Structural Asymmetries and Financial Imbalances in the Eurozone

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June 25, 2019

Abstract

Many southern European economies experience large capital inflows during periods of expansion that are followed by abrupt reversals when a recession hits. This paper studies the dynamics of capital flows between the North and South of Europe in a two-country DSGE model with incomplete international asset markets. Over the business cycle, the direction of capital flows between the two regions can be explained in a model in which common shocks have asymmetric effects on debtor and creditor economies. This mechanism explains why aggregate consumption is more volatile in the South than in the North and generates a higher welfare cost of business cycle fluctuations in the region that experiences procyclical net capital inflows. We also study the adjustment to asymmetric financial shocks.

- *Keywords:* Cross-border financial markets, international business cycle, financial frictions, habits in the composite good.
- *JEL:* F32, F20, G17.

*European Central Bank. The views expressed in this paper are those of the authors and do not necessarily reflect the views of the European Central Bank or the Eurosystem. A previous version of this paper has circulated under the title: "Capital flows, intermediation frictions and the adjustment to common shocks". This project has benefited from comments and suggestions from M. Ehrmann, S. Schmitt-Grohé, M. Onofri, D. Krueger, C. Tille, M. Aguiar, M. Chang, G. Gopinath, B. Eichengreen, M. Hoffmann, U. Jermann, D. Lopez-Salido, V. Quadrini, P. Bacchetta, J. Gali, D. Sandri, R. Wouters, L. Dedola, G. Dlugoszek, R. Kollmann and from conference/seminar participants at the 2017 Swiss National Bank Research Conference, the DNB, the 2015 Bank of Korea International Conference, The 2015 Bank of Spain/Banque de France conference on Structural reforms, T2M 2015, Humboldt University, the University of Nottingham, the ECB and the NY Fed/Banque de France workshop on cross-border capital flows.

1 Introduction

A key characteristic of the Eurozone business cycle is that the trade deficits of Southern European economies vis-à-vis Germany increase during periods of expansion and decline in recessions (See Figure A.1).[1] At the same time, the trade surplus ran by Germany vis-à-vis the South of Europe increases in boom times and declines during periods of recession (see Figure A.2).[2] Net exports being a measure net capital outflows, this implies that Southern European economies increase borrowing in boom periods and therefore need to reduce external debt during periods of recession. Since the opposite co-movement is observed in Germany, net capital inflows are thus procyclical in the South and countercyclical in the North.

The second piece of the puzzle is that these large swings in net capital outflows occur between regions that exhibit a high degree of business cycle synchronization. Indeed, at business cycle frequency, output fluctuations in the North and in the South of Europe have remained highly correlated, even during the Subprime crisis (see Figure A.3).[3] What explains the direction of net capital flows between the North and South of Europe? And since net capital inflows are procyclical in the South and countercyclical in the North, what are the welfare implications of these cross-border flows?

Taking the seminal contribution of Glick and Rogoff (1995) as a starting point, this paper addresses these questions by focussing on the issue of cross-country heterogeneity. In a model composed of two symmetric economies that are hit by common shocks, trade balances are always constant and equal to zero. In the presence of common shocks, however, cross-border capital flows can arise if the two economies differ in their economic structure. Given the high degree of cross-country heterogeneity observed across Eurozone countries, this paper studies the implications of diverging economic structures and common shocks for the dynamics of capital flows. Following Glick and Rogoff (1995) and for the sake of parsimony, we start by considering the case in which technology shocks are the only source of common disturbances. The simplifying assumption of common technology shocks, which will be relaxed later on, can also be motivated by the high correlation between measures of total factor productivity

[1] From 1995 to 2018, the hp-filtered correlation between the trade balance to GDP ratio in the South of Europe and output in the South is -0.59.

[2] From 1995 to 2018, the hp-filtered correlation between the trade balance to output of Germany vis-à-vis South Europe and output in Germany is 0.52.

[3] From 1995 to 2018, the hp-filtered correlation between real output in the North and South of Europe is 0.78.

observed in the two regions at business cycle frequency (see Figure A.4).[4]

The degree of cross-country heterogeneity is calibrated by selecting a set of structural parameters that maximizes the model's ability to replicate some key stylized facts characterizing the Eurozone business cycle. The magnitude of the fluctuations in net capital flows that we obtain is therefore determined by the degree of structural asymmetry implied by the data. The stronger the degree of structural asymmetry between the two regions, the more volatile the fluctuations in net capital flows generated by this mechanism.

Our results suggest that the dynamics of capital flows critically depends on the magnitude of initial net asset positions. In other words, whether a region is a net debtor or a net creditor has a first-order impact on the propagation mechanism of common shocks. In the Eurozone, over the period under consideration, the average trade surplus of Germany with respect to the South of Europe amounted to about 1.6% of German GDP. In the South, the average deficit observed during this period represented about 1.4% of the region's GDP. The North is therefore a net creditor and the South a net debtor. In our environment, it is possible to reproduce this difference in trade balance to output ratios by introducing asymmetries in the demand in each region for the foreign asset issued by the respective trading partner. In this model, the structural parameter that determines domestic holdings of the foreign asset can be interpreted as a measure of the degree of home bias in portfolio holdings. We have also cross-checked that the calibration obtained using our moment matching procedure is consistent with available external evidence. For instance, in line with the model's prediction, Lau et al. (2010) report a higher degree of home bias in portfolio holdings in Southern European economies, such as Greece, Italy, Portugal and Spain, than in Germany.

Suppose that a favorable shock reduces real interest rates in the entire area, how do the regions' net asset positions affect the transmission mechanism of a common shock? Whereas the positive shock leads to a synchronized increase in output, the key is that creditor and debtor regions are differently impacted by a decline in real interest rates. In the debtor region, which in our case is the South, a decline in real interest rates reduces the cost of issuing debt on the international asset market. In the North by contrast, lower real interest rates reduce the revenue from lending to the South, where, in net terms, lending is achieved by purchasing the asset issued by the debtor region. Over the business cycle, common fluctuations in real interest rates are therefore a source of procyclicality in the South, since

[4] From 1995 to 2018, the hp-filtered correlation between total factor productivity in the North and South of Europe is 0.8.

the cost of borrowing from the North declines during periods of expansions and increases precisely when the economy is hit by a recession.

The key driver of net capital flows is the differentiated effect of common shocks on creditor and debtor economies. Since in this model real interest rates rise during recessions, the cross-border asset market amplifies the effects of negative common shocks in the debtor region. During periods of expansion and low interest rates, the incentive to build buffers is therefore stronger in the South than in the North because agents in the debtor economy anticipate that borrowing costs increase when a recession hits. In other words, common fluctuations in real interest rates generate a stronger intertemporal smoothing motive in the South, in the sense that marginal utility of consumption is more volatile in the debtor economy. In the creditor region by contrast, the need to self-insure is less pressing because the cross-border asset market provides a hedge against business cycle fluctuations. In response to a common favorable shock that reduces real interest rates, the decline in marginal utility of consumption is therefore more pronounced in the South than in the North.

We find that this stronger intertemporal smoothing motive in the South is a key determinant of cross-border flows. To understand this result, note that in this model intertemporal smoothing can be achieved via two margins. Agents can firstly use investment to accumulate physical capital, which is a fixed asset. The second intertemporal margin is provided by financial markets, which allow agents to accumulate, in net terms, a foreign asset that can be traded across borders. The cyclicality of net capital flows in turn depends on how agents combine these two margins to achieve consumption smoothing. If net foreign asset accumulation increases, the trade balance improves, whereas it deteriorates if net foreign asset accumulation declines.

For the set of parameter values that maximizes the model's ability to match the data, the model predicts that physical capital is the preferred hedge against business cycle fluctuations. Agents in the debtor economy therefore find it optimal to satisfy their desire to accumulate capital by running a trade deficit in good times. In other words, during periods of expansion, investment in the debtor economy is partly financed by net issuance of debt. Since this implies a deterioration of the region's trade balance during periods of expansion, this mechanism therefore provides an explanation for the procyclicality of net capital inflows observed in the South.

Our main mechanism, which implies that the South finances an investment boom during periods of expansion by borrowing from abroad, can be motivated by the strong negative co-movement between investment and the trade balance in the South. As illustrated by Figure A.5, which shows the investment to output and trade balance to output ratios in the South, the investment boom observed from the end of the 1990's until the crisis period coincided with a sharp deterioration of the region's trade balance. The decline in investment that occurred after the crisis was also accompanied by a marked reduction in the region's trade deficit.

At business cycle frequency, it should be noted that the model only explains around 22% and 27% of the standard deviation of the trade balance to output ratios observed in each region. One interesting implication of our mechanism is that the model's ability to reproduce the volatility of these ratios improves once medium term frequencies are taken into consideration. For cycles ranging from 32 to 120 quarters, we find that the model can account for about 40 and 50 percent of the fluctuations in the trade balance to output ratios observed in the North and South of Europe, respectively.

Although common shocks generate fluctuations in capital flows that are much lower than in the data, the magnitude that we obtain is sufficient to generate significant differences in the welfare cost of business cycle fluctuations (e.g., Lucas 2003) across regions. In the South, the fact that the region needs to reduce its trade deficit during recessions, precisely when marginal utility of consumption is high, exacerbates the effect of common shocks. In the North, by contrast, cross-border capital flows attenuate the effects of common shocks because the net income that creditors receive from the debtor region rises during recessions. Whereas net capital flows facilitate consumption smoothing in the creditor region, they make consumption smoothing more difficult to achieve in the debtor economy. The direction of cross-border capital flows therefore matters since it generates a higher cost of business cycle fluctuations in the region that experiences procyclical net inflows.

Given the limited ability of our model to account for the magnitude of net capital inflows observed in the data, we next study the adjustment of our two-region economy to asymmetric financial shocks. In the Eurozone, the introduction of asymmetric financial shocks can be motivated by the disproportionate effect that the 2011-2012 Sovereign Debt Crisis had on the South of Europe. This period was characterized by an increase in spreads between short-term financial assets issued by the South relative to those issued by Northern European economies, such as Germany. The shock also generated a sudden stop, in the sense that it led to a reduction in trade deficits in the South that was accompanied by a reduction in surpluses in the North.

Following the narrative of Milesi-Ferretti et al. (2011), we model this episode as a shock that reduces the share of foreign assets in portfolio holdings. In our case, the "retrenchment" shock takes the form of an exogenous reduction in the quantity of foreign asset that investors in the North are willing to hold. We find that this particular sort of asymmetric financial shock reproduces some main empirical regularities observed during this period. In the South, the asymmetric shock increases spreads, generates a deeper recession than in the North and forces the region to reduce its trade balance deficit. Introducing asymmetric financial shocks into the analysis also considerably increases the volatility of trade balance to output ratios.

It is important to emphasize that the present paper studies imbalances at business cycle frequency and completely abstracts from long-term growth. Introducing endogenous growth into the analysis would be necessary to capture the effects of low frequency fluctuations on cross-border flows. A second main limitation of the analysis is that the paper assumes that technology shocks are the only source of common shocks. Of course, other types of shocks are also very likely to play an important role in explaining the Eurozone business cycle (e.g., Smets and Wouters 2003).

The starting point of our analysis is the basic two-country version of the standard one-sector stochastic growth model with complete asset markets (e.g., Backus et al. 1992). The first key departure from the baseline model is the introduction of restrictions in the extent to which international capital markets permit to pool risk across economies. Following Cole (1988), Baxter and Crucini (1993), Baxter (1995), Kollmann (1996), Arvanitis and Mikkola (1996), Boileau (1999), Heathcote and Perri (2002) and Corsetti et al. (2008) among others, we develop a model in which individuals have incomplete access to international risk-sharing.

Relative to the frictionless neoclassical growth model, the second main difference is that we introduce credit into the analysis by assuming that in each country firms need to pay workers and capital owners in advance of production. Following Jermann and Quadrini (2012), financial intermediation is subject to frictions and credit conditions depend on the tightness of an enforcement constraint.

We also depart from the frictionless benchmark by introducing a specification of habit formation in the composite of consumption and leisure (e.g., Jaccard 2014), which, when combined with financial frictions and adjustment costs, amplifies the endogenous propagation mechanism of the neoclassical growth model (e.g., Jaccard 2018). This preference specification was first studied in the context of a two-country business cycle model in Dimitriev (2017), who showed that habits in the composite good considerably improve the baseline model's ability to account for the quantity anomaly and international co-movement puzzles.

In Gourio et al. (2013), volatile fluctuations in exchange rates are obtained by augmenting the baseline model with Epstein-Zin-Weil preferences and by introducing disaster risk into the analysis. Fogli and Perri (2015) study the effects of volatility shocks on financial imbalances and show that precautionary saving has a significant impact on net foreign asset positions.

Our main mechanism builds on the work of Kraay and Ventura (2000). Following the intertemporal approach to the current account, they show how favorable shocks can lead to deficits in debtor countries and surpluses in creditor regions, and also provide empirical evidence in support of the model's implications. Our work is also related to the literature that studies the dynamics and long-run determinants of global imbalances between countries with heterogeneous financial markets. In Mendoza et al. (2009), financial integration between two countries in different stages of financial development reproduces the evolution of imbalances between the United States and China observed over the last decades. In Caballero et al. (2008), the main mechanism relies on differences in countries' ability to generate financial assets from real investments. Prades and Rabitsch (2012) explain the evolution of imbalances in the U.S. in a model where countries differ in their degree of openness to international financial markets.

In line with the stylized facts on emerging markets documented in Aguiar and Gopinath (2007), our model predicts that the volatility of consumption should be higher in the region experiencing procyclical net capital inflows.[5] In the Eurozone, we also observe a clear relationship between the volatility of consumption and the cyclicality of net exports. Consumption is generally more volatile in economies where the trade balance to output correlation is more negative (see Figure A.8) and this relationship is robust to the introduction of other European Union economies (see Figure A.9).

This paper also contributes to the literature initiated by the euro area crisis. Lane (2013) documents the boom-bust cycle in capital flows in the euro area and shows that the reversal in net capital flows was very costly for the high deficit countries. Reis (2013) emphasizes the role played by frictions leading to a misallocation of resources. Gopinath et al. (2017)

[5] See also Schmitt-Grohé and Uribe (2017) for a more recent overview of the stylized facts.

document a significant loss in total factor productivity in South Europe and develop a small open economy model with heterogeneous firms that is able to rationalize these novel empirical findings. In their model, the decline in total factor productivity is due to a misallocation of resources that is caused by a capital wedge. Relative to this strand of the literature, we explain the deeper recession observed in the South of Europe after 2011 by an asymmetric financial shock. The policy trade-offs created by asymmetric shocks in monetary unions are studied in Lane (2000), Gali and Monacelli (2008) and Ferrero (2009). Gali and Monacelli (2016) study the effect of wage flexibility in a small open economy belonging to a currency union.

Gilchrist et al. (2018) study imbalances in the Eurozone in a model in which financial frictions affect the pricing behavior of firms. Kollmann et al. (2014) estimate a three country DSGE model and explain the boom-bust cycle in Spain by combining financial frictions with risk premium shocks. Rubio (2014) studies the implications of cross-country housing-market heterogeneity for the transmission mechanism of shocks in a monetary union.

Fernández-Villaverde and Ohanian (2015) argue that the stagnation observed in some European economies can be attributed to sluggish productivity growth originating from political economy distortions (see also Fernandez-Villaverde et al. 2013). Using a large panel of countries, Challe et al. (2016) document that persistent capital inflows are systematically followed by a decline in the quality of domestic institutions and develop a model in which government intervention plays a role in allocating resources to the private sector. Martin and Phillipon (2017) develop a model that can be used to study the nexus between fiscal policy, credit and current account dynamics and conclude that stronger fiscal discipline during the boom would have made the recession less severe in some Southern European economies (see also Gourinchas et al. 2016).

Another strand of the literature studies the contribution of expectations about long-run growth in driving current account dynamics (e.g., Hoffmann et al. 2013). Following a related approach, Siena (2018) studies this question in the context of a small open economy and finds that anticipated reductions in international borrowing costs are important drivers of current account imbalances. In Bonam and Goy (2017), a home bias in expectations is introduced into the analysis to study imbalances in a monetary union.

Finally, concerns that diverging economic structures could lead to asymmetries in the transmission mechanism of common shocks were documented in the early stages of the euro area's existence. In Cecchetti (1999) for instance, differences in financial structure across European economies are attributed to their dissimilar legal structure (see also Danthine et al. 1999). This argument, which also draws on the work of La Porta et al. (1997, 1998), is motivated by a series of empirical facts demonstrating the impact of the legal system of a country on the structure of financial intermediation. In the same vein, Cacciatore et al. (2016) focus on product and labor market deregulation and study the implications of asymmetric deregulation for the conduct of optimal monetary policy in the Eurozone

2 The model

The economy is composed of two regions, the North and the South, that are linked by a financial market that can be used to trade securities. International markets are incomplete and each domestic economy is composed of a representative agent, a financial intermediary, and a representative firm. A role for banks is introduced by assuming that in each region the non-financial sector needs to obtain a loan to pay workers and capital owners in advance of production. The extent to which external financing is needed is determined by the tightness of the loan-in-advance constraint. Institutional differences are captured by introducing a "walk away" constraint that links the amount of external financing that non-financial corporations can obtain to the quality of the country's institutional framework.

The competitive equilibrium in the North

The notation $\widetilde{y}$ is adopted to denote variables, such as output, that represent prices or quantities in the South and y will be the corresponding counterpart in the North. Technology and preferences are consistent with balanced growth and the deterministic growth rate along the balanced growth path is denoted by γ. Since the market structure across the two blocks is identical, we focus the analysis on the Northern economy.

Households

The period t budget constraint of the representative household is given by the following equation:

$$\pi_{Tt} + r_{Kt}k_t + r_{Dt}d_t + w_tN_t + p_{St}\gamma s_{t+1} + \widetilde{s}_t = c_t + i_t + \kappa d_t + s_t + \varsigma s_t + \widetilde{p}_{St}\gamma\widetilde{s}_{t+1}, \quad (1)$$

and the representative agent divides his or her time between leisure activities L, and hours worked in final goods-producing sector N :

$$L_t = 1 - N_t, \tag{2}$$

The wage rate received by workers is denoted by w and total income also consists of a revenue from depositing funds in the banking sector, $r_D d$, where r_D denotes the rate at which deposits are remunerated. The representative agent owns the domestic intermediary as well as firms in the final goods-producing sector and total dividend income is denoted by π_T. Consumption expenditures are denoted by c, and k is the stock of domestic capital accumulated by the agent. Households incur a monitoring cost when supplying deposits to the banking sector. The monitoring cost takes the form of a fixed cost that is proportional to the amount deposited and is denoted by κ. With this structure, the supply of deposit will therefore be completely elastic.

The presence of a cross-border financial market allows households in the North to issue a domestic risk-free asset that is purchased by agents in the South. In period t, the revenue from selling a domestically issued risk-free asset to consumers in the South is denoted by $p_S s$, where p_S denotes the asset price. On the expenditures side, the coupon paid in period t by domestic agents to remunerate bondholders who purchased the quantity of safe asset issued in $t-1$ is denoted by s. To ensure that the problem is well-behaved, we further assume that issuing financial assets is costly and that issuers incur a fixed cost that is proportional to the stock of safe asset available at time t. The fixed cost of issuing debt is denoted by ς.

Agents in the North also have access to a one-period risk-free bond that is issued by agents in the South. On the expenditures side, the quantity of foreign bonds purchased at time t is denoted by $\widetilde{s}$, where $\widetilde{p}_S$ is the price of the bond issued by agents in the South. On the revenue side, $\widetilde{s}$ denotes the payment received from holding the quantity of foreign bonds that was purchased in period $t-1$. The issue of steady state indeterminacy is avoided by assuming that agents in each country derive utility from holding the stock of safe asset issued by consumers in the other region. In the North, a demand for safe assets is therefore obtained by introducing $\widetilde{s}$ directly into the utility function. We simplify the analysis by abstracting from domestic issuance of bonds purchased by domestic agents, since domestic flows have no effect on net foreign asset positions.

Following Baxter and Crucini (1993) among others, we assume that capital accumulation is subject to an adjustment cost and adopt the following functional form:

$$\gamma k_{t+1} = (1-\delta)k_t + \left(\frac{\theta_1}{1-\epsilon}\left(\frac{i_t}{k_t}\right)^{1-\epsilon} + \theta_2\right)k_t, \tag{3}$$

where i denotes investment and δ is the depreciation rate of capital. The parameter that determines the elasticity of Tobin's Q with respect to changes in the investment to capital ratio is denoted by ϵ. The two constant θ_1 and θ_2 are calibrated to ensure that the introduction of adjustment costs has no effect on the deterministic steady state of the model.

