a traditional sector with limited scope for productivity improvements. The non-tradable good is produced by a large number of competitive firms using labor, according to the production function $Y_{i,t}^{N} = L_{i,t}^{N}$. $Y_{i,t}^{N}$ is the output of the non-tradable good, while $L_{i,t}^{N}$ is the amount of labor employed by the non-tradable sector. The zero profit condition thus requires that $P_{i,t}^{N} = W_{i,t}$.

3.3 Tradable good production

The tradable good is produced by competitive firms using labor and a continuum of measure one of intermediate inputs $x_{i,t}^{j}$, indexed by $j \in [0,1]$. Intermediate inputs cannot be traded across the two regions.[17] Denoting by $Y_{i,t}^{T}$ the output of tradable good, the production function is

$$Y_{i,t}^{T} = \left(L_{i,t}^{T}\right)^{1-\alpha} \int_{0}^{1} \left(A_{i,t}^{j}\right)^{1-\alpha} \left(x_{i,t}^{j}\right)^{\alpha} dj, \tag{8}$$

where $0 < \alpha < 1$, and $A_{i,t}^{j}$ is the productivity, or quality, of input j.[18]

Profit maximization implies the demand functions

$$(1-\alpha) \left(L_{i,t}^{T}\right)^{-\alpha} \int_{0}^{1} \left(A_{i,t}^{j}\right)^{1-\alpha} \left(x_{i,t}^{j}\right)^{\alpha} dj = W_{i,t} \tag{9}$$

[16] Often, this optimality condition is coupled with a constraint ruling out Ponzi schemes to obtain a transversality condition (see for example Obstfeld and Rogoff, 1996). Here, the presence of the borrowing limit (3) makes the no-Ponzi condition redundant. We elaborate further on this point in footnote 28.

[17] We make this assumption, following the literature on technology diffusion, to generate asymmetries in productivity across the two regions. In the case of a single large developing country, this is equivalent to assuming that intermediate goods are non-tradables. If several developing countries are present, instead, we are effectively assuming that intermediate inputs can be perfectly traded among developing countries. This assumption simplifies the exposition, but our results would hold also if trade of intermediate goods across developing countries was not possible.

[18] More precisely, for every good j, $A_{i,t}^{j}$ represents the highest quality available. In principle, firms could produce using a lower quality of good j. However, as in Aghion and Howitt (1992), the structure of the economy is such that in equilibrium only the highest quality version of each good is used in production.

$$\alpha \left(L^T_{i,t}\right)^{1-\alpha} \left(A^j_{i,t}\right)^{1-\alpha} \left(x^j_{i,t}\right)^{\alpha-1} = P^j_{i,t}, \tag{10}$$

where $P^j_{i,t}$ is the price in terms of the tradable good of intermediate input j. Due to perfect competition, firms producing the tradable good do not make any profit in equilibrium.

3.4 Intermediate goods production and profits

Every intermediate good is produced by a single monopolist. One unit of tradable output is needed to manufacture one unit of the intermediate good, regardless of quality. In order to maximize profits, each monopolist sets the price of its good according to

$$P^j_{i,t} = \frac{1}{\alpha} > 1. \tag{11}$$

This expression implies that each monopolist charges a constant markup $1/\alpha$ over its marginal cost.

Equations (10) and (11) imply that the quantity produced of a generic intermediate good j is

$$x^j_{i,t} = \alpha^{\frac{2}{1-\alpha}} A^j_{i,t} L^T_{i,t}. \tag{12}$$

Combining equations (8) and (12) gives:

$$Y^T_{i,t} = \alpha^{\frac{2\alpha}{1-\alpha}} A_{i,t} L^T_{i,t}, \tag{13}$$

where $A_{i,t} \equiv \int_0^1 A^j_{i,t} dj$ is an index of average productivity of the intermediate inputs. Hence, production of the tradable good is increasing in the average productivity of intermediate goods and in the amount of labor employed in the tradable sector. Moreover, the profits earned by the monopolist in sector j are given by

$$P^j_{i,t} x^j_{i,t} - x^j_{i,t} = \varpi A^j_{i,t} L^T_{i,t},$$

where $\varpi \equiv (1/\alpha - 1)\alpha^{2/(1-\alpha)}$. According to this expression, the profits earned by a monopolist are increasing in the productivity of its intermediate input and in employment in the tradable sector. The dependence of profits on employment is due to a market size effect. Intuitively, high employment in the tradable sector is associated with high production of the tradable good and high demand for intermediate inputs, leading to high profits in the intermediate sector.

3.5 Innovation in the United States

In the United States, firms operating in the intermediate sector can invest in innovation in order to improve the quality of their products. In particular, a U.S. firm that employs in innovation $L^j_{u,t}$

units of labor sees its productivity evolve according to[19]

$$A^j_{u,t+1} = A^j_{u,t} + \chi A_{u,t} L^j_{u,t}, \tag{14}$$

where $\chi > 0$ determines the productivity of research. This expression embeds the assumption, often present in the endogenous growth literature, that innovators build on the existing stock of knowledge $A_{u,t}$. This assumption captures an environment in which existing knowledge is non-excludable, so that inventors cannot prevent others from drawing on their ideas to innovate.[20]

Defining firms' profits net of expenditure in research as $\Pi^j_{u,t} \equiv \varpi A^j_{u,t} L^T_{u,t} - W_{u,t} L^j_{u,t}$, firms producing intermediate goods choose investment in innovation to maximize their discounted stream of profits

$$\sum_{t=0}^{\infty} \frac{\omega \beta^t}{C^T_{u,t}} \Pi^j_{u,t},$$

subject to (14). Since firms are fully owned by domestic households, they discount profits using the households' discount factor $\omega\beta^t / C^T_{u,t}$.

From now on, we assume that firms are symmetric and so $A^j_{u,t} = A_{u,t}$. Moreover, we focus on equilibria in which investment in innovation by U.S. firms is always positive. Optimal investment in research then requires

$$\frac{W_{u,t}}{\chi A_{u,t}} = \frac{\beta C^T_{u,t}}{C^T_{u,t+1}} \left(\varpi L^T_{u,t+1} + \frac{W_{u,t+1}}{\chi A_{u,t+1}} \right). \tag{15}$$

Intuitively, firms equalize the marginal cost from performing research $W_{u,t}/(\chi A_{u,t})$ to its marginal benefit discounted using the households' discount factor. The marginal benefit is given by the increase in next period profits $(\varpi L^T_{u,t+1})$ plus the savings on future research costs $(W_{u,t+1}/(\chi A_{u,t+1}))$.

As it will become clear later on, a crucial aspect of the model is that the return from innovation is increasing in the size of the U.S. tradable sector, as captured by $L^T_{u,t+1}$. This happens because higher economic activity in the tradable sector boosts the profits that firms producing intermediate goods enjoy from improving the quality of their products. In this sense, the tradable sector is the engine of growth in our model.

3.6 Technology adoption by developing countries

In developing countries, firms producing intermediate goods improve the quality of their products by adopting technological advances originating from the United States.[21] Following the literature on international technology diffusion (Barro and Sala-i Martin, 1997), we formalize this notion by

[19]In Appendix B we demonstrate that our results are robust toward assuming that investment in innovation is done in terms of the tradable final good (a lab equipment model) rather than in terms of labor.

[20]This assumption, however, is not crucial for our results. In fact, we could equally assume that knowledge is a private good with respect to U.S. firms. In this case their productivity would follow the process $A^j_{u,t+1} = A^j_{u,t} + \chi A^j_{u,t} L^j_{u,t}$. None of our results would be affected by this alternative assumption.

[21]This assumption captures the idea that, due to institutional features, the United States enjoys a strong comparative advantage in conducting innovation activities compared to developing countries. In Appendix D we study a version of the model in which innovation may take place in developing countries.

assuming that firms in developing countries draw on the U.S. stock of knowledge when performing research. Productivity of a generic intermediate input j thus evolves according to

$$A^j_{d,t+1} = A^j_{d,t} + \xi A^{\phi}_{u,t} A^{1-\phi}_{d,t} L^j_{d,t}, \tag{16}$$

where $\xi > 0$ captures the productivity of research in developing countries, and $0 < \phi \leq 1$ determines the extent to which developing countries' firms benefit from the U.S. stock of knowledge. Since we think of the United States as the technological leader and developing countries as the followers, we will focus on scenarios in which $A_{u,t} > A_{d,t}$ for all t.[22]

Firms producing intermediate goods in developing countries choose investment in research to maximize their stream of profits, net of research costs, subject to (16). We restrict attention to equilibria in which firms in developing countries are symmetric ($A^j_{d,t} = A_{d,t}$), and their investment in technology adoption is always positive. Optimal investment in research then requires

$$\frac{W_{d,t}}{\xi A^{\phi}_{u,t} A^{1-\phi}_{d,t}} = \frac{\beta C^T_{d,t}}{C^T_{d,t+1}} \left(\varpi L^T_{d,t+1} + \frac{W_{d,t+1}}{\xi A^{\phi}_{u,t+1} A^{1-\phi}_{d,t+1}} \right). \tag{17}$$

As it was the case for the U.S., optimal investment in research equates the marginal cost from investing to its marginal benefit.[23] The difference is that for developing countries the marginal cost of performing research is decreasing in their distance from the technological frontier, as captured by the term $A_{u,t}/A_{d,t}$. This force pushes toward convergence in productivity between the two regions. Moreover, as it was the case for the U.S., the benefit from investing in research is increasing in the size of the tradable sector ($L^T_{d,t+1}$). Also in developing countries, therefore, the tradable sector is the source of productivity growth.

3.7 Aggregation and market clearing

Value added in the tradable sector is equal to total production of tradable goods net of the amount spent in producing intermediate goods. Using equations (12) and (13) we can write value added in the tradable sector as

$$Y^T_{i,t} - \int_0^1 x^j_{i,t} dj = \Psi A_{i,t} L^T_{i,t}, \tag{18}$$

where $\Psi \equiv \alpha^{2\alpha/(1-\alpha)} \left(1 - \alpha^2\right)$.

Market clearing for the non-tradable good requires that in every region consumption is equal

[22] In Appendix D we consider an alternative scenario, in which developing countries technologically leapfrog the U.S. in the long run.

[23] Notice that we are assuming that profits are discounted at rate $\omega \beta^t / C^T_{d,t}$. This corresponds to a case in which the subsidy on savings τ is restricted to investment in bonds only. Alternatively, we could have assumed that the subsidy on savings applies also to investment in research. Our main insights would also apply to this alternative setting. The only wrinkle is that then we would have to assume, as in Benigno and Fornaro (2018), that every firm has a constant probability of losing its stream of monopoly profits (perhaps because its technology is copied by another firm, or for some other shock that leads to the firm's death). This would be needed to maintain firms' value finite, even in environments in which the interest rate is persistently higher than the growth rate of the economy.

to production, so that

$$C_{i,t}^N = Y_{i,t}^N = L_{i,t}^N. \tag{19}$$

The market clearing condition for the tradable good can be instead written as

$$C_{i,t}^T + \frac{B_{i,t+1}}{R_{i,t}} = \Psi A_{i,t} L_{i,t}^T + B_{i,t}. \tag{20}$$

To derive this expression, we have used the facts that domestic households receive all the income from production, and that governments run balanced budgets every period. Moreover, global asset market clearing requires that

$$B_{u,t} = -B_{d,t}. \tag{21}$$

Finally, in every region the labor market must clear

$$\bar{L} = L_{i,t}^N + L_{i,t}^T + L_{i,t}^R. \tag{22}$$

In this expression, we have defined $L_{i,t}^R = \int_0^1 L_{i,t}^j dj$ as the total amount of labor devoted to research in region i.

3.8 Equilibrium

In the balanced growth path of the economy some variables remain constant, while others grow at the same rate as $A_{u,t}$.[24] In order to write down the equilibrium in stationary form, we normalize this second group of variables by $A_{u,t}$. To streamline notation, for a generic variable $X_{i,t}$ we define $x_{i,t} \equiv X_{i,t}/A_{u,t}$. We also denote the growth rate of the technological frontier as $g_t \equiv A_{u,t}/A_{u,t-1}$, and the proximity of a region to the frontier by $a_{i,t} \equiv A_{i,t}/A_{u,t}$ (of course, $a_{u,t} = 1$).

The model can be narrowed down to three sets of equations or "blocks". The first block describes the path of tradable consumption and capital flows. Using the notation spelled out above, the households' Euler equation becomes

$$\frac{\omega}{c_{i,t}^T} = R_{i,t}(1 + \tau_{i,t}) \left(\frac{\beta \omega}{g_{t+1} c_{i,t+1}^T} + \tilde{\mu}_{i,t} \right), \tag{23}$$

where $\tilde{\mu}_{i,t} \equiv A_{u,t} \mu_{i,t}$. To ensure the existence of a balanced growth path, we assume that the borrowing limit of each region is proportional to productivity ($\kappa_{i,t} = \kappa_t A_{i,t+1} > 0$), where κ_t is a time-varying parameter with steady state value $\kappa > 0$. Condition (5) can thus be written as

$$b_{i,t+1} \geq -\kappa_t a_{i,t+1} \quad \text{with equality if} \quad \tilde{\mu}_{i,t} > 0. \tag{24}$$

[24] As we noted above, our model abstracts from the forces linked to structural transformation, meaning that the sectoral employment shares are constant along the balanced growth path. Therefore, some of the variables in our model can be interpreted as the deviation of their actual value from the structural transformation path.

Moreover, the optimality condition for asymptotic bond holdings (6) becomes

$$\lim_{k\to\infty} \frac{b_{i,t+1+k}g_{t+1}...g_{t+1+k}}{R_{i,t}(1+\tau_{i,t})...R_{i,t+k}(1+\tau_{i,t+k})} \leq 0. \tag{25}$$

Finally, the market clearing conditions for the tradable good and for bonds become

$$c_{i,t}^T + \frac{g_{t+1}b_{i,t+1}}{R_{i,t}} = \Psi a_{i,t} L_{i,t}^T + b_{i,t} \tag{26}$$

$$b_{u,t} = -b_{d,t}. \tag{27}$$

These equations define the path of $c_{i,t}^T$, $b_{i,t}$ and $R_{i,t}$ given a path for productivity and tradable output. In a financially integrated world, these equations determine the behavior of capital flows across the two regions.

The second block of the model describes how productivity evolves. Throughout, we will focus on interior equilibria in which $L_{i,t}^N > 0$ for every i and t. In this case, as it is easy to verify, $W_{i,t} = (1-\alpha)\alpha^{2\alpha/(1-\alpha)}A_{i,t}$. In equilibrium, equation (15) then becomes

$$g_{t+1} = \frac{\beta c_{u,t}^T}{c_{u,t+1}^T}\left(\chi\alpha L_{u,t+1}^T + 1\right). \tag{28}$$

This equation captures the optimal investment in research by U.S. firms, and implies a positive relationship between productivity growth and expected future employment in the tradable sector. Intuitively, a rise in production of tradable goods is associated with higher monopoly profits. In turn, higher expected profits induce entrepreneurs to invest more in research, leading to a positive impact on the growth rate of productivity.[25] This is the classic market size effect emphasized by the endogenous growth literature, with a twist. The twist is that the allocation of labor across the two sectors matter for productivity growth.[26] Moreover, productivity growth is decreasing in the growth rate of normalized tradable consumption, $c_{u,t+1}^T/c_{u,t}^T$. A rise in expected consumption growth, the reason is, leads households to discount more heavily future dividends, which translates into a fall in firms' investment.

Following similar steps, we can use (17) to obtain an expression describing the evolution of productivity in developing countries

$$a_{d,t}^{\phi} = \frac{\beta c_{d,t}^T}{g_{t+1}c_{d,t+1}^T}\left(\xi\alpha L_{d,t+1}^T + a_{d,t+1}^{\phi}\right). \tag{29}$$

[25]To be more precise, higher growth reduces households' desire to save, leading to an increase in the cost of funds for firms investing in research. In fact, in the new equilibrium the rise in growth and in the cost of funds are exactly enough to offset the impact of the rise in expected profits on the return from investing in research.

[26]To clarify, what matters for our main results is that productivity growth is increasing in the share of labor allocated to the tradable sector. This means that our key results would also apply to a setting in which scale effects related to population size were not present. For instance, in the spirit of Young (1998) and Howitt (1999), these scale effects could be removed by assuming that the number of intermediate inputs available inside a country is proportional to population size.

This equation describes how the proximity of developing countries to the technological frontier evolves in response to firms' investment in research. As in the U.S., a larger tradable sector induces more investment in research by developing countries and thus leads to a closer proximity to the frontier.

The last block describes the use of productive resources, that is how labor is allocated across the production of the two consumption goods and research. To derive an expression for $L_{i,t}^N$, we can use $Y_{i,t}^N = L_{i,t}^N$ and $W_{i,t} = P_{i,t}^N$ to write equation (7) as

$$L_{i,t}^N = \frac{1-\omega}{\omega(1-\alpha)\alpha^{\frac{2\alpha}{1-\alpha}}} \frac{c_{i,t}^T}{a_{i,t}} \equiv \Gamma \frac{c_{i,t}^T}{a_{i,t}}. \tag{30}$$

The interesting aspect of this equation is that production of non-tradable goods is positively related to consumption of tradables, because of households' desire to balance their consumption across the two goods. Hence, as tradable consumption rises more labor is allocated to the non-tradable sector. As we will see, this effect plays a key role in mediating the impact of capital flows on productivity growth.

Expressions for $L_{i,t}^R$ can be derived by writing equations (14) and (16) as

$$L_{u,t}^R = \frac{g_{t+1}-1}{\chi}$$

$$L_{d,t}^R = \frac{g_{t+1}a_{d,t+1} - a_{d,t}}{\xi a_{d,t}^{1-\phi}}.$$

As it is intuitive, faster productivity growth or a closer proximity to the frontier requires larger innovation effort, and hence more labor allocated to research.

Plugging these expressions in the market clearing condition for labor then gives

$$L_{u,t}^T = \bar{L} - \Gamma c_{u,t}^T - \frac{g_{t+1}-1}{\chi} \tag{31}$$

$$L_{d,t}^T = \bar{L} - \Gamma \frac{c_{d,t}^T}{a_{d,t}} - \frac{g_{t+1}a_{d,t+1} - a_{d,t}}{\xi a_{d,t}^{1-\phi}}. \tag{32}$$

These equations can be interpreted as the resource constraints of the economy.

We collect these observations in the following lemma.

Lemma 1 *In equilibrium the paths of real allocations* $\{c_{i,t}^T, b_{i,t+1}, \tilde{\mu}_{i,t}, a_{i,t+1}, L_{i,t}^T\}_{i,t}$*, interest rates* $\{R_{i,t}\}_{i,t}$ *and growth rate of the technological frontier* $\{g_{t+1}\}_t$*, satisfy (23), (24), (25), (26), (27), (28), (29), (31) and (32) given a path for the borrowing limit* $\{\kappa_t\}_t$ *and initial conditions* $\{b_{i,0}, a_{i,0}\}_i$*.*

4 Financial integration and global productivity growth

In this section we study the impact of financial integration on global productivity growth. We start by characterizing the balanced growth path - or steady state - of the model. Focusing on steady states, and thus on the long-run behavior of the economy, allows us to derive analytically our key results about the impact of financial integration on global productivity growth. Thereafter, we consider transitional - or medium-run - dynamics.