Relative to the specification of preferences studied in Jaccard (2014), we assume that habits are formed over a composite good consisting of consumption, the stock of safe asset purchased from abroad and leisure. The law of motion for the habit stock is given as follows:

$$\gamma x_{t+1} = m x_t + (1-m)c_t^{\varkappa}\widetilde{s}_t^{1-\varkappa}(\psi + L_t^{\nu}), \tag{4}$$

where m is the habit parameter that controls the speed at which the habit stock depreciates. The share of consumption in utility is denoted by $\varkappa$ and this parameter also determines the domestic economy's exposure to the foreign asset. Since domestic holdings of the foreign asset are equal to zero when $\varkappa$ is set to 1, this parameter can be interpreted as the degree of home bias in portfolio holdings. This parameter captures the degree of home bias in the sense that low values for $\varkappa$ imply a higher exposure to the foreign asset, whereas the importance of the foreign asset in the domestic economy declines as $\varkappa$ tends towards 1. ν and ψ are two labor supply parameters that control the Frisch elasticity of labor supply (e.g., Jaccard 2014) as well as the steady state allocation of time between leisure and hours worked, respectively.

Each period, the representative household chooses optimally consumption, hours worked, the quantity of deposits to allocate to the banking sector, investment and controls the evolution of its capital stock, its habits stock, its stock of foreign asset purchased from abroad and the stock of domestic asset issued to foreigners by maximizing lifetime expected utility,

$$\max_{c_t, N_t, d_t, i_t, k_{t+1}, x_{t+1}, s_{t+1}, \widetilde{s}_{t+1}} E_0 \sum_{t=0}^{\infty} \widehat{\beta}^t \log\left(c_t^{\varkappa}\widetilde{s}_t^{1-\varkappa}(\psi + L_t^{\nu}) - x_t\right),$$

subject to constraints (1) to (4) and where $\widehat{\beta}$ is the modified discount factor (e.g., Kocherlakota 1990).

The non-financial corporate sector

In period t, profits in the non-financial sector are given as follows:

$$\pi_{Ft} = y_t - r_{Kt}k_t - w_t N_t - r_{Lt}l_t, \tag{5}$$

The final output good, which is denoted by y, is produced by firms in the non-financial corporate sector using hours worked N and domestic capital k. Domestic capital and hours worked are both supplied by the domestic household. r_K is the cost of renting domestic capital from the domestic consumers, w is the wage paid to workers. The total cost from obtaining external finance from the domestic banking sector is denoted by $r_L l$, where r_L is the cost of borrowing funds from the domestic financial intermediary.

The production function takes a Cobb-Douglas form with constant returns to scale:

$$y_t = A_t k_t^{\alpha} N_t^{1-\alpha}, \tag{6}$$

where k is the quantity of domestic capital allocated to the production of the final output good, and where the labor share is denoted by $1-\alpha$. The technology shock that is common to both regions is denoted by A_t and follows an autoregressive process of order one:

$$\log A_t = \rho_A \log A_{t-1} + \varepsilon_{At},$$

where ε_{At} is a random disturbance that is normally distributed and ρ_A is the autoregressive parameter. Technology shocks are the only source of business cycle fluctuations and are common to both country blocks.

A role for banks is introduced by assuming that firms need to obtain a loan to pay inputs in advance. The loan-in-advance constraint can be expressed as follows:

$$l_t \geq \eta \left(w_t N_t + r_{Kt} k_t \right), \tag{7}$$

where η is the parameter that determines the tightness of the constraint. The model reduces to a frictionless economy when η is set to 0. In the South, the tightness of the loan-in-advance constraint is denoted by $\widetilde{\eta}$.

Following the approach of Jermann and Quadrini (2012), the impact of the legal system on credit is captured by introducing an enforcement constraint. In our case, we assume that entrepreneurs in the final-good sector default and run away with the funds borrowed from banks, if the value of their debt exceeds the net present value from operating the firm for a sufficiently long period of time. Bankers understand this incentive structure and make sure that entrepreneurs always have the incentive to reimburse the loan so that default never occurs in equilibrium. This incentive compatibility constraint, which is internalized by entrepreneurs, implies that the maximum amount that firms can borrow is given as follows:

$$\mu l_t \leq \upsilon_t, \tag{8}$$

where υ denotes the present value from operating the firm. For simplicity, υ, which is taken as given by agents, is expressed as the infinite discounted sum of future profits. The payoff from operating the firm instead of walking away with the loan can thus be given as follows:

$$\upsilon_t = \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \left[\pi_{Ft+1} + \upsilon_{t+1} \right], \tag{9}$$

where $\beta = \widehat{\beta}/\gamma$.[6]

Since firms in the final-good sector are owned domestically, managers use the stochastic discount factor of the domestic representative agent to discount future profits. The impact of the country's institutional framework on agents' access to credit is captured by the parameter μ. A lower value for μ decreases the payoff from defaulting and therefore makes it less likely that the case $\mu l > \upsilon$ will occur. A lower value for this parameter therefore corresponds to an improvement in the country's institutional framework and reduces debtors' incentives to walk away with the loan. By lowering the payoff from defaulting, a lower value for μ implies that for any given value of υ, more credit will be extended to firms. Our interpretation of this parameter is therefore that it captures the ease at which contracts can be enforced.

Managers in the final goods-producing sector maximize the discounted value of future dividends and take υ as given:

$$\max_{N_t, k_t, l_t} E_0 \sum_{t=0}^{\infty} \widehat{\beta}^t \frac{\lambda_t}{\lambda_0} \pi_{Ft},$$

subject to equations (5) to (8).

Banks

In each country block, the provision of credit is undertaken by a regional banking sector that simply channels funds from households to firms in its domestic non-financial sector.

[6] This adjustment to the modified subjective discount factor implies that υ is not growing along the steady state.

Profits in the banking sector are given as follows:

$$\pi_{Bt} = r_{Lt} l_t - r_{Dt} d_t,$$

We assume that the technology used by banks to transform deposits into loans is linear in deposits:

$$l_t = z d_t,$$

where z is an exogenous technology parameter measuring the efficiency of the financial intermediation sector.

Market equilibrium

A competitive equilibrium in the economy is a sequence of prices:

$$w, \widetilde{w}, r_L, \widetilde{r}_L, r_D, \widetilde{r}_D, \lambda, \widetilde{\lambda}, \upsilon, \widetilde{\upsilon}, \varpi, \widetilde{\varpi}, \psi, \widetilde{\psi}, p_S, \widetilde{p}_S$$

where ϖ and $\widetilde{\varpi}$ denote the Lagrange multipliers associated with the loan-in-advance constraints in the two regions, ψ and $\widetilde{\psi}$ are the Lagrange multipliers associated with the enforcement constraints in each region, λ and $\widetilde{\lambda}$ marginal utility, and quantities:

$$l, \widetilde{l}, y, \widetilde{y}, c, \widetilde{c}, i, \widetilde{i}, d, \widetilde{d}, N, \widetilde{N}, k, \widetilde{k}, s, \widetilde{s}$$

that satisfy households and firms efficiency conditions as well as the two resource constraints:

$$y_t + \widetilde{s}_t + \gamma p_{St} s_{t+1} = c_t + i_t + \kappa d_t + (1 + \varsigma) s_t + \gamma \widetilde{p}_{St} \widetilde{s}_{t+1},$$

$$\widetilde{y}_t + s_t + \gamma \widetilde{p}_{St} \widetilde{s}_{t+1} = \widetilde{c}_t + \widetilde{i}_t + \widetilde{\kappa} \widetilde{d}_t + (1 + \widetilde{\varsigma}) \widetilde{s}_t + \gamma p_{St} s_{t+1},$$

for all states, for t=1...∞, and given initial values for the six endogenous state variables $k, \widetilde{k}, x, \widetilde{x}, s$ and $\widetilde{s}$.[7]

Financial imbalances

In the context of our model, the trade balance in the North is given by domestic absorption, which can be defined as follows:

[7]In each country, the aggregate resource constraint is obtained by substituting profits in each sector in the budget constraint of the households, who owns the domestic banking and non-financial corporate sectors.

$$tb_t = y_t - c_t - i_t - \kappa d_t - \varsigma s_t,$$

Similarly, in the South, the trade balance is given by:

$$\widetilde{tb}_t = \widetilde{y}_t - \widetilde{c}_t - \widetilde{i}_t - \widetilde{\kappa}\widetilde{d}_t - \widetilde{\varsigma}\widetilde{s}_t,$$

and the aggregate market clearing condition implies that:

$$tb_t = -\widetilde{tb}_t,$$

From the perspective of international capital flows, the trade balance can equivalently be expressed as the change in net foreign asset position[8] minus the net income received from holding the foreign asset:

$$tb_t = (\gamma \widetilde{p}_{St}\widetilde{s}_{t+1} - \gamma p_{St} s_{t+1}) - (\widetilde{s}_t - s_t),$$

$$\widetilde{tb}_t = (\gamma p_{St} s_{t+1} - \gamma \widetilde{p}_{St}\widetilde{s}_{t+1}) - (s_t - \widetilde{s}_t),$$

3 Calibration

We use Eurozone data to calibrate our model. Given the importance of Germany's trade surplus in the policy debate (e.g., Bernanke 2015), we use the German economy as a proxy for the North. We include Greece, Italy, Portugal and Spain in our definition of the South of Europe, which were the countries most affected by the capital flow reversal observed during the different stages of the Eurozone crisis.[9]

As illustrated in Figure A.6, the degree of business cycle synchronization between output in the North and in the South of Europe declined after 2011. From the first quarter of 1995 to the third quarter of 2011, the correlation between the two series is 0.90. From the fourth quarter of 2011 to the fourth quarter of 2018, this correlation is much lower and stands at 0.45. This decline in correlation illustrates that asymmetric shocks are likely to have played

[8]where we have assumed that the internationally traded assets are one period assets, *i.e.* assets that depreciate fully after one period.

[9]The reason we exclude Ireland from the analysis is because, within the Eurozone, Ireland is a surplus economy.

a more important role from 2011 onwards. A natural explanation is that the Eurozone Sovereign Debt Crisis, which hit the continent in 2011, had a much stronger impact on the periphery countries.

Given that the first objective of this paper is to study the effect of common shocks on the dynamics of net capital flows, we therefore choose to calibrate the model using the period from 1995 to 2011. We simplify the analysis by assuming that technology shocks are the only source of common shocks during this period.[10] The effects of asymmetric financial shocks are studied in section 6. Whenever possible, we use available empirical evidence to calibrate the main structural parameters of the model. A first set of parameters is chosen to match long-run steady state ratios following standard practice in the real business cycle literature. As second set of parameters is calibrated to maximize the model's ability to reproduce a series of key stylized facts characterizing the dynamics of the main business cycle aggregates in the North and South of Europe. The data used in this section is described in the appendix.

Deterministic growth rates and depreciation rates

Over the period from the first quarter of 1995 to the third quarter of 2011, the average quarterly growth rate of output stood at 0.34% and 0.37% in North and in the South, respectively. Once uncertainty is taken into account, it is not possible to reject the null hypothesis that the estimated mean growth rates are equal across country blocks. We therefore assume a common deterministic trend rate γ and set this parameter value to 1.0036, which corresponds to the average growth rate of aggregate output in the two regions over this period.

To calibrate the depreciation rates of capital, we use the annual depreciation rate computed by Feenstra et al. (2015). For Germany, the average annual depreciation rate observed from 1995 to 2011 stood at 0.035. For the South, using country weights to calculate an average depreciation rate for the region, we find a value close to the one observed in the North. Given that the difference across the two country blocks is only marginal, we assume a common value and set the quarterly depreciation rate δ to 0.0085.

Solow Residuals

The parameter values for the shock process are obtained by firstly deriving a measure

[10] See Jermann and Quadrini (2012) for a detailed analysis of the role of financial shocks during the subprime crisis. See also Jaccard (2018) for a paper about the transmission of financial shocks in the Eurozone.

of Solow residuals that corresponds to aggregate output in the two regions. Under the hypothesis of a common technology shock process, the aggregate production function is given as follows:

$$Y_t + \widetilde{Y}_t = A_t \left(K_t^{\alpha} \left(\Gamma_t N_t \right)^{1-\alpha} + \widetilde{K}_t^{\alpha} \left(\Gamma_t \widetilde{N}_t \right)^{1-\alpha} \right) \tag{10}$$

where capital letters are used to denote variables that are growing in the steady state and where Γ_t is the deterministic component of labor augmenting technological progress, which is common to both regions. To compute the empirical counterpart of A_t, we use data on hours worked and construct a measure of capital stock in the two regions. Given the above values for the depreciation rate, the capital share and the deterministic growth rate, a measure of capital stock can be derived using data on investment and the law of motion for capital accumulation.[11] The starting values for the capital stock in each country blocks are obtained by using the capital to output ratios reported in the Penn Tables (e.g., Feenstra et al. 2015).

Using equation (10), this procedure allows us to derive an aggregate measure of Solow Residuals that corresponds to the growing economy:[12]

$$\Gamma_t^{1-\alpha} A_t = \frac{Y_t + \widetilde{Y}_t}{K_t^{\alpha} N_t^{1-\alpha} + \widetilde{K}_t^{\alpha} \widetilde{N}_t^{1-\alpha}}$$

The deterministic component $\Gamma_t^{1-\alpha}$ can be eliminated by removing the linear trend and the persistence and shock standard deviation parameters can be obtained by estimating the following regression:

$$\log A_t = \overline{\rho}_A + \rho_A \log A_{t-1} + \varepsilon_{At}$$

Running the above regression yields an estimated value for the persistence parameter ρ_A of 0.925, whereas the constant $\overline{\rho}_A$ is not significantly different from zero. As for the shock standard deviation, the estimated value for σ_{ε_A} that we obtain is 0.0051.

Labor market and capital intensity

To our knowledge, evidence on potential differences in labor supply characteristics or

[11] With this particular specification of adjustment costs, up to a first-order approximation, adjustment costs have no effect on the law of motion of capital accumulation.

[12] In section 2, since our model is consistent with balanced growth, we present the detrended economy directly.

capital intensities are not available for the Eurozone economies analyzed in this study. We therefore assume that this set of parameters is identical across country blocks and calibrate them using values that are considered standard in the literature. With this preference specification, the curvature parameter ν controls the Frisch elasticity of labor supply (e.g., Jaccard 2014). In line with recent findings, we choose a value for ν and $\widetilde{\nu}$ that implies a Frisch elasticity of about 0.7 (e.g., Pistaferri 2003, Hall 2009, Chetty et al. 2011). The second labor supply parameters ψ in the North and $\widetilde{\psi}$ in the South are chosen to ensure that in the steady state, agents spend on average about twenty percent of their time on work-related activities. These two parameters pin down the steady state values of N and $\widetilde{N}$, which are set to 0.2. The capital share parameters α and $\widetilde{\alpha}$ are assumed to be common across regions and are set to 1/3, a standard value in the literature.

Financial intermediation

Given that lending and borrowing costs are a potentially important source of cross-country heterogeneity, we use harmonized data on lending and borrowing rates to calibrate the set of parameters associated with the structure of financial intermediaries across the two regions. Real rates are obtained by deflating the nominal values computed for each country using the harmonized index of consumer prices.

Given the simplifying assumption that deposit rates in each region are determined by monitoring costs, the two parameters κ and $\widetilde{\kappa}$ can be used to calibrate the average cost of funding in each country block. The Euribor rate, which provides a measure of the cost of obtaining funds on the interbank market, can be used to compute an average deposit rate. In each country, the real deposit rate can then be obtained using the harmonized consumer price index. As an average over the period from the first quarter of 1995 to the third quarter of 2011, the average real rate paid by banks to obtain funds on the interbank market stood at 1.86%, -0.25%, 1.00%, 0.86 and 0.65% in Germany, Greece, Italy, Portugal and Spain, respectively. Using GDP weights to compute a weighted average, we obtain an average real cost of funding in the South of 0.79% as compared to 1.86% in Germany.

Given that the difference in average deposit rates across the two country blocks is statistically significant, we introduce region-specific financial intermediation costs. In our quarterly model, the average annual rate observed in the two regions can be matched by setting κ to 0.0047 and $\widetilde{\kappa}$ to 0.0020.

Since the financial efficiency parameters z and $\widetilde{z}$ drive a wedge between deposit and lending rates, we use data on short-term loans to non-financial corporations to calibrate these two parameters. As an average over the period from the first quarter of 2000 to the third quarter of 2011, the average cost of obtaining short-term credit for non-financial corporations stood at 3.25%, 3.04%, 2.30%, 3.50% and 1.95% in Germany, Greece, Italy, Portugal and Spain, respectively. Using country weights to compute an index of the cost of credit in the South of Europe, we obtain an average lending cost in that region of 2.31%. Given the linear production function in the banking sector, these moments can be matched by setting z to 0.5723 and $\widetilde{z}$ to 0.342.

Cross-border asset market

The fixed costs of issuing the safe asset in the North and South are denoted by ς and $\widetilde{\varsigma}$, respectively. In the absence of evidence suggesting otherwise, we assume that the structure of the cross-border asset market is symmetric across country blocks. In each country, the fixed cost of issuance is set to 0.01, which implies that a cost amounting to one percent of the total stock of debt must be paid each period to issue debt internationally.

Moment matching procedure

The remaining parameters are calibrated to maximize the model's ability to jointly reproduce a series of stylized facts. The parameters characterizing the degree of cross-country heterogeneity across the two economies are firstly identified by matching the standard deviation in both regions of investment and credit, which in Table 2 are denoted by $std(i)$ and $std(l)$ in the North, and $std(\widetilde{i})$ and $std(\widetilde{l})$ in the South. To maximize the model's ability to account for the cyclicality of capital flows, we also include the correlation between output and the trade balance to output ratios in the North and in the South, which are denoted by $corr\left(\log y_t, tb_t/y_t\right)$ and $corr\left(\log \widetilde{y}_t, \widetilde{tb}_t/\widetilde{y}_t\right)$, respectively.

As we explain below, the dynamics of trade balances crucially depends on the effectiveness of the investment margin, which in turn depends on the degree of capital adjustment costs. Since adjustment costs modify the supply elasticity of capital, the parameters ϵ and $\widetilde{\epsilon}$ also have a first-order impact on the volatility of investment and the cyclicality of the trade balance. The extent to which the investment margin is used by agents also depends on the strength of their consumption smoothing motive, which is determined by the elasticity of intertemporal substitution. Including the volatility of investment into the loss function therefore also allows us to identify the two habit parameters m and $\widetilde{m}$. In each country block, the ease at which contracts can be enforced is captured by the two parameters μ and

$\widetilde{\mu}$. For any given values of v and $\widetilde{v}$, a weaker institutional environment, which in this model implies higher values for μ and $\widetilde{\mu}$, makes it less likely that the enforcement constraints will be satisfied. A tighter enforcement constraint not only reduces the equilibrium quantity of loans that firms will obtain but also affects the ease at which consumption smoothing can be achieved. Whereas μ and $\widetilde{\mu}$ affect the entire system through general equilibrium effects, including the volatility of credit in the set of moments to be matched mainly serves to identify these two contract enforcement parameters.

To further identify the main sources of cross-country heterogeneity between the North and South of Europe, we also maximize the model's ability to account for long-term averages, which capture persistent structural differences across the two blocks. The first long-term ratios included into the loss function are the capital to output ratios in the two regions, *i.e.* $E(k/y)$ and $E(\widetilde{k}/\widetilde{y})$. In the data, the capital stock to output ratio is computed using the database constructed by Feenstra et al. (2015). Over the period from 1995 to 2011, the average capital to output ratio expressed in quarterly terms stood at 15.1 in the North, as compared to 17.6 in the South. To capture differences in the extent to which firms rely on credit to finance their activity, we also use an indicator of the quantity of credit to non-financial corporations as a fraction of output in the two regions. As an average over the period from the first quarter of 1995 to the third quarter of 2011, the average loan to output ratio $E(l/y)$ stood at 0.56 in the Germany. In the South of Europe, this ratio denoted by $E(\widetilde{l}/\widetilde{y})$ reached 0.72. On average, the South therefore accumulates more capital and is more reliant on bank credit than the North. Moreover, the difference in capital and credit intensities across the two regions is statistically significant.

Given that we have fixed the value of the two capital depreciation parameters, introducing differences in the two subjective discount factor β and $\widetilde{\beta}$ is the only margin left to match the difference in capital to output ratios observed across the two regions. Whereas these two parameters are mainly identified by $E(k/y)$ and $E(\widetilde{k}/\widetilde{y})$, they also have a first-order impact on the volatility of investment $std(i)$ and $std(\widetilde{i})$. Since the parameters η and $\widetilde{\eta}$ measure the tightness of the loan-in-advance constraint, they can be associated to the loan-to-output ratios $E(l/y)$ and $E(\widetilde{l}/\widetilde{y})$, respectively.

Finally, given that one objective of the paper is to provide a quantitative assessment of the importance of common shocks for the dynamics of imbalances, it is important to ensure that the average trade balance to output ratios observed in the data can also be reproduced.

As an average from the first quarter of 1995 to the third quarter of 2011, the average trade surplus of the North with respect to the South amounted to 1.59% of GDP. In the South, the average deficit with the North observed over this period stood at -1.39% of GDP.

Table 1: Benchmark Calibration

ϵ	$\widetilde{\epsilon}$	m	$\widetilde{m}$	μ	$\widetilde{\mu}$	η	$\widetilde{\eta}$	$\varkappa$	$\widetilde{\varkappa}$	β	$\widetilde{\beta}$
1.31	3.31	0.89	0.94	6.22	8.22	0.59	0.76	0.95	0.99	0.991	0.994

Table 2: Business Cycle Moments

HP-filtered Data

	Data		Model
	Estimated	95% CI	Generated
$std(\log i_t)$	3.67	[3.14, 4.43]	3.62
$std(\log \widetilde{i}_t)$	2.70	[2.30, 3.25]	2.72
$std(\log l_t)$	2.48	[2.12, 2.98]	2.48
$std(\log \widetilde{l}_t)$	3.25	[2.77, 3.91]	3.25
$corr\,(\log y_t, tb_t/y_t)$	0.58	[0.40, 0.72]	0.57
$corr\left(\log \widetilde{y}_t, \widetilde{tb}_t/\widetilde{y}_t\right)$	-0.58	[-0.72, -0.39]	-0.56

Long-term Average Ratios

	Data		Model
	Estimated	95% CI	Generated
$E(k/y)$	15.1	[14.4, 15.8]	15.1
$E(\widetilde{k}/\widetilde{y})$	17.6	[15.9, 19.3]	17.6
$E(l/y)$	0.56	[0.55, 0.57]	0.56
$E(\widetilde{l}/\widetilde{y})$	0.72	[0.67, 0.77]	0.72
$E(100\ tb/y)$	1.59	[1.38, 1.81]	1.57
$E(100\ \widetilde{tb}/\widetilde{y})$	-1.39	[-1.55, -1.22]	-1.41

In the context of our model, the demand for the foreign asset, which in turn determines net foreign asset positions, depends on the utility share parameters $1-\varkappa$ and $1-\widetilde{\varkappa}$. Since we have assumed that the cost of producing the internationally traded asset is symmetric across countries, these two parameters are mainly identified by the trade balance to output ratios $E(tb/y)$ and $E(\widetilde{tb}/\widetilde{y})$. Given our Cobb-Douglas specification, $\varkappa$ and $\widetilde{\varkappa}$ measure the share of consumption in the utility function and also affect agents' consumption and saving decisions. These two parameters therefore also have a significant impact on the volatility of investment.

Introducing a demand for a safe asset using this strategy is similar in spirit to the strand of literature that introduces real money balances into the utility function. Available estimates of the share of money in the utility function using a Cobb-Douglas specification typically suggests that the utility weight of money is likely to be small (e.g., Finn et al. 1990, Holman 1998). To ensure that the value that we obtain for these two parameters remains in the range of values accepted in the literature, we restrict $1-\varkappa$ and $1-\widetilde{\varkappa}$ to coefficients strictly superior than 0 but inferior or equal to 0.05. The outcome of this moment matching procedure is shown in Table 1, which reports the combination of parameter values that maximizes the model's ability to reproduce the moments reported in Table 2.

Are the constraints always binding?

In this model where lending and borrowing decisions occur within the period, it can be shown that the enforcement and loan-in-advance constraints, which are given by equations (7) and (8) in the North, are always strictly binding. This can be established by considering the three following cases: (i) a version of the model that abstracts from the loan-in-advance constraints but in which the enforcement constraints are present, (ii) a version of the model in which the loan-in-advance constraints are present but that abstracts from the enforcement constraints and (iii) a version of the model without these two constraints; and by showing that, if present, these constraints are always satisfied with strict equality.

(i) Start by considering a version of the model that abstracts from the loan-in-advance constraints. In this case, notice that the quantity of loans produced in this economy goes to zero. This follows from the maximization problem of firms in the non-financial corporate sector. Since obtaining credit lines is costly, profit maximizing firms have no interest in demanding credit in a version of the model in which the loan-in-advance constraints are not present. Moreover, the fact that a monitoring cost given by κ and $\widetilde{\kappa}$ in the South has to be paid by households when depositing funds in the banking sector ensures that deposit and lending rates are always strictly positive.

Since the cost of obtaining credit is always strictly positive, this ensures that the quantity of loans is equal to zero in the model without the loan-in-advance constraints. The quantity of output produced in this model being always strictly positive, the cases $l_t > \eta \left(w_t N_t + r_{Kt} k_t\right)$ and/or $\widetilde{l}_t > \widetilde{\eta}\left(\widetilde{w}_t \widetilde{N}_t + \widetilde{r}_{Kt} \widetilde{k}_t\right)$ therefore never occur in the version of the model that abstracts from the loan-in-advance constraints. This establishes that, if present, the loan-in-advance constraints must therefore always be satisfied with strict equality.

Notice that in the version of the model in which the loan-in-advance constraints are not present, the enforcement constraints are always satisfied with equality. This follows from the fact that, without the loan-in-advance constraints, profits are given by output minus the cost of renting capital and labor, which with a Cobb-Douglas production function implies zero profit. When firms make zero profit, the payoffs from operating the firm instead of walking away υ and $\widetilde{\upsilon}$ are also equal to zero, since they are determined by the discounted sum of future profits. The case $\mu l_t < \upsilon_t$ and/or $\widetilde{\mu}\widetilde{l}_t < \widetilde{\upsilon}_t$ therefore never occurs when the loan-in-advance constraint is not present.

(ii) We can also verify that the constraints are never weakly binding in the version of the model in which the loan-in-advance constraints are present but that abstracts from the enforcement constraints. This follows from the fact that profits are always equal to zero in this case. In the North, this can be seen by noticing that in this particular case, the loan-in-advance constraints and profit conditions are given as follows:

$$l_t = \frac{\eta y_t}{1 + \eta \frac{\varpi_t}{\lambda_t}}$$

$$\pi_{Ft} = \frac{\eta \frac{\varpi_t}{\lambda_t}}{1 + \eta \frac{\varpi_t}{\lambda_t}} y_t - r_{Lt} l_t$$

where ϖ is the Lagrange multiplier associated with the loan-in-advance constraint and where the optimality conditions with respect to credit implies that $r_{Lt} = \frac{\varpi_t}{\lambda_t}$. Combining these first-order conditions, we therefore have that $\pi_{Ft} = 0$, which in turn implies that $\upsilon_t = 0$. Since output and as a result credit are always strictly positive when the loan-in-advance constraints are present, the cases $\mu l_t < \upsilon_t$ and/or $\widetilde{\mu}\widetilde{l}_t < \widetilde{\upsilon}_t$ therefore never occur in equilibrium.

(iii) Finally, when none of these constraints are present, the model reduces to a frictionless neoclassical growth model in which the quantity of credit produced in the economy is zero and where firms make zero profit. As discussed above, these constraints are never weakly satisfied in this case.

4 Results

The outcome of this moment matching procedure is reported in Table 1 and the estimated moments that are used to calibrate the main parameters are reported in the first column of Table 2. The second column reports the estimated 95% confidence interval for the estimated moment and the corresponding model implications are reported in the third column.

The results reported in Table 2 suggest that the model is able to replicate the moments that were targeted. As in the data, investment is more volatile in the North than in the South, whereas credit is more volatile in the South. As can be seen in Table 1, the higher volatility of investment in the North is firstly explained by selecting a higher adjustment coefficient in the South than in the North, *i.e.* $\epsilon < \widetilde{\epsilon}$. Secondly, introducing a greater elasticity of intertemporal substitution in the South than in the North also contributes to explain the higher volatility of investment in the North. With this preference specification, this is achieved by selecting a lower habit parameter in the North, *i.e.* $m < \widetilde{m}$.

As for credit, the results shown in Table 2 illustrate that the higher volatility of credit in the South can be accounted for if the walk away constraint is tighter in the South than in the North. A value for $\widetilde{\mu}$ that is higher than μ implies that contracts are relatively more difficult to enforce in the South than in the North. We have cross-checked this result by comparing this prediction with a series of indicators measuring contract enforcement. As illustrated by Figure A.7, the rule of law index, an indicator that includes proxies for contract enforcement such as the number of days needed to enforce a contract, clearly suggests that contracts enforcement is typically weaker in the South than in the North.

The higher subjective discount factor in the South that we obtain, *i.e.* $\widetilde{\beta} > \beta$, reflects the difference in average capital to output ratios observed in the data. Since a greater value for this parameter implies higher capital accumulation, the model explains the difference in capital to output ratios by making agents in the South more patient than in the North. The higher value for the loan-in-advance parameter in the South than in the North, *i.e.* $\widetilde{\eta} > \eta$, can be explained by the stronger dependence on bank credit observed in the South. On average, the loan to output ratio is greater in the South, which in our model implies a tighter loan-in-advance constraint in that region.

The difference in trade balance to output ratios is explained by selecting a higher degree of home bias in portfolio holdings in the South than in the North, *i.e.* $\widetilde{\varkappa} > \varkappa$. Given our assumption of a common cost of producing financial assets across countries, this stronger appetite for foreign assets in the North implies that, in equilibrium, net foreign asset accumulation is on average positive in the North and negative in the South, *i.e.* $E(\widetilde{s}) > E(s)$.

To gain intuition into this result, it is useful to analyze how the relative net asset position of a country affects its trade balance in the deterministic version of the model. The trade balance measures the change in net foreign asset accumulation minus the net income received from abroad, which in the North is given as follows:

$$tb_t = (\gamma \widetilde{p}_{St} \widetilde{s}_{t+1} - \gamma p_{St} s_{t+1}) - (\widetilde{s}_t - s_t),$$

After a few manipulations, it can be shown that, in the deterministic version of the model, a positive trade balance in the North, *i.e.* $tb > 0$, is observed if:

$$\widetilde{s} > \left(\frac{\gamma p_S - 1}{\gamma \widetilde{p}_S - 1} \right) s$$

Since a small difference in subjective discount factors is necessary to reproduce the capital to output ratios in the two regions, the price of the safe assets in the two regions p_S and $\widetilde{p}_S$ are almost equal to each other. Given the assumption of a common deterministic growth rate γ, the term $(\gamma p_S - 1)/(\gamma \widetilde{p}_S - 1)$ is approximately equal to unity. Since a higher demand for foreign assets in the North implies that $\widetilde{s} > s$, the region's trade balance is therefore positive when $1 - \varkappa > 1 - \widetilde{\varkappa}$. Although this relationship is also affected by uncertainty, the effect of the two preference parameters $\varkappa$ and $\widetilde{\varkappa}$ on foreign asset accumulation remains the main driver of long-term imbalances in the stochastic version of the model.

The dynamics and cyclicality of financial imbalances

To illustrate how the different sources of structural heterogeneity affect the dynamics of trade balances, Table 3 below reports the correlations between output and the trade balance to output ratios, the mean trade balance to output ratios and the standard deviation of the trade balance to output ratios in four different cases. As in Table 2, the stylized facts are shown in the first part of the table and the four different versions of the model are reported in columns 1 to 4.

The symmetric model, which is reported in column 1, is a version of the model in which all sources of heterogeneity are eliminated. This calibration is obtained by computing an average value across regions for the parameters reported in Table 1. In the case of the adjustment cost parameters ϵ and $\widetilde{\epsilon}$ for instance, the symmetric calibration is obtained by taking the average value between 1.31 and 3.31. As shown in column 1, in a model with common shocks and without any source of cross-country heterogeneity, trade balances in each country bloc are constant and always equal to zero. Relative to the symmetric baseline model, column 2 shows a version of the model in which the difference in the degree of home bias, *i.e.* $\varkappa < \widetilde{\varkappa}$, is the only source of cross-country heterogeneity. Notice that introducing different preferences for holding the foreign asset is sufficient to broadly reproduce the dynamics of trade balance to output ratios. In the North, this version of the model not only matches the average trade balance to output ratio but also explains its procyclicality. Moreover, Model 2 generates fluctuations in the trade balance to output ratios of a magnitude close to that observed in the data.

TABLE 3: FINANCIAL IMBALANCES AND CONSUMPTION

	Data		Models			
			1	2	3	4
	Estimated Moment	95% Conf. Interval	Symm. Model	$\varkappa < \widetilde{\varkappa}$ only	$\varkappa < \widetilde{\varkappa}$, $\epsilon < \widetilde{\epsilon}$ only	Heterog. Model
$corr\,(\log y_t, tb_t/y_t)$	0.58	[0.40, 0.72]	NA	0.99	-0.77	0.57
$corr\left(\log \widetilde{y}_t, \widetilde{tb}_t/\widetilde{y}_t\right)$	-0.58	[-0.72, -0.39]	NA	-0.99	0.76	-0.56
$E(100\ tb/y)$	1.59	[1.38, 1.81]	0	1.60	1.47	1.57
$E(100\ \widetilde{tb}/\widetilde{y})$	-1.39	[-1.55, -1.22]	0	-1.51	-1.40	-1.41
Additional implications						
$std(tb_t/y_t)$	0.23	[0.20, 0.28]	0	0.24	0.05	0.05
$std(\widetilde{tb}_t/\widetilde{y}_t)$	0.19	[0.17, 0.23]	0	0.24	0.05	0.04
$std\,(\log c_t)$	0.73	[0.62, 0.88]	1.10	1.01	0.88	0.80
$std\,(\log \widetilde{c}_t)$	0.98	[0.84, 1.18]	1.10	1.19	1.03	1.21

Model 3 shows how the introduction of capital adjustment costs affects the dynamics of financial imbalances. Relative to Model 2, the only change is that we reintroduce different values for the capital adjustment costs parameters by using the values reported in Table 1. Relative to Model 2, the first main change is that the model is no longer able to correctly account for the direction of capital flows. In both regions, the correlation coefficient changes sign. While it is still possible to generate a steady state surplus in the North and a deficit in the South, the volatility of trade balances decreases dramatically. Relative to Model 2, in both regions, introducing heterogeneity in the cost of adjusting capital reduces the standard deviation of the trade balance to output ratios from 0.24 to 0.05.

Model 4 is the benchmark version with all sources of cross-country heterogeneity that matches the moments reported in Table 2. Relative to Model 3, the main difference is that this version reproduces the correlation between output and the trade balance observed in the two countries. Relative to Model 2, however, the main difference is that Model 4 cannot generate fluctuations in trade balances that are sufficiently volatile. The results obtained using Model 2 illustrate that it is in principle possible to generate fluctuations in trade balances that are as volatile as in the data in a model with common shocks and structural differences across countries. This also illustrates that the low standard deviation of trade balances reported in Table 2 is essentially due to the difference in adjustment costs that is necessary to match the volatility of investment in the two regions.

The volatility of consumption and welfare

As illustrated in Figure A.8 and A.9, in the Eurozone and in the European Union, consumption relative to output is generally more volatile in countries where the trade balance is more countercyclical, as it is the case in the South of Europe. The last two rows of Table 3 compare the standard deviation of consumption predicted by the four different models with the data.

Although this moment was not targeted, Model 4 is still able to generate fluctuations in consumption in the South that are more volatile than in the North. The results reported in column 2 illustrate that the difference in consumption volatility obtained in Model 4 is essentially due to differences in the degree of home bias. Indeed, the model in which $\varkappa < \widetilde{\varkappa}$ is the only source of heterogeneity is able to generate a sizeable difference in consumption volatility across the two regions. This can be explained by the countercyclical fluctuations in the trade balance in the South, which implies that the region increases its deficit during periods of expansion. Increasing borrowing in good times also implies that the region needs to close its trade deficit during recessions. The greater volatility of consumption in the South is therefore explained by the procyclicality of net capital inflows, which makes consumption smoothing more difficult to achieve.

Notice that this difference in the cyclicality of net capital inflows experienced by the two trading partners also has welfare implications. As shown in Table 4 below, the procyclicality of net capital inflows in the South implies a greater welfare cost of business cycle fluctuations (e.g., Lucas 2003) than in the North. This can be illustrated by analyzing how uncertainty affects the ergodic mean of consumption in both regions. Relative to the deterministic case, which is obtained by setting the shock standard deviation to zero, in the South consumption is on average 1.5% higher in the model that reproduces the moments shown in Table 2. This illustrates that in equilibrium agents need to be compensated by a higher average level of consumption in economies subject to procyclical net capital inflows. In the North, by contrast, this risk compensation is equal to zero because the countercyclicality of net capital inflows experienced in that region works like an insurance against shocks.

Table 4: Welfare Cost and Imbalances

	Heterog. model	Symmetric model
$\frac{E(c)-c}{c}$	0.0	0.35
$\frac{E(\widetilde{c})-\widetilde{c}}{c}$	1.5	0.35
$corr\left(\log y_t, tb_t/y_t\right)$	0.57	NA
$corr\left(\log \widetilde{y}_t, \widetilde{tb}_t/\widetilde{y}_t\right)$	-0.56	NA

The welfare cost measures reported in the second column of Table 4 correspond to the symmetric baseline model in which trade balances are constant and equal to zero. Without any fluctuations in trade balances, the welfare cost is symmetric across countries.[13] Once fluctuations in trade balances are introduced, relative to the symmetric benchmark, the welfare cost increases in the region experiencing procyclical net capital inflows and declines in the region where net inflows are countercyclical.

The persistence of imbalances

The left panel of Figure B.1 shows the response of the trade balance to output ratios in the North and in the South in response to a positive technology shock. The response of output is shown on right panel. Whereas the model calibrated to match the moments reported in Table 2 cannot explain the high standard deviation of trade balances, the fluctuations in net capital flows generated by this mechanism can be very persistent. To further illustrate this point, we also report a measure of medium-term frequency volatility. This is achieved by filtering the data using a band-pass filter and by selecting a frequency ranging from 32

[13] Relative to a standard model, the larger cost obtained in the symmetric model is due to the introduction of habit formation and adjustment costs.

to 120 quarters. The first column reports the short-term volatility of the trade balance, which corresponds to fluctuations from 8 to 32 quarters. The comparison between the model implications and the data confirms that this model is only able to explain a small fraction of the volatility of net capital flows observed at business cycle frequency.

	Band Pass 8-32			Band Pass 32-120		
	Data	95% CI	Model	Data	95% CI	Model
$std(tb_t/y_t)$	0.18	[0.15, 0.22]	0.04	0.45	[0.38, 0.54]	0.17
$std(\widetilde{tb}_t/\widetilde{y}_t)$	0.15	[0.13, 0.18]	0.04	0.32	[0.28, 0.39]	0.16

As can be seen in the second column, which reports standard deviations corresponding to frequencies ranging from 32 to 120 quarters, the model's ability to reproduce the volatility of net capital flows improves once lower frequency fluctuations are taken into consideration. At medium-term frequency, the model explains about 40% and 50% of the standard deviation of the trade balance to output ratios observed in the North and in the South, respectively. In sum, our study confirms that common technology shocks are unlikely to explain much of the fluctuations in trade balances at business cycle frequency (e.g., Glick and Rogoff 1995). At the same time, our main novel result is that the combination of common shocks and structural asymmetries could contribute to explain a non-negligible fraction of the fluctuations observed at medium-term frequencies.

From a policy perspective, it must be emphasized that in Europe long-term developments that can lead to the build-up of persistent trade deficits or surpluses are subject to particular scrutiny. In particular, lower frequency movements in trade balances are closely monitored and persistent deviations from long-term trends can trigger corrective actions if judged unsustainable by the regulator (e.g., European Commission 2016).

Main limitations

The main limitation of the model is its inability to reproduce cross-country correlations. As shown on the right panel of Figure B.1, output in the two regions increases in response to a positive shock. Whereas the net inflow of capital in the South generates a more persistent expansion in that region, on impact the common shock leads to increases in output that are perfectly synchronized. This implies a correlation between output in the North and South of 0.99, which is at variance with the facts. Although the introduction of incomplete international markets implies that marginal utilities of consumption are not equalized across regions, the model also fails to reproduce the low correlation between consumption in the two regions that we observe in the data.[14] The banking sector is also too stylized. And while it is possible to reproduce the volatility of credit, it is for instance not possible to simultaneously account for the dynamics of deposits.

5 Deconstructing the mechanism

In the literature, the build-up of financial imbalances in the euro area is often associated with the decline in real rates observed since the mid-1990's (e.g., Gopinath et al. 2017; Fernandez-Villaverde et al. 2013). In our environment, the effect of real interest rates on the dynamics of trade balances is captured by the fluctuations in the price of the traded asset induced by common shocks. In response to a positive technology shock, as shown in Figure B.2, real rates decline and the price of the traded asset issued by both regions increases. Since the price of the traded assets p_S and $\widetilde{p}_S$ is inversely related to fluctuations in real rates, a change in real interest rates has a direct effect on net capital flows by affecting the terms at which countries lend and borrow on the cross-border asset market. Introducing common technology shocks is therefore a way to capture the effect of changes in real interest rates on the dynamics of capital flows across the two regions.

A stronger intertemporal smoothing motive in the South

As shown in Table 4, the dynamics of capital flows implied by this mechanism leads to differences in the welfare cost of business cycle fluctuations across regions. Intuitively, a decline in real interest rates is good news for the debtor region since it lowers the cost at which the region finances its trade deficit. But the fact that this decline in real interest rates occurs in good times is a source of procyclicality because, in net terms, it means that the income raised on the cross-border asset market increases in booms and therefore declines during periods of recession.