Steady state equilibria can be represented using two simple diagrams. The first diagram connects global productivity growth to the size of the tradable sector in the United States. Start by considering that in steady state $c_{i,t}^T$, $L_{i,t}^T$ and g_{t+1} are all constant. We can then write equation (28) as

$$g = \beta\left(\chi\alpha L_u^T + 1\right), \tag{GG_u}$$

where the absence of a time subscript denotes the steady state value of a variable. The GG_u schedule captures the incentives to innovate for U.S. firms. Due to the market size effect described above, optimal investment in innovation in the United States gives rise to a positive relationship between g and L_u^T. A second relationship between g and L_u^T can be obtained by writing equation (31) as

$$L_u^T = \bar{L} - \Gamma c_u^T - \frac{g-1}{\chi}. \tag{RR_u}$$

The RR_u schedule captures the resource constraint of the U.S. economy. Faster productivity growth requires more research effort, leaving less labor to be allocated to production. This explains why the RR_u schedule describes a negative relationship between g and L_u^T. Together, these two schedules determine the equilibrium in the United States for a given value of c_u^T (Figure 3a).

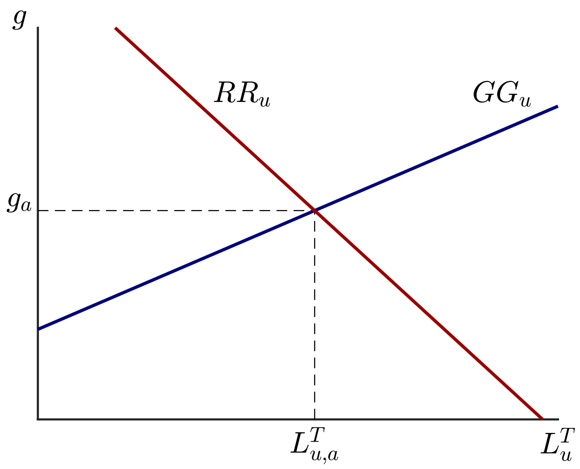
A similar approach can be used to describe the equilibrium in developing countries. Recall that we are focusing on equilibria in which investment in research by developing countries is always positive. This implies that in steady state productivity in developing countries grows at rate g, and so their proximity to the technological frontier is constant. Hence, in steady state (29) reduces to

$$a_d^\phi = \frac{\beta\xi\alpha L_d^T}{g-\beta}. \tag{GG_d}$$

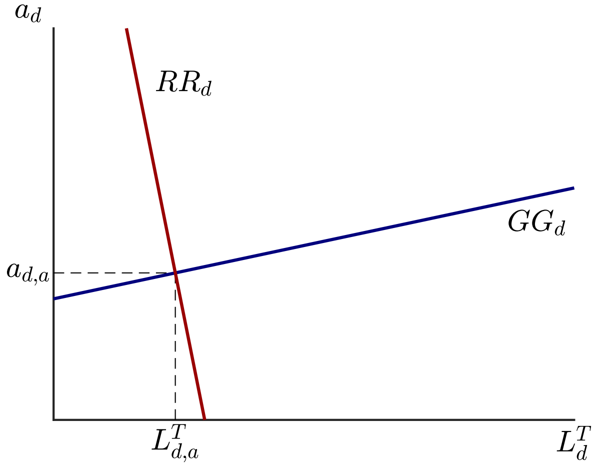
The GG_d schedule captures the incentives of firms in developing countries to adopt technologies from the frontier. As production of tradables by developing countries increases, the return to increasing productivity rises, leading to higher investment in research and a closer proximity to the frontier. Instead, the steady state counterpart of (32) is

$$L_d^T = \bar{L} - \Gamma\frac{c_d^T}{a_d} - \frac{(g-1)a_d^\phi}{\xi}. \tag{RR_d}$$

Intuitively, maintaining a closer proximity to the frontier requires more research labor, leaving less labor to production of tradable goods. This explains the negative relationship between a_d and L_d^T implied by the RR_d schedule, for a given value of c_d^T/a_d. The intersection of these two schedules determines the equilibrium value of a_d and L_d^T (Figure 3b) - again holding constant c_u^T and c_d^T/a_d. To fully characterize the equilibrium we need to specify a financial regime. We turn to this task next.



(a) United States.



(b) Developing countries.

Figure 3: Steady state equilibria.

4.1 Financial autarky

Under financial autarky, financial flows across the two regions are not allowed. Since households inside every region are symmetric, it must then be that $b_{u,t} = b_{d,t} = 0$. We can thus define an equilibrium under financial autarky as follows.

Definition 1 *An equilibrium under financial autarky satisfies the conditions stated in Lemma 1 and $b_{i,t} = 0$ for all i and t.*

In each region consumption of tradable goods must be equal to output, and so $c_{i,t}^T = a_{i,t}\Psi L_{i,t}^T$. It is then a matter of simple algebra to solve for the steady state values of g and a_d. Combining the GG_u and RR_u equations one gets that

$$g_a = \beta \left(\frac{\alpha \left(\chi \bar{L} + 1 - \beta \right)}{1 + \Gamma\Psi + \alpha\beta} + 1 \right), \tag{33}$$

where the subscript a denotes the value of a variable under financial autarky. According to this expression, a higher productivity of research in the U.S. (i.e. a higher χ) leads to faster growth in the world technological frontier. Moreover, as the tradable sector share of value added rises (i.e. as ω increases, and so Γ falls), more resources are devoted to innovation leading to faster productivity growth.

To solve for the equilibrium in developing countries we can combine equations GG_d and RR_d to obtain

$$a_{d,a}^{\phi} = \frac{\alpha\beta\xi\bar{L}}{(g_a - \beta)(1 + \Gamma\Psi) + (g_a - 1)\alpha\beta}. \tag{34}$$

Naturally, a higher ξ is associated with a more efficient process of technology adoption in developing countries, and thus to a closer proximity to the frontier in steady state.[27] Moreover, a larger size

[27] $a_{d,a}$, instead, is decreasing with the growth rate of the technological frontier g_a. This happens because a faster

of the tradable sector (i.e. a lower Γ) is associated with a closer proximity to the frontier, because technology adoption is the result of research efforts by firms in the tradable sector.

Finally, under financial autarky the two regions feature different interest rates. Recalling that $\tau_{u,t} = 0$, using U.S. households' Euler equation gives

$$R_{u,a} = \frac{g_a}{\beta}.$$

Instead, since $\tau_{d,t} = \tau > 0$, the households' Euler equation in developing countries implies that

$$R_{d,a} = \frac{g_a}{\beta(1+\tau)} < R_{u,a}.$$

Hence, in the long run developing countries feature a lower interest rate compared to the United States. This is just the outcome of the higher propensity to save characterizing households in developing countries compared to U.S. ones.

Proposition 1 *Suppose that*

$$i) \quad \beta\left(\frac{\alpha\left(\chi\bar{L}+1-\beta\right)}{1+\Gamma\Psi+\alpha\beta}+1\right) > 1 \quad and \quad ii) \quad \xi < \chi. \tag{35}$$

Then under financial autarky there is a unique steady state in which productivity in both regions grows at rate $g_a > 1$, given by (33), and developing countries' proximity to the frontier is equal to $a_{d,a} < 1$, given by (34). Moreover, $R_{u,a} = g_a/\beta$ and $R_{d,a} = g_a/((1+\tau)\beta) < R_{u,a}$.

Proposition 1 summarizes the results derived so far. The role of condition (35) is to guarantee that in steady state productivity grows at a positive rate ($g_a > 1$), and that developing countries do not catch up fully with the technological frontier ($a_{d,a} < 1$). This second condition is satisfied if the ability of developing countries to adopt U.S. technologies is sufficiently small compared to the productivity of research in the United States.

4.2 Financial integration

What is the impact of financial globalization on growth? To answer this question, we now turn to a scenario in which the two regions are financially integrated. Since capital flows freely across the two regions, interest rates must be equalized and so $R_{u,t} = R_{d,t}$. We are now ready to define an equilibrium under financial integration.

Definition 2 *An equilibrium under financial integration satisfies the conditions stated in Lemma 1 and $R_{u,t} = R_{d,t}$ for all t.*

Recall that households in developing countries have a higher propensity to save compared to U.S. ones. In the long-run U.S. households thus borrow up to their limit and $b_{u,f} = -\kappa$, where the

pace of innovation in the U.S. requires more resources devoted to research by developing countries in order to maintain a constant proximity to the frontier.

subscript f denotes the value of a variable in the steady state with financial integration. Conversely, households in developing countries have positive assets in the long run. Their Euler equation thus implies that in steady state

$$R_f = \frac{g_f}{\beta(1+\tau)}, \tag{36}$$

where R_f denotes the steady state world interest rate under financial integration. We can then use equation (26) to write

$$c_{u,f}^T = \Psi L_{u,f}^T + \kappa \left(\frac{g_f}{R_f} - 1 \right) = \Psi L_{u,f}^T + \kappa \left(\beta(1+\tau) - 1 \right). \tag{37}$$

This equation highlights how the U.S. trade balance in steady state ($\Psi L_{u,f}^T - c_{u,f}^T$) crucially depends on the ratio g_f/R_f, which is in turn determined by $\beta(1+\tau)$.

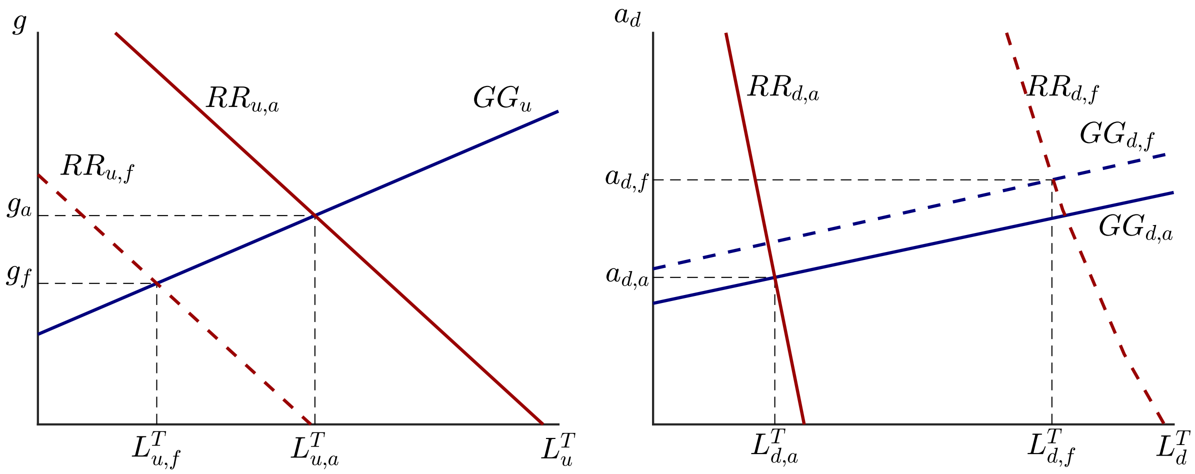
In what follows, we will focus on the case $g_f > R_f$ by assuming that $\beta(1+\tau) > 1$.[28] Empirically, at least if one interprets R_f as the return on U.S. government bonds, this condition is in line with the experience of the United States since the mid-1990s. Moreover, under this assumption, in steady state the U.S. trade balance is in deficit. This feature of the model is consistent with the fact that the U.S. has been running persistent trade deficits over the last 30 years (Figure 1) without significantly raising its external-debt-to-GDP position.[29] To be clear, our main insights do not rely on this assumption. In Appendix C, we consider an economy in which $g_f < R_f$, and we show that in this case a global financial resource curse can arise during the transition toward the final steady state.

Perhaps the best way to understand the impact of financial integration on productivity growth is to employ the diagrams presented in Figure 4. Let us start from the United States. In a financially integrated world, since $\beta(1+\tau) > 1$, the United States ends up running trade deficits in the long run. In turn, trade deficits sustain consumption of tradable goods, which rises above production ($c_{u,f}^T > \Psi L_{u,f}^T$). Higher consumption of tradable goods pushes up demand for non-tradables. In order to satisfy this increase in demand, labor migrates from the tradable sector toward the non-

[28] As is well known, studying economies in which the interest rate is lower than the growth rate of output might be tricky, since the present value of the economy's resources might be unbounded (see the discussion on page 65 of Obstfeld and Rogoff (1996)). Luckily, our model can accommodate this case. Let us start by considering households in developing countries. The interest rate faced by these households is $R_f(1+\tau)$, which, by equation (36), is larger than g_f. Hence, from the point of view of households in developing countries, the present value of income is finite and the terminal condition (25) is satisfied with equality.

Things are a bit more complicated for households in the United States. Since they face an interest rate lower than the growth rate of output, the present value of their expected income is infinite. Still, the utility enjoyed by U.S. households is finite, since the borrowing limit (3) prevents them from fully frontloading the consumption of their expected stream of future income. What about the no-Ponzi condition usually imposed by lenders? Notice that here the lenders are households in developing countries, which receive an interest rate equal to $R_f(1+\tau)$. Moreover, consider that, due to the borrowing limit (3), in steady state U.S. households' liabilities cannot grow at a rate larger than g_f. It follows that, since $R_f(1+\tau) > g_f$, the borrowing limit (3) is more stringent than the conventional constraint imposed by lenders to rule out Ponzi schemes.

[29] As documented by Mehrotra and Sergeyev (2019), the rate of return on U.S. government bonds has been lower than the growth rate of the U.S. economy for most of the post-WWII period. Gourinchas and Rey (2007) show that the United States earns a large excess return on its foreign portfolio, which allows it to run persistent trade deficits without significant increases in net foreign debt. It would be easy to incorporate this feature of the data in the model, for instance by assuming that bonds issued by the United States earn some convenience premium, due to their safety and liquidity.



(a) United States. **(b) Developing countries.**

Figure 4: Impact of financial integration.

tradable one, and so L_u^T falls. Graphically, this is captured by the leftward shift of the RR_u curve. This is not, however, the end of the story. As the tradable sector shrinks, firms' incentives to innovate fall - because the profits appropriated by successful innovators are now smaller.[30] The result is a drop in productivity growth in the United States.[31] Therefore, paradoxically, cheap access to capital inflows depresses investment and productivity growth, because these inflows end up financing a boom in the non-tradable sector. This is consistent with the empirical observation that credit booms in the non-tradable sector are typically followed by slowdowns in productivity growth (Müller and Verner, 2021), especially when credit is financed by inflows of foreign capital (Richter and Diebold, 2021) .

All these results can be derived analytically, by combining the GG_u and RR_u equations with (37) to obtain

$$g_f = g_a - \frac{\alpha\beta\chi\Gamma}{1+\Gamma\Psi+\alpha\beta}\kappa\left(\beta(1+\tau)-1\right). \tag{38}$$

Because we assume $\beta(1+\tau) > 1$, this expression shows that financial integration depresses g below its value under financial autarky. Moreover, this effect is stronger the larger the capital inflows toward the United States, here captured by a higher value of the parameter κ.

[30] For completeness, let us mention that the model embeds a second effect that could lead to a positive relationship between capital inflows into the United States and investment in innovation by U.S. firms. Indeed, capital inflows lead to a reduction in the cost of funds for U.S. firms, and so to a fall in the cost of investing in innovation. Hence, the model is consistent with the empirical finding by Varela (2018), who documents that capital inflows foster investment in innovation by credit-constrained firms, relative to unconstrained ones. In steady state, however, it turns out that this cost of funds effect is always dominated by the profit effect described in the main text. We further elaborate on this point in Section 4.3.

[31] Besides lower innovation in the tradable sector, there is also a composition effect depressing productivity growth in the United States. Since productivity growth is lower in the non-tradable sector, the shift of factors of production from the tradable to the non-tradable sector mechanically lowers productivity growth. To streamline the exposition, throughout the paper we focus on the - less mechanical and arguably more interesting - behavior of productivity in the tradable sector. Empirically, the productivity growth slowdown in the United States has been characterized by a sharp fall in productivity growth in manufacturing (Syverson, 2016).

In some respects, the impact of financial integration on developing countries is the mirror image of the U.S. one. In developing countries, tradable consumption is given by

$$c_{d,f}^{T} = \Psi a_{d,f} L_{d,f}^{T} - \kappa \left(\beta(1+\tau) - 1\right). \tag{39}$$

Naturally, to finance trade surpluses consumption of tradables has to fall below production ($c_{d,f}^{T} < \Psi a_{d,f} L_{d,f}^{T}$).[32] This causes a drop in demand for non-tradable goods, which induces labor to shift out of the non-tradable sector toward the tradable one. Graphically, this effect corresponds to a rightward shift of the RR_d curve.[33] As the tradable sector grows larger, firms in developing countries increase their spending in research. They do so in order to appropriate the now higher profits derived from upgrading their productivity. As illustrated by Figure 4*b*, this process pushes developing countries closer to the technological frontier.

More precisely, by combining the GG_d and RR_d equations with (39) one finds that

$$a_{d,f}^{\phi} = \frac{\alpha\beta\xi\left(\bar{L} + \Gamma\frac{\kappa(\beta(1+\tau)-1)}{a_{d,f}}\right)}{(g_f - \beta)(1+\Gamma\Psi) + (g_f - 1)\alpha\beta}. \tag{40}$$

Comparing this expression with (34) shows that, since $\beta(1+\tau) > 1$ and $g_f < g_a$, financial integration increases developing countries' proximity to the frontier. Again, this effect is stronger the larger the capital flows out of developing countries, i.e. the higher κ.

In spite of the increase in a_d, however, it is far from clear that financial integration generates long run productivity improvements in developing countries. The reason is that developing countries absorb technological advances originating from the United States. Therefore, lower innovation activities in the United States translate into a drop in the steady state rate of productivity growth in developing countries. Hence, at least in the long run, the process of financial integration generates a fall in global productivity growth.

Proposition 2 *Suppose that $\beta(1+\tau) > 1$ and that*

$$i) \quad \kappa\left(\beta(1+\tau) - 1\right) < \frac{(g_a - 1)\left(1 + \Gamma\Psi + \alpha\beta\right)}{\alpha\beta\chi\Gamma} \quad \text{and} \quad ii) \quad \kappa\left(\beta(1+\tau) - 1\right) < \frac{\bar{L}(\chi - \xi)}{\Gamma(\chi + \xi)}, \tag{41}$$

where g_a is given by (33). Then under financial integration there is a unique steady state in which productivity in both regions grows at rate g_f, given by (38), satisfying $1 < g_f < g_a$. Developing countries' proximity to the frontier is equal to $a_{d,f}$, given by (40), with $a_{d,a} < a_{d,f} < 1$. Both regions share the same interest rate given by $R_f = g_f/((1+\tau)\beta)$.

Proposition 2 summarizes our observations about the impact of financial integration on productivity. As it was the case under financial autarky, the role of condition (41) is to guarantee that in steady state productivity grows at a positive rate ($g_f > 1$), and that developing countries do

[32] We restrict the analysis to values of κ small enough so that tradable consumption in developing countries is always positive.

[33] The shift in the GG_d curve, instead, is due to the impact of financial integration on U.S. productivity growth.

not catch up fully with the technological frontier ($a_{d,f} < 1$). Because financial integration reduces g_f and raises $a_{d,f}$ relative to their values under financial autarky, this amounts to assuming that capital flows, captured by the variable $\kappa(\beta(1+\tau)-1)$, are not too large.