The key is that the differentiated impact of common shocks on creditor and debtor regions generates a stronger intertemporal smoothing motive in the South. To illustrate this point, the upper left panel of Figure B.3 shows the response of marginal utility in the two regions in Model 2, which corresponds to the case in which differences in the utility share parameters $\varkappa$ and $\widetilde{\varkappa}$ are the only source of cross-country heterogeneity. There is a stronger intertemporal

[14] See Dimitriev (2017) for a resolution of the co-movement puzzle in a two-country model.

smoothing motive in the South in the sense that the decline in marginal utility in that region is more pronounced. A favorable shock increases consumption and lowers marginal utility in both regions on impact but the key difference is that this decline in marginal utility is more persistent in the debtor economy.

The upper right panel in Figure B.3 shows the response of marginal utilities in Model 2 when habit formation in both regions is switched off by setting $m = \widetilde{m} = 1$. Compared to the left panel, which corresponds to the case $m = \widetilde{m} = 0.92$, the difference in the response of marginal utilities is much smaller in the model without habits. This illustrates that the introduction of habits strengthens the model's endogenous propagation mechanism by amplifying the effect of cross-country heterogeneity.

The lower left panel shows again the response of marginal utilities to a positive common shock but this time in the benchmark model with all sources of heterogeneity that is calibrated to match the moments reported in Table 2. As can be seen by comparing the upper left and lower left panels, most of the difference in the dynamics of marginal utilities can be obtained in the version of the model in which $\widetilde{\varkappa} > \varkappa$ is the only source of cross-country heterogeneity. The lower right panel shows the dynamics of marginal utility in the benchmark model when we abstract from habit formation. This illustrates that the stronger intertemporal smoothing motive in the South is obtained by combining the difference in home bias with a degree of habit intensity that could be common across regions.

The sharp and more persistent decline in marginal utility in the South in response to a favorable shock implies a stronger desire to build buffers than in the North. In this economy, this is achieved by accumulating physical capital, which as we explain below, is the best hedge against business cycle fluctuations for this particular combination of parameter values. This point can be illustrated by comparing the response of capital in the two economies (see Figure B.4). In response to a favorable common shock that lowers real interest rates, physical capital accumulation is much faster in the South than in the North.

The presence of a cross-border asset market allows agents in the South to increase capital accumulation beyond the level that could have been reached in closed economy. As shown by the strong increase in the region's capital stock, during boom periods, the South uses some of the increase in revenue induced by the increase in asset prices to finance capital accumulation. In other words, during periods of expansion, the debtor economy increases its net issuance of financial assets and takes advantage of the lower real interest rates to finance an investment boom. Whereas favorable shocks lead to stronger increase in investment in the North on impact, the key is that the increase in investment in the South is more persistent that in the North. Moreover, this increase in investment in the South is financed by persistent net capital inflows. This persistence of net capital flows is illustrated by the hump-shaped response of the trade balances in both regions shown in Figure B.1. Relative to a closed economy, capital flows therefore explain the much larger effect of common shocks on capital accumulation in the South than in the North.

The valuation effect

Changes in real interest rates have a direct effect on net capital flows by changing the price at which the two assets are traded across borders. Since fluctuations in net capital flows also depend on the response of quantities, this subsection starts by isolating the contribution of the valuation effect, *i.e.* the impact of a change in p_S and $\widetilde{p}_S$, on the dynamics of trade balances. The contribution of the quantity effect is studied in the next subsection. The objective of this first subsection is to show that the valuation effect is the main cause of the procyclicality in the debtor region, which in turn leads to differences in intertemporal smoothing motives.

A decline in real interest rates affects net asset positions through the response of the price at which the two assets p_S and $\widetilde{p}_S$ are traded. The effect of asset prices on the respective economies, which we refer to as a valuation effect, critically depends on the country's steady state net asset position. At steady state, whether a country is net debtor or a net creditor is determined by the difference in home bias, which we capture by introducing different parameter values for the utility share parameters $\varkappa$ and $\widetilde{\varkappa}$. The first-order effect of these two utility share parameters on s and $\widetilde{s}$ can be illustrated using the deterministic steady state of the model. In the North, the demand for the foreign asset is determined by the optimality condition with respect to $\widetilde{s}$:

$$\widetilde{p}_{St}\lambda_t = \beta E_t \lambda_{t+1} \left\{ 1 + \frac{1-\varkappa}{\varkappa} \frac{c_{t+1}}{\widetilde{s}_t} \right\}$$

In the South, the supply of asset is determined by the fixed cost of issuance and is given as follows:

$$\widetilde{p}_{St}\widetilde{\lambda}_t = \widetilde{\beta} E_t \widetilde{\lambda}_{t+1} \left(1 + \widetilde{\varsigma}\right)$$

In the deterministic steady state of the model, the quantity of foreign assets held in the North is therefore given by following formula:

$$\frac{\widetilde{s}}{c} = \frac{\beta}{\widetilde{\beta}(1+\widetilde{\varsigma}) - \beta} \frac{1-\varkappa}{\varkappa}$$

which illustrates that, up to a first-order approximation, and for a given level of consumption, a lower degree of home bias in the North, *i.e.* a smaller value for $\varkappa$, raises the equilibrium quantity of foreign assets held in the North. A similar relationship can be derived in the South where the link between the utility share parameter and s is given as follows:

$$\frac{s}{\widetilde{c}} = \frac{\widetilde{\beta}}{\beta\,(1+\varsigma) - \widetilde{\beta}} \frac{1-\widetilde{\varkappa}}{\widetilde{\varkappa}}$$

Given the difference between $\varkappa$ and $\widetilde{\varkappa}$ needed to match the average trade balances in the two regions, this calibration implies a positive net steady state asset position in the North, *i.e.* $\widetilde{s} > s$ and a negative one in the South, *i.e.* $s < \widetilde{s}$. In other words, this difference in home bias implies that, in the steady state, the North is a net creditor whereas the South is a net debtor. Of course, average net asset positions are also affected by uncertainty. But as we explain below, the difference in $\varkappa$ and $\widetilde{\varkappa}$ has a first-order effect on net asset positions.

Next, in order to better understand how the initial asset position affects the transmission of shocks, consider the case of a favorable common shock that decreases real interest rates in both regions. In both economies, the decline in real interest rates, or increase in asset prices, raises the revenue received from selling the traded asset abroad. But since the South is a net debtor, in the sense that the average quantity of asset issued by the region and sold abroad is greater than the quantity purchased from abroad, a decline in real borrowing cost is good news for the region. In net terms, the higher value of asset prices implies that the net income from trading on the international asset market received by agents in the South increases. In the North, since the region is a net creditor, a decline in real interest rates has the opposite effect. Of course, the evolution of the trade balance in both regions not only depends on this valuation effect but also on the dynamics of quantities. On impact, however, this valuation effect has a dominating impact on the dynamics of trade balances. This point can be illustrated by totally differentiating the expression that defines the trade balance in the North:

$$dtb_t = \underbrace{(\gamma\widetilde{s}d\widetilde{p}_{St} - \gamma s dp_{St})}_{\text{Valuation effect}} + \underbrace{(\gamma\widetilde{p}_S d\widetilde{s}_{t+1} - \gamma p_S ds_{t+1}) + (ds_t - d\widetilde{s}_t)}_{\text{Quantity effect}}$$

where we use the model's deterministic model as the approximation point.[15] Changes in the trade balance in the North dtb_t can thus be decomposed into a valuation and a quantity effects. The valuation effect isolates the contribution of a change in prices, which are denoted by $d\widetilde{p}_{St}$ and dp_{St}, on the dynamics of the trade balance and the above expression illustrates that this effect crucially depends on the steady state values of $\widetilde{s}$ and s. Without any difference in $\widetilde{s}$ and s, the change in prices would almost completely offset each other since, as shown on Figure B.2, the dynamics of asset prices is very similar across countries. When $\widetilde{s}$ and s differ, the key is that this valuation effect can be positive or negative depending on whether the country is a net debtor or a net creditor.

In the North, the region's positive net steady state asset position, *i.e.* $\widetilde{s} > s$, implies that this valuation effect has a positive impact on the trade balance. To illustrate this point, Figure B.5 shows the response of the trade balance in the North, in deviation from steady state , *i.e.* $tb_t - tb$, and decomposes the total effect into the valuation and quantity effects shown above. This decomposition illustrates that, on impact, the higher trade surplus obtained in the North in response to a positive shock is driven by this valuation effect. In our environment, common technology shocks therefore lead to movements in real interest rates that are common across countries and, as in Kraay and Ventura (2000), favorable shocks lead to a deficit in the debtor country and to a surplus in the creditor economy.

A hedging motive

For the calibration that we consider, the response of quantities attenuates the valuation effect induced by changes in real interest rates and can therefore be interpreted as a hedging motive. In the South, since the fluctuations in asset prices are a source of procyclicality, the strong increase in the demand for the foreign asset (see the red dotted line in the left panel of Figure B.6) in that region contributes to attenuate the procyclicality of net capital inflows experienced during periods of expansion.

[15] dtb_t therefore denotes the difference between the trade balance at time t and its value in the deterministic steady state of the model, *i.e.* tb.

In the North, since the cyclical behavior of asset prices attenuates the cost of business cycle fluctuations, it is optimal for the region to reduce its exposure to the foreign asset (see the blue continuous line in Figure B.6) in response to a favorable shock. The decline in real rates induced by a positive shock increases asset prices which therefore implies that purchasing the foreign asset becomes more expensive during booms. Since the cost of business cycle fluctuations is low in the North, agents are unwilling to pay a higher price to accumulate the foreign asset during periods of expansion. In good times, the region therefore reduces its exposure to fluctuations in the price of the foreign asset $\widetilde{p}_S$, which explains the decline in $\widetilde{s}$ induced by this hedging motive.

Figure B.5, which shows this decomposition between the hedging motive and valuation effect in the North, illustrates that the quantity effect reduces the rise in the region's trade surplus in response to a favorable shock. In both regions, the optimal portfolio allocation therefore attenuates the valuation effect induced by the fluctuations in the two asset prices p_S and $\widetilde{p}_S$. The hump-shaped dynamics of trade balances shown in Figure B.1 can therefore be explained by this hedging motive, which attenuates the impact of price movements on net capital flows.

The cyclicality of capital flows and the investment margin

Given the higher intertemporal smoothing motive in the South induced by this mechanism, whether net capital inflows are procyclical or countercyclical very much depends on the efficiency of the investment margin. As documented in the asset pricing literature (e.g., Jermann 1998), combining frictions that reduce the potential for intertemporal smoothing with habit formation increases the volatility of marginal utility. In terms of the consumption and saving decision, theses larger fluctuations in marginal utility create a stronger demand for capital in good times, since accumulating capital when consumption is high allows agents to transfer wealth from today to tomorrow, which is how consumption smoothing is achieved in this class of models.

In our environment, the main difference is that two assets are available to achieve consumption smoothing. For the benchmark model that reproduces the moments shown in Table 2, the large effect of favorable shocks on capital accumulation in the South shows that investment is the main margin that agents in that region use to achieve consumption smoothing. Since physical capital only depreciates slowly over time, and since the financial asset is a short-term asset, domestic capital accumulation is a better hedge against business cycle fluctuations. In response to a positive shock, consumption increases and since the increase in domestic production is not sufficient to finance the desired level of capital accumulation, the optimal choice is to borrow from abroad to finance part of the increase in domestic capital by increasing the region's trade deficit.

Whether the trade balance in the South deteriorates or improves in response to a positive shock critically depends on the efficiency of the investment margin. In a model with capital adjustment costs, the efficiency of the investment margin is determined by the two parameters ϵ and $\widetilde{\epsilon}$. This point is illustrated in Figure B.7, which compares the response of the trade balance to output ratios in the South in three different cases. The black dotted line shows the response obtained in the benchmark model that reproduces the moments shown in Table 2. The blue continuous line is the case in which capital adjustment costs in the South are removed by setting $\widetilde{\epsilon}$ to zero. The dashed red line is the model without capital adjustment costs in the North, which, relative to the benchmark model is obtained by setting ϵ to zero. Table 5 below reports the welfare cost of business cycle fluctuations and the correlation between the trade balance to output ratios and output in each case.

Notice first that the cost of business cycle fluctuations in always higher in the South than in the North, even in the version of the model that abstracts from adjustment costs in the South. In all three cases, we also have checked that marginal utility is always more volatile in the South than in the North. The stronger intertemporal smoothing motive in the South than in the North is therefore not due differences in capital adjustment costs.

Given this stronger intertemporal smoothing motive in the South, what critically depends on the degree of adjustment costs is the margin that is used to achieve consumption smoothing. In response to a favorable shock, whether the deficit in the South improves or deteriorates depends on the relative efficiency of the country's investment margin. Consider first the case in which the investment margin in the South is made more attractive than in the benchmark calibration by setting $\widetilde{\epsilon}$ to 0. When capital adjustment costs in the South are removed, domestic capital accumulation in that region provides an even better hedge against business cycle fluctuations. As illustrated by the blue continuous line in Figure B.7, relative to the response obtained in the benchmark model, the decline in the region's trade balance in response to a favorable shock is even more pronounced in this case. If the investment margin is efficient, the region most affected by business cycle fluctuations finances domestic capital accumulation by running a trade deficit in good times. The magnitude of the deterioration of the region's trade balance therefore increases as the degree of capital adjustment costs in the region declines.

TABLE 5: INVESTMENT MARGIN AND NET CAPITAL FLOWS

	Benchmark Model	No adj. costs, South	No adj. costs, North
	$\widetilde{\epsilon} > \epsilon$	$\widetilde{\epsilon} = 0$	$\epsilon = 0$
$\frac{E(c)-c}{c}$	0.0	0.05	0.06
$\frac{E(\widetilde{c})-\widetilde{c}}{c}$	1.5	0.1	0.14
$corr\left(\log y_t, tb_t/y_t\right)$	0.57	0.99	-0.98
$corr\left(\log \widetilde{y}_t, \widetilde{tb}_t/\widetilde{y}_t\right)$	-0.56	-0.99	0.99

If, in relative terms, the investment margin in the South is made sufficiently unattractive, the foreign asset becomes the preferred hedge against business cycle fluctuations. This point is illustrated by the dashed red line in Figure B.7. If we eliminate capital adjustment costs in the North, a positive shock generates a trade surplus in the South. Intertemporal smoothing in the South is therefore best achieved by using the cross-border asset market instead of the investment margin when accumulating capital is, in relative terms, too inefficient. In terms of the decomposition shown above, when capital accumulation is relatively too costly, the hedging motive is so strong that the quantity effect has a dominating impact on the dynamics of trade balances. In this case, consumption smoothing in the South is therefore achieved by accumulating net foreign assets in good times, which implies fluctuations in net capital inflows that are countercyclical.

A stronger precautionary saving motive in the South

The direction of capital flows is determined by the difference in intertemporal smoothing motives, which leads to larger fluctuations in marginal utilities in the South than in the North. This mechanism also generates a stronger precautionary saving motive in the South than in the North. This point can be illustrated by analyzing how risk affects capital accumulation in the two economies. In the benchmark model, as shown in Table 2, the average capital to output ratios observed in the two regions can be matched and this ratio is 15.1 and 17.6 in the North and in the South, respectively. In the deterministic version of the model, which is obtained by setting the shock standard deviation σ_{ε_A} to zero, the capital to output ratio declines by about 1.6% in the South. In the North, risk has a smaller effect on capital accumulation and the average capital to output ratio is only 0.4% higher in the economy subject to business cycle fluctuations.

In the South, this precautionary increase in the capital to output ratio due to risk is financed by running a larger deficit. As shown in Table 2, the average trade balance to output ratio in the South predicted by the model is -1.41%. Removing uncertainty would reduce the magnitude of this deficit from -1.41% to -1.2%. This comparison also illustrates that risk only has a second-order effect on the magnitude of average imbalances in this environment. Introducing a difference in the degree of home bias, which we capture with different values for $\varkappa$ and $\widetilde{\varkappa}$, is the main driver of long-term imbalances. Relative to Fogli and Perri (2015), precautionary saving therefore plays a smaller role in our case.

The effects of financial frictions

Given that financial frictions could potentially play a role, this subsection studies the sensitivity of the main result to a change in calibration of the loan-in-advance and enforcement parameters. The upper left panel in Figure B.8 shows how a change in the tightness of the walk away constraint in the South $\widetilde{\mu}$ affects the correlation of the trade balance with output in the two regions. The upper right panel shows the effect of a change in $\widetilde{\mu}$ on the standard deviation of the trade balance to output ratios in both regions. As shown by the two upper panels, varying $\widetilde{\mu}$ from 1 to 10 only has a moderate impact on the dynamics of capital flows. In both regions, the trade balance to output ratios become less volatile as the degree of financial frictions in the South increases but the effect remains small in magnitude. Varying $\widetilde{\mu}$ also has a moderate impact on the cyclicality of the trade balance in the two regions.

The two lower panels of Figure B.8 illustrate that the tightness of the loan-in-advance constraint has an impact on the dynamics of capital flows that is very similar to the one obtained by varying $\widetilde{\mu}$. Overall, this suggests that the degree of cross-country heterogeneity in financial frictions only has a moderate impact on the cyclicality and volatility of trade balances.

It should be noted that the sensitivity of capital flows to changes in the tightness of the financial constraints crucially depends on the degree of capital adjustment costs. For low levels of adjustment costs, differences in financial frictions have a much stronger impact on the volatility and correlation with output of the ratios tb/y and $\widetilde{tb}/\widetilde{y}$.

The role of habits

As explained above, the strength of the model's endogenous propagation mechanism critically relies on the introduction of habits in the composite good. As illustrated by Figure B.3, a stronger intertemporal smoothing motive in the South can still be obtained in a version of the model in which differences in the preference for holding the safe asset is the only source of cross-country heterogeneity. Introducing differences in elasticities of intertemporal substitution is however a source of cross-country heterogeneity that has a strong impact on the dynamics of capital flows. This point is illustrated in Figure B.9, which shows how a change in the habit parameter in the South affects the volatility and correlation with output of the trade balance to output ratios in both regions.

As shown on the left panel, relative to the benchmark calibration, reducing the intensity of habits by raising $\widetilde{m}$ above 0.94 increases the volatility of trade balances in both regions. In the North, for instance, increasing $\widetilde{m}$ from 0.94 to 0.99 generates an increase in the volatility of the trade balance to output ratio from 0.05 to 0.4. Although common technology shocks are the only source of fluctuations, this sensitivity analysis illustrates that this model has the potential to match the volatility of the trade balance to output ratios observed in the data.

The right panel shows that reducing the intensity of habits in the South exacerbates the procyclicality of net capital inflows that the region experiences. Relative to the benchmark calibration, consumption in the South becomes too volatile when $\widetilde{m}$ is set to values higher than 0.94. If by contrast, the elasticity of intertemporal is substantially smaller in the South than in the North, which with this preference specification is achieved by setting $\widetilde{m}$ below m, the correlation between output and the trade balance changes sign. Such a calibration would also be inconsistent with the stylized facts reported in Table 3, since it would generate fluctuations in consumption that would be too volatile in the North and too smooth in the South.

6 Asymmetric Shocks

The large increase in spreads between government bond yields observed after 2011 in the Eurozone could suggest that the Sovereign Debt Crisis was an asymmetric shock. Since our model abstracts from default risk, we focus our analysis on spreads with a very short maturity. Although short-term rates can also contain a default premium, default risk is likely to play a more important role for longer maturities. Figure A.10 shows the spread between Italian and German Government bonds with a maturity of 3 and 12 months, which are depicted by the blue continuous and red dotted lines, respectively.

Figure A.11 shows how this asymmetric increase in government bond yields impacted the real economy. The left panel shows the dynamics of output from the fourth quarter of 2011 until the second quarter of 2018, where output is detrended using a linear trend and expressed in deviation from its mean. Together with the large increase in spreads, the longer and deeper recession observed in the South suggests that the Sovereign Debt Crisis had an asymmetric effect on the Eurozone. As can be seen on the right panel of Figure A.11, which shows the trade balance to output ratios expressed in deviation from their long-term averages, another important fact is that the increase in spreads was accompanied by a reduction in the trade deficit in the South, whereas the surplus in the North declined.

Simulating the effect of asymmetric financial shocks

The rise in spreads shown in Figure A.10 coincided with the announcement made by a major credit rating agency to put 15 eurozone economies on negative credit watch.[16] This announcement was followed by credit rating downgrades for nine eurozone economies (e.g., Baum et al. 2016). Since Germany's credit rating remained unaffected, the asymmetric credit rating downgrade could be one of the factors that could explain the sharp increase in spreads observed during this period. In the context of our model, we interpret this episode as a shock that reduces the demand for the asset issued by the country hit by the credit rating downgrade. This is achieved by assuming that the parameter that determines the demand for the foreign asset in the North, which is denoted by $\varkappa$, is subject to random disturbances. In line with the narrative of Milesi-Ferretti et al. (2011), the sudden stop is modelled as a "retrenchment" shock in the sense that it reduces the share of foreign assets in portfolio holdings by agents in the North.

Augmenting the model with financial shocks affects spreads by modifying the expected payoff from holding the foreign asset. In the North, the demand for the foreign asset is given by the following optimality condition:

$$\widetilde{p}_{St}\lambda_t = \beta E_t \lambda_{t+1} \left\{ 1 + \frac{(1-\zeta_{t+1}\varkappa)}{\zeta_{t+1}\varkappa} \frac{c_{t+1}}{\widetilde{s}_t} \right\}$$

[16] See for instance Financial Times (2011). "S&P warns eurozone of mass downgrade", Dec. 6th 2011.

where the process for the demand shock, which is denoted by ζ_t, follows an autoregressive process of order 1:

$$\log \zeta_t = \rho_\zeta \zeta_{t-1} + \varepsilon_{\zeta t}$$

The persistence of the shock is denoted by ρ_ζ and the random disturbance $\varepsilon_{\zeta t}$ is normally distributed with mean 0 and standard deviation σ_ζ. An increase in ζ_t therefore generates a reduction in the demand in the North for the asset issued by the South. Although the shock is asymmetric, notice that a shock originating in the North is propagated to the South through the non-arbitrage condition in the cross-border asset market. In the South, the supply of the asset is determined by the following optimality condition, which relates the price received from selling the asset abroad to the issuance cost:

$$\widetilde{p}_{St} = \widetilde{\beta}\left(1+\widetilde{\varsigma}\right) E_t \frac{\widetilde{\lambda}_{t+1}}{\widetilde{\lambda}_t}$$

A decline in $\widetilde{p}_S$ induced by a financial shock in the North ζ_t, which lowers the demand for the Southern asset, is therefore equivalent to a stochastic discount factor shock in the South since it implies that $E_t\left(\widetilde{\lambda}_{t+1}/\widetilde{\lambda}_t\right)$ must decline. This decline in stochastic discounting in the South in turn lowers the value of asset prices in the economy. Since in the South, the demand for the safe asset issued by the North is given by the following condition:

$$p_{St} = \widetilde{\beta} E_t \frac{\widetilde{\lambda}_{t+1}}{\widetilde{\lambda}_t}\left\{1 + \frac{1-\widetilde{\varkappa}}{\widetilde{\varkappa}}\frac{\widetilde{c}_{t+1}}{s_t}\right\}$$

the decline in $E_t\left(\widetilde{\lambda}_{t+1}/\widetilde{\lambda}_t\right)$ in turn affects the price of the Northern asset. Through this stochastic discount factor effect, a negative demand shock for the Southern asset $\widetilde{p}_S$ therefore lowers the price of the Northern asset p_S. Since the shock has a direct effect on the demand for assets in the North, the direct effect of the shock is stronger than the indirect effect. The fall in $\widetilde{p}_S$ is therefore more pronounced than that of p_S. Defining the yield on the traded asset as one over the price, the spread between the yield of the 3-month asset issued by the South relative to the North can be expressed as follows:

$$spread_t = \frac{1}{\widetilde{p}_S} - \frac{1}{p_S}$$

To evaluate the effect of financial shocks, we next simulate the effect of a shock to ζ that reduces the demand in the North for the asset issued by the South. The shock standard deviation parameter $\varepsilon_{\zeta t}$ is calibrated to generate an increase in the spread between the 3-month yield of a Southern bond and a Northern security of 3%. Setting the shock standard deviation to 0.029 allows us to generate an increase in spreads of 3% on impact. The persistence parameter ρ_{ς} is calibrated to match the length of the recession in the North. In contrast to what was observed in the South, in the North, the recession was less dramatic and detrended output returned to its pre-crisis level, *i.e.* the level observed in the third quarter of 2011, about 5 years later. Setting the shock persistence to 0.85 ensures that output in the North returns to its steady state level 20 quarters after the shock hit. Figure B.10 shows the response to an asymmetric financial shock of the spread as well as output, the trade balance and consumption in the two regions.

On the positive side, the increase in spreads induced by the asymmetric financial shock generates a decline in output in the South that is more pronounced than in the North. The shock also explains the direction of capital flows generated by the shock. In particular, it is possible to capture the large net outflow of capital observed in the South, as well as the corresponding inflow in the North, a dynamics of net capital flows that was sometimes compared to a sudden stop. As demonstrated by the large effect of the shock on trade balances, introducing asymmetric financial shock helps to increase the volatility of the trade balance to output ratios. Overall, this suggests that augmenting the benchmark model with asymmetric financial shocks should help us generate fluctuations in net capital flows that are in closer conformity with the data.

Although the model augmented with asymmetric financial shocks is able to capture some key features of the Sovereign Debt Crisis, the quantitative magnitude of the effects that we obtain remain far from what was observed in the data. The model underpredicts the fall in output in the South and the increase in spreads is too persistent. As illustrated by the lower right panel, the asymmetric shock also generates differences in the response of consumption across regions. Although the shock had a much smaller effect in the North, the increase in consumption in the North predicted by the model is at variance with the facts.

Why not other kind of asymmetric shocks?

Although our analysis only provides a partial account of the Sovereign Debt Crisis, it still provides some useful directions for future work on the topic. Whereas the much larger fall in output observed in the South of Europe suggests that the region was hit by an asymmetric shock, the fact that the recession generated a reduction in the region's trade deficit limits the number of possible explanations. In particular, region specific shocks that do not directly impact the cross-border asset market cannot explain why the region had to close its trade deficit in the middle of a severe recession. In a model with optimizing agents and a well-functioning cross-border market, risk sharing implies that the region affected by an adverse shock will borrow from the other region to prevent consumption from falling too rapidly, which is the opposite from what happened. This suggests that the shock must have originated in the cross-border asset market and reduced the availability of funding available to finance the trade deficit of the debtor region.

Our analysis also emphasizes the importance of considering deviations from the complete international market assumption. The large increase in spreads shown in Figure A.10 illustrates that the Sovereign Debt Crisis affected bond yields at the very short-end of the maturity spectrum. An increase in spreads of this magnitude cannot be explained in a model in which the risk sharing condition is satisfied. In terms of transmission channels, the effects of the Sovereign Debt Crisis can thus be interpreted as a wedge in the risk sharing condition that generates a sudden increase in the cost that the debtor region has to pay to finance its trade deficit.

7 Conclusion

This paper explores the importance of common shocks in explaining imbalances in the presence of cross-country asymmetries. Our results suggest that the dynamics of capital flows critically depends on the magnitude of initial net asset positions. If shocks are common but countries differ in their economic structure, common shocks can have an asymmetric impact on debtor and creditor regions. Although this particular mechanism only explains a modest fraction of the observed volatility of the trade balance to output ratios, the magnitude that we obtain is sufficient to generate significant differences in the welfare cost of business cycle fluctuations across the two regions. In contrast to the complete market model, common shocks give rise to large differences in the dynamics of marginal utilities. Our results therefore suggest that substantial deviations from perfect risk sharing can arise even if a risk-free bond can be traded across borders.

It is important to emphasize that this paper studies imbalances from one particular angle, namely the contribution of common shocks in the presence of cross-country asymmetries.

Given our focus on the Eurozone, asking whether common shocks could account for the magnitudes of imbalances observed in a currency union seems like a natural starting point. As illustrated in section 6, our framework can also be used to study the effects of asymmetric shocks and our results suggest that introducing financial shocks into the analysis could be a promising direction. Moreover, since cross-country asymmetries amplify the propagation mechanism of common shocks, studying the transmission of monetary policy would be another natural extension.

8 References

Adjemian, S. & Bastani, H. & Karame, F. & Juillard, M. & Maih, J. & Mihoubi, F. & Perendia, G. & Pfeifer, J. & Ratto, M. & Villemot, S. (2014). "Dynare: Reference Manual Version 4," Dynare Working Papers 1, CEPREMAP.

Aguiar, M. and Gopinath, G. (2007). "Emerging Market Business Cycles: The Cycle Is the Trend," *Journal of Political Economy*, vol. 115, p. 69-102.

Arvanitis, A. & Mikkola, A. (1996). "Asset-Market Structure and International Trade Dynamics," *American Economic Review*, vol. 86(2), p. 67-70.

Backus, D. & Kehoe, P. & Kydland, F. (1992). "International Real Business Cycles," *Journal of Political Economy*, vol. 100(4), p. 745-75.

Baum, C. & Schafer, D. & Stephan, A. (2016). "Credit Rating Agency Downgrades and the Eurozone Sovereign Debt Crises," *Journal of Financial Stability*, vol. 24(C), . 117-131.

Baxter, M. & Crucini, M. (1993). "Explaining Saving-Investment Correlations," *American Economic Review*, vol. 83(3), p. 416-36.

Baxter, Marianne, (1995). "*International trade and business cycles*," in: G. M. Grossman & K. Rogoff (ed.), Handbook of International Economics, edition 1, volume 3, chapter 35, p. 1801-1864.

Baxter, M. & Crucini, M., (1995). "Business Cycles and the Asset Structure of Foreign Trade," *International Economic Review*, vol. 36(4), pages 821-54.

Bernanke, B. (2015). "Germany's Trade Surplus is a Problem". Brooking Institute, blog article, April 3, 2015.

Boileau, M. (1999). "Trade in Capital Goods and the Volatility of Net Exports and the Terms of Trade," *Journal of International Economics*, vol. 48(2), p. 347-365.

Bonam, D. & Goy, G. (2017). "Home Biased Expectations and Macroeconomic Imbalances in a Monetary Union," DNB Working Papers 556, Netherlands Central Bank.

CABALLERO, R. & FARHI, E. & GOURINCHAS, P. (2008). "An Equilibrium Model of "Global Imbalances" and Low Interest Rates." *American Economic Review*, 98 (1), p. 358-93.

CACCIATORE, M. & FIORI, G. & GHIRONI, F. (2016). "Market Deregulation and Optimal Monetary Policy in a Monetary Union," *Journal of International Economics*, vol. 99(C), p. 120-137.

CHALLE, E. & LOPEZ, J. & MENGUS, E. (2016). "Southern Europe's Institutional Decline". HEC Paris Research Paper No. ECO/SCD-2016-1148.

CECCHETTI, S. (1999). "Legal Structure, Financial Structure, and the Monetary Policy Transmission Mechanism," *Economic Policy Review*, issue Jul, p. 9-28.

CHETTY, R. & GUREN, A. & MANOLI, D. & WEBER, A. (2011). "Are Micro and Macro Labor Supply Elasticities Consistent? A Review of Evidence on the Intensive and Extensive Margins." *American Economic Review*, 101(3), p. 471-75.

COLE, H. (1988). "Financial Structure and International Trade," *International Economic Review*, vol. 29(2), p. 237-59.

CORSETTI, G. & DEDOLA, L. & LEDUC, S. (2008). "International Risk Sharing and the Transmission of Productivity Shocks," *Review of Economic Studies*, vol. 75(2), p. 443-473.

DANTHINE, J., & GIAVAZZI, G. & VIVES, X. & VON THADDEN, E. (1999). The Future of European Banking. London: Centre for Economic Policy Research.

DIMITRIEV, A. (2017). "Composite Habits and International Transmission of Business Cycles," *Journal of Economic Dynamics and Control*, vol. 76(C), p. 1-34.

DRAGHI, M. (2014). "Recovery and Reform in the Euro Area", Brookings Institution, Washington, 9 October 2014.

ECB (2014). "SME Access to Finance in the Euro Area: Barriers and Potential Policy Remedies", ECB Monthly Bulletin, July 2014.

European Commission (2016). "The Macroeconomic Imbalance Procedure: Rationale, Process, Application: A Compendium", Institutional Paper 039.

Feenstra, R., & Inklaar, R. & Timmer, M. (2015), "The Next Generation of the Penn World Table" *American Economic Review*, 105(10), p. 3150-3182.

Fernandez-Villaverde, J. & Garicano, L. & Santos, T. (2013). "Political Credit Cycles: The Case of the Eurozone," *Journal of Economic Perspectives*, vol. 27(3), p. 145-66

Fernandez-Villaverde, J. & Ohanian, L. (2015). "The Political Economy of European Economic Stagnation", mimeo University of Pennsylvania.

Ferrero, A. (2009). "Fiscal and Monetary Rules for a Currency Union," *Journal of International Economics*, vol. 77(1), p. 1-10.

Finn, M. & Hoffman, D. & Schlagenhauf, D. (1990). "Intertemporal Asset-pricing Relationships in Barter and Monetary Economies An Empirical Analysis," *Journal of Monetary Economics*, vol. 25(3), p. 431-451.

Fogli, A. & Perri, F. (2015). "Macroeconomic Volatility and External Imbalances," *Journal of Monetary Economics,* vol. 69, p. 1–15.

Gali, J. & Monacelli, T. (2005). "Monetary Policy and Exchange Rate Volatility in a Small Open Economy," *Review of Economic Studies* 72 (3), p. 707–34.

Gali, J. & Monacelli, T. (2016). "Understanding the Gains from Wage Flexibility: The Exchange Rate Connection," *American Economic Review*, 106 (12), p. 3829-68.

Gilchrist, S. & Schoenle, R. & Sim, J. & Zakrajsek, E. (2018). "Financial Heterogeneity and Monetary Union," Finance and Economics Discussion Series 2018-043, Board of Governors of the Federal Reserve System (US).

Glick, R. & Rogoff, K. (1995). "Global versus Country-Specific Productivity Shocks and the Current Account," *Journal of Monetary Economics,* 35, p. 159-92.

Gopinath, G. & Kalemli-Ozcan, S. & Karabarbounis, L. & Villegas-Sanchez, C. (2017). "Capital Allocation and Productivity in South Europe", *Quarterly Journal of Economics*, 132 (4), p. 1915-1967.

Gourinchas, P. & Philippon, T. & Vayanos, D. (2016). "The Analytics of the Greek Crisis," NBER Working Paper No. 22370.

Gourio, F. & Siemer, M. & Verdelhan, A. (2013). "International Risk Cycles," *Journal of International Economics*, vol. 89(2), p. 471-484.

Hall, R. (2009). "Reconciling Cyclical Movements in the Marginal Value of Time and the Marginal Product of Labor," *Journal of Political Economy*, 117(2), p. 281-323.

Heathcote, J. & Perri, F. (2002). "Financial Autarky and International Business Cycles," *Journal of Monetary Economics*, vol. 49(3), p. 601-627.

Holman, J. "GMM Estimation of a Money-in-the-Utility-Function Model: The Implications of Functional Forms", *Journal of Money, Credit and Banking*, vol. 30, no. 4, 1998, p. 679–698.

Hoffmann, M. & Krause, M. & Laubach, T. (2019). "The Expectations-Driven US Current Account," *The Economic Journal,* vol. 129, iss. 618, p. 897–924.

Jaccard, I. (2014). "Asset Returns and Labor Supply in a Production Economy", *Journal of Money, Credit and Banking*, vol. 46, iss. 5, p. 889–919.

Jaccard, I. (2018). "Asset Pricing and the Propagation of Macroeconomic Shocks,". *Journal of the European Economic Association,* vol. 16, iss. 2, p. 436-486.

Jermann, U., (1998). "Asset Pricing in Production Economies," *Journal of Monetary Economics*, vol. 41(2), pages 257-275.

Jermann, U. & Quadrini, V. (2012). "Macroeconomic Effects of Financial Shocks," *American Economic Review*, vol. 102(1), p. 238-71.

King, R. & Plosser, C. & Rebelo, S. (1988). "Production, Growth and Business Cycles", *Journal of Monetary Economics,* vol. 21(2-3), p. 195-232.

King, R. & Rebelo, S., (1999). "Resuscitating Real business Cycles," *Handbook of Macroeconomics*, J. B. Taylor & M. Woodford (ed.), edition 1, volume 1, chapter 14, p. 927-1007.

Kocherlakota, N. (1990). "On the 'Discount' Factor in Growth Economies." *Journal of Monetary Economics*, vol. 25(1), p. 43-47.

Kollmann, R. (1996). "Incomplete Asset Markets and the Cross-country Consumption Correlation Puzzle," *Journal of Economic Dynamics and Control*, vol. 20(5), p. 945-961.

Kollmann, R. & Pataracchia, B. & Ratto, M. & in't Veld, J. & Roeger, W. (2014). "International Capital Flows and the Boom-bust Cycle in Spain," *Journal of International Money and Finance*, vol. 48(PB), p. 314-335.

Kraay, A. & Ventura, J. (2000). "Current Accounts in Debtor and Creditor Countries," *The Quarterly Journal of Economics*, vol. 115, Issue 4, 1 Nov. 2000, p. 1137–1166.

La Porta, R. & Lopez-de-Silanes, F. & Shleifer, A. & Vishny, R. (1997). "Legal Determinants of External Finance,". *Journal of Finance* 52, no. 3: 1131-1150.

La Porta, R. & Lopez-de-Silanes, F. & Shleifer, A. & Vishny, R. (1998). "Law and Finance," *Journal of Political Economy* 106 (1998): 1113-1155.

Lane, P. (2000). "Asymmetric Shocks and Monetary Policy in a Currency Union," *The Scandinavian Journal of Economics*, 102(4), p. 585-604.

Lane, P. (2013). "Capital Flows in the Euro Area," European Economy - Economic Papers 2008 - 2015 497, European Commission.

Lau, S. & Ng, L. & Zhang, B. (2010). "The World Price of Home Bias," *Journal of Financial Economics*, vol. 97(2), p. 191-217.

Lucas, R. (2003). "Macroeconomic Priorities," *American Economic Review*, vol. 93(1), p. 1-14.

Martin, P. & Philippon, T. (2017). "Inspecting the Mechanism: Leverage and the Great Recession in the Eurozone," *American Economic Review*, vol. 107(7), p. 1904-1937.

MENDOZA, E. & QUADRINI, V. & RIOS-RULL, J. (2009). "Financial Integration, Financial Development, and Global Imbalances," *Journal of Political Economy*, vol. 117(3), p. 371-416, 06.

MILESI-FERRETTI, G., & TILLE, C., & OTTAVIANO, G., & RAVN, M. (2011). "The Great Retrenchment: International Capital Flows During the Global Financial Crisis. " *Economic Policy*, 26(66), p. 285-342.

PISTAFERRI, L. (2003). "Anticipated and Unanticipated Wage Changes, Wage Risk, and Intertemporal Labor Supply," *Journal of Labor Economics*, vol. 21(3), p. 729-754.

PRADES, E. & RABITSCH, K. (2012). "Capital Liberalization and the US External Imbalance," *Journal of International Economics*, vol. 87(1), p. 36-49.

REIS, R. (2013). "The Portugese Slump and Crash and the Euro Crisis," *Brookings Papers on Economic Activity*, vol. 46 (1), p. 143-210.

RUBIO, M. (2014). "Housing-market Heterogeneity in a Monetary Union," *Journal of International Money and Finance*, vol. 40(C), p. 163-184.

SIENA, D. (2018). "The Euro Area Periphery and Imbalances: Is it an Anticipation Story?", Working papers 501, Banque de France.

SCHMITT-GROHE, S. & URIBE, M. (2017). "Open Economy Macroeconomics", Graduate Textbook, Princeton University Press, April 2017.

SMETS, F. & RAF, W. (2003). "An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area," *Journal of the European Economic Association*, vol. 1(5), p. 1123-1175.

9 Appendix A: Motivating Stylized Facts

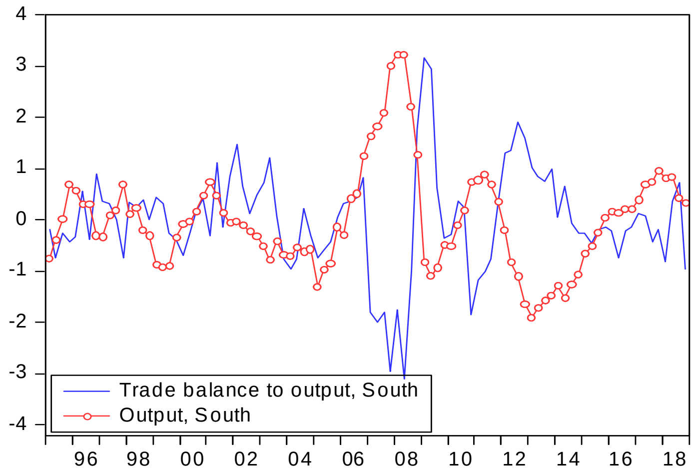

Figure A.1: Trade balance to output ratio South Europe vs. Germany and nominal output in South Europe in logs, hp-filtered data. South Europe consists of Greece, Portugal, Spain and Italy. The series have been normalized to have the same scale. Data source: OECD, IMF direction of trade.

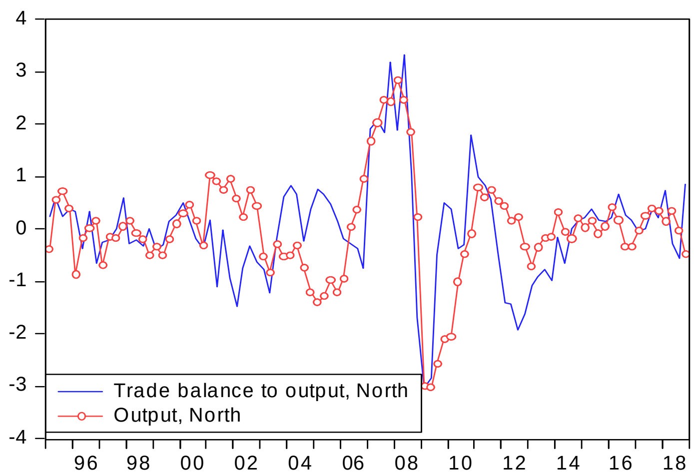

Figure A.2: Trade balance to output ratio South Europe vs. Germany and nominal output Germany in logs, hp-filtered data. Data source: OECD, IMF direction of trade.