Our framework also gives a new perspective on the impact of financial integration on interest rates. In standard models, after two regions integrate financially, the equilibrium interest rate lies somewhere in between the two autarky rates. This is not the case here. In fact, it is easy to see that the interest rate under financial integration lies below both autarky rates ($R_f < R_{d,a} < R_{u,a}$). This happens because financial integration depresses the rate of global productivity growth. Lower productivity growth boosts households' supply of savings, and drives down the world interest rate below the values observed under financial autarky.

Corollary 1 *Suppose that (41) holds and that $\beta(1+\tau) > 1$. Then the world interest rate under financial integration is lower than the two autarky rates ($R_f < R_{d,a} < R_{u,a}$).*

Several commentators have argued that the integration in the international financial markets of developing countries, by giving rise to a global saving glut, had a large negative impact on global interest rates (Bernanke, 2005). In our model this effect is present, but it is magnified by the drop in global productivity growth associated with financial globalization. Hence, here the global saving glut leads to a regime of superlow global interest rates, characterized by weak investment and low growth.

What about the return to investment? It turns out that financial globalization opens up a wedge between the interest rate on U.S. bonds and the return to investment in innovation. To see this point, note that the return enjoyed by U.S. firms on their investment is equal to

$$R^I_{u,t+1} \equiv \frac{\varpi L^T_{u,t+1} + \frac{W_{u,t+1}}{\chi A_{u,t+1}}}{\frac{W_{u,t}}{\chi A_{u,t}}}.$$

Using equation (15), it is easy to see that in steady state $R^I_u = g/\beta$. Therefore, under financial autarky, the return to investment in innovation is equal to the U.S. interest rate ($R^I_{u,a} = g_a/\beta = R_{u,a}$). Following financial globalization, however, the return to investment ends up being higher than the world rate ($R^I_{u,f} = g_f/\beta > R_f$). This happens because, due to the presence of financial frictions, the high demand for bonds coming from developing countries translates into an only mild decline in the U.S. return to investment. This feature of the model is consistent with the fact that, since the early 2000s, there has been a rise in the spread between the interest rate and the return to capital in the United States (Farhi and Gourio, 2018).[34]

Before concluding this section, two remarks are in order. First, in our model inflows of foreign capital depress productivity growth in the recipient country because they reduce economic activity in the tradable sector. Due to its similarities with the notion of natural resource curse, in Benigno

[34] The increase in the spread between bonds, which are associated with safety, and capital, whose return is instead inherently risky, has often being attributed to a rise in investors' risk aversion. It would be straightforward to capture these type of considerations in the model. We would just need to assume, as done for instance in Aghion and Howitt (1992), that investment in innovation is risky.

and Fornaro (2014) this effect has been dubbed the *financial resource curse*. Here, however, the implications are much more dramatic. In fact, one could naively think that countries experiencing capital outflows - and so an expansion of their tradable sector - would enjoy faster productivity growth. But, as we have just shown, this conclusion is not correct. In our model the slowdown in productivity growth affects capital-exporting countries too, giving rise to a *global financial resource curse*.

Second, there is a literature emphasizing how capital flows from developing countries to the United States are driven by the role of the dollar as the world's dominant currency (Gopinath and Stein, 2018). In fact, the United States' ability to issue reserve assets highly demanded by developing countries has been referred to as an exorbitant privilege (Gourinchas et al., 2019). A distinctive feature of our model is that the country issuing the dominant currency is also the world technological leader. But this might transform the exorbitant privilege in an exorbitant burden, since capital flows can generate a growth slowdown in the country issuing the dominant currency.[35] Worse yet, the exorbitant burden spreads to the countries whose growth depends on technology adoption from the frontier. To the best of our knowledge, we are the first to emphasize this connection between the central role played by the United States in the international monetary and technological system.

4.3 Medium-run dynamics

So far, we have focused our analysis on steady states, that is on the long run behavior of the economy. In this section, instead, we focus on the medium run, that is on the transition from a regime of financial autarky to financial integration. To anticipate our main finding, during the transition developing countries can experience an acceleration in productivity growth, as they push themselves closer to the technological frontier.[36] Therefore, when developing countries start joining the international credit markets, global productivity growth might accelerate. But this growth acceleration might only be temporary and, due to the logic of the global financial resource curse, global productivity growth might eventually slow down in the long run.[37]

To make these points we resort to some simple numerical simulations. To be clear, our goal here is not to be quantitative, but to illustrate the forces at the heart of the model for some reasonable values of the parameters. We perform the following experiment. The economy is in the financial autarky steady state in period $t = 0$. In period $t = 1$ international credit markets open up, and the economy transits toward the steady state with financial integration. We model the opening of the international credit markets as a gradual increase in the borrowing limit κ_t, which follows the path

$$\kappa_t = \frac{1}{1+\rho}\kappa_{t-1} + \frac{\rho}{1+\rho}\kappa, \tag{42}$$

[35] Pettis (2011) coined the term exorbitant burden, to describe the notion that the exorbitant privilege hurts U.S. manufacturing.

[36] This is consistent with the experience of several developing countries, in which capital outflows were coupled with fast productivity growth (Gourinchas and Jeanne, 2013).

[37] In Appendix G, we present some evidence in line with this prediction.

where $\kappa > 0$ continues to denote the steady state value of the borrowing limit, and $\kappa_0 = 0$.[38] The parameter ρ determines the speed with which restrictions on cross-border capital flows are lifted. We set $\rho = 0.15$ so that the transition lasts about 25 years. This assumption guarantees that the global economy experiences a protracted period of sizable current account imbalances, in line with the pattern of capital flows shown in Figure 1a.

Figure 5 displays the economy's transitional dynamics, following the opening of international credit markets to developing countries.[39] The top-left panel shows that the process of financial integration is characterized by large capital flows out of developing countries and toward the United States. As a result, the United States experiences a persistent spell of sizable trade balance deficits, which result in a consumption boom. Moreover, the rise in U.S. consumption induces a reallocation of labor in the United States toward the non-tradable sector, at the expense of the tradable one (top-right panel). As economic activity in the tradable sector falls, U.S. firms cut back their investment in innovation, resulting in a drop in the U.S. rate of productivity growth. These dynamics are all in line with the steady state analysis discussed in Section 4.

Turning to developing countries, financial integration is associated with large trade balance surpluses, and thus with an increase in economic activity in the tradable sector. Higher profits in the tradable sector lead firms in developing countries to increase their investment in technology adoption. Initially, this effect generates an acceleration in productivity growth in developing countries, which pushes them closer to the technological frontier. Hence, in the medium run, the model reproduces the positive correlation between productivity growth and capital outflows documented for developing countries by Gourinchas and Jeanne (2013). Eventually, however, productivity growth in developing countries slows down falling below the growth rate in the initial autarky steady state. The reason, of course, is that low productivity growth in the United States reduces the scope for technology adoption in developing countries. The model thus qualifies the view that developing countries can boost technology adoption and productivity growth by running trade balance surpluses, that is the Bretton Woods II view popularized by Dooley et al. (2004). We will go back to this point in Section 5.3.

The bottom-right panel of Figure 5 shows the path of interest rates. Financial globalization leads to interest rate equalization between the United States and developing countries. As standard frameworks would predict, on impact the world interest rate lies between the two autarky rates. This means that the United States experiences a fall in its interest rate, while the interest rate in

[38] Financial integration is modeled as an unexpected shock, in the sense that in periods $t < 1$ agents expect the world to remain in financial autarky forever. From period $t = 1$ on agents have perfect foresight.

[39] To construct the figure, we target an initial growth rate in the U.S. of 2%, a share of R&D expenditure to GDP of 2.5%, a share of tradables in consumption of 25%, and a trade balance deficit in the financial integration steady state of 2% relative to GDP. In developing countries, we target an initial proximity to the frontier of 50%, and we set $\phi = 1$ for the degree of knowledge spillovers. Moreover, we normalize $\bar{L} = 1$. This yields the parameters $\beta = 0.96$, $\omega = 0.25$, $1 - \alpha = 0.53$, $\chi = 0.74$, $\xi = 0.32$, $\kappa = 0.045$, $\tau = 0.11$. As we noted before, this parameterization is purely illustrative and not meant to be quantitative. For instance, our simulations feature an excessively large drop in the U.S. interest rate upon financial integration. This is due to the fact that in our model the United States earns the same return on its foreign assets and liabilities, and so to generate a sizable trade balance deficit in steady state an interest rate far below the growth rate of the economy is needed. In reality, the United States earns large excess returns on its foreign portfolio (Gourinchas and Rey, 2007). It would be easy to introduce this feature in the model, which would reconcile persistent U.S. trade balance deficits with a realistic drop in the interest rate.

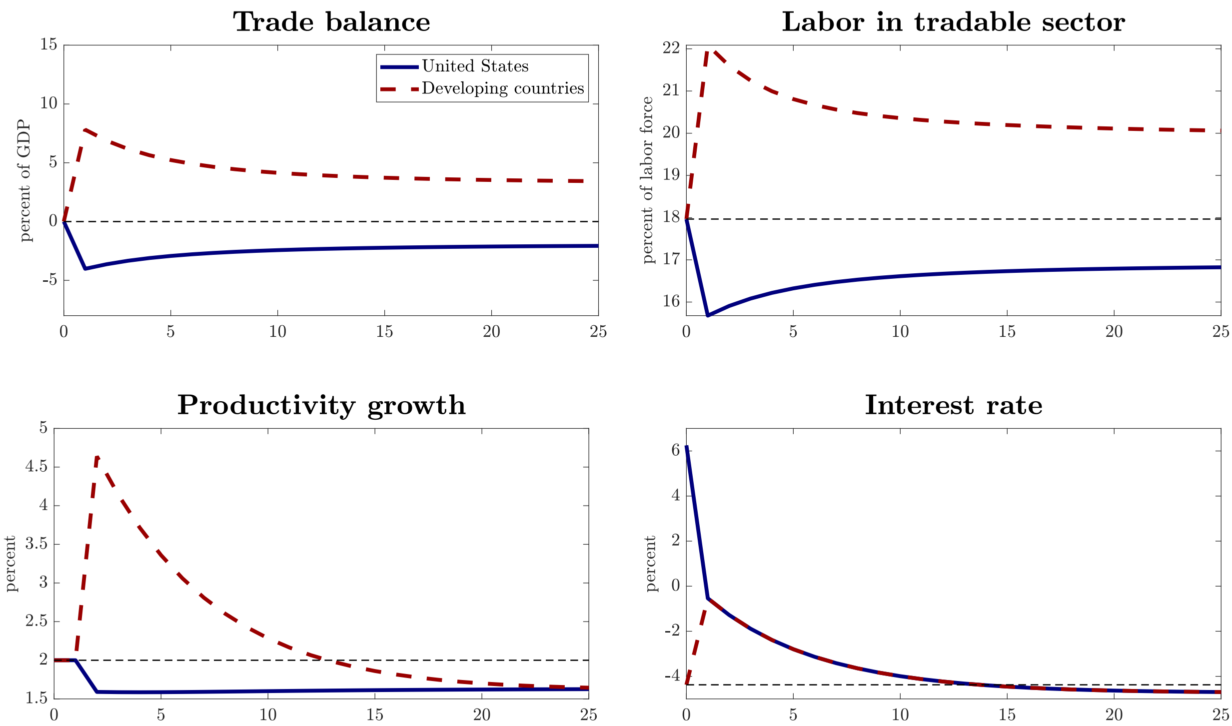


Figure 5: An example of transition from autarky to financial integration steady state. Notes: the process of financial integration is captured by a gradual rise in κ_t, which is governed by (42). Financial integration is not anticipated by agents in periods $t < 1$. From period $t = 1$ on agents have perfect foresight.

developing countries increases above its autarky value. This situation, however, is only temporary. As global growth slows down the world interest rate keeps falling. After a few years since the start of financial globalization, in fact, the world interest rate falls below both autarky rates. Therefore, in the long run the world enters a state of superlow interest rates, in which both the United States and developing countries experience a drop in their interest rate below the autarky values.[40]

To close this section, let us spend a few words on the behavior of U.S. productivity during the transition. Under our baseline parametrization, financial integration is associated with an immediate drop in U.S. productivity growth. However, one can design examples in which productivity growth in the United States rises at the start of the transition, and then gradually declines below its value in the initial steady state. To gain intuition, it is useful to go back to the equilibrium condition on the market for innovation (28)

$$g_{t+1} = \frac{\beta c_{u,t}^T}{c_{u,t+1}^T} \left(\chi \alpha L_{u,t+1}^T + 1 \right).$$

According to this expression, there are two contrasting channels through which capital inflows influence firms' incentives to invest in innovation. As discussed above, by causing a drop in $L_{u,t+1}^T$ capital inflows depress profits in the tradable sector, and so the return to investment. But capital

[40]Similar to what happens in steady state, the return to investment in innovation in the United States instead experiences only a mild fall. It follows that along the transition triggered by financial globalization a positive spread between the return to investment in the U.S. and the world interest rate opens up.

inflows also induce a consumption boom and a rise in $c^T_{u,t}/c^T_{u,t+1}$ - or equivalently a drop in the rate at which U.S. households discount future profits. Through this channel, capital inflows reduce U.S. firms' cost of funds and increase firms' incentives to invest.

It turns out that the persistency of capital inflows is the key determinant of which effect prevails. To see why, notice that the profit effect depends on future capital flows, since investment decisions are based on future expected profits. The cost of funds effect, instead, is determined by current capital flows, since firms' cost of investment depends on current consumption. The profit effect, therefore, tends to dominate when capital inflows are persistent - as it has been the case for the United States since the late 1990s.[41] The cost of funds effect, instead, tends to dominate when movements in capital flows are abrupt and short-lived. An example where this effect dominates is given in Appendix E.2, where we study the implications for global productivity growth of a sudden stop in capital flows toward the United States.

5 Extensions and policy scenarios

In this section we consider several extensions to the baseline model, as well as some policy scenarios. First, we consider a version of the model in which innovation activities take place in both sectors. We then discuss how capital inflows from developing countries to the U.S. affect the dollar. Next we turn to the global consequences of developing countries pursuing a strategy of export-led growth. Finally, we trace the impact of innovation policies implemented by the United States.[42,43]

5.1 Innovation in both sectors

In our baseline model productivity in the non-tradable sector is stagnant. In reality, however, even if the lion's share of investment in innovation occurs within tradable sectors (see Figure 2a), productivity-enhancing activities take place in non-tradable sectors as well. In this section we revisit the impact of capital inflows on U.S. productivity growth using a version of the model in which firms in both sectors can invest in innovation. For brevity, here we just outline the main results, while Appendix E contains the detailed analysis.

We start by discussing a case in which the two sectors are symmetric, in the sense that they share the same assumptions regarding monopoly rents and investment in innovation. The only difference between the two sectors is then in terms of parameter values. As in the baseline model, growth in the tradable sector is given by equation (28)

$$g^T_{u,t+1} = \beta \frac{c^T_{u,t}}{c^T_{u,t+1}} (\chi^T \alpha^T L^T_{u,t+1} + 1), \tag{43}$$

[41] In fact, as we discussed in footnote 30, in steady state the profit effect always dominates the cost of funds effect.

[42] In Appendix E we discuss two additional policy scenarios. First, we study the effects of a sudden stop in capital inflows hitting the United States. Second, we study the global implications of barriers to capital inflows imposed by the United States.

[43] To be clear, we discuss policy interventions from a purely positive perspective. We instead refrain from performing normative analyses and deriving optimal policy interventions. This is an interesting exercise, but it is beyond the scope of this paper.

where we now define $g^T_{u,t+1}$, α^T and χ^T respectively as productivity growth, the share of intermediates in the production function and the productivity of research in the tradable sector. Productivity growth in the non-tradable sector evolves according to

$$g^N_{u,t+1} = \beta \frac{c^T_{u,t}}{c^T_{u,t+1}} (\chi^N \alpha^N L^N_{u,t+1} + 1), \tag{44}$$

where $g^N_{u,t+1}$, α^N and χ^N denote respectively productivity growth, the share of intermediates in the production function and the productivity of research in the non-tradable sector. The labor market clearing condition (22) in this version of the model is

$$\bar{L} = L^T_{u,t} + L^N_{u,t} + L^{R,T}_{u,t} + L^{R,N}_{u,t}, \tag{45}$$

where $L^{R,k}_{u,t} = (g^k_{u,t+1} - 1)/\chi^k$, for $k \in \{T, N\}$, denotes respectively research labor in the tradable and non-tradable sectors. Moreover, labor allocated to the production of non-tradable goods is now

$$L^N_{u,t} = \frac{1-\omega}{\omega(1+\alpha^N)(1-\alpha^T)(\alpha^T)^{\frac{2\alpha^T}{1-\alpha^T}}} c^T_{u,t} \equiv \tilde{\Gamma} c^T_{u,t}, \tag{46}$$

which replaces equation (30). Evaluated on the balanced growth path, these four equations determine $g^T_u, g^N_u, L^T_u, L^N_u$, for given consumption of tradable goods c^T_u.

Now consider the impact of financial integration on long-run productivity growth. The key difference with respect to the baseline model is that now capital inflows toward the U.S. generate an increase in productivity growth in the non-tradable sector. To see this point, recall that c^T_u rises after financial integration. It is then easy to see that, as a result, both L^N_u and g^N_u rise. Intuitively, capital inflows boost profits in the non-tradable sector, inducing firms producing non-tradable goods to invest more in innovation. The implication is that capital inflows reduce productivity growth in the tradable sector, but boost it in the non-tradable one. Therefore, the effect on *aggregate* productivity growth of a surge in capital flows toward the United States is now ambiguous.

To make progress, let us focus on the growth rate of real value added weighted by each sector's employment share.[44] Using this definition, on the balanced growth path aggregate productivity growth g_u evolves according to[45]

$$g_u = \frac{L^T_u}{\bar{L}} g^T_u + \frac{L^N_u}{\bar{L}} g^N_u + \frac{L^{T,R}_u + L^{N,R}_u}{\bar{L}}.$$

In the data value added originating from the research sector is small, so that approximately $L^{T,R}_u +$

[44]We focus on growth weighted by employment shares to obtain analytic insights. We verified numerically that the results are not much different if we use the Fisher index to compute the growth rate of aggregate GDP, in line with NIPA methodology (see for example León-Ledesma and Moro, 2020).

[45]Notice that productivity growth in the research sector is stagnant. Value added in the research sector is labor allocated to carrying out research times the wage. *Real* value added in the research sector, which is obtained by deflating value added by the wage, is thus constant on the balanced growth path. See Appendix E for the details.

$L_u^{N,R} \approx 0$. Using this approximation and (43)-(44), we then obtain

$$g_u = \frac{L_u^T}{\bar{L}}(\chi^T \alpha^T L_u^T + 1) + \frac{\bar{L} - L_u^T}{\bar{L}}(\chi^N \alpha^N (\bar{L} - L_u^T) + 1). \tag{47}$$

On the balanced growth path, capital inflows reduce the share of labor allocated to the tradable sector. We can thus trace their impact on long-run productivity growth by considering the response of g_u to a drop in $L_u^T/\bar{L}$. Differentiating (47) with respect to $L_u^T/\bar{L}$ gives

$$\frac{\partial g_u}{\partial (L_u^T/\bar{L})} = 2(g_u^T - g_u^N). \tag{48}$$

Capital inflows thus depress U.S. productivity growth if $g_u^T > g_u^N$. Indeed, as we have argued in Section 2, in the United States productivity growth has been much higher in sectors producing tradable goods compared to sectors producing non-tradables (at least before the emergence of the global saving glut). Hence, even after taking into account innovation activities in the non-tradable sector, our main insight that capital inflows reduce U.S. growth is still valid.

What is the intuition behind this result? There are two effects at play. First, there is a composition effect. Since $g_u^T > g_u^N$, a shift of labor from the tradable to the non-tradable sector mechanically reduces aggregate productivity growth. Second, and more interestingly, if $g_u^T > g_u^N$ the reallocation of labor across the two sectors depresses g_u^T by more than it raises g_u^N. To see why, consider that for a generic sector k

$$\frac{\partial g_u^k}{\partial L_u^k} L_u^k = \frac{g_u^k}{\beta} - 1.$$

Hence, the sector characterized by faster growth is also the one in which productivity growth is more sensitive to changes in employment.[46] Both effects point toward a negative impact on aggregate growth of a reallocation of labor from the tradable to the non-tradable sector.[47]

In Appendix E we also discuss two additional extensions of the model with innovation activities in both sectors. First, we study an economy in which tradable goods enter as intermediate inputs the production of non-tradables. Through this channel, productivity improvements in the tradable sector partly spill over to the non-tradable one. For instance, this extension captures a scenario in which productivity improvements in sectors producing ICT technologies positively affect productivity in non-tradable services. Second, we consider a version of the model in which knowledge is more excludable in the tradable sector compared to the non-tradable one. This asymmetry could explain why in the data private investment in R&D is concentrated in tradable sectors. Compared

[46] To understand this point, note that $g_u^T > g_u^N$ implies that $\chi^T \alpha^T L_u^T > \chi^N \alpha^N L_u^N$. For plausible parametrizations, $L_u^T < L_u^N$, meaning that the model interprets the sector producing tradable goods as the one in which research is more productive (higher χ) and in which intermediate inputs - the driver of long-run growth - are more important for production (higher α).

[47] What about the growth implications for developing countries? As it turns out, the spillover effect of the decline in U.S. growth on growth prospects in developing countries is now even larger compared to the baseline model. To understand this, recall that the non-tradable sector shrinks in developing countries following international financial integration. Hence if innovation activities also take place in this sector, aggregate growth in developing countries falls by even more. Key to this result is that knowledge spillovers across countries are confined to the tradable sector, in line with the evidence by Rodrik (2012).

to the symmetric model, both extensions reinforce the negative impact of capital inflows on U.S. productivity growth.

5.2 Implications for the real exchange rate

There is a long-standing interest in international macroeconomics on the consequences of capital flows in and out of the U.S. for the dollar (Obstfeld and Rogoff, 2005). We now revisit this issue with the help of our model. It turns out that, in our framework, capital flows toward the United States affect the U.S. real exchange rate through two contrasting channels. On the one hand, a surge in capital inflows sustains demand for U.S. goods and appreciates the U.S. real exchange rate. On the other hand, capital inflows depress U.S. productivity relative to developing countries in the tradable sector, pointing to a depreciation of the U.S. real exchange rate due to the Balassa-Samuelson effect. As we will see, these two effects tend to operate at different horizons, implying a non-monotonic response of the U.S. real exchange rate to changes in capital flows.

To make these results stand out, we modify our baseline model in one direction. We assume that firms operating in the tradable sector face diminishing returns from employing labor in production.[48] The production function (8) is therefore replaced by

$$Y_{i,t}^{T} = \left(\left(L_{i,t}^{T}\right)^{1-\alpha}\right)^{\gamma} \int_{0}^{1} \left(A_{i,t}^{j}\right)^{1-\alpha} \left(x_{i,t}^{j}\right)^{\alpha} dj, \tag{49}$$

where $0 < \gamma \leq 1$ captures the extent of decreasing returns. The real exchange rate is proportional to the relative price of consumption in the two groups of countries. In particular, the U.S. real exchange rate is given by

$$\left(\frac{P_{u,t}^{N}}{P_{d,t}^{N}}\right)^{1-\omega} = \left(\frac{1}{a_{d,t}}\right)^{1-\omega} \left(\frac{L_{d,t}^{T}}{L_{u,t}^{T}}\right)^{(1-\omega)(1-\gamma)}, \tag{50}$$

where recall that $a_{d,t} \equiv A_{d,t}/A_{u,t}$ denotes the proximity of developing countries to the technological frontier.

Equation (50) captures the two competing effects which shape the real exchange rate adjustment. On the one hand, higher demand for non tradables in the U.S. relative to developing countries appreciates the U.S. exchange rate. This effect is encapsulated by the term $L_{d,t}^{T}/L_{u,t}^{T}$ which increases when consumption of non tradables rises in the U.S. relative to developing countries.[49] On the other hand, a rise in developing countries' proximity to the frontier - i.e. a rise in $a_{d,t}$ - depreciates the U.S. real exchange rate. This is the Balassa-Samuelson effect.

We illustrate these effects in Figure 6, which shows the equilibrium path of the U.S. real exchange rate following financial integration. Specifically, in the figure, we repeat the experiment

[48] Results would be similar if we modified the production function in the non-tradable sector, or if we modified both production functions simultaneously.

[49] Note that in our baseline model ($\gamma = 1$), this effect is not visible in equilibrium. Intuitively, when the production function is linear, the sectoral labor allocation adjusts exactly so as to offset the impact of changes in demand on the relative price of non-tradable goods.

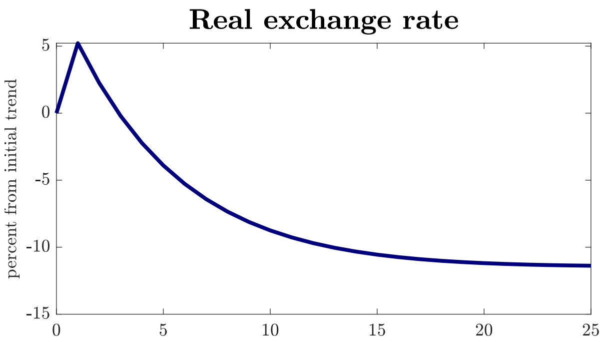


Figure 6: Transition from autarky to financial integration: real exchange rate Notes: the process of financial integration is captured by a gradual rise in κ_t, which is governed by (42). Financial integration is not anticipated by agents in periods $t < 1$. From period $t = 1$ on agents have perfect foresight.

from Section 4.3, but we assume for the sake of illustration that $\gamma = 0.8$, such that labor is characterized by decreasing returns. The figure shows that the U.S. real exchange rate first appreciates, but eventually depreciates.[50] This happens because it takes time for firms' investment to affect productivity. So, on impact, only the demand effect operates. The Balassa-Samuelson effect, instead, becomes stronger over time, and it dominates the demand one in the long run.

Hence, our model shows the key role played by endogenous productivity dynamics in affecting the exchange rate, and that as a result, the exchange rate response to capital flows may be non-monotonic and time dependent.

5.3 Export-led growth by developing countries

A widespread belief, especially in policy circles, is that productivity growth in developing countries can be fostered by policies that stimulate trade surpluses. For instance, Dooley et al. (2004) put this notion at the center of their Bretton Woods II perspective on the international monetary system. They argue that governments in East Asian countries have based their development strategy on export-led growth, supported by policies - such as capital controls and accumulation of foreign reserve assets - encouraging capital outflows toward the United States.[51]

Perhaps surprisingly, little research has been devoted to assess the viability of this growth strategy, especially when implemented on a global scale. In this section, we revisit this question through the lens of our framework. To do so, we trace the impact on the global economy of an increase in τ. A rise in τ, the reason is, can be interpreted as an increase in the subsidy imposed by governments in developing countries on capital outflows.

Let us start by focusing on the steady state. Combining (38) and (40) gives

$$a^{\phi}_{d,f} = \frac{\xi\left(\bar{L} + \frac{\Gamma\kappa(\beta(1+\tau)-1)}{a_{d,f}}\right)}{\chi(\bar{L} - \Gamma\kappa(\beta(1+\tau)-1))}. \tag{51}$$

[50] The empirical evidence, in fact, suggests that on impact capital inflows are associated with real exchange rate appreciations (Benigno et al., 2015).

[51] Consistent with this hypothesis, Alfaro et al. (2014) show that the positive correlation between capital outflows and productivity growth observed in developing countries is driven by public flows - especially in the form of large foreign reserve accumulation by the public sector of fast-growing East Asian economies.

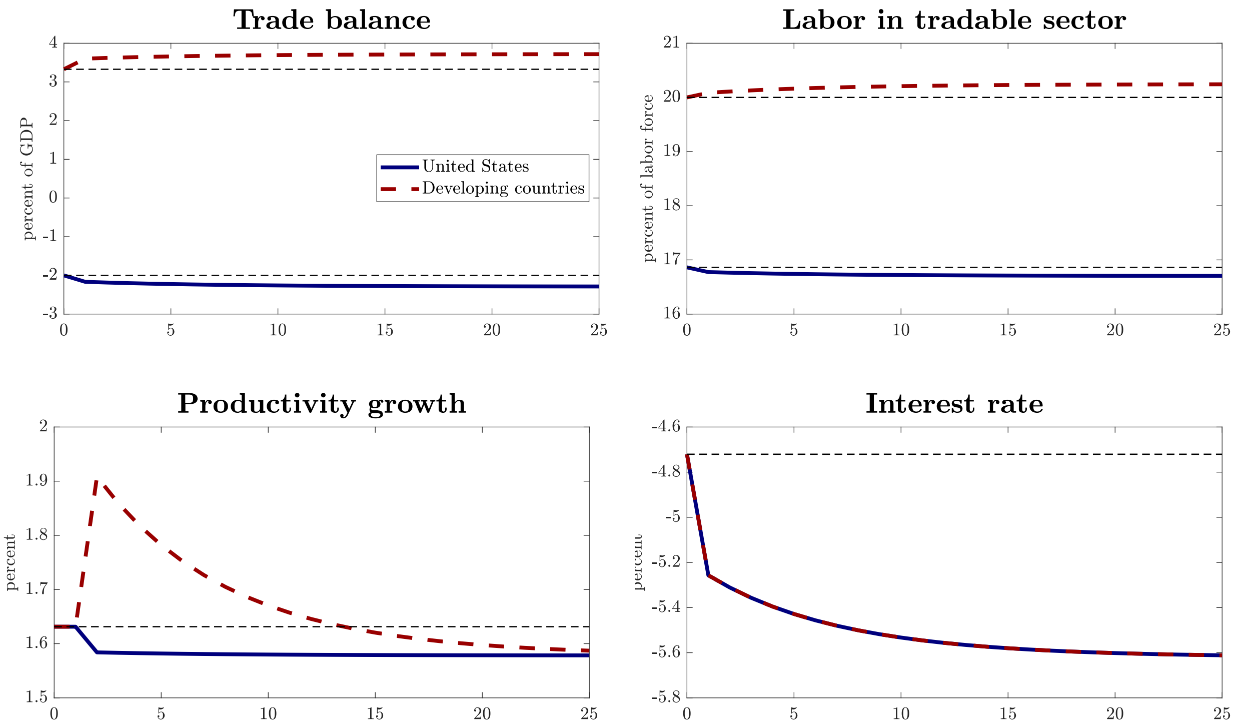


Figure 7: Export-led growth by developing countries. Notes: Response to a 1 percentage point permanent rise in τ, starting from the initial financial integration steady state. The rise in τ is not anticipated by agents in periods $t < 1$. From period $t = 1$ on agents have perfect foresight.

This expression implies that a rise in τ increases developing countries' proximity to the technological frontier. This result squares well with the notion of export-led growth. By subsidizing capital outflows, governments in developing countries increase economic activity in the tradable sector. This generates a rise in investment in technology adoption, which reduces the gap with the technological frontier.

The story, however, does not stop here. From equation (38), it is immediate to see that a rise in τ lowers the rate of productivity growth in the United States. As capital flows toward the United States, the U.S. tradable sector shrinks, inducing a drop in investment in innovation by U.S. firms. Through this effect, the export-led growth strategy pursued by developing countries depresses productivity growth in the United States. But innovation by the U.S. determines the world technological frontier, and thus the scope for technology adoption by developing countries. Hence, a rise in τ ends up depressing long-run productivity growth in developing countries, too.

Figure 7 shows the dynamic impact of a permanent rise in τ. Initially, developing countries experience a growth acceleration, as they narrow the gap with the technological frontier. In the long run, however, productivity growth in developing countries declines, and eventually converges to the U.S. one. The model thus suggests that an export-led growth strategy might be successful in raising productivity growth in the medium run. In the long run, however, this strategy might backfire and cause a drop in global productivity growth. This result sounds a note of caution on the use of export-led growth as a development strategy. These policies, in fact, can aggravate the global financial resource curse.

To conclude, let us note that the negative effects of export-led growth arise when this strategy is implemented on a global scale. To see this point, imagine that the developing countries region is composed of a continuum of small open economies. Then, an increase in the subsidy to capital outflows by a single country does not affect the rest of the world at all. Capital outflows from a single small open economy, in fact, are not large enough to affect economic activity in the United States. But this suggests that developing countries can fall in a coordination trap. A single small country, in fact, does not internalize the impact of its policies on the growth rate of the world technological frontier.[52] Therefore, avoiding the negative side effects triggered by export-led growth might require coordination among developing countries. Designing an optimal export-led growth strategy for developing countries is beyond the scope of this paper, but represents a promising area for future research.

5.4 Innovation policies in the United States

Governments frequently implement policies to foster innovation activities (Bloom et al., 2019). While innovation policies have been studied in the context of trade liberalization (Akcigit et al., 2018) or business cycle stabilization (Benigno and Fornaro, 2018), little is known about their relationship with capital flows. We now take a first stab at this issue, by showing how innovation policies can be designed in order to insulate U.S. productivity growth from the negative impact of financial globalization.

Imagine that the U.S. government subsidizes spending on innovation at rate $\iota_{u,t}$, so that equation (15) is replaced by

$$(1-\iota_{u,t})\frac{W_{u,t}}{\chi A_{u,t}} = \frac{\beta C^T_{u,t}}{C^T_{u,t+1}}\left(\varpi L^T_{u,t+1} + (1-\iota_{u,t+1})\frac{W_{u,t+1}}{\chi A_{u,t+1}}\right) \tag{52}$$

The subsidy $\iota_{u,t}$ is financed with lump-sum taxes on U.S. households. Now assume that, once the financial integration steady state is reached, the U.S. government subsidizes spending on innovation at rate

$$\iota_{u,f} = \frac{\chi\Gamma(1-\alpha\beta+\Gamma\Psi)}{(1+\Gamma\Psi)(\chi\bar{L}+1-\beta)}\kappa(\beta(1+\tau)-1). \tag{53}$$

This policy intervention implies that $g_f = g_a$,[53] and so that steady state growth is not affected by international capital flows. Notice that $\iota_{u,f}$ is increasing in the U.S. trade deficit, as captured by the term $\kappa(\beta(1+\tau)-1)$. As argued above, in steady state a larger U.S. trade deficit is associated

[52] Even the government of a country, large enough to internalize the impact of its policies on the world technological frontier, would have no incentives to take into account how its actions affect welfare in the rest of the world. Hence, also large developing countries might gain from coordinating their policy interventions.

[53] With the subsidy in place, equation (GG_u) is replaced by

$$g(1-\iota_u) = \beta(\chi\alpha L^T_u + (1-\iota_u)).$$

To derive the result for $\iota_{u,f}$, we re-derive equation (38) by assuming that $\iota_{u,a} = 0$, but that $\iota_{u,f} > 0$. We then set $g_f = g_a$ in this equation and solve for the implied level of $\iota_{u,f}$.

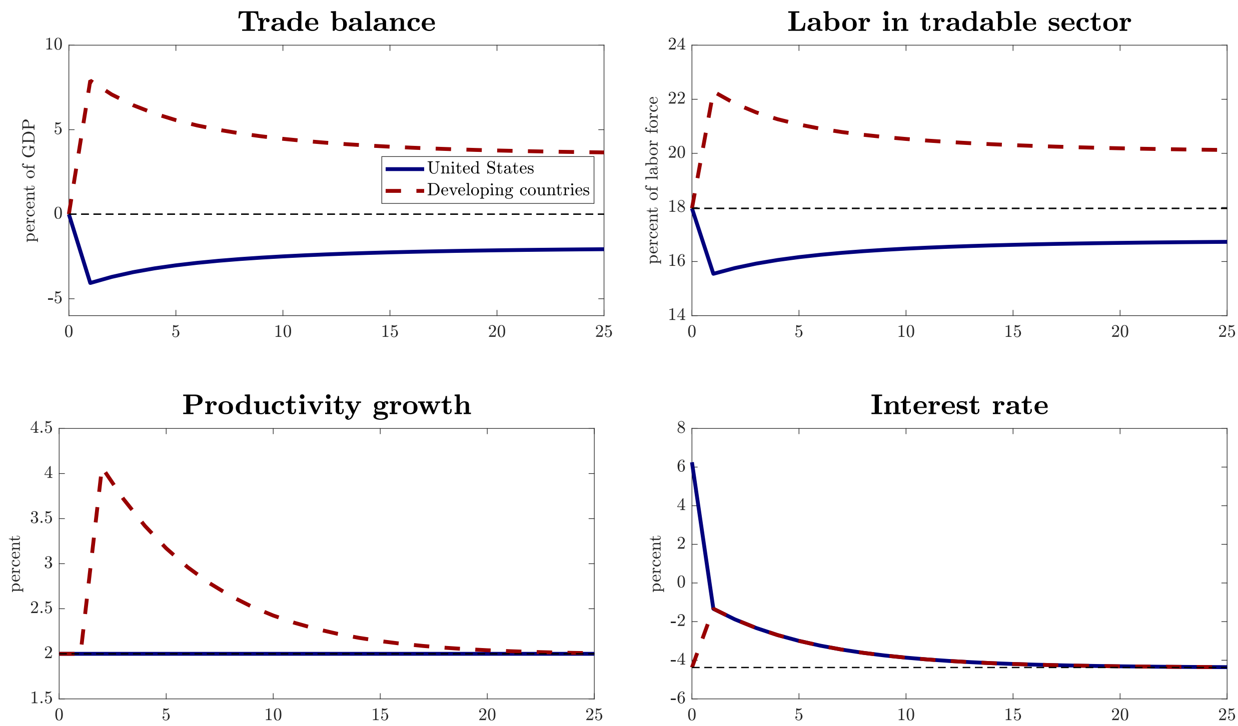


Figure 8: Innovation policies in the United States. Notes: the process of financial integration is captured by a gradual rise in κ_t, which is governed by (42). Financial integration is not anticipated by agents in periods $t < 1$. From period $t = 1$ on agents have perfect foresight. The U.S. government implements a subsidy on innovation to keep productivity growth equal to its value under financial autarky.

with lower incentives to innovate by U.S. firms. To counteract this effect, the U.S. government has to respond to larger capital inflows with more aggressive subsidies to innovation.