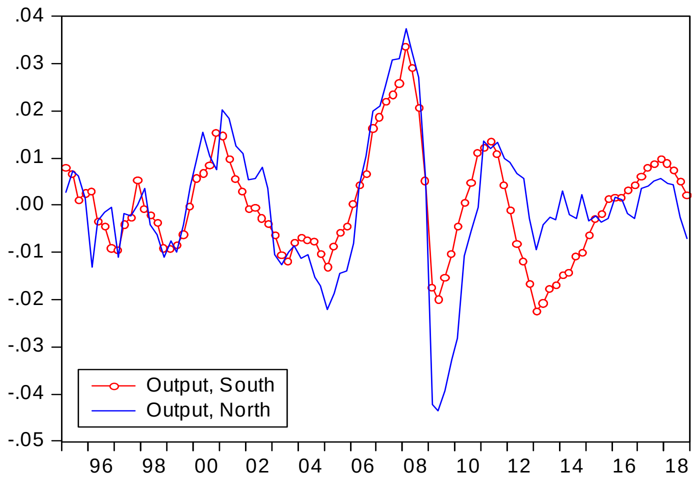

Figure A.3: Real output in Germany and South Europe, hp-filtered data. South Europe consists of Greece, Italy, Spain and Portugal. Data source: OECD.

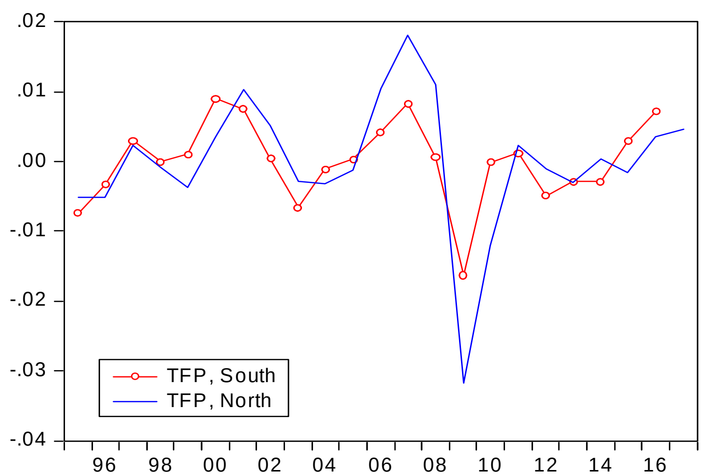

Figure A.4: Multifactor productivity Germany and South Europe. South Europe consists of Italy, Portugal and Spain. Data source: OECD.

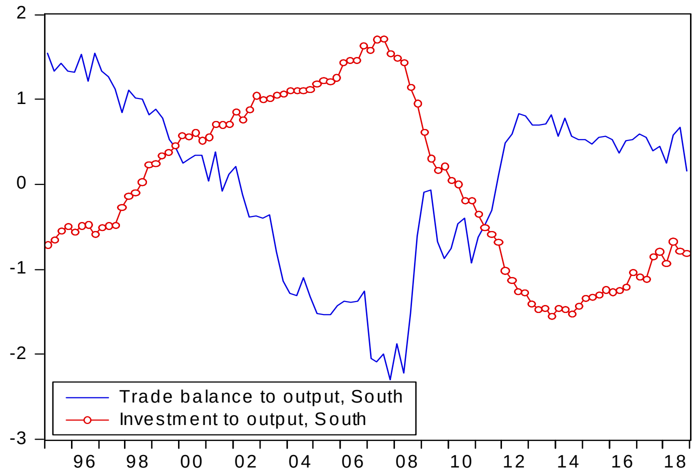

Figure A.5: Trade balance to output ratio and investment to output ratio in South Europe. South Europe consists of Greece, Portugal, Spain and Italy, normalized data. Data source: OECD, IMF direction of trade.

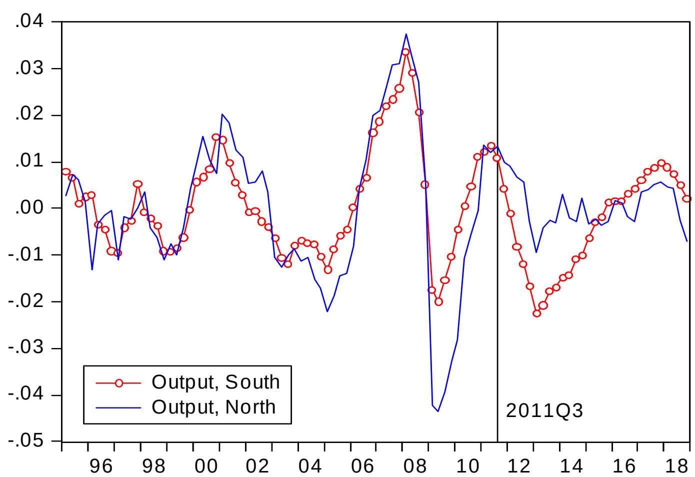

Figure A.6: hp-filtered output in logs. Data source: OECD

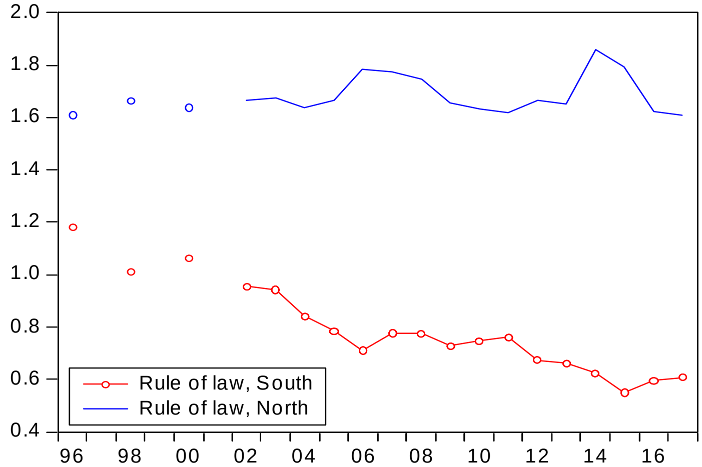

Figure A.7: Rule of law index. Data source: World Bank/NRGI/Brookings. For the South, the index is obtained by computing a weighted average using GDP shares for Greece, Italy, Portugal and Spain.

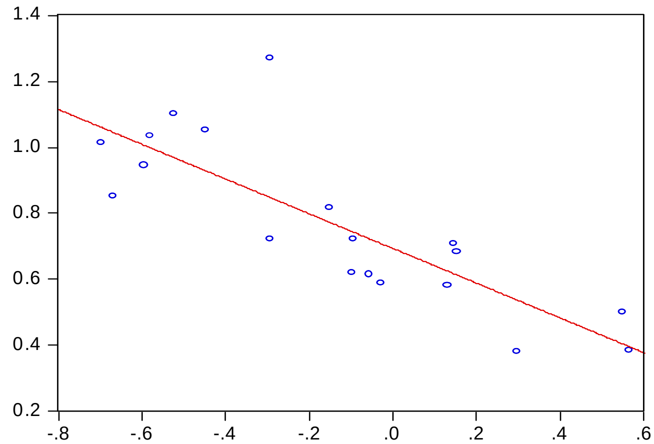

Figure A.8: Euro zone data, 19 countries. x axis: Correlation trade balance to output with output, hp-filtered data. y axis: Standard deviation of consumption relative to output, hp-filtered data. Data source: Statistical Office of the European Commission.

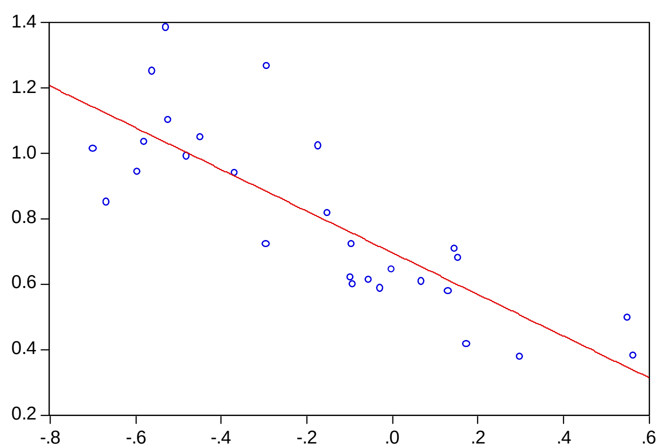

Figure A.9: European Union data, 28 countries. x axis: Correlation trade balance to output with output, hp-filtered data. y axis: Standard deviation of consumption relative to output, hp-filtered data. Data source: Statistical Office of the European Commission.

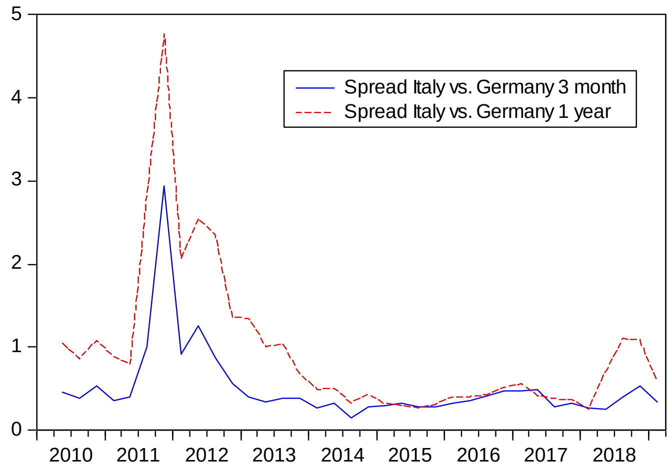

Figure A.10: Spreads between 3-month and 12-month government bond of Italy vs. Germany. Data source: Tullett Prebon Information.

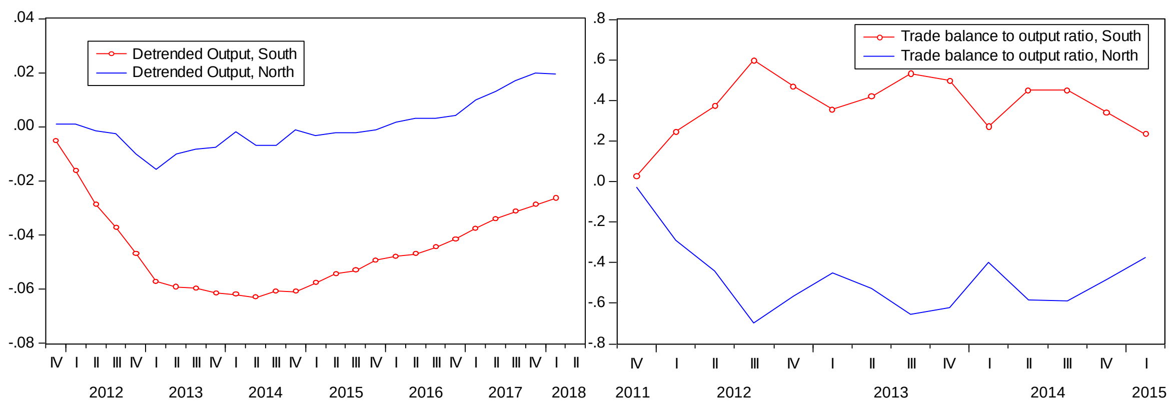

Figure A.11: Detrended output and trade balance to output ratios during the Sovereign Debt Crisis.

10 Appendix B: Figures

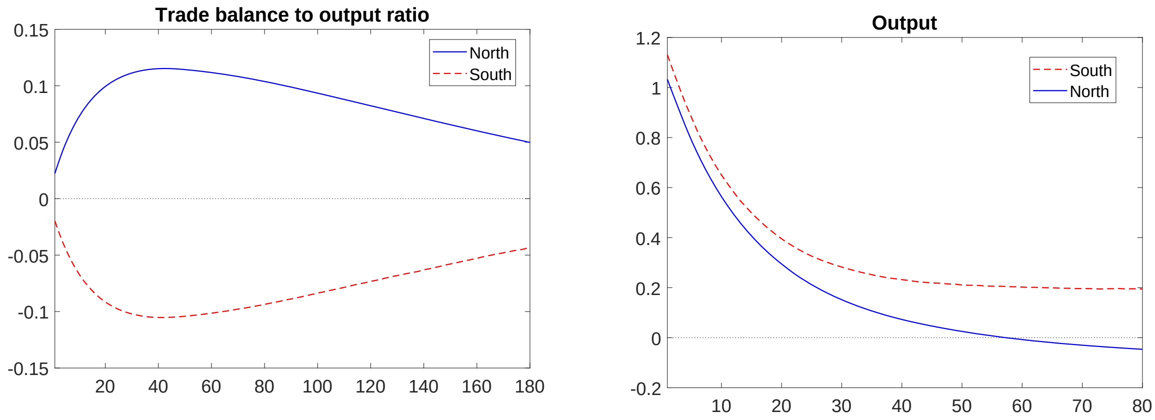

Figure B.1: Impulse response of the trade balance to output ratio and of output in logs in the North and in the South to a positive common TFP shock. x axis: quarters after the shock. y axis: deviation from steady state.

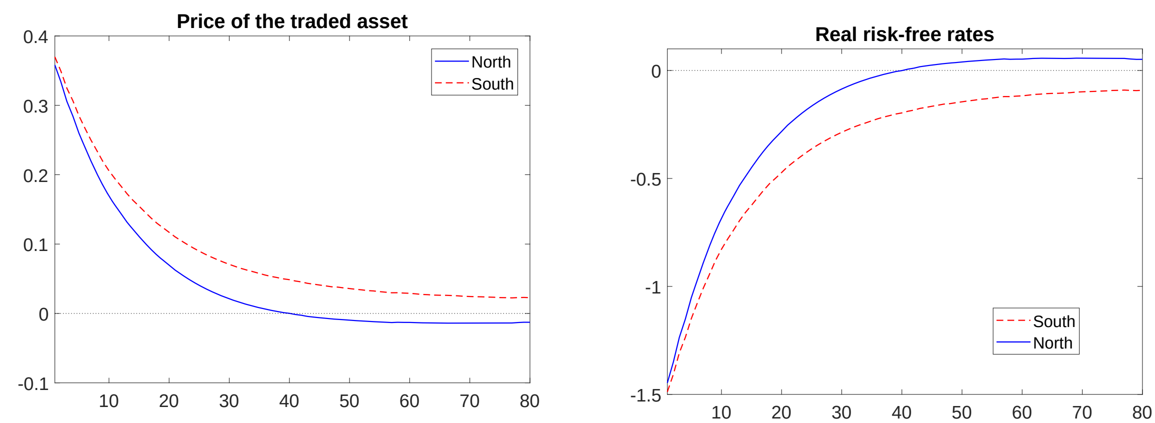

Figure B.2: Impulse response of the price of the traded asset and risk-free rates to a positive common TFP shock. x axis: quarters after the shock. y axis: deviation from steady state. The asset prices are reported in logs and the risk-free rates in annualized percent.

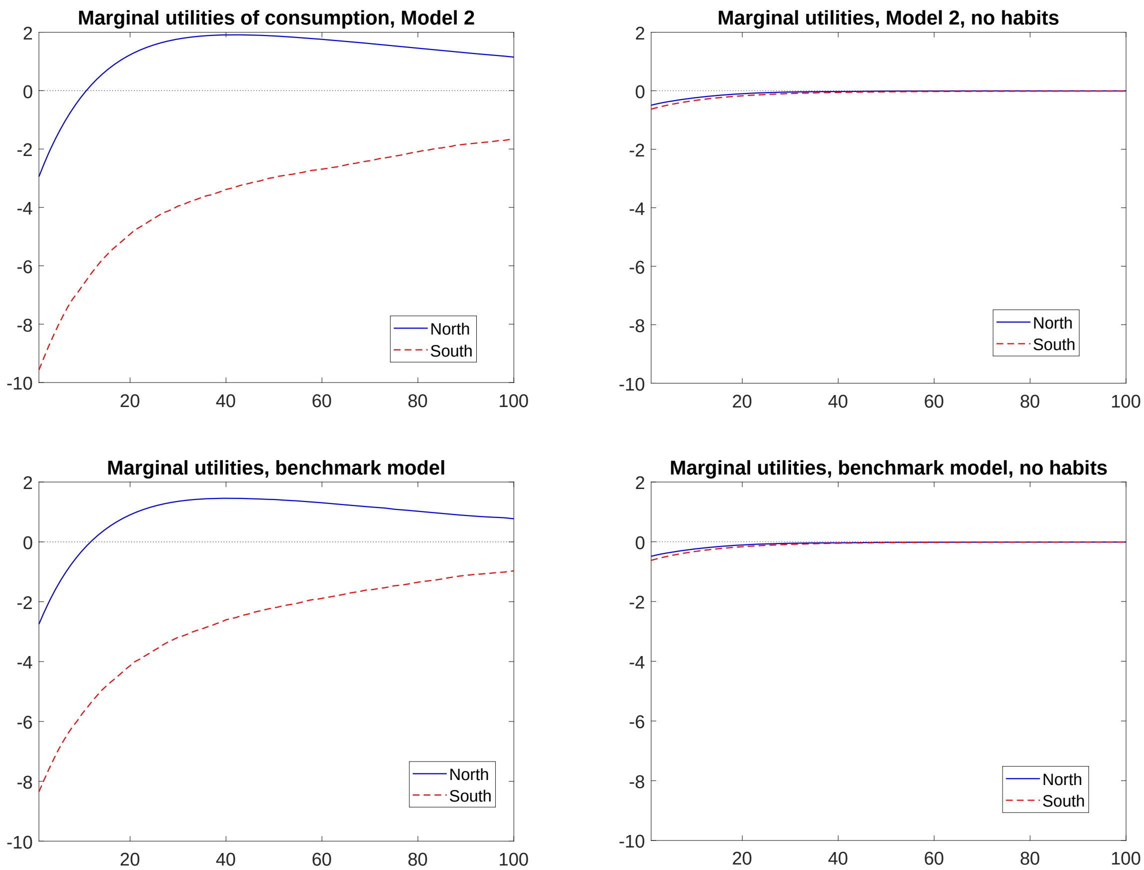

Figure B.3: Impulse response of marginal utility in logs to a positive common TFP shock in the different models. x axis: quarters after the shock. y axis: deviation from steady state.

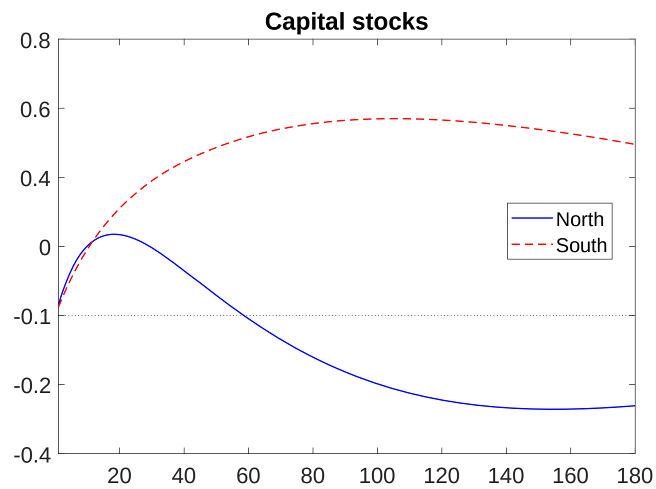

Figure B.4: Impulse response of the capital stocks in logs to a positive common TFP shock. x axis: quarters after the shock. y axis: deviation from steady state.

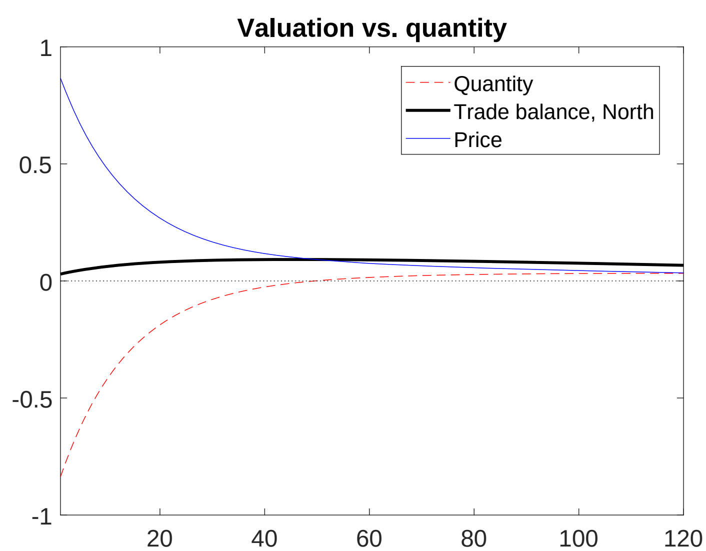

Figure B.5: Impulse response of the trade balance in the North to a positive common TFP shock and contribution of the valuation vs. quantity effects. x axis: quarters after the shock. y axis: deviation from steady state.