A similar insight applies to the transition toward the financial integration steady state. As shown by Figure 8, in order to prevent U.S. productivity growth from falling, the process of financial globalization has to be accompanied by a sharp rise in the subsidy $\iota_{u,t}$. Interestingly, with this policy in place financial globalization is associated with an acceleration in global growth in the medium run. The reason is that financial globalization triggers an expansion in the tradable sector in developing countries, encouraging technology adoption by developing countries' firms and pushing them closer to the technological frontier.

These results suggest that it is possible to couple financial globalization and a global saving glut with robust productivity growth. However, for this to happen, governments might need to implement policies supporting investment in innovation.

6 Conclusion

In this paper, we have presented a model to study the impact of financial integration on global productivity growth. We have shown that capital flows from developing countries to the United States can generate a global productivity growth slowdown, by triggering a fall in economic activity in the U.S. tradable sectors. We have dubbed this effect the global financial resource curse.

This paper represents just a first step in a broader research agenda. For instance, here we have just touched on the issue of policy interventions. But the world that we describe is ripe with externalities and international spillovers. It would then be interesting to use our model to design optimal policies to manage financial globalization. Moreover, in this paper we have abstracted from the impact of demand factors on aggregate employment and output. However, low interest rates are a key feature of our narrative. If equilibrium interest rates are too low, monetary policy might be unable to maintain full employment because of the zero lower bound constraint on nominal rates. To study these effects one should integrate nominal rigidities in this framework, in the spirit of the Keynesian growth model developed by Benigno and Fornaro (2018). This represents a promising area for future research.

Appendix (for online publication)

A Proofs

This appendix contains the proofs of all propositions.

A.1 Proof of Proposition 1

Proof. Existence of the steady state has been discussed in the main text. Moreover, in the financial autarky steady state, the terminal condition (25) holds with equality in all countries because $b_{i,t} = 0$ for all t.

We now prove uniqueness. First, consider that (RR_u) and (GG_u), once $c^T_{u,a}$ is substituted out, imply respectively a positive and negative relationship between $L^T_{u,a}$ and g_a. This means that there can be at most one value for $L^T_{u,a}$ and g_a consistent with equilibrium. Likewise, (RR_d) and (GG_d), once $c^T_{d,a}$ is substituted out, imply respectively a positive and negative relationship between $L^T_{d,a}$ and $a_{d,a}$. Again, this means that the equilibrium values of $L^T_{d,f}$ and $a_{d,f}$ are uniquely pinned down.

It is immediate to see that the first part of condition (35) implies $g_a > 1$, since the expression appearing in (35) equals exactly the equation for g_a in (33).

We now show that $\xi < \chi$ implies $a_{d,a} < 1$. Inserting g_a given by (33) into (34) yields

$$a^{\phi}_{d,a} = \frac{\beta\xi\alpha\bar{L}}{\frac{\alpha\beta(\chi\bar{L}+1-\beta)}{1+\Gamma\Psi+\alpha\beta}(1+\Gamma\Psi) + \alpha\beta\left(\frac{\alpha\beta(\chi\bar{L}+1-\beta)}{1+\Gamma\Psi+\alpha\beta} + \beta - 1\right)}.$$

Canceling $\alpha\beta$ and multiplying with $1 + \Gamma\Psi + \alpha\beta$, this can be written as

$$a^{\phi}_{d,a} = \frac{\xi\bar{L}(1+\Gamma\Psi+\alpha\beta)}{(1+\Gamma\Psi)(\chi\bar{L}+1-\beta) + \alpha\beta(\chi\bar{L}+1-\beta) - (1-\beta)(1+\Gamma\Psi+\alpha\beta)}.$$

The denominator can be simplified to $\chi\bar{L}(1+\Gamma\Psi+\alpha\beta)$. Canceling variables then leads to

$$a_{d,a}^{\phi} = \frac{\xi}{\chi}.$$

Since $\phi > 0$, then $\xi < \chi$ implies $a_{d,a} < 1$.

We are left with determining $R_{u,a}$ and $R_{d,a}$. Since households inside each region are symmetric and financial flows across regions are not allowed, it must be that $b_{i,t} = 0$. Credit market clearing inside each region then requires $\tilde{\mu}_{i,t} = 0$.[54] Using the households' Euler equations evaluated in steady state then gives $R_{u,a} = g_a/\beta$ and $R_{d,a} = g_a/(\beta(1+\tau))$. ■

A.2 Proof of Proposition 2

Proof. We first show that $R_f = g_f/((\beta(1+\tau))$. From the Euler equation in both regions (23), evaluated in steady state

$$\frac{\omega}{c_{u,f}^T} = R_f\left(\frac{\beta\omega}{g_f c_{u,f}^T} + \tilde{\mu}_{u,f}\right)$$
$$\frac{\omega}{c_{d,f}^T} = R_f(1+\tau)\left(\frac{\beta\omega}{g_f c_{d,f}^T} + \tilde{\mu}_{d,f}\right).$$

Since $\tau > 0$, it must be that $\tilde{\mu}_{u,f} > 0$ and $\tilde{\mu}_{d,f} = 0$ to ensure the credit markets clear.[55] U.S. households are therefore borrowing constrained in steady state, and so $b_{u,f} = -\kappa$. Moreover, developing countries' Euler equation implies

$$R_f = \frac{g_f}{\beta(1+\tau)}. \tag{36}$$

Since $b_{u,f} = -\kappa = -b_{d,f}$, tradable consumption in both regions is

$$c_{u,f}^T = \Psi L_{u,f}^T - \kappa\left(1 - \frac{g_f}{R_f}\right) = \Psi L_{u,f}^T + \kappa\left(\beta(1+\tau) - 1\right)$$
$$c_{d,f}^T = \Psi a_{d,f} L_{d,f}^T + \kappa\left(1 - \frac{g_f}{R_f}\right) = \Psi a_{d,f} L_{u,f}^T - \kappa\left(\beta(1+\tau) - 1\right),$$

where we have used (36). To complete the proof of existence, note that the terminal conditions (25) are satisfied for all countries in the financial integration steady state described. For households in

[54] Strictly speaking, if $\kappa = 0$ then $\tilde{\mu}_{i,t} = 0$ is not a necessary condition for credit markets to clear. This implies that with $\kappa = 0$ interest rates are not uniquely pinned down in equilibrium. This source of multiplicity, however, disappears as soon as $\kappa > 0$. We therefore impose the equilibrium refinement condition $\tilde{\mu}_{i,t} = 0$ also for the case $\kappa = 0$.

[55] More precisely, if $\kappa = 0$ then $\tilde{\mu}_{d,f} = 0$ is not a necessary condition for credit markets to clear. This implies that with $\kappa = 0$ interest rates are not uniquely pinned down in equilibrium. This source of multiplicity, however, disappears as soon as $\kappa > 0$. We therefore impose the equilibrium refinement condition $\tilde{\mu}_{d,f} = 0$ also for the case $\kappa = 0$.

developing countries, this equation becomes

$$\lim_{k\to\infty} \frac{b_{d,f} g_f^k}{R_f^k (1+\tau)^k} = \lim_{k\to\infty} \beta^k b_{d,f} = 0,$$

where we have used equation (36). For households in the U.S., instead, this equation becomes

$$\lim_{k\to\infty} \frac{b_{u,f} g_f^k}{R_f^k} = \lim_{k\to\infty} \frac{(-\kappa) g_f^k}{R_f^k} = -\infty < 0,$$

where we used that $\beta(1+\tau) > 1$ implying that $R_f < g_f$. In the U.S., the terminal condition is thus satisfied with strict inequality.

We next prove uniqueness. First, consider that (RR_u) and (GG_u), once $c_{u,f}^T$ is substituted out, imply respectively a positive and negative relationship between $L_{u,f}^T$ and g_f. This means that there can be at most one value for $L_{u,f}^T$ and g_f consistent with equilibrium. Likewise, (RR_d) and (GG_d), once $c_{d,f}^T$ is substituted out, imply respectively a positive and negative relationship between $L_{d,f}^T$ and $a_{d,f}$. Again, this means that the equilibrium values of $L_{d,f}^T$ and $a_{d,f}$ are uniquely pinned down.

We now turn to the condition (41) stated in Proposition 2. From combining (GG_u) and (RR_u) the growth rate under financial integration is given by

$$g_f = \beta \left(\frac{\alpha(\chi \bar{L} + 1 - \beta - \chi \Gamma \kappa (\beta(1+\tau) - 1))}{1 + \Psi\Gamma + \alpha\beta} + 1 \right),$$

which corresponds to (38) in the main text after inserting (33). Therefore, the first part of condition (41) guarantees that $g_f > 1$. Moreover, it is easy to check that if $g_f > 1$ then it must be that $L_{u,f}^T > 0$.

We are left to prove that $a_{d,f} < 1$. Start by combining (GG_d) and (RR_d) to derive an equation for $a_{d,f}$

$$a_{d,f}^{\phi} = \frac{\alpha\beta\xi \left(\bar{L} + \Gamma \frac{\kappa(\beta(1+\tau)-1)}{a_{d,f}} \right)}{(g_f - \beta)(1 + \Gamma\Psi) + (g_f - 1)\alpha\beta}, \tag{40}$$

which corresponds to (40) from the main text. Inserting g_f using (38) and taking identical steps as in Appendix A.1 this can be written as

$$a_{d,f}^{\phi} = \frac{\xi \left(\bar{L} + \frac{\Gamma\kappa(\beta(1+\tau)-1)}{a_{d,f}} \right)}{\chi(\bar{L} - \Gamma\kappa(\beta(1+\tau) - 1))}.$$

The left-hand side of this expression is increasing in $a_{d,f}$, while the right-hand side is decreasing in it. Hence, $a_{d,f} < 1$ if and only if

$$\frac{\xi \left(\bar{L} + \Gamma\kappa(\beta(1+\tau) - 1) \right)}{\chi(\bar{L} - \Gamma\kappa(\beta(1+\tau) - 1))} < 1,$$

which, after rearranging, corresponds to the second part of condition (41). ■

B Lab equipment model

In this appendix we consider a lab equipment model, in which investment in R&D requires units of the final tradable good, rather than labor. To anticipate our main result, this version of the model preserves all the insights of the one in the main text.

B.1 Changes to economic environment

The only change, with respect to the model in the main text, is that here investment in innovation requires units of the traded final good. In particular, the law of motion for productivity of a generic U.S. firm j now becomes

$$A^j_{u,t+1} = A^j_{u,t} + \chi I^j_{u,t},$$

where $I^j_{u,t}$ captures investment in research - in terms of the tradable final good - by intermediate goods firm j. This equation replaces (14) of the baseline model. Thus firms' profits net of expenditure in research become

$$\Pi^j_{u,t} = \varpi A^j_{u,t} L^j_{u,t} - I_{j,t}.$$

As in the main text, firms choose investment in innovation to maximize their discounted stream of profits

$$\sum_{t=0}^{\infty} \frac{\omega \beta^t}{C^T_{u,t}} \Pi^j_{u,t}.$$

In an interior optimum ($I^j_{u,t} > 0$), optimal investment requires

$$\frac{1}{\chi} = \frac{\beta C^T_{u,t}}{C^T_{u,t+1}} \left(\varpi L^T_{u,t+1} + \frac{1}{\chi} \right)$$

which replaces (17). Similarly, we replace (16) for developing countries with

$$A^j_{d,t+1} = A^j_{d,t} + \xi \left(\frac{A_{u,t}}{A_{d,t}} \right)^{\phi} I^j_{d,t}.$$

Profit maximization leads to the first order condition

$$\frac{1}{\xi} \left(\frac{A_{u,t}}{A_{d,t}} \right)^{-\phi} = \frac{\beta C^T_{d,t}}{C^T_{d,t+1}} \left(\varpi L^T_{d,t+1} + \frac{1}{\xi} \left(\frac{A_{u,t+1}}{A_{d,t+1}} \right)^{-\phi} \right).$$

Aggregation and market clearing works as follows. First, value added in the tradable sector is still given by (18). Market clearing for the non-tradable good is still given by (19). However, the market clearing condition for tradable goods is now given by

$$C_{i,t} + I_{i,t} + \frac{B_{i,t+1}}{R_{i,t}} = \Psi A_{i,t} L^T_{i,t} + B_{i,t},$$

where $I_{i,t} = \int_0^1 I^j_{i,t} dj$ is the total amount of tradable goods devoted to investment in region i. This equation replaces (20) in the main text. Finally, asset market clearing is still given by (21), whereas labor market clearing (22) is replaced by

$$\bar{L} = L_{i,t}^N + L_{i,t}^T.$$

B.2 Equilibrium

As it was the case for the baseline model, the model can be cast in terms of three "blocks" . These blocks capture, in turn, the paths of tradable consumption and capital flows, the behavior of productivity, and the resource constraint.

First, the households' Euler equation becomes

$$\frac{\omega}{c_{i,t}^T} = R_{i,t}(1+\tau_{i,t})\left(\frac{\beta\omega}{g_{t+1}c_{i,t+1}^T} + \tilde{\mu}_{i,t}\right),$$

where the borrowing limit is given by

$$b_{i,t+1} \geq -\kappa_t a_{i,t+1} \quad \text{with equality if} \quad \tilde{\mu}_{i,t} > 0.$$

and where the market clearing conditions for the tradable good and for bonds are

$$c_{i,t}^T + i_{i,t} + \frac{g_{t+1}b_{i,t+1}}{R_{i,t}} = \Psi a_{i,t} L_{i,t}^T + b_{i,t}$$

$$b_{u,t} = -b_{d,t}.$$

Second, optimal investment in innovation by U.S. firms implies

$$g_{t+1} = \frac{\beta c_{u,t}^T}{c_{u,t+1}^T}\left(\chi\varpi L_{u,t+1}^T + 1\right),$$

while optimal investment in technology adoption by firms in developing countries requires

$$a_{d,t}^\phi = \frac{\beta c_{d,t}^T}{g_{t+1}c_{d,t+1}^T}\left(\xi\varpi L_{d,t+1}^T + a_{d,t+1}^\phi\right).$$

The law of motion for productivity can be written as

$$g_{t+1} = 1 + \chi i_{u,t},$$

in the U.S., and as

$$g_{t+1}a_{d,t+1} = a_{d,t} + \xi a_{d,t}^{-\phi} i_{d,t},$$

in the developing countries.

Third and last, the labor market clearing condition can be written as

$$L_{u,t}^T = \bar{L} - \Gamma c_{u,t}^T$$

for the U.S., as well as

$$L_{d,t}^T = \bar{L} - \Gamma \frac{c_{d,t}^T}{a_{d,t}}$$

for the developing countries.

B.3 Results

We now provide a brief comparison of the steady states under financial autarky and financial integration. To do so, we next derive the analogues of the (GG_u), (RR_u) as well as (GG_d) and (RR_d) curves. Starting with the U.S., note that the (GG_u) curve is now given by

$$g = \beta(\chi \varpi L_u^T + 1), \tag{GG_u}$$

and is thus almost identical as in the baseline model (the only difference being that α is replaced by the composite parameter ϖ).

In turn, the (RR_u) curve is now given by

$$L_u^T = \bar{L} - \Gamma \left(\Psi L_u^T + b_u \left(1 - \frac{g}{R} \right) \right) + \Gamma \frac{g-1}{\chi}, \tag{RR_u}$$

the term $b_u(1 - g/R)$ capturing capital flows. Notice that $b_u = 0$ under financial autarky, but $b_u = -\kappa$ under international financial integration. Moreover, in the latter case $1 - g/R = \beta(1+\tau) - 1$.

Relative to the baseline model, a key difference of the current environment is that (RR_u) posits another positive relationship between L_u^T and g, i.e. both (GG_u) and (RR_u) are upward sloping lines in (L_u^T, g) space. However, the slope of (RR_u) is necessarily larger than the slope of (GG_u), since

$$\chi \frac{(1+\Gamma\Psi)}{\Gamma} = \chi \left(\Psi + \frac{1}{\Gamma} \right) = \chi \left(\frac{1+\alpha}{\alpha} \varpi + \frac{1}{\Gamma} \right) > \chi \beta \varpi,$$

which follows from $0 < \alpha < 1$, $\beta < 1$, $\chi > 0$, $\varpi > 0$ and $\Gamma > 0$.[56]

Therefore, the impact of financial integration is as in the baseline model: a shift of the (RR_u) curve to the left triggered by capital inflows reduces g and L_u^T. Formally,

$$g_a = \beta \left(\frac{\varpi(\chi \bar{L} - (1-\beta)\Gamma)}{1 + \Gamma(\Psi - \beta\varpi)} + 1 \right)$$

under financial autarky (compare (33) from the main text), but

$$g_f = g_a - \frac{\varpi \beta \chi \Gamma}{1 + \Gamma(\Psi - \beta\varpi)} \kappa(\beta(1+\tau) - 1) < g_a$$

[56] Recall the definitions of $\Psi \equiv \alpha^{\frac{2\alpha}{1-\alpha}}(1-\alpha^2)$ and $\varpi \equiv \alpha^{\frac{2}{1-\alpha}}(1/\alpha - 1)$. Hence $\Psi/\varpi = (1+\alpha)/\alpha$.

under international financial integration (compare (38) from the main text). The last inequality follows again from $\Psi > \varpi$ (as argued above) and all parameters being positive.

The impact of financial integration on developing countries is also the same as in the baseline model. In fact, the (GG_d) curve is now given by

$$a_d^\phi = \frac{\beta\xi\varpi L_d^T}{g-\beta}, \tag{GG_d}$$

and is therefore almost identical as in the baseline model. In turn, the (RR_d) curve is given by

$$L_d = \bar{L} - \Gamma\left(\Psi L_d^T + \frac{b_d}{a_d}\left(1-\frac{g}{R}\right)\right) + \Gamma\frac{(g-1)a_d^\phi}{\xi}. \tag{RR_d}$$

Compared with the baseline model, the difference is (again) that (RR_d) in the current model posits a positive relationship between a_d^ϕ and L_d^T, with a slope coefficient strictly larger than that of (GG_d). Therefore, capital outflows which shift (RR_d) to the right necessarily raise both a_d and L_d^T - as in the baseline model. Formally,

$$a_{d,a}^\phi = \frac{\varpi\beta\xi\bar{L}}{(g_a-\beta)(1+\Gamma\Psi)-(g_a-1)\varpi\beta\Gamma}$$

under financial autarky (compare (34) from the main text), but

$$a_{d,f}^\phi = \frac{\varpi\beta\xi\left(\bar{L}+\Gamma\frac{\kappa(\beta(1+\tau)-1)}{a_{d,f}}\right)}{(g_f-\beta)(1+\Gamma\Psi)-(g_f-1)\varpi\beta\Gamma} > a_{d,a}$$

under financial integration (compare (40) from the main text). Hence, our qualitative results on the impact of financial integration on steady state productivity growth are robust to the assumption that investment in innovation is done in terms of the traded final good.

C The case $R_f > g_f$

In the main text, we had assumed that developing countries' propensity to save, captured by $\tau > 0$, is large enough to guarantee that the return on U.S. bonds is below the growth rate of the economy in the financial integration steady state ($R_f < g_f$). As we argued in the main text, this is the empirically relevant case at least in the last decades. Nonetheless, there remains substantial uncertainty about whether interest rates will remain persistently low in the future. In this Appendix we therefore ask how our results would change if we instead assume that $R_f > g_f$ under financial integration.

As it is easy to see, in the financial integration steady state our results would flip, as growth would accelerate in the U.S. (and therefore globally) due to persistent capital outflows giving rise to a larger U.S. tradable sector. This happens because, being a net debtor, the U.S. is forced to run trade balance surpluses in order to maintain a constant net-liabilities position in steady state.

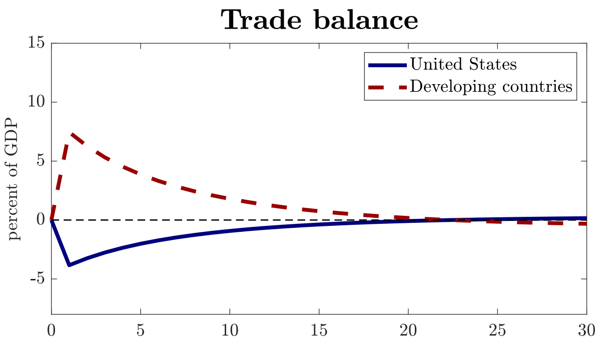


Figure 9: Transition from autarky to financial integration when $\beta(1+\tau) < 1$. Notes: the process of financial integration is captured by a gradual rise in κ_t, which is governed by (42). Financial integration is not anticipated by agents in periods $t < 1$. From period $t = 1$ on agents have perfect foresight.

In the long run, financial integration therefore leads to a regime of higher productivity growth.

However, this does not imply that the global financial resource curse does not play a role in this case, as it still arises in the medium run. To illustrate this, we repeat the numerical exercise from Section 4.3, but we now assume that the U.S. runs a trade balance *surplus* equal to 0.25% of GDP in the financial integration steady state. From equation (37), a U.S. trade balance surplus requires that $\beta(1+\tau) < 1$ or, equivalently, that $R_f > g_f$.[57]

Figure 9 shows the result. We find that, in the medium run, the model exhibits the same dynamics as in our baseline parametrization. As the two regions integrate financially, capital starts flowing toward the U.S. which generates a fall in the growth rate of U.S. productivity. Again as in the baseline model, developing countries experience an initial productivity growth acceleration.

Overall, this exercise suggests that the emergence of a global financial resource curse does not depend on whether the U.S. trade balance is in deficit or surplus in the final steady state. In fact, even if financial integration generates U.S. trade balance surpluses and faster global productivity growth in the long run, the transition might still be characterized by a long-lasting global productivity growth slowdown.

D Technological leapfrogging by developing countries

Our baseline model focuses on a scenario in which the United States permanently retains its technological leadership, so that $A_{u,t} > A_{d,t}$ for all t. In this appendix, we consider an alternative scenario in which developing countries may technologically leapfrog the U.S. in the long run. Our formalization follows closely Barro and Sala-i Martin (1997).

Let us start by allowing innovation activities to take place in developing countries as well. If

[57] Targeting a trade balance surplus of 0.25% to GDP leads to $\tau = 0.033$, rather than $\tau = 0.11$ as in our baseline (see footnote 39). As it turns out, because developing countries' households are more patient under this alternative calibration, the adjustment after financial liberalization is somewhat slowed down relative to our baseline. We therefore plot results until 30 years (rather than 25 years) after the start of financial integration.

firms in developing countries choose to innovate, their productivity evolves according to

$$A^j_{d,t+1} = A^j_{d,t} + \xi A_{d,t} L^j_{d,t}. \tag{D.1}$$

If instead firms in developing countries choose to adopt technologies originating from the U.S. their productivity evolves according to equation (16). Clearly, it is profitable for firms in developing countries to innovate rather than imitate if and only if $A_{d,t} > A^{\phi}_{u,t} A^{1-\phi}_{d,t}$, or equivalently, if $A_{d,t} > A_{u,t}$.[58] Symmetrically, we assume that U.S. firms can imitate technological discoveries made in developing countries, in which case their technology evolves as

$$A^j_{u,t+1} = A^j_{u,t} + \chi A^{1-\phi}_{u,t} A^{\phi}_{d,t} L^j_{u,t}. \tag{D.2}$$

Comparing this with equation (14) reveals that imitation is cheaper than innovation for U.S. firms if and only if $A_{u,t} < A^{1-\phi}_{u,t} A^{\phi}_{d,t}$, or $A_{u,t} < A_{d,t}$. In sum, if $A_{d,t} > A_{u,t}$ the world technological leadership passes from the U.S. to developing countries, and investment in innovation by developing countries becomes the driver of improvements in the world technological frontier.

Under what conditions does technological leapfrog occur in equilibrium? Using equation (40), one can see that under financial integration developing countries eventually become the technological leaders if

$$\kappa(\beta(1+\tau) - 1) > \frac{\bar{L}}{\Gamma} \frac{\chi - \xi}{\chi + \xi}. \tag{D.3}$$

There are two reasons why developing countries may become the technological leaders in the long run. First, independently of the size of capital flows, this occurs if firms in developing countries are intrinsically better at innovation activities than firms in the United States (i.e. if $\xi > \chi$). In this case, developing countries would eventually leapfrog the U.S. even under financial autarky. The second, and perhaps more interesting, case is one in which leapfrogging occurs due to financial integration. That is, if capital flows are sufficiently large (i.e. if $\kappa(\beta(1+\tau) - 1)$ is big enough), developing countries may eventually become the global technological leaders even if investment in innovation is more productive in the United States (i.e. if $\xi < \chi$). As we argued before, this happens because capital outflows increase the profitability of investing in innovation for firms in developing countries. If this effect is strong enough, financial integration can be the trigger of a change in the world's technological leadership.

Let us now revisit the impact of financial integration on global growth. There are two cases to consider. First, imagine that $\xi > \chi$, so that developing countries are more productive in performing research than the United States. In this case, regardless of the financial regime, in the balanced growth path developing countries are the technological leaders and global productivity growth is

[58] For simplicity, we assume that ξ captures the efficiency of both innovation and imitation activities in developing countries. By allowing different efficiencies of innovation and imitation, one could capture a scenario in which developing countries start innovating before or after they reach the level of productivity in the U.S. (Barro and Sala-i Martin, 1997).

equal to

$$g = \beta(\xi\alpha L_d^T + 1).$$

Now recall that, in developing countries, financial integration is associated with capital outflows and a larger size of the tradable sector (i.e. higher L_d^T). Hence, in this scenario financial integration boosts global growth.

But now imagine that $\xi < \chi$, so that the U.S. have an advantage in performing research compared to developing countries. Under financial autarky, it is the United States who retain the global technological leadership, so that global growth is given by expression (33), which we rewrite here for convenience

$$g_a = \beta \left(\frac{\alpha \left(\chi \bar{L} + 1 - \beta \right)}{1 + \Gamma\Psi + \alpha\beta} + 1 \right).$$

Now consider a case in which condition (D.3) holds, so that upon financial integration developing countries leapfrog the United States in the new balanced growth path. It is then easy to show that under financial integration global growth is equal to

$$g_f = g_a - \alpha\beta \frac{(\chi - \xi)\bar{L} - \xi\Gamma\kappa \left(\beta(1 + \tau) - 1 \right)}{1 + \Gamma\Psi + \alpha\beta}. \tag{D.4}$$

This expression reveals that now financial integration may lead to a drop in global growth. The reason is that developing countries are less efficient at performing research compared to the United States. So now the global financial resource curse takes a new form, in the sense that financial integration may push developing countries to become the world technological leaders, even if they have a disadvantage in performing research compared to the United States.

E Additional extensions and policy scenarios

In this Appendix, we complement the analysis in Section 5 by studying three additional extensions and policy scenarios. First, we outline the model extension where innovation activities also take place in non-tradable sectors. Second, we study the global implications of a sudden stop in capital inflows hitting the United States. Third, we study the global implications of the U.S. imposing barriers to capital inflows.

E.1 Growth in both sectors

This Appendix develops a version of the model in which investment in R&D and productivity growth take place in both sectors (see Section 5.1). We start with a case where the growth process in the tradable and non-tradable sectors is symmetric, and then we turn to two potential sources of asymmetry. To streamline the analysis, we focus only on the U.S. economy.

E.1.1 Symmetric model

The household side of the economy is unchanged with respect to the baseline model, so we start directly by describing firms' behavior.

Final good firms. The final output of tradable and non-tradable goods is given respectively by

$$Y_{u,t}^{T} = \left(L_{u,t}^{T}\right)^{1-\alpha^T} \int_0^1 \left(A_{u,t}^{j,T}\right)^{1-\alpha^T} \left(x_{u,t}^{j,T}\right)^{\alpha^T} dj$$
$$Y_{u,t}^{N} = \left(L_{u,t}^{N}\right)^{1-\alpha^N} \int_0^1 \left(A_{u,t}^{j,N}\right)^{1-\alpha^N} \left(x_{u,t}^{j,N}\right)^{\alpha^N} dj.$$

Both sectors thus share a symmetric technology, but may be characterized by different levels of intensities of factors of production ($\alpha^T \neq \alpha^N$). Moreover, intermediate inputs are sector specific ($x_{u,t}^{j,T} \neq x_{u,t}^{j,N}$), meaning that the two sectors can be characterized by different productivities ($A_{u,t}^{j,T} \neq A_{u,t}^{j,N}$). Demand for labor is then given by

$$(1-\alpha^T)\left(L_{u,t}^{T}\right)^{-\alpha^T} \int_0^1 \left(A_{u,t}^{j,T}\right)^{1-\alpha^T} \left(x_{u,t}^{j,T}\right)^{\alpha^T} dj = W_{u,t} \tag{E.1}$$
$$P_{u,t}^{N}(1-\alpha^N)\left(L_{u,t}^{N}\right)^{-\alpha^N} \int_0^1 \left(A_{u,t}^{j,N}\right)^{1-\alpha^N} \left(x_{u,t}^{j,N}\right)^{\alpha^N} dj = W_{u,t}. \tag{E.2}$$

As in the baseline model, perfect mobility of labor ensures that the wage is equalised across the two sectors. Demand for intermediate inputs is given by

$$\alpha^T \left(L_{u,t}^{T}\right)^{1-\alpha^T} \left(A_{u,t}^{j,T}\right)^{1-\alpha^T} \left(x_{u,t}^{j,T}\right)^{\alpha^T-1} = P_{u,t}^{j,T}$$
$$P_{u,t}^{N}\alpha^N \left(L_{u,t}^{N}\right)^{1-\alpha^N} \left(A_{u,t}^{j,N}\right)^{1-\alpha^N} \left(x_{u,t}^{j,N}\right)^{\alpha^N-1} = P_{u,t}^{j,N}.$$

Intermediate goods production and profits. Every intermediate good is produced by a single monopolist. In the tradable sector, one unit of the tradable good is needed to manufacture one unit of intermediate inputs. Symmetrically, in the non-tradable sector, one unit of the non-tradable good is required to produce one unit of intermediate inputs. Hence, the per period profits of monopolists in the tradable sector are $P_{u,t}^{j,T} x_{u,t}^{j,T} - x_{u,t}^{j,T}$, while per period profits in the non-tradable sector are $P_{u,t}^{j,N} x_{u,t}^{j,N} - P_{u,t}^{N} x_{u,t}^{j,N}$. Optimal pricing the implies

$$P_{u,t}^{j,T} = \frac{1}{\alpha^T}$$
$$P_{u,t}^{j,N} = \frac{P_{u,t}^{N}}{\alpha^N}$$

so that the equilibrium quantity of intermediate goods is

$$
\begin{aligned}
x_{u,t}^{j,T} &= (\alpha^T)^{\frac{2}{1-\alpha^T}} A_{u,t}^{j,T} L_{u,t}^T \\
x_{u,t}^{j,N} &= (\alpha^N)^{\frac{2}{1-\alpha^N}} A_{u,t}^{j,N} L_{u,t}^N
\end{aligned}
$$

and profits are

$$
\begin{aligned}
P_{u,t}^{j,T} x_{u,t}^{j,T} - x_{u,t}^{j,T} &= \varpi^T A_{u,t}^{j,T} L_{u,t}^T \\
P_{u,t}^{j,N} x_{u,t}^{j,N} - P_{u,t}^N x_{u,t}^{j,N} &= P_{u,t}^N \varpi^N A_{u,t}^{j,N} L_{u,t}^N,
\end{aligned}
$$

where $\varpi^T \equiv (1/\alpha^T - 1)(\alpha^T)^{2/(1-\alpha^T)}$ and $\varpi^N \equiv (1/\alpha^N - 1)(\alpha^N)^{2/(1-\alpha^N)}$.

Innovation. Sectoral productivity evolves according to

$$
\begin{aligned}
A_{u,t+1}^{j,T} &= A_{u,t}^{j,T} + \chi^T A_{u,t}^T L_{u,t}^{j,N} \\
A_{u,t+1}^{j,N} &= A_{u,t}^{j,N} + \chi^N A_{u,t}^N L_{u,t}^{j,N},
\end{aligned}
$$

where $L_{u,t}^{j,T}$ and $L_{u,t}^{j,N}$ denote the amount of research labor employed by firm j in sector T and N, respectively. In turn, aggregate productivity in each sector is denoted $A_{u,t}^T \equiv \int_0^1 A_{u,t}^{j,T} dj$ as well as $A_{u,t}^N \equiv \int_0^1 A_{u,t}^{j,N} dj$. Notice that the efficiency of research may differ across the two sectors ($\chi^T \neq \chi^N$).

Firms' optimal investment in research maximises the expected profits

$$
\begin{aligned}
&\sum_{t=0}^{\infty} \frac{\omega \beta^t}{C_{u,t}^T} \left(\varpi^T A_{u,t}^{j,T} L_{u,t}^T - W_{u,t} L_{u,t}^{j,T} \right) \\
&\sum_{t=0}^{\infty} \frac{\omega \beta^t}{C_{u,t}^T} \left(P_{u,t}^N \varpi^N A_{u,t}^{j,N} L_{u,t}^N - W_{u,t} L_{u,t}^{j,N} \right)
\end{aligned}
$$

subject to the respective law of motion of technology in each sector. Their first order conditions are given by

$$
\frac{W_{u,t}}{\chi^T A_{u,t}^T} = \frac{\beta C_{u,t}^T}{C_{u,t+1}^T} \left(\varpi^T L_{u,t+1}^T + \frac{W_{u,t+1}}{\chi^T A_{u,t+1}^T} \right) \tag{E.3}
$$

$$
\frac{W_{u,t}}{\chi^N A_{u,t}^N} = \frac{\beta C_{u,t}^T}{C_{u,t+1}^T} \left(P_{u,t+1}^N \varpi^N L_{u,t+1}^N + \frac{W_{u,t+1}}{\chi^N A_{u,t+1}^N} \right), \tag{E.4}
$$

which completes the description of the intermediate goods firms.

Aggregation and market clearing. Value added is final output in each sector net of the amount used to produce intermediate goods

$$Y_{u,t}^{T}-\int_{0}^{1}x_{u,t}^{j,T}dj=\Psi^{T}A_{u,t}^{T}L_{u,t}^{T}$$
$$P_{u,t}^{N}\left(Y_{u,t}^{N}-\int_{0}^{1}x_{u,t}^{j,N}dj\right)=P_{u,t}^{N}\Psi^{N}A_{u,t}^{N}L_{u,t}^{N},$$

where $\Psi^T=(\alpha^T)^{2\alpha^T/(1-\alpha^T)}(1-(\alpha^T)^2)$ and $\Psi^N=(\alpha^N)^{2\alpha^N/(1-\alpha^N)}(1-(\alpha^N)^2)$. The goods market clearing conditions then are

$$C_{u,t}^{T}+\frac{B_{u,t+1}}{R_{u,t}}=\Psi^{T}A_{u,t}^{T}L_{u,t}^{T}+B_{u,t}$$
$$C_{u,t}^{N}=\Psi^{N}A_{u,t}^{N}L_{u,t}^{N}.$$

Finally, the labor market clears when

$$\bar{L}=L_{u,t}^{T}+L_{u,t}^{N}+L_{u,t}^{R,T}+L_{u,t}^{R,N},$$

where $L_{u,t}^{R,T}\equiv\int_0^1 L_{u,t}^{j,T}dj$ and $L_{u,t}^{R,N}\equiv\int_0^1 L_{u,t}^{j,N}dj$ are total research labor employed in the tradable and non-tradable sectors.

Equilibrium conditions. We next derive equations (43)-(46) in Section 5.1 of the main text. Let us start from equations (43)-(44). We first insert the equilibrium value of $x_{u,t}^{j,T}$ in equation (E.1) to obtain

$$(1-\alpha^{T})\alpha^{\frac{2\alpha^{T}}{1-\alpha^{T}}}A_{u,t}^{T}=W_{u,t}.$$

Combining this expression with (E.3) and using

$$(1-\alpha^{T})\alpha^{\frac{2\alpha^{T}}{1-\alpha^{T}}}=\frac{1}{\alpha^{T}}\left(\frac{1}{\alpha^{T}}-1\right)(\alpha^{T})^{\frac{2}{1-\alpha^{T}}}=\frac{\varpi^{T}}{\alpha^{T}}$$

gives

$$\frac{1}{\chi^{T}}=\frac{\beta C_{u,t}^{T}}{C_{u,t+1}^{T}}\left(\alpha^{T}L_{u,t+1}^{T}+\frac{1}{\chi^{T}}\right).$$

Defining $c_{u,t}^T\equiv C_{u,t}^T/A_{u,t}^T$ and $g_{u,t}^T=A_{u,t}^T/A_{u,t-1}^T$ gives equation (43) in the main text.

Inserting the equilibrium value of $x_{u,t}^{j,N}$ in equation (E.2) gives

$$P_{u,t}^{N}(1-\alpha^{N})\alpha^{\frac{2\alpha^{N}}{1-\alpha^{N}}}A_{u,t}^{N}=W_{u,t}.$$

Again, using

$$(1-\alpha^{N})\alpha^{\frac{2\alpha^{N}}{1-\alpha^{N}}}=\frac{1}{\alpha^{N}}\left(\frac{1}{\alpha^{N}}-1\right)(\alpha^{N})^{\frac{2}{1-\alpha^{N}}}=\frac{\varpi^{N}}{\alpha^{N}}$$

we can write

$$P_{u,t}^{N}\frac{\varpi^{N}}{\alpha^{N}}A_{u,t}^{N}=W_{u,t}.$$

Inserting this expression in equation (E.4) gives

$$\frac{W_{u,t}}{\chi^N A_{u,t}^N} = \frac{\beta C_{u,t}^T}{C_{u,t+1}^T}\left(\frac{W_{u,t+1}}{A_{u,t+1}^N}\alpha^N L_{u,t+1}^N + \frac{W_{u,t+1}}{\chi^N A_{u,t+1}^N}\right).$$

Substituting the equilibrium value for $W_{u,t}$ we can write

$$\frac{A_{u,t}^T}{\chi^N A_{u,t}^N} = \frac{\beta C_{u,t}^T}{C_{u,t+1}^T}\left(\frac{A_{u,t+1}^T}{A_{u,t+1}^N}\alpha^N L_{u,t+1}^N + \frac{A_{u,t+1}^T}{\chi^N A_{u,t+1}^N}\right),$$

which again using $c_{u,t}^T \equiv C_{u,t}^T / A_{u,t}^T$ becomes

$$\frac{1}{\chi^N A_{u,t}^N} = \frac{\beta c_{u,t}^T}{c_{u,t+1}^T}\left(\frac{1}{A_{u,t+1}^N}\alpha^N L_{u,t+1}^N + \frac{1}{\chi^N A_{u,t+1}^N}\right).$$

Using the definition $g_{u,t}^N = A_{u,t}^N / A_{u,t-1}^N$ gives equation (44) in the main text.