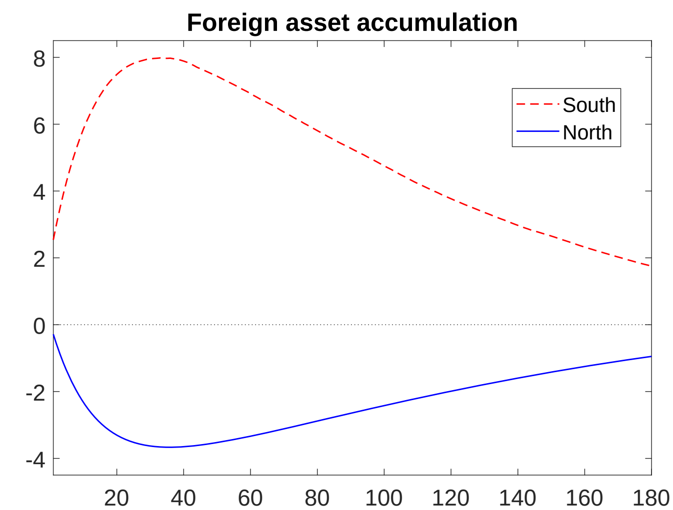

Figure B.6: Impulse response of foreign asset holdings to a positive common TFP shock. x axis: quarters after the shock. y axis: deviation from steady state.

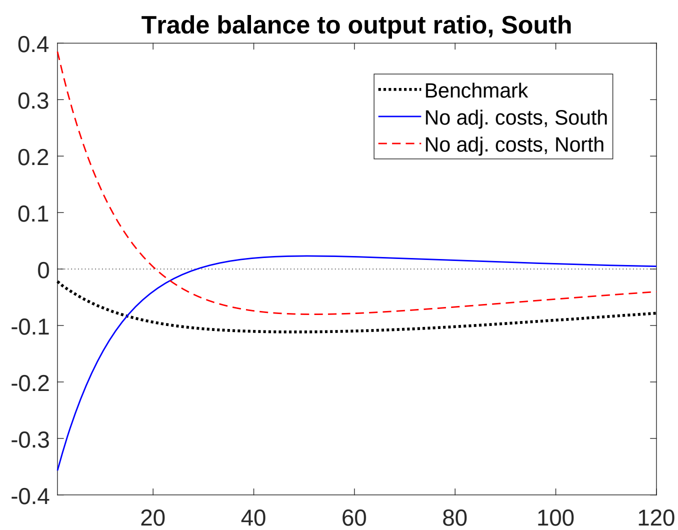

Figure B.7: Impulse response of the trade balance to output ratio in the South to a positive common TFP shock in three cases.

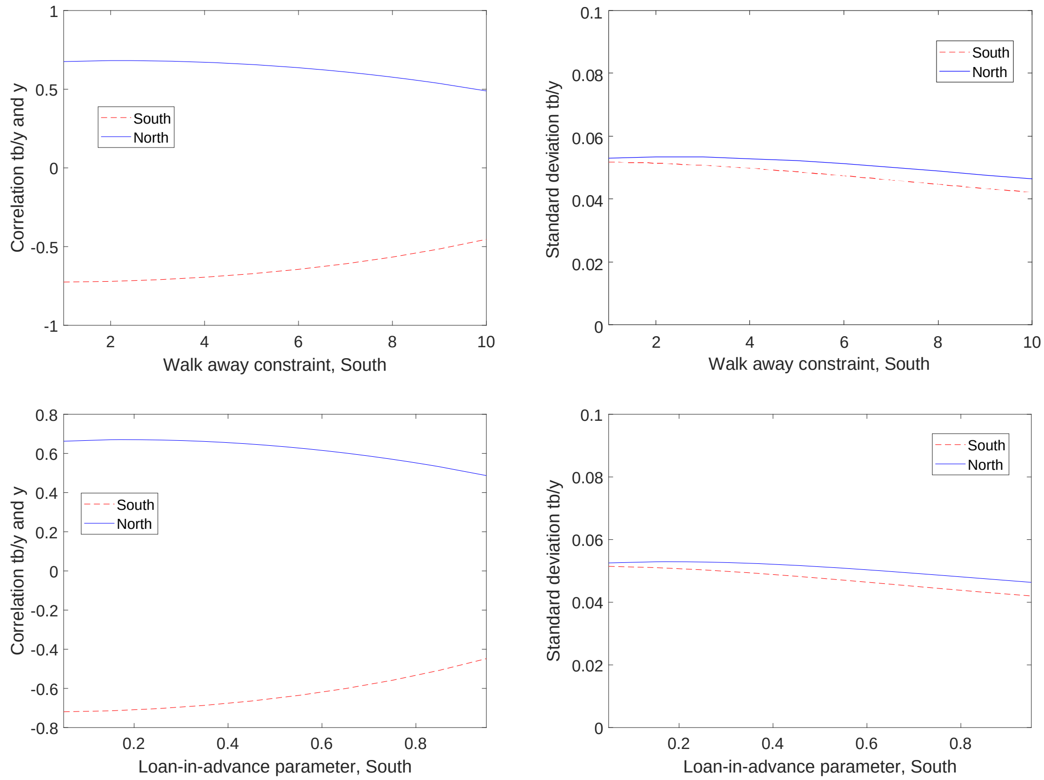

Figure B.8: Sensitivity to the tightness of the enforcement and liquidity constraints in the South.

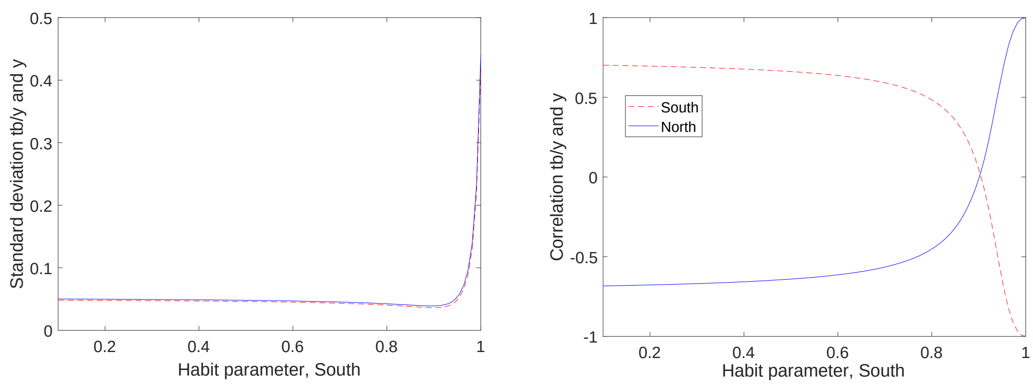

Figure B.9: Sensitivity to the habit parameter.

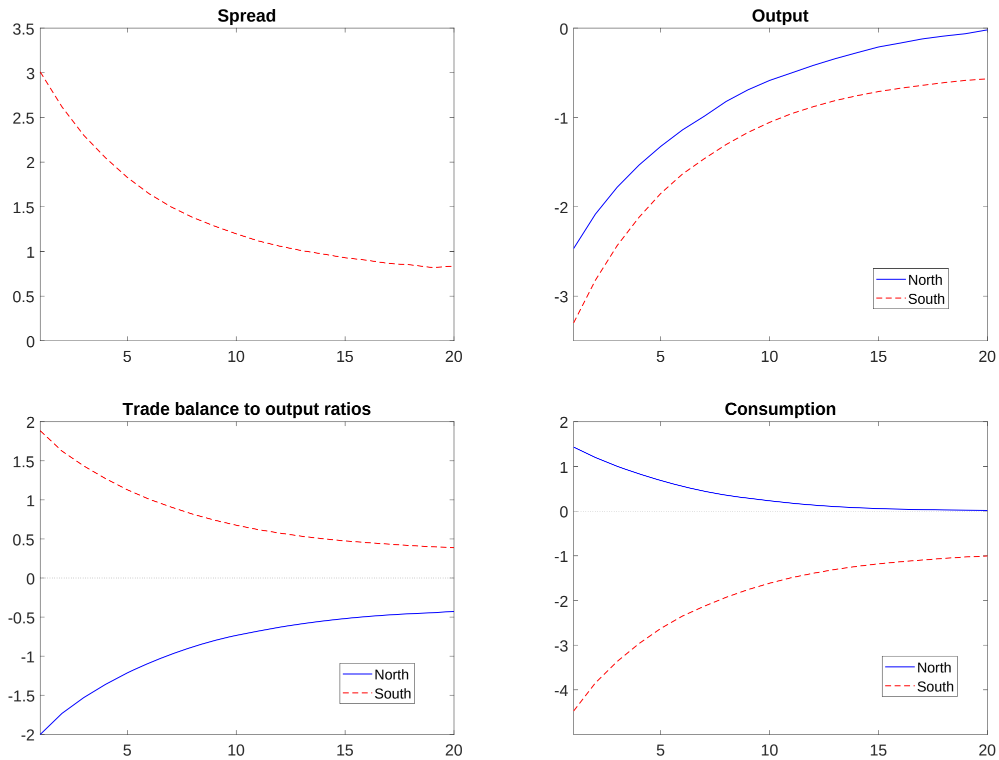

Figure B.10: Impulse response to an asymmetric negative financial shock. x axis: quarters after the shock. y axis: deviation from steady state.

11 Appendix C: Data description

Appendix to section 3

Variable	Data description	Data source
Real GDP	Expenditure based mio. of chained euros	OECD Quarterly, 1995-2011
Depreciation rates	Average depreciation rate capital stock	Penn Tables 9.1 Annual, 1995-2011
Lending rates	Loans less than 1 mio and less than 1 year	ECB Quarterly, 2000-2011
Deposit rates	Euro area: 11–19 3-month deposit	ECB Quarterly, 1995-2011
Price level	Harmonized index consumer prices	Stat. Office of the EC Quarterly, 1995-2011

Solow Residuals

The capital stock is constructed using investment and the average estimated depreciation rates. The starting value for the capital stock for the first quarter of 1995 is obtained by using the capital to output ratio, which we take from the Penn Tables. A quarterly time-series for the capital stock is then computed using the law of motion shown in equation (3).[17]

Variable	Data description	Data source
Real investment	Gross fixed capital formation mio. of 2010 chained euros	OECD Quarterly, 1995-2011
Hours worked	Hours worked by industry total employment	OECD Quarterly, 1995-2011

[17] With this particular specification, up to a first-order approximation, adjustment costs have no impact on the law of motion for capital accumulation.

Appendix to Tables 2 and 3

Variable	Data description	Data source
Real investment	Gross fixed capital formation mio. of chained euros	OECD Quarterly, 1995-2011
Credit and credit to GDP ratios	Credit to non-financial corporations	BIS Quarterly, 1995-2011
Price level	Harmonized index consumer prices	Stat. Office of the EC Quarterly, 1995-2011
Trade balance	Trade balance with Germany	IMF Direction of Trade Quarterly, 1995-2011
Nominal GDP	Expenditure based mio. of euros	OECD Quarterly, 1995-2011
Capital to GDP	Capital stock divided by GDP Current prices	Penn Tables 9.1 Annual, 1995-2011
Real Consumption	Final consumption expenditures Mio of chained 2010 euros	OECD Quarterly, 1995-2011

12 Appendix C: Technical appendix (not intended for publication)

Given the large number of state variables, the model is solved using perturbation methods. The welfare analysis is conducted using a second-order approximation to the policy function (e.g., Adjemian et al. 2014).

12.1 The home economy

The domestic consumer

$$\max\ E_0 \sum_{t=0}^{\infty} \widehat{\beta}^t \frac{\left(c_t^{\varkappa} \widetilde{s}_t^{1-\varkappa}\left(\psi+(1-N_t)^{\nu}\right)-x_t\right)^{1-\sigma}}{1-\sigma}$$

The Lagrangian:

$$L = E_0 \left\{ \begin{array}{c} \sum_{t=0}^{\infty} \widehat{\beta}^t \frac{\left[c_t^{\varkappa} \widetilde{s}_t^{1-\varkappa}(\psi+(1-N_t)^{\nu})-x_t\right]^{1-\sigma}}{1-\sigma} \\ +\sum_{t=0}^{\infty} \widehat{\beta}^t \lambda_t \left[\begin{array}{c} \pi_{Tt} + \widetilde{s}_t + r_{Kt}k_t + r_{Dt}d_t + w_t N_t \\ +p_{St}\gamma s_{t+1} - s_t - \varsigma s_t - c_t - i_t - \kappa d_t - \widetilde{p}_{St}\gamma \widetilde{s}_{t+1} \end{array} \right] \\ +\sum_{t=0}^{\infty} \widehat{\beta}^t \varphi_t \left[m x_t + (1-m) c_t^{\varkappa} \widetilde{s}_t^{1-\varkappa}\left(\psi + (1-N_t)^{\nu}\right) - \gamma x_{t+1} \right] \\ +\sum_{t=0}^{\infty} \widehat{\beta}^t q_t \lambda_t \left[(1-\delta) k_t + \left[\frac{\theta_1}{1-\epsilon} \left(\frac{i_t}{k_t}\right)^{1-\epsilon} + \theta_2 \right] k_t - \gamma k_{t+1} \right] \end{array} \right\}$$

First-order conditions:

c_t :

$$\left\{\left[c_t^{\varkappa} \widetilde{s}_t^{1-\varkappa}\left(\psi+(1-N_t)^{\nu}\right)-x_t\right]^{-\sigma}+\varphi_t(1-m)\right\} \varkappa c_t^{\varkappa-1} \widetilde{s}_t^{1-\varkappa}\left(\psi+(1-N_t)^{\nu}\right)=\lambda_t$$

N_t :

$$\left\{\left[c_t^{\varkappa} \widetilde{s}_t^{1-\varkappa}\left(\psi+(1-N_t)^{\nu}\right)-x_t\right]^{-\sigma}+\varphi_t(1-m)\right\} c_t^{\varkappa} \widetilde{s}_t^{1-\varkappa} \nu (1-N_t)^{\nu-1}=w_t \lambda_t$$

x_{t+1} :

$$\varphi_t = m\beta E_t \varphi_{t+1} - \beta E_t \left[c_{t+1}^{\varkappa} \widetilde{s}_{t+1}^{1-\varkappa}\left(\psi+(1-N_{t+1})^{\nu}\right)-x_{t+1}\right]^{-\sigma}$$

where to economize on notation, we have defined:

$$\beta = \widehat{\beta}/\gamma$$

φ_t :

$$mx_t + (1-m)c_t^{\varkappa}\widetilde{s}_t^{1-\varkappa}\left(\psi + (1-N_t)^{\nu}\right) - \gamma x_{t+1} = 0$$

k_{t+1} :

$$\begin{aligned} q_t\lambda_t &= \beta E_t q_{t+1}\lambda_{t+1}\left\{(1-\delta) + \left[\frac{\theta_1}{1-\epsilon}\left(\frac{i_{t+1}}{k_{t+1}}\right)^{1-\epsilon} + \theta_2\right] - \theta_1\left(\frac{i_{t+1}}{k_{t+1}}\right)^{1-\epsilon}\right\} \\ &\quad + \beta E_t\lambda_{t+1}r_{Kt+1} \end{aligned}$$

i_t :

$$q_t\theta_1\left(\frac{i_t}{k_t}\right)^{-\epsilon} = 1$$

s_{t+1} :

$$p_{St}\lambda_t = \beta E_t\lambda_{t+1}\left(1+\varsigma\right)$$

$\widetilde{s}_{t+1}$:

$$\begin{aligned} \widetilde{p}_{St}\lambda_t &= \beta E_t\lambda_{t+1} \\ &\quad + \beta E_t\left\{\left[c_{t+1}^{\varkappa}\widetilde{s}_{t+1}^{1-\varkappa}\left(\psi + (1-N_{t+1})^{\nu}\right) - x_{t+1}\right]^{-\sigma} + \varphi_{t+1}(1-m)\right\} \\ &\quad (1-\varkappa)c_{t+1}^{\varkappa}\widetilde{s}_{t+1}^{-\varkappa}\left(\psi + (1-N_{t+1})^{\nu}\right) \end{aligned}$$

d_t :

$$r_{Dt} = \kappa$$

q_t :

$$(1-\delta)k_t + \left[\frac{\theta_1}{1-\epsilon}\left(\frac{i_t}{k_t}\right)^{1-\epsilon} + \theta_2\right]k_t - \gamma k_{t+1} = 0$$

λ_t :

$$\pi_{Tt} + \widetilde{s}_t + r_{Kt}k_t + r_{Dt}d_t + w_t N_t + p_{St}\gamma s_{t+1} - s_t - \varsigma s_t - c_t - i_t - \kappa d_t - \widetilde{p}_{St}\gamma \widetilde{s}_{t+1} = 0$$

The bank

$$\pi_{Bt} = r_{Lt}l_t - r_{Dt}d_t$$

such that:

$$l_t = z d_t$$

First-order conditions:

$$r_{Lt} = \frac{r_{Dt}}{z}$$

The domestic firm

$$E_0 \sum_{t=0}^{\infty} \widehat{\beta}^t \frac{\lambda_t}{\lambda_0} \pi_{Ft}$$

such that:

$$\pi_{Ft} = A_t k_t^{\alpha} N_t^{1-\alpha} - w_t N_t - r_{Kt}k_t - r_{Lt}l_t$$

$$l_t \geq \eta \left(w_t N_t + r_{Kt}k_t\right)$$

$$\mu l_t \leq \upsilon_t$$

where:

$$\upsilon_t = \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \left[\upsilon_{t+1} + \pi_{Ft+1} \right]$$

The Lagrangian:

$$L = E_0 \sum_{t=0}^{\infty} \widehat{\beta}^t \frac{\lambda_t}{\lambda_0} \left\{ \left[A_t k_t^{\alpha} N_t^{1-\alpha} - w_t N_t - r_{Kt} k_t - r_{Lt} l_t \right] \right.$$

$$\left. + \frac{\varpi_t}{\lambda_t} \left[l_t - \eta \left(w_t N_t + r_{Kt} k_t \right) \right] + \frac{\psi_t}{\lambda_t} \left[\upsilon_t - \mu l_t \right] \right\}$$

First-order conditions:

N_t :

$$w_t = (1-\alpha) \frac{y_t}{N_t} \frac{1}{1 + \eta \frac{\varpi_t}{\lambda_t}}$$

k_t :

$$r_{Kt} = \alpha \frac{y_t}{k_t} \frac{1}{1 + \eta \frac{\varpi_t}{\lambda_t}}$$

l_t :

$$r_{Lt} + \mu \frac{\psi_t}{\lambda_t} = \frac{\varpi_t}{\lambda_t}$$

λ_t :

$$\pi_{Ft} = A_t k_t^{\alpha} N_t^{1-\alpha} - w_t N_t - r_{Kt} k_t - r_{Lt} l_t$$

Market clearing domestic economy

$$y_t - c_t - i_t - \kappa d_t - \varsigma s_t = s_t - p_{St} \gamma s_{t+1} + \widetilde{p}_{St} \gamma \widetilde{s}_{t+1} - \widetilde{s}_t$$

12.2 The foreign economy

The Lagrangian:[18]

[18] where we have assumed that σ and γ are the same in each country block.

$$\widetilde{L}=E_0\left\{\begin{array}{c}\sum_{t=0}^{\infty}\widetilde{\widetilde{\beta}}^t\frac{\left[\widetilde{c}_t^{\widetilde{\varkappa}}s_t^{1-\widetilde{\varkappa}}\left(\widetilde{\psi}+(1-\widetilde{N}_t)^{\nu}-\widetilde{x}_t\right)\right]^{1-\sigma}}{1-\sigma}\\+\sum_{t=0}^{\infty}\widetilde{\widetilde{\beta}}^t\widetilde{\lambda}_t\left[\begin{array}{c}\widetilde{\pi}_{Tt}+\widetilde{r}_{Kt}\widetilde{k}_t+\gamma\widetilde{p}_{St}\widetilde{s}_{t+1}+s_t+\widetilde{w}_t\widetilde{N}_t\\+\widetilde{r}_{Dt}\widetilde{d}_t-\widetilde{s}_t-\widetilde{\varsigma}\widetilde{s}_t-\widetilde{c}_t-\widetilde{i}_t-\widetilde{\kappa}\widetilde{d}_t-\gamma p_{St}s_{t+1}\end{array}\right]\\+\sum_{t=0}^{\infty}\widetilde{\widetilde{\beta}}^t\widetilde{\varphi}_t\left[\widetilde{m}\widetilde{x}_t+(1-\widetilde{m})\widetilde{c}_t^{\widetilde{\varkappa}}s_t^{1-\widetilde{\varkappa}}\left(\widetilde{\psi}+(1-\widetilde{N}_t)^{\nu}\right)-\gamma\widetilde{x}_{t+1}\right]\\+\sum_{t=0}^{\infty}\widetilde{\widetilde{\beta}}^t\widetilde{q}_t\widetilde{\lambda}_t\left[(1-\widetilde{\delta})\widetilde{k}_t+\left[\frac{\widetilde{\theta}_1}{1-\widetilde{\epsilon}}\left(\frac{\widetilde{i}_t}{\widetilde{k}_t}\right)^{1-\widetilde{\epsilon}}+\widetilde{\theta}_2\right]\widetilde{k}_t-\gamma\widetilde{k}_{t+1}\right]\end{array}\right\}$$