We next turn to expression (46). Note that households' optimal allocation of expenditure between the two consumption goods implies

$$C_{u,t}^N = \frac{1-\omega}{\omega}\frac{C_{u,t}^T}{P_{u,t}^N}.$$

Using $C_{u,t}^N = \Psi^N A_{u,t}^N L_{u,t}^N$ and the equilibrium expression for $P_{u,t}^N$, we obtain

$$\Psi^N A_{u,t}^N L_{u,t}^N = \frac{1-\omega}{\omega}\frac{C_{u,t}^T}{W_{u,t}}\frac{\varpi^N}{\alpha^N}A_{u,t}^N.$$

Canceling $A_{u,t}^N$ and using the equilibrium expression for $W_{u,t}$ gives

$$\Psi^N L_{u,t}^N = \frac{C_{u,t}^T}{A_{u,t}^T}\frac{1-\omega}{\omega(1-\alpha^T)\alpha^{\frac{2\alpha^T}{1-\alpha^T}}}\frac{\varpi^N}{\alpha^N}.$$

Using $c_{u,t}^T \equiv C_{u,t}^T / A_{u,t}^T$ and

$$\frac{\Psi^N}{\varpi^N} = \frac{1+\alpha^N}{\alpha^N},$$

yields expression (46) in the main text. The labor market clearing, equation (45), has already been derived above.

Aggregate growth. We compute aggregate growth g_u as the sum of the growth rates of sectoral value added, weighted by their respective employment shares. There are three sectors, the two goods-producing sectors and the research sector. As shown before, value added in the tradable and non-tradable sectors, in terms of the tradable goods, are respectively equal to $\Psi^T A_{u,t}^T L_{u,t}^T$ and $P_{u,t}^N \Psi^N A_{u,t}^N L_{u,t}^N$. Value added in the research sector is $W_{u,t}(L_{u,t}^{R,T} + L_{u,t}^{R,N})$.

To obtain real value added, we deflate value added in each sector with the relative price of the good produced by that sector with respect to the tradable good. In the tradable sector, the deflator thus equals one. In the non-tradable sector, instead, the deflator is $P^N_{u,t}$. Finally, in the research sector the deflator is $W_{u,t}$. Hence, the sectoral real value added are $\Psi^T A^T_{u,t} L^T_{u,t}$, $\Psi^N A^N_{u,t} L^N_{u,t}$ and $L^{R,T}_{u,t} + L^{R,N}_{u,t}$. On the balanced growth path, these grow respectively at rates g^T_u, g^N_u and 1. On the balanced growth path, aggregate growth is thus given by

$$g_u = \frac{L^T_u}{\bar{L}} g^T_u + \frac{L^N_u}{\bar{L}} g^N_u + \frac{L^{R,T}_u + L^{R,N}_u}{\bar{L}},$$

which is the expression used in the main text.

E.1.2 Tradable inputs in the production of non-tradables

We now break the symmetry across the two sectors. We start by considering a case in which the production of non-traded goods requires tradable goods as intermediate inputs. This is meant to capture a scenario in which manufactured goods are used as intermediate inputs in the production of nontradable services.

Intermediate goods production and profits. In the non-tradable sector, one unit of the tradable good is now needed to produce one unit of intermediate inputs. Intermediate goods firms in the non-tradable sector thus maximize profits $P^{j,N}_{u,t} x^{j,N}_{u,t} - x^{j,N}_{u,t}$, subject to the usual demand from firms producing the final good. The optimality condition is now

$$P^{j,N}_{u,t} = \frac{1}{\alpha^N}.$$

As a result, the equilibrium quantity of intermediate inputs produced is

$$x^{j,N}_{u,t} = (P^N_{u,t})^{\frac{1}{1-\alpha^N}} (\alpha^N)^{\frac{2}{1-\alpha^N}} A^{j,N}_{u,t} L^N_{u,t}$$

and firms' equilibrium profits are

$$P^{j,N}_{u,t} x^{j,N}_{u,t} - x^{j,N}_{u,t} = (P^N_{u,t})^{\frac{1}{1-\alpha^N}} \varpi^N A^{j,N}_{u,t} L^N_{u,t},$$

where ϖ^N is the same as before.

Innovation. In the non-tradable sector, the investment problem is the same as before. However, the first order condition changes because firms' monopoly profits are different. Namely, we now obtain the first order condition

$$\frac{W_{u,t}}{\chi^N A^N_{u,t}} = \frac{\beta C^T_{u,t}}{C^T_{u,t+1}} \left((P^N_{u,t+1})^{\frac{1}{1-\alpha^N}} \varpi^N L^N_{u,t+1} + \frac{W_{u,t+1}}{\chi^N A^N_{u,t+1}} \right).$$

In the tradable sector, the first order condition is the same as before.

Aggregation and market clearing. Sectoral value added is respectively given by

$$Y_{u,t}^{T} - \int_0^1 x_{u,t}^{j,T} dj = \Psi^T A_{u,t}^T L_{u,t}^T$$

$$P_{u,t}^N Y_{u,t}^N - \int_0^1 x_{u,t}^{j,N} dj = (P_{u,t}^N)^{\frac{1}{1-\alpha^N}} \left((\alpha^N)^{\frac{2\alpha^N}{1-\alpha^N}} - (\alpha^N)^{\frac{2}{1-\alpha^N}} \right) A_{u,t}^N L_{u,t}^N.$$

The goods market clearing conditions now become

$$C_{u,t}^T + \frac{B_{u,t+1}}{R_{u,t}} = \Psi^T A_{u,t}^T L_{u,t}^T - (P_{u,t}^N)^{\frac{1}{1-\alpha^N}} (\alpha^N)^{\frac{2}{1-\alpha^N}} A_{u,t}^N L_{u,t}^N + B_{u,t}$$
$$C_{u,t}^N = (P_{u,t}^N)^{\frac{\alpha^N}{1-\alpha^N}} (\alpha^N)^{\frac{2\alpha^N}{1-\alpha^N}} A_{u,t}^N L_{u,t}^N.$$

The labor market clearing conditions are the same as in the version of the model with symmetric sectors.

Equilibrium conditions. The wage $W_{u,t}$ is given by

$$(1-\alpha^T)\alpha^{\frac{2\alpha^T}{1-\alpha^T}} A_{u,t}^T = W_{u,t}. \tag{E.5}$$

Inserting the equilibrium for $x_{u,t}^{j,N}$ in equation (E.2) gives

$$(P_{u,t}^N)^{\frac{1}{1-\alpha^N}} (1-\alpha^N)\alpha^{\frac{2\alpha^N}{1-\alpha^N}} A_{u,t}^N = W_{u,t}. \tag{E.6}$$

Inserting, productivity growth in the two sectors evolve as in the symmetric model, according to

$$g_{u,t+1}^N = \beta \frac{c_{u,t}^T}{c_{u,t+1}^T} (\chi^N \alpha^N L_{u,t+1}^N + 1)$$

$$g_{u,t+1}^T = \beta \frac{c_{u,t}^T}{c_{u,t+1}^T} (\chi^T \alpha^T L_{u,t+1}^T + 1),$$

The labor market clearing condition, with research labor replaced by the law of motion for technology, is also unchanged from before and is given by

$$\bar{L} = L_{u,t}^T + L_{u,t}^N + \frac{g_{u,t+1}^T - 1}{\chi^T} + \frac{g_{u,t+1}^N - 1}{\chi^N}.$$

We have three out of four equations in the four variables $(g_{u,t}^T, g_{u,t}^N, L_{u,t}^T, L_{u,t}^N)$, for given $c_{u,t}^T$. The equation missing is the link between $c_{u,t}^T$ and $L_{u,t}^N$. To obtain this equation, we again start from households' first order condition

$$C_{u,t}^N = \frac{1-\omega}{\omega} \frac{C_{u,t}^T}{P_{u,t}^N}.$$

We insert goods market clearing for non-tradables to obtain

$$(P_{u,t}^N)^{\frac{\alpha^N}{1-\alpha^N}}(\alpha^N)^{\frac{2\alpha^N}{1-\alpha^N}}A_{u,t}^N L_{u,t}^N = \frac{1-\omega}{\omega}\frac{C_{u,t}^T}{P_{u,t}^N}.$$

Multiplying with $P_{u,t}^N$, and replacing $(P_{u,t}^N)^{1/(1-\alpha^N)}$ with its equilibrium expression gives

$$W_{u,t}(\alpha^N)^{\frac{2\alpha^N}{1-\alpha^N}}L_{u,t}^N = \frac{1-\omega}{\omega(1-\alpha^N)\alpha^{\frac{2\alpha^N}{1-\alpha^N}}}C_{u,t}^T.$$

Last, replacing $W_{u,t}$ by its equilibrium expression, we obtain

$$L_{u,t}^N = \frac{1-\omega}{\omega(1-\alpha^N)\alpha^{\frac{4\alpha^N}{1-\alpha^N}}(1-\alpha^T)\alpha^{\frac{2\alpha^T}{1-\alpha^T}}}c_{u,t}^T \equiv \tilde{\tilde{\Gamma}}c_{u,t}^T.$$

Aggregate growth. Again we define the growth rate of aggregate GDP as a labor-force weighted average of the growth rates of real value added in the economy's respective sectors.

In the tradable sector, real value added is $\Psi^T A_{u,t}^T L_{u,t}^T$, and so in the balanced growth path it grows at rate g_u^T. Turning to the non-tradable sector, real value added is

$$\frac{(P_{u,t}^N)^{\frac{1}{1-\alpha^N}}\left((\alpha^N)^{\frac{2\alpha^N}{1-\alpha^N}}-(\alpha^N)^{\frac{2}{1-\alpha^N}}\right)A_{u,t}^N L_{u,t}^N}{P_{u,t}^N} = \frac{(P_{u,t}^N)^{\frac{1}{1-\alpha^N}}\frac{A_{u,t}^N}{A_{u,t}^T}\left((\alpha^N)^{\frac{2\alpha^N}{1-\alpha^N}}-(\alpha^N)^{\frac{2}{1-\alpha^N}}\right)L_{u,t}^N}{P_{u,t}^N/A_{u,t}^T}.$$

Since the wage is equalized across sectors, $(P_{u,t}^N)^{\frac{1}{1-\alpha^N}}(A_{u,t}^N/A_{u,t}^T)$ is a constant (see equations (E.5) and (E.6)). This implies that on the balanced growth path $P_{u,t}^N$ grows at rate $(1-\alpha^N)(g_u^T-g_u^N)$. It follows that, on the balanced growth path, real value added in the non-tradable sector grows at rate $\alpha^N g_u^T + (1-\alpha^N)g_u^N$.

Hence, now output growth in the non-tradable sector partly depends on productivity growth in the tradable one. The reason is that higher productivity in the production of tradables reduces the cost of the intermediate inputs used by firms in the non-tradable sector, leading to an increase in the output of non-tradable goods. In a sense, productivity growth in the tradable sector now partly spills over to the non-tradable one. The weight with which this happens is α^N, which captures the intensity with which tradable intermediates enter the production of non-tradable goods.

Finally, in the research sector we deflate value added by using $W_{u,t}$, which implies that real value added, on the balanced growth path, is constant.

Aggregate growth on the balanced growth path is thus equal to

$$g_u = \frac{L_u^T}{\bar{L}}g_u^T + \frac{L_u^N}{\bar{L}}(\alpha^N g_u^T + (1-\alpha^N)g_u^N) + \frac{L_u^{R,T}+L_u^{R,N}}{\bar{L}}.$$

As in the main text, we assume that labor allocated to research is small, implying that $L_u^{R,T}$ +

$L_u^{R,N} \approx 0$, so that

$$\begin{aligned} g_u &= \frac{L_u^T}{\bar{L}} g_u^T + \frac{\bar{L} - L_u^T}{\bar{L}} (\alpha^N g_u^T + (1-\alpha^N) g_u^N) \\ &= (1-\alpha^N) \left(\frac{L_u^T}{\bar{L}} g_u^T + \frac{\bar{L} - L_u^T}{\bar{L}} g_u^N \right) + \alpha^N g_u^T. \end{aligned}$$

Compared to the symmetric model, now the weight attached to productivity growth in the tradable sector is higher. Following the steps outlined above, the derivative of aggregate growth with respect to a change in the sectoral composition of production can be written as

$$\frac{\partial g_u}{\partial (L_u^T/\bar{L})} = (1-\alpha^N) 2 (g_u^T - g_u^N) + \alpha^N \frac{g_u^T - \beta}{L_u^T/\bar{L}}.$$

Now suppose that - consistent with empirical evidence - $g_u^T > \beta$ and $L_u^T/\bar{L} < 1/2$. Then, compared to the symmetric model, a reallocation of labor from the tradable to the non-tradable sector now produces a bigger drop in productivity growth. In particular, the higher α^N the more the drop in growth is amplified compared to the symmetric model.

E.1.3 Heterogeneity in knowledge spillovers

We now consider a version of the model in which knowledge is more excludable in the tradable sector compared to the non-tradable one, meaning that it is easier for firms to appropriate the social return from investment in innovation in the tradable sector compared to the non-tradable one. This extension is interesting, because it may help explain why empirically the bulk of innovation activities takes place within tradable sectors.

To explore this possibility, we now generalize the process of knowledge accumulation to

$$A_{u,t+1}^{j,T} = A_{u,t}^{j,T} + \chi^T (A_{u,t}^{j,T})^{\lambda^T} (A_{u,t}^T)^{1-\lambda^T} L_{u,t}^{j,T} \tag{E.7}$$

$$A_{u,t+1}^{j,N} = A_{u,t}^{j,N} + \chi^N (A_{u,t}^{j,N})^{\lambda^N} (A_{u,t}^N)^{1-\lambda^N} L_{u,t}^{j,N}. \tag{E.8}$$

The parameters $0 \leq \lambda^T \leq 1$ and $0 \leq \lambda^N \leq 1$ capture the degree of excludability of knowledge in the two sectors. Our baseline model corresponds to the case $\lambda^T = \lambda^N = 0$, that is to a low degree of knowledge excludability. In this case - when investing in innovation - firms build exclusively on the aggregate stock of knowledge. As λ^k rises firms in sector k rely more on their own private stock of knowledge when performing innovation. Indeed, the case $\lambda^T = \lambda^N = 1$ corresponds to a scenario in which knowledge is perfectly excludable, and there are no knowledge spillovers across U.S. firms.

Compared to the baseline model, this change in the process of knowledge accumulation only affects the optimal investment decisions of firms producing intermediate goods. We go through these next and then discuss the implications for aggregate growth.

Optimal investment in innovation. Firms' optimal investment maximizes profits

$$\sum_{t=0}^{\infty}\frac{\omega\beta^t}{C_{u,t}^T}\left(\varpi^T A_{u,t}^{j,T}L_{u,t}^T - W_{u,t}L_{u,t}^{j,T}\right)$$
$$\sum_{t=0}^{\infty}\frac{\omega\beta^t}{C_{u,t}^T}\left(P_{u,t}^N\varpi^N A_{u,t}^{j,N}L_{u,t}^N - W_{u,t}L_{u,t}^{j,N}\right)$$

subject to equations (E.7)-(E.8). The first order conditions are

$$\frac{W_{u,t}}{\chi^T(A_{u,t}^{j,T})^{\lambda_T}(A_{u,t}^T)^{1-\lambda_T}} =$$
$$\frac{\beta C_{u,t}^T}{C_{u,t+1}^T}\left(\varpi^T L_{u,t+1}^T + \frac{W_{u,t+1}}{\chi^T(A_{u,t+1}^{j,T})^{\lambda^T}(A_{u,t+1}^T)^{1-\lambda^T}}\left(1+\lambda^T\chi^T(A_{u,t+1}^{j,T})^{\lambda^T-1}(A_{u,t+1}^T)^{1-\lambda^T}L_{u,t+1}^{j,T}\right)\right).$$

in the tradable sector and

$$\frac{W_{u,t}}{\chi^N(A_{u,t}^{j,T})^{\lambda^N}(A_{u,t}^N)^{1-\lambda^N}} =$$
$$\frac{\beta C_{u,t}^T}{C_{u,t+1}^T}\left(P_{u,t+1}^N\varpi^N L_{u,t+1}^N + \frac{W_{u,t+1}}{\chi^N(A_{u,t+1}^{j,N})^{\lambda^N}(A_{u,t+1}^N)^{1-\lambda^N}}\left(1+\lambda^N\chi^N(A_{u,t+1}^{j,N})^{\lambda^N-1}(A_{u,t+1}^N)^{1-\lambda^N}L_{u,t+1}^{j,N}\right)\right).$$

in the non-tradable one. In equilibrium, $A_{u,t}^{j,T} = A_{u,t}^T$ as well as $A_{u,t}^{j,N} = A_{u,t}^N$, and the first order conditions simplify to

$$\frac{W_{u,t}}{\chi^T A_{u,t}^T} = \frac{\beta C_{u,t}^T}{C_{u,t+1}^T}\left(\varpi^T L_{u,t+1}^T + \frac{W_{u,t+1}}{\chi^T A_{u,t+1}^T}\left(1+\lambda^T\chi^T L_{u,t+1}^{j,T}\right)\right)$$
$$\frac{W_{u,t}}{\chi^N A_{u,t}^N} = \frac{\beta C_{u,t}^T}{C_{u,t+1}^T}\left(P_{u,t+1}^N\varpi^N L_{u,t+1}^N + \frac{W_{u,t+1}}{\chi^N A_{u,t+1}^N}\left(1+\lambda^N\chi^N L_{u,t+1}^{j,N}\right)\right).$$

By using the law of motion for technology, this simplifies further to

$$\frac{W_{u,t}}{\chi^T A_{u,t}^T} = \frac{\beta C_{u,t}^T}{C_{u,t+1}^T}\left(\varpi^T L_{u,t+1}^T + \frac{W_{u,t+1}}{\chi^T A_{u,t+1}^T}\left(1+\lambda^T\frac{A_{u,t+2}^T - A_{u,t+1}^T}{A_{u,t+1}^T}\right)\right)$$
$$\frac{W_{u,t}}{\chi^N A_{u,t}^N} = \frac{\beta C_{u,t}^T}{C_{u,t+1}^T}\left(P_{u,t+1}^N\varpi^N L_{u,t+1}^N + \frac{W_{u,t+1}}{\chi^N A_{u,t+1}^N}\left(1+\lambda^N\frac{A_{u,t+2}^N - A_{u,t+1}^N}{A_{u,t+1}^N}\right)\right).$$

The equilibrium expressions for $W_{u,t}$ and $P_{u,t}^N$ are the same as in the symmetric model, hence we obtain the equilibrium growth rates in the tradable and non-tradable sector

$$g_{u,t+1}^T = \beta\frac{c_{u,t}^T}{c_{u,t+1}^T}(\chi^T\alpha^T L_{u,t+1}^T + 1 + \lambda^T(g_{u,t+2}^T - 1)) \tag{E.9}$$
$$g_{u,t+1}^N = \beta\frac{c_{u,t}^T}{c_{u,t+1}^T}(\chi^N\alpha^N L_{u,t+1}^N + 1 + \lambda^N(g_{u,t+2}^N - 1)). \tag{E.10}$$

Note that, once $\lambda^T > 0$ and $\lambda^N > 0$, firms now internalize that a higher innovation today raises the return from innovating again in the future.