$\widetilde{c}_t$:

$$\left\{\left[\widetilde{c}_t^{\widetilde{\varkappa}}s_t^{1-\widetilde{\varkappa}}\left(\widetilde{\psi}+(1-\widetilde{N}_t)^{\nu}\right)-\widetilde{x}_t\right]^{-\sigma}+\widetilde{\varphi}_t(1-\widetilde{m})\right\}\widetilde{\varkappa}\widetilde{c}_t^{\widetilde{\varkappa}-1}s_t^{1-\widetilde{\varkappa}}\left(\widetilde{\psi}+(1-\widetilde{N}_t)^{\nu}\right)=\widetilde{\lambda}_t$$

$\widetilde{N}_t$:

$$\left\{\left[\widetilde{c}_t^{\widetilde{\varkappa}}s_t^{1-\widetilde{\varkappa}}\left(\widetilde{\psi}+(1-\widetilde{N}_t)^{\nu}\right)-\widetilde{x}_t\right]^{-\sigma}+\widetilde{\varphi}_t(1-\widetilde{m})\right\}\widetilde{c}_t^{\widetilde{\varkappa}}s_t^{1-\widetilde{\varkappa}}\nu(1-\widetilde{N}_t)^{\nu-1}=\widetilde{w}_t\widetilde{\lambda}_t$$

$\widetilde{x}_{t+1}$:

$$\widetilde{\varphi}_t=\widetilde{m}\widetilde{\beta}E_t\widetilde{\varphi}_{t+1}-\widetilde{\beta}E_t\left[\widetilde{c}_{t+1}^{\widetilde{\varkappa}}s_{t+1}^{1-\widetilde{\varkappa}}\left(\widetilde{\psi}+(1-\widetilde{N}_{t+1})^{\nu}\right)-\widetilde{x}_{t+1}\right]^{-\sigma}$$

where:

$$\widetilde{\beta}=\frac{\widetilde{\widetilde{\beta}}}{\gamma}$$

s_{t+1} :

$$\begin{aligned}p_{St}\widetilde{\lambda}_t &= \widetilde{\beta}E_t\widetilde{\lambda}_{t+1}\\&\quad+\widetilde{\beta}E_t\left\{\left[\widetilde{c}_{t+1}^{\widetilde{\varkappa}}s_{t+1}^{1-\widetilde{\varkappa}}\left(\widetilde{\psi}+(1-\widetilde{N}_{t+1})^{\nu}\right)-\widetilde{x}_{t+1}\right]^{-\sigma}+\widetilde{\varphi}_{t+1}(1-\widetilde{m})\right\}\\&\quad(1-\widetilde{\varkappa})\widetilde{c}_{t+1}^{\widetilde{\varkappa}}s_{t+1}^{-\widetilde{\varkappa}}\left(\widetilde{\psi}+(1-\widetilde{N}_{t+1})^{\nu}\right)\end{aligned}$$

$\widetilde{s}_{t+1}$:

$$\widetilde{p}_{St}\widetilde{\lambda}_t = \widetilde{\beta} E_t \widetilde{\lambda}_{t+1} (1+\widetilde{\varsigma})$$

$\widetilde{\varphi}_t$:

$$\widetilde{m}\widetilde{x}_t + (1-\widetilde{m})\widetilde{c}_t^{\widetilde{\varkappa}} s_t^{1-\widetilde{\varkappa}} \left(\widetilde{\psi} + (1-\widetilde{N}_t)^{\nu}\right) - \gamma \widetilde{x}_{t+1} = 0$$

$\widetilde{k}_{t+1}$:

$$\begin{aligned} \widetilde{q}_t\widetilde{\lambda}_t &= \widetilde{\beta} E_t \widetilde{q}_{t+1}\widetilde{\lambda}_{t+1} \left\{ (1-\widetilde{\delta}) + \left[\frac{\widetilde{\theta}_1}{1-\widetilde{\epsilon}} \left(\frac{\widetilde{i}_{t+1}}{\widetilde{k}_{t+1}} \right)^{1-\widetilde{\epsilon}} + \widetilde{\theta}_2 \right] - \widetilde{\theta}_1 \left(\frac{\widetilde{i}_{t+1}}{\widetilde{k}_{t+1}} \right)^{1-\widetilde{\epsilon}} \right\} \\ &+ \widetilde{\beta} E_t \widetilde{\lambda}_{t+1} \widetilde{r}_{Kt+1} \end{aligned}$$

$\widetilde{i}_t$:

$$\widetilde{q}_t\widetilde{\theta}_1 \left(\frac{\widetilde{i}_t}{\widetilde{k}_t} \right)^{-\widetilde{\epsilon}} = 1$$

$\widetilde{d}_t$:

$$\widetilde{r}_{Dt} = \widetilde{\kappa}$$

$\widetilde{q}_t$:

$$(1-\widetilde{\delta})\widetilde{k}_t + \left[\frac{\widetilde{\theta}_1}{1-\widetilde{\epsilon}} \left(\frac{\widetilde{i}_t}{\widetilde{k}_t} \right)^{1-\widetilde{\epsilon}} + \widetilde{\theta}_2 \right] \widetilde{k}_t - \gamma \widetilde{k}_{t+1} = 0$$

$\widetilde{\lambda}_t$:

$$\widetilde{\pi}_{Tt} + s_t + \widetilde{r}_{Kt}\widetilde{k}_t + \widetilde{r}_{Dt}\widetilde{d}_t + \widetilde{w}_t\widetilde{N}_t + \widetilde{p}_{St}\gamma\widetilde{s}_{t+1} - \widetilde{s}_t - \widetilde{\varsigma}\widetilde{s}_t - \widetilde{c}_t - \widetilde{i}_t - \widetilde{\kappa}\widetilde{d}_t - p_{St}\gamma s_{t+1} = 0$$

The foreign firm

$$E_0 \sum_{t=0}^{\infty} \widetilde{\beta}^t \frac{\widetilde{\lambda}_t}{\widetilde{\lambda}_0} \widetilde{\pi}_{Ft}$$

such that:

$$\widetilde{\pi}_{Ft} = \widetilde{A}_t \widetilde{k}_t^{\widetilde{\alpha}} \widetilde{N}_t^{1-\widetilde{\alpha}} - \widetilde{w}_t \widetilde{N}_t - \widetilde{r}_{Kt} \widetilde{k}_t - \widetilde{r}_{Lt} \widetilde{l}_t$$

and:

$$\widetilde{l}_t \geq \widetilde{\eta} \left(\widetilde{w}_t \widetilde{N}_t + \widetilde{r}_{Kt} \widetilde{k}_t \right)$$

$$\widetilde{\mu} \widetilde{l}_t \leq \widetilde{\upsilon}_t$$

First-order conditions:
$\widetilde{N}_t$:

$$\widetilde{w}_t = (1 - \widetilde{\alpha}) \frac{\widetilde{y}_t}{\widetilde{N}_t} \frac{1}{1 + \widetilde{\eta} \frac{\widetilde{\varpi}_t}{\widetilde{\lambda}_t}}$$

$\widetilde{k}_t$:

$$\widetilde{r}_{Kt} = \widetilde{\alpha} \frac{\widetilde{y}_t}{\widetilde{k}_t} \frac{1}{1 + \widetilde{\eta} \frac{\widetilde{\varpi}_t}{\widetilde{\lambda}_t}}$$

$\widetilde{l}_t$:

$$\widetilde{r}_{Lt} + \widetilde{\mu} \frac{\widetilde{\psi}_t}{\widetilde{\lambda}_t} = \frac{\widetilde{\varpi}_t}{\widetilde{\lambda}_t}$$

$\widetilde{\lambda}_t$:

$$\widetilde{\pi}_{Ft} = \widetilde{A}_t \widetilde{k}_t^{\widetilde{\alpha}} \widetilde{N}_t^{1-\widetilde{\alpha}} - \widetilde{w}_t \widetilde{N}_t - \widetilde{r}_{Kt} \widetilde{k}_t - \widetilde{r}_{Lt} \widetilde{l}_t$$

Market clearing foreign economy

$$\widetilde{y}_t - \widetilde{c}_t - \widetilde{\kappa} \widetilde{d}_t - \widetilde{i}_t - \widetilde{\varsigma} \widetilde{s}_t = \widetilde{s}_t - \gamma \widetilde{p}_{St} \widetilde{s}_{t+1} + \gamma p_{St} s_{t+1} - s_t$$

12.3 The dynamic system

Controls: $c, \widetilde{c}, N, \widetilde{N}, i, \widetilde{i}, d, \widetilde{d}, l, \widetilde{l}, \pi_F, \widetilde{\pi}_F, y, \widetilde{y}, tb, \widetilde{tb}$

States: $k, \widetilde{k}, s, \widetilde{s}, x, \widetilde{x}$

Co-states: $\lambda, \widetilde{\lambda}, p_S, \widetilde{p}_S, \varpi, \widetilde{\varpi}, \upsilon, \widetilde{\upsilon}, \psi, \widetilde{\psi}, q, \widetilde{q}, \omega, \widetilde{\omega}$

Equation (1)

$$\left\{\left[c_t^{\varkappa}\widetilde{s}_t^{1-\varkappa}\left(\psi+(1-N_t)^{\nu}\right)-x_t\right]^{-\sigma}+\varphi_t(1-m)\right\}\varkappa c_t^{\varkappa-1}\widetilde{s}_t^{1-\varkappa}\left(\psi+(1-N_t)^{\nu}\right)=\lambda_t$$

$$\left\{\left[\widetilde{c}_t^{\widetilde{\varkappa}}s_t^{1-\widetilde{\varkappa}}\left(\widetilde{\psi}+(1-\widetilde{N}_t)^{\nu}\right)-\widetilde{x}_t\right]^{-\sigma}+\widetilde{\varphi}_t(1-\widetilde{m})\right\}\widetilde{\varkappa}\widetilde{c}_t^{\widetilde{\varkappa}-1}s_t^{1-\widetilde{\varkappa}}\left(\widetilde{\psi}+(1-\widetilde{N}_t)^{\nu}\right)=\widetilde{\lambda}_t$$

Equation (2)

$$\begin{aligned}&\left\{\left[c_t^{\varkappa}\widetilde{s}_t^{1-\varkappa}\left(\psi+(1-N_t)^{\nu}\right)-x_t\right]^{-\sigma}+\varphi_t(1-m)\right\}c_t^{\varkappa}\widetilde{s}_t^{1-\varkappa}\nu(1-N_t)^{\nu-1}\\ =&\ \lambda_t(1-\alpha)\frac{y_t}{N_t}\frac{1}{1+\eta\frac{\varpi_t}{\lambda_t}}\end{aligned}$$

$$\begin{aligned}&\left\{\left[\widetilde{c}_t^{\widetilde{\varkappa}}s_t^{1-\widetilde{\varkappa}}\left(\widetilde{\psi}+(1-\widetilde{N}_t)^{\nu}\right)-\widetilde{x}_t\right]^{-\sigma}+\widetilde{\varphi}_t(1-\widetilde{m})\right\}\widetilde{c}_t^{\widetilde{\varkappa}}s_t^{1-\widetilde{\varkappa}}\nu(1-\widetilde{N}_t)^{\nu-1}\\ =&\ \widetilde{\lambda}_t(1-\widetilde{\alpha})\frac{\widetilde{y}_t}{\widetilde{N}_t}\frac{1}{1+\widetilde{\eta}\frac{\widetilde{\varpi}_t}{\widetilde{\lambda}_t}}\end{aligned}$$

Equation (3)

$$\begin{aligned}\widetilde{p}_{St}\lambda_t =&\ \beta E_t\lambda_{t+1}\\ &+\beta E_t\left\{\left[c_{t+1}^{\varkappa}\widetilde{s}_{t+1}^{1-\varkappa}\left(\psi+(1-N_{t+1})^{\nu}\right)-x_{t+1}\right]^{-\sigma}+\varphi_{t+1}(1-m)\right\}\\ &(1-\varkappa)c_{t+1}^{\varkappa}\widetilde{s}_{t+1}^{-\varkappa}\left(\psi+(1-N_{t+1})^{\nu}\right)\end{aligned}$$

$$
\begin{aligned}
p_{St}\widetilde{\lambda}_t &= \widetilde{\beta} E_t \widetilde{\lambda}_{t+1} \\
&+\widetilde{\beta} E_t \left\{ \left[\widetilde{c}_{t+1}^{\widetilde{\varkappa}} s_{t+1}^{1-\widetilde{\varkappa}} \left(\widetilde{\psi} + (1-\widetilde{N}_{t+1})^{\nu} \right) - \widetilde{x}_{t+1} \right]^{-\sigma} + \widetilde{\varphi}_{t+1}(1-\widetilde{m}) \right\} \\
&(1-\widetilde{\varkappa})\widetilde{c}_{t+1}^{\widetilde{\varkappa}} s_{t+1}^{-\widetilde{\varkappa}} \left(\widetilde{\psi} + (1-\widetilde{N}_{t+1})^{\nu} \right)
\end{aligned}
$$

Equation (4)

$$
p_{St}\lambda_t = \beta \left(1+\varsigma\right) E_t \lambda_{t+1}
$$

$$
\widetilde{p}_{St}\widetilde{\lambda}_t = \widetilde{\beta} \left(1+\widetilde{\varsigma}\right) E_t \widetilde{\lambda}_{t+1}
$$

Equation (5)

$$
\begin{aligned}
q_t\lambda_t &= \beta E_t q_{t+1}\lambda_{t+1} \left\{ (1-\delta) + \left[\frac{\theta_1}{1-\epsilon} \left(\frac{i_{t+1}}{k_{t+1}} \right)^{1-\epsilon} + \theta_2 \right] - \theta_1 \left(\frac{i_{t+1}}{k_{t+1}} \right)^{1-\epsilon} \right\} \\
&+\beta E_t \lambda_{t+1} \alpha \frac{y_{t+1}}{k_{t+1}} \frac{1}{1+\eta \frac{\varpi_{t+1}}{\lambda_{t+1}}}
\end{aligned}
$$

$$
\begin{aligned}
\widetilde{q}_t\widetilde{\lambda}_t &= \widetilde{\beta} E_t \widetilde{q}_{t+1}\widetilde{\lambda}_{t+1} \left\{ (1-\widetilde{\delta}) + \left[\frac{\widetilde{\theta}_1}{1-\widetilde{\epsilon}} \left(\frac{\widetilde{i}_{t+1}}{\widetilde{k}_{t+1}} \right)^{1-\widetilde{\epsilon}} + \widetilde{\theta}_2 \right] - \widetilde{\theta}_1 \left(\frac{\widetilde{i}_{t+1}}{\widetilde{k}_{t+1}} \right)^{1-\widetilde{\epsilon}} \right\} \\
&+\widetilde{\beta} E_t \widetilde{\lambda}_{t+1} \widetilde{\alpha} \frac{\widetilde{y}_{t+1}}{\widetilde{k}_{t+1}} \frac{1}{1+\widetilde{\eta} \frac{\widetilde{\varpi}_{t+1}}{\widetilde{\lambda}_{t+1}}}
\end{aligned}
$$

Equation (6)

$$
(1-\delta)k_t + \left[\frac{\theta_1}{1-\epsilon} \left(\frac{i_t}{k_t} \right)^{1-\epsilon} + \theta_2 \right] k_t - \gamma k_{t+1} = 0
$$

$$
(1-\widetilde{\delta})\widetilde{k}_t + \left[\frac{\widetilde{\theta}_1}{1-\widetilde{\epsilon}} \left(\frac{\widetilde{i}_t}{\widetilde{k}_t} \right)^{1-\widetilde{\epsilon}} + \widetilde{\theta}_2 \right] \widetilde{k}_t - \gamma \widetilde{k}_{t+1} = 0
$$

Equation (7)

$$q_t\theta_1\left(\frac{i_t}{k_t}\right)^{-\epsilon}=1$$

$$\widetilde{q}_t\widetilde{\theta}_1\left(\frac{\widetilde{i}_t}{\widetilde{k}_t}\right)^{-\widetilde{\epsilon}}=1$$

Equation (8)

$$\varphi_t=m\beta E_t\varphi_{t+1}-\beta E_t\left[c_{t+1}^{\varkappa}\widetilde{s}_{t+1}^{1-\varkappa}\left(\psi+(1-N_{t+1})^{\nu}\right)-x_{t+1}\right]^{-\sigma}$$

$$\widetilde{\varphi}_t=\widetilde{m}\widetilde{\beta}E_t\widetilde{\varphi}_{t+1}-\widetilde{\beta}E_t\left[\widetilde{c}_{t+1}^{\widetilde{\varkappa}}s_{t+1}^{1-\widetilde{\varkappa}}\left(\widetilde{\psi}+(1-\widetilde{N}_{t+1})^{\nu}\right)-\widetilde{x}_{t+1}\right]^{-\sigma}$$

Equation (9)

$$mx_t+(1-m)c_t^{\varkappa}\widetilde{s}_t^{1-\varkappa}\left(\psi+(1-N_t)^{\nu}\right)-\gamma x_{t+1}=0$$

$$\widetilde{m}\widetilde{x}_t+(1-\widetilde{m})\widetilde{c}_t^{\widetilde{\varkappa}}s_t^{1-\widetilde{\varkappa}}\left(\widetilde{\psi}+(1-\widetilde{N}_t)^{\nu}\right)-\gamma\widetilde{x}_{t+1}=0$$

Equation (10)

$$l_t=\frac{\eta y_t}{1+\eta\frac{\varpi_t}{\lambda_t}}$$

$$\widetilde{l}_t=\frac{\widetilde{\eta}\widetilde{y}_t}{1+\widetilde{\eta}\frac{\widetilde{\varpi}_t}{\widetilde{\lambda}_t}}$$

Equation (11)

$$\pi_{Ft}=\frac{\eta\frac{\varpi_t}{\lambda_t}}{1+\eta\frac{\varpi_t}{\lambda_t}}y_t-r_{Lt}l_t$$

$$\widetilde{\pi}_{Ft}=\frac{\widetilde{\eta}\frac{\widetilde{\varpi}_t}{\widetilde{\lambda}_t}}{1+\widetilde{\eta}\frac{\widetilde{\varpi}_t}{\widetilde{\lambda}_t}}\widetilde{y}_t-\widetilde{r}_{Lt}\widetilde{l}_t$$

Equation (12)

$$\mu l_t - \upsilon_t = 0$$

$$\widetilde{\mu}\widetilde{l}_t - \widetilde{\upsilon}_t = 0$$

Equation (13)

$$\upsilon_t = \beta E_t \frac{\lambda_{t+1}}{\lambda_t}\left[\upsilon_{t+1} + \pi_{Ft+1}\right]$$

$$\widetilde{\upsilon}_t = \widetilde{\beta} E_t \frac{\widetilde{\lambda}_{t+1}}{\widetilde{\lambda}_t}\left[\widetilde{\upsilon}_{t+1} + \widetilde{\pi}_{Ft+1}\right]$$

Equation (14)

$$r_{Lt} + \mu \frac{\psi_t}{\lambda_t} = \frac{\varpi_t}{\lambda_t}$$

$$\widetilde{r}_{Lt} + \widetilde{\mu} \frac{\widetilde{\psi}_t}{\widetilde{\lambda}_t} = \frac{\widetilde{\varpi}_t}{\widetilde{\lambda}_t}$$

Equation (15)

$$l_t = z d_t$$

$$\widetilde{l}_t = \widetilde{z}\widetilde{d}_t$$

Equation (16)

$$y_t - c_t - \kappa d_t - i_t - \varsigma s_t = s_t - p_{St}\gamma s_{t+1} + \widetilde{p}_{St}\gamma \widetilde{s}_{t+1} - \widetilde{s}_t$$

$$\widetilde{y}_t - \widetilde{c}_t - \widetilde{\kappa}\widetilde{d}_t - \widetilde{i}_t - \widetilde{\varsigma}\widetilde{s}_t = \widetilde{s}_t - \gamma \widetilde{p}_{St}\widetilde{s}_{t+1} + \gamma p_{St} s_{t+1} - s_t$$

Equation (17)

$$y_t = A_t k_t^{\alpha} N_t^{1-\alpha}$$

$$\widetilde{y}_t = \widetilde{A}_t \widetilde{k}_t^{\widetilde{\alpha}} \widetilde{N}_t^{1-\widetilde{\alpha}}$$

Equation (18)

$$tb_t = s_t - p_{St}\gamma s_{t+1} + \widetilde{p}_{St}\gamma \widetilde{s}_{t+1} - \widetilde{s}_t$$

$$\widetilde{tb}_t = \widetilde{s}_t - \gamma \widetilde{p}_{St}\widetilde{s}_{t+1} + \gamma p_{St} s_{t+1} - s_t$$