Aggregate growth. Following the steps outlined in previous section, and again focusing on the approximation $L_u^{R,T} + L_u^{R,N} \approx 0$, aggregate growth in the balanced growth path can be written as

$$g_u = \frac{L_u^T}{\bar{L}} \frac{\beta(\chi^T \alpha^T L_u^T + 1 - \lambda^T)}{1 - \beta\lambda^T} + \frac{\bar{L} - L_u^T}{\bar{L}} \frac{\beta(\chi^N \alpha^N (\bar{L} - L_u^T) + 1 - \lambda^N)}{1 - \beta\lambda^N}.$$

Taking the derivative with respect to the share of labor in the tradable sector gives

$$\frac{\partial g_u}{\partial(L_u^T/\bar{L})} = 2(g_u^T - g_u^N) - \beta\left(\frac{1-\lambda^T}{1-\beta\lambda^T} - \frac{1-\lambda^N}{1-\beta\lambda^N}\right).$$

If $\lambda^T = \lambda^N$ the response of aggregate productivity growth to a reallocation of labor from the tradable to the non-tradable sector is exactly the same as in the symmetric model. However, as λ^T increases relative to λ^N the drop in growth generated by capital inflows is magnified with respect to the symmetric model.

Intuitively, the case $\lambda^T > \lambda^N$ corresponds to a scenario in which it is easier to appropriate the social return from innovation for firms in the tradable sector compared to the non-tradable one.[59] Now consider that a higher λ^k is associated with a higher elasticity of investment in innovation to changes in profits in sector k. Hence, when $\lambda^T > \lambda^N$, capital inflows produce a bigger drop in investment in innovation in the tradable sector than investment in innovation rises in the non-tradable one. This effect explains why the drop in aggregate productivity growth triggered by capital inflows is larger the bigger the difference $\lambda^T - \lambda^N$.

E.2 A sudden stop in capital flows toward the United States

The possibility that the United States might suffer a sudden stop in capital inflows is recurrently debated by policymakers and academics (Obstfeld and Rogoff, 2000, 2007; Krugman, 2014). Little effort, however, has been devoted to understand how global growth would respond to an abrupt reduction in the U.S. trade deficit, triggered by a sudden stop. Our analysis so far might suggest that an improvement in the U.S. trade balance would lead to higher global growth. But matters are not so simple. As we argue in this section, a reduction in the U.S. trade deficit triggered by a sudden stop in capital flows is likely to result in a drop in global productivity growth.

We consider a scenario in which a fall in foreign demand for U.S. assets induces a sharp improvement in the U.S. trade balance. Formally, we assume that in period $t = 1$ a previously unexpected drop in foreign agents' demand for U.S. bonds $\tau_{d,t}$ occurs. From period $t = 2$ on, $\tau_{d,t}$

[59] We are not aware of any empirical evidence on the sectoral strength of knowledge spillovers from investing innovation. However, the case $\lambda^T > \lambda^N$ may not be empirically implausible. As we have seen, in the U.S. the bulk of innovation activities takes place in manufacturing, a typical tradable sector. While many factors could explain this fact, one possibility is that - due to technological reasons - firms in manufacturing are better able to appropriate the social return from innovation than firms operating in other sectors.

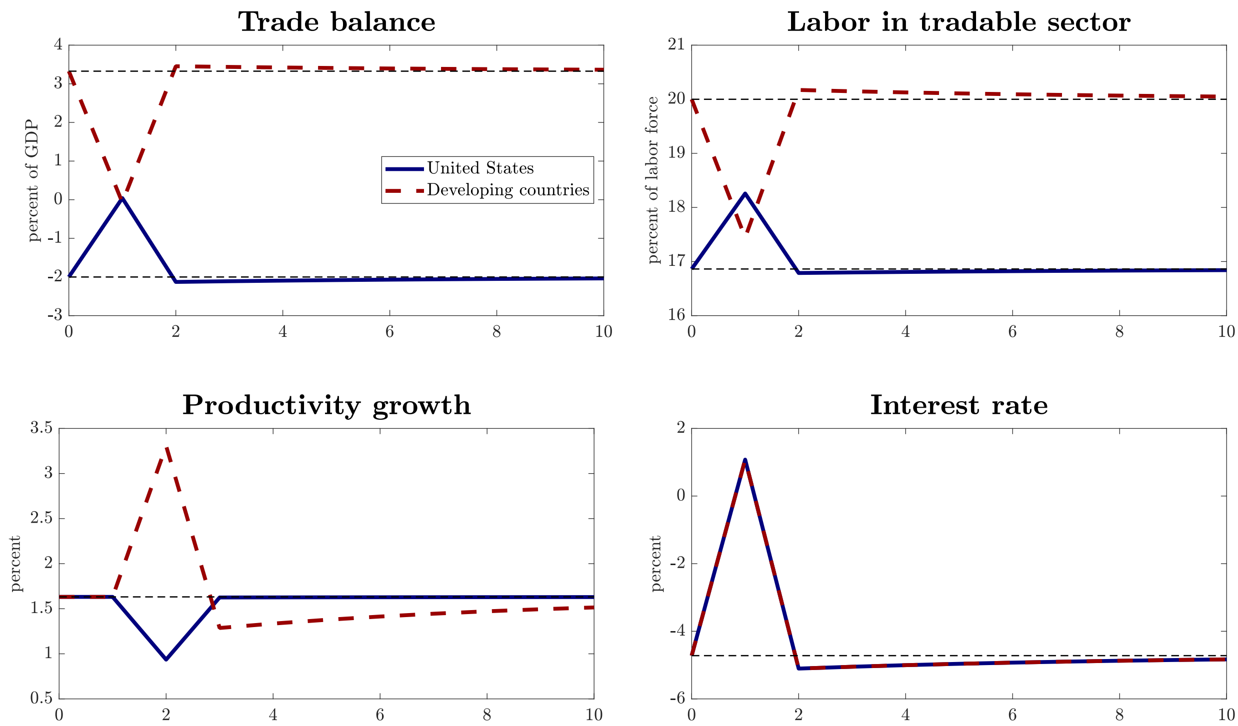


Figure 10: Sudden stop in the United States. Notes: the sudden stop is captured by a temporary reversal in the propensity to save by developing countries $\tau_{d,t}$. In period $t = 1$, $\tau_{d,t}$ unexpectedly declines such that the U.S. trade balance reverses from -2% of GDP to zero. From period $t = 2$ onwards, $\tau_{d,t}$ moves back to its steady state value. From period $t = 1$ on agents have perfect foresight.

goes back to its initial steady state value.[60] The results are displayed in Figure 10.

First, the drop in demand for bonds by households in developing countries generates a rise in the world interest rate. In turn, U.S. households respond by reducing their debt positions, which causes a sharp improvement in the U.S. trade balance. The adjustment in the U.S. trade balance is accomplished with a combination of lower consumption and higher production of tradable goods in the United States.

Perhaps surprisingly, in spite of the rise in economic activity in the tradable sector, investment in innovation by U.S. firms drops. The reason is that the sudden stop results in a rise in the cost of funds for U.S. firms. The drop in consumption by U.S. households, in fact, translates into a rise in the rate at which U.S. firms discount future profits. Moreover, since the improvement in the U.S. trade balance is not persistent, the rise in economic activity in the U.S. tradable sector is short lived, and so does not increase by much firms' return from investing in innovation. Since the cost-of-funds effect dominates the profit effect, the sudden stop causes a temporary slowdown in U.S. productivity growth (recall the discussion at the end of Section 4.3). While productivity growth eventually recovers, the sudden stop is associated with a permanent reduction in the level of output in the United States. This result is in line with the empirical observation that sudden stops tend to be accompanied by permanent output drops (Cerra and Saxena, 2008; Ates and

[60] We obtain very similar results by modeling the sudden stop as a short-lived reduction in the U.S. borrowing limit κ_t.

Saffie, 2016; Queralto, 2019)

In developing countries, instead, productivity growth initially rises. In fact, as capital flies away from the United States, the cost of investment in developing countries drops. This burst in investment and growth is only temporary, however, and it is followed by a productivity growth slowdown. Once again, this is due to the fact that lower productivity growth in the U.S. eventually drags down productivity growth in developing countries too. As a result, albeit with a lag, the sudden stop experienced by the U.S. ends up causing a permanent output drop in developing countries too. Summing up, in our model, a sudden stop in capital flows toward the United States causes a temporary slowdown in global productivity growth.

E.3 Capital account policies in the United States

In response to the recent productivity growth slowdown, a host of policies have been proposed to revive growth in the United States. In the main text we have focused on innovation policies, such as subsidies to R&D investment, directly aiming at fostering firms' innovation activities. In this appendix we briefly discuss another proposal, that consists in stimulating growth by reducing the trade deficits that the United States runs against the rest of the world.

Ultimately, in order to achieve smaller trade deficits, net capital inflows toward the United States have to fall. To achieve this objective, the U.S. government could impose barriers to capital inflows, for instance in the form of capital controls or financial regulation. In our framework, the impact of these policies can be studied by considering a permanent tightening in the U.S. borrowing limit, that is a drop in κ.[61]

Let us begin by considering the steady state. Using equation (38), it is easy to see that a drop in κ leads to an acceleration in U.S. productivity growth in the long run. A lower κ, the reason is, reduces the U.S. trade deficit. Lower trade deficits, in turn, are associated with lower consumption of non-tradable goods by U.S. households. The result is an increase in economic activity in the U.S. tradable sector, at the expense of the non-tradable one. This induces U.S. firms to increase their investment in innovation, which fosters productivity growth. Hence, a policy-induced reduction in U.S. trade deficits leads to faster productivity growth in the long run.

Developing countries are going to be affected as well. Equation (51), in fact, implies that a lower κ reduces developing countries' proximity to the frontier. As it should be clear by now, lower capital outflows from developing countries depress economic activity in their tradable sector, which slows down the process of technology adoption. In spite of this, in the long run developing countries enjoy faster productivity growth, due to the rise in innovation activities in the United States. These contrasting effects are illustrated by Figure 11, which shows the dynamic impact of an increase in the barriers to capital inflows in the United States. Initially, productivity growth in developing countries experiences a sharp slowdown. It is then easy to imagine that policymakers in developing economies might have a negative view on these policies. In the long run, however,

[61] For instance, the U.S. government could achieve a drop in κ by imposing on its citizens a borrowing limit tighter than the market one.

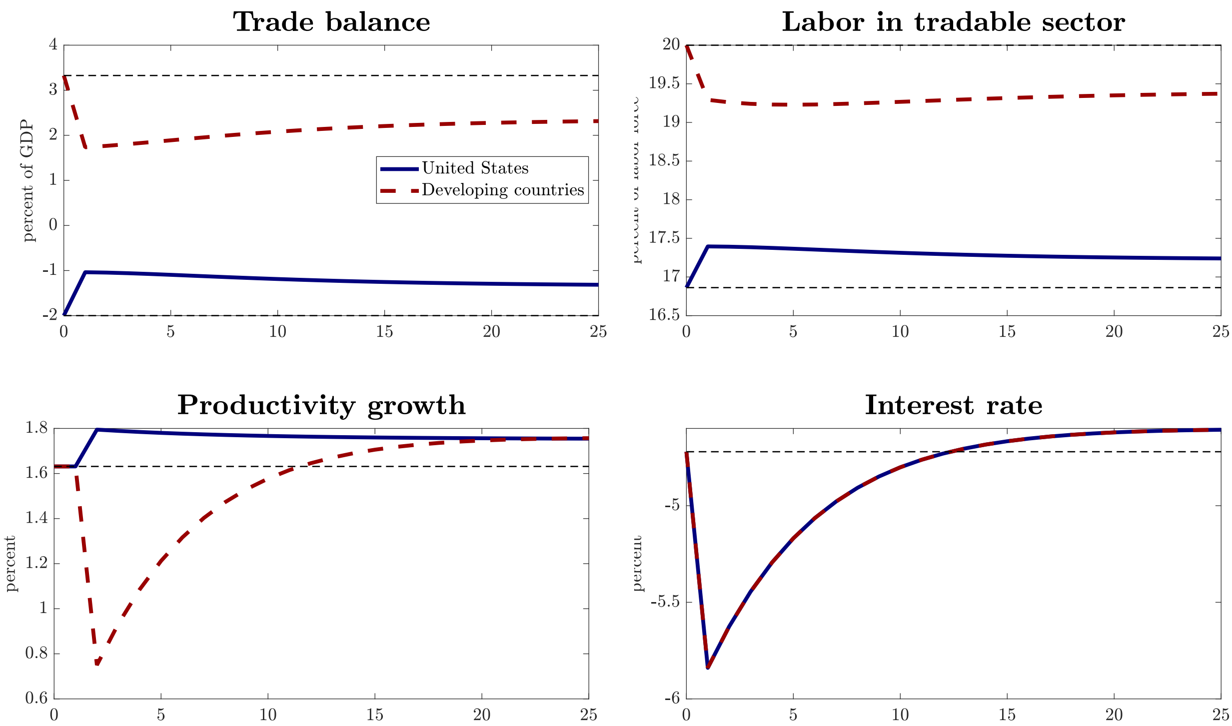


Figure 11: Barriers to capital inflows in the United States. Notes: Response to a decline in κ generating a 10% long-run drop in the U.S. foreign debt-to-GDP ratio, relative to the initial financial integration steady state. In the medium run, the process for κ_t is governed by (42). The drop in κ is not anticipated by agents in periods $t < 1$. From period $t = 1$ on agents have perfect foresight.

the growth acceleration in the United States spreads to developing countries, which experience a pickup in productivity growth.

Another interesting result illustrated by Figure 11 concerns the response of global rates. On impact, an increase in the barriers to capital inflows in the U.S. produces a sharp fall in global rates. This is not surprising, since these policy interventions are effectively restricting the global supply of assets. In the long run, however, faster productivity growth lifts interest rates, which rise above their initial value.[62] These results suggest that the response of interest rates to restrictions on capital flows toward the United States might be complex, and depend on the time horizon considered.

F Data Appendix

F.1 Data used in Figure 1

To construct the current-account-to-GDP ratio of developing countries in Figure 1a, we draw on current account data from the World Economic Outlook (WEO) 2019. Specifically, we extract current-account-to-GDP data for all countries which WEO classifies as "analytical group: Emerging market and developing economies" (a total of 154 countries).

[62]The undershooting result is typical of models of international deleveraging, such as Benigno and Romei (2014) and Fornaro (2018).

Thereafter, we use real GDP data of these countries - in terms of 2018 dollars and converted by using PPP exchange rates - to construct weights in each year. Last, we construct an average current account ratio by using the formula

$$\left(\frac{CA}{GDP}\right)_{\text{Developing countries},t} \equiv \sum_{i\in\text{Developing countries}} \frac{GDP_{i,t}^{real}}{\sum_{i\in\text{Developing countries}} GDP_{i,t}^{real}} \left(\frac{CA}{GDP}\right)_{i,t}$$

for each year $t \in \{1985, ..., 2018\}$.

To construct Figure 1b, we extract a labor productivity growth series (GDP per hours worked) from the 2019 IMF World Economic Outlook. Moreover, we extract the investment to GDP ratio from FRED, using the following time series: ”Shares of gross domestic product: Gross private domestic investment: Fixed investment: Nonresidential, Percent, Annual, Not Seasonally Adjusted”.

F.2 Data used in Figure 2

The data underlying Figure 2a has been obtained from the OECD, series name “Business enterprise R&D expenditure by industry”. The series is expressed in millions of U.S. dollars. We obtain shares of total spending by dividing sectoral R&D spending by total R&D spending.

To construct Figure 2b, we download annual growth rate data from the U.S. Bureau of Labor Statistics, series name “Labor productivity (output per hour)”. We extract data for “manufacturing” and for “business”. We then plot a 5-year moving average.

G Additional figures

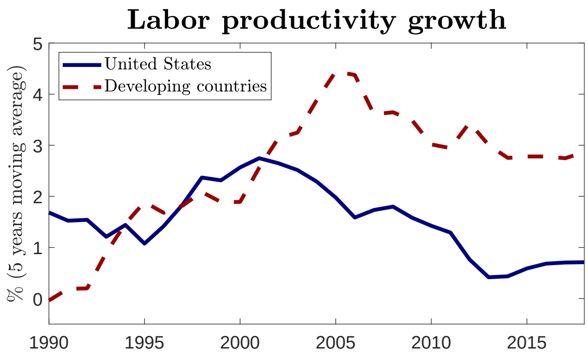
G.1 Productivity growth dynamics in developing countries

Figure 12 compares labor productivity growth in the United States and in our sample of developing countries. During the early phases of the global saving glut, productivity growth in developing countries accelerated, while later on it experienced a mild slowdown.

To construct the time series for labor productivity growth in developing countries, we extract Employment data (number of workers) for 132 out of the 154 developing countries in our sample (recall Appendix F.1). The data sources used are Conference Board, HAVER analytics and Penn World Table. Thereafter, we compute labor productivity as real GDP divided by employment, and take log changes to compute growth rates. We then construct an average growth rate by using the same weighting scheme as for the average current account to GDP ratio in developing countries.

G.2 Removing China from the sample of developing countries

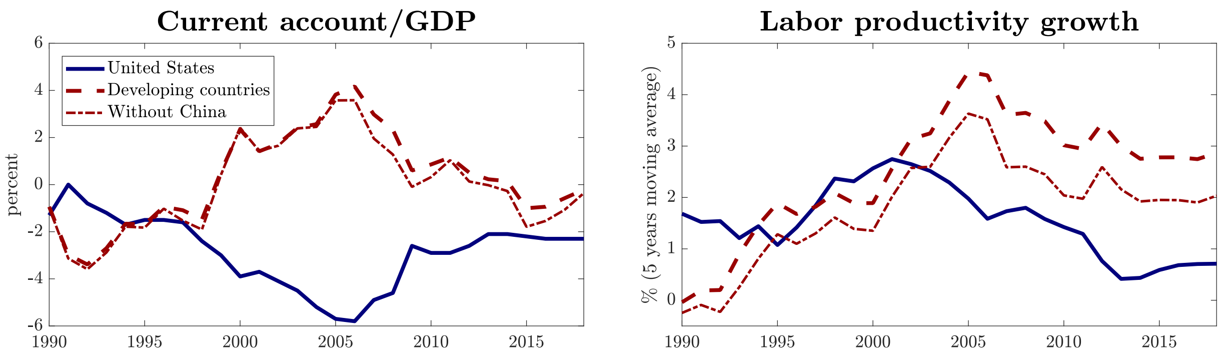
In this Appendix, we verify that our empirical results on current account and productivity growth dynamics in developing countries are not driven by China. The result is in Figure 13. Figure 13a reproduces Figure 1a, the current account to GDP dynamics. As it can be seen from the figure,



(a) Productivity growth.

Figure 12: Productivity growth dynamics in developing countries.

the pattern of current account to GDP is virtually unchanged when excluding China. In turn, Figure 13b reproduces Figure 12, from Appendix G.1. It shows that the pattern of labor productivity growth in developing countries experiences a downward shift, but remains also qualitatively unchanged when excluding China.



(a) Capital flows. **(b) Productivity growth.**

Figure 13: Capital flows and productivity growth: Robustness toward excluding China.

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