Currency Risk and Business Cycle Risk in the Geography of Debt Flows to Peripheral Europe

By

Eylem Ersal Kiziler and Ha Nguyen

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University of Wisconsin – Whitewater
Department of Economics
4th Floor Hyland Hall
800 W. Main Street
Whitewater, WI 53190

Tel: (262) 472 -1361

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Abstract

Since the start of the Eurozone, the pattern of debt flows to Peripheral Europe seems puzzling: they were mostly indirect and intermediated by the large countries of the euro area. This paper examines the euro currency risk and the business cycle risk as two opposing forces: while the currency risk favors Core Europe in lending to Peripheral Europe, business cycle risk favors outsider lenders. We explain the mechanisms and show that both forces are strong. In a 3-country DSGE model with endogenous portfolio choices, without the business cycle risk, currency risk completely pushes outside lenders out of the Peripheral bond market. With both types of risk, Core Europe and outside lenders hold 40 and 60 percents of Peripheral bonds respectively. The results suggest that other factors such as asymmetric information or bailout discrimination are also at play.

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1 Introduction

The formation of the European Monetary Union in 1999 has had a clear impact on capital flows to and within Europe. Lane and Milesi-Ferretti (2007), Spiegel (2009) show that capital flows within the Eurozone increased after 1999. Kalemli-Ozcan, Papaioannou, and Peydro (2010) empirically find that the increasing financial integration is primarily driven by the elimination of the currency risk, and to a lesser extent, regulatory convergence. Recently, Chen, Milesi-Ferretti, and Tressel (2013) and Hale and Obstfeld (2014) uncover an interesting and puzzling stylized fact: since the start of the Eurozone, the financing of Peripheral Europe's trade deficits versus the rest of the world was mostly indirect and intermediated by the large countries of the euro area[1]. Peripheral Europe's debts were held mainly Core Europe countries such as Germany and France. In turn, Core Europe's debts were largely held by outside investors.

As Chen, Milesi-Ferretti, and Tressel (2013) stress in their paper, it is difficult to explain why investors outside the euro area were more reluctant to hold Peripheral bonds. Why did outsiders not lend to Peripheral Europe directly and collect a higher interest return? Hale and Obstfeld (2014) suggest, in a stylized model, that this is because the transaction costs of lending from Core Europe to Peripheral Europe are lower than from the Rest of the World to Peripheral Europe.

This paper builds on Hale and Obstfeld (2014) and investigates the Euro currency risk as an explanation for the puzzle. We argue that the Core Europe has a clear advantage compared to outside lenders when lending to Peripheral Europe. They share the same currency with Peripheral Europe and are not concerned about the euro currency risk. This "Eurozone" advantage allows them absorb the bad shocks to the Peripheral bonds' return better than outside investors do. The mechanism is as follows: when the value of the euro is depreciated, Core Europe lenders can still use euros to purchase local goods which are denominated in euros, whereas outside investors have to convert euros to their currencies for consumption. Since the euro's value declines, outside investors take a bigger hit. Even when the law of one price for tradable goods holds, the existence of non-tradable goods and nominal rigidity guarantee the "currency channel" works in favor of the Core Europe lenders[2]. In other words, being in the same

[1]Peripheral Europe refers to Portugal, Italy, Ireland, Greece, and Spain. Core Europe refers to Germany, Austria, France, Belgium and the Netherlands.

[2]Nominal shocks, such as currency risk, only work in the presence of nominal rigidity. If prices are

monetary union gives the Core Europe an advantage over outside lenders in terms of lending to the Peripheral Europe. In our model, the currency risk alone can explain the entire puzzle. Outsiders lenders are effectively pushed out of Peripheral bond market, without any exogenous market segmentations.

A natural question is why outside lenders are not pushed out from the Core Europe's bond market too? This is a legitimate question because when it comes to holding Core Europe's bonds, Peripheral Europe investors also have the currency risk advantage compared to outsider lenders. We argue that while this is true, it does not matter much. First of all, Peripheral Europe is small and can not saturate Core Europe's debt market. More importantly, Peripheral Europe has little incentive to hold Core Europe's debt, for two reasons. First, holding Core Europe's bonds is not a good hedge for Peripheral Europe's income shocks. Since Peripheral Europe's output is more volatile than Core Europe's, it does not make sense for them to provide insurance to Core Europe (by holding Core Europe's bond). Second, lending to Core Europe is costly, and does not help Peripheral Europe meet their financing needs. This is costly because an additional euro lent to Core Europe has to be offset by an additional euro raised by issuing Peripheral bonds, which carry a higher interest premium. For those reasons, Peripheral Europe has little incentives to hold Core Europe's bonds. Consequently, outside investors face less competition in the Core bond market than in the Peripheral bond market, and end up parking their savings at the Core bonds.

There is another channel that actually works against the Core Europe lenders. We refer to this as the "business cycle" channel. Specifically, Core Europe's business cycle is more correlated to Peripheral Europe's than outsiders' is. Since the real return of Peripheral bonds is pro-cyclical (i.e. it goes down in bad times), Peripheral bonds are a better hedge for outside investors than for Core Europe, which puts Core Europe in an inferior position compared to outside lenders. In our model, the two effects- the currency effect and the business cycle effect - compete with each other in the portfolio choice of Core Europe and outside lenders. The calibrated model shows that when the two types of risk are at play, Core Europe supplies only about 40 percent the lending to Peripheral Europe. The result implies that the business cycle risk is also a very important force to consider in any attempt to explain the pattern of capital flows to Europe.

completely flexible, nominal shocks would have no impact.

Note that we do not rule out other theories for this market segmentation, such as information asymmetry or bailout discrimination. Information asymmetry refers to the possibility that Core Europe's lenders know and understand Peripheral Europe borrowers better than outsiders. Bailout discrimination refers to the possibility that Europe's bond holders can be bailed out first before investors from the rest of the world. This scenario, even just a possibility, is enough to give Core Europe lenders an advantage over outsiders. Related to the argument, Broner, Erce, Martin, and Ventura (2014) and Brutti and Saur (2014) postulate that possible preferential bailout treatment to domestic debt holders caused debt to repatriate during the euro crisis. The fact that our model predicts about 40 percent of Peripheral bonds are held by Core Europe also suggests that other factors are at play.

We describe in details the mechanism in a framework of a DSGE model with incomplete markets. The model features three agents (Peripheral Europe, Core Europe, and foreign lenders), two sectors (tradable and non-tradable goods), two assets (Peripheral debt and Core debt) with endogenous debt portfolio choices. We explicitly model the currency risk with nominal rigidities. In the model, the market segmentation arises endogenously based on optimal portfolio choice and does not rely on some exogenous market frictions, such as information asymmetry or bailout discrimination. We adopt the solution method developed by Devereux and Sutherland (2010) and Tille and van Wincoop (2010) to solve for the long run (i.e. zero order) currency choice of countries. The paper is organized as follows: section 2 presents some empirical stylized facts, section 3 describes the model. Section 4 presents the solution and findings of the model. Finally section 5 concludes.

2 Stylized facts

This section presents the empirical stylized facts that motivate our theoretical model. As in Hale and Obstfeld (2014), we focus on the period between 1999 – when the Eurozone was formed– until before the crisis. This is to avoid the complications of capital flows that the crisis might have caused. [3]

We show that most of Peripheral Europe's debts were held by the Core Europe,

[3]For example, Brutti and Saur (2014) find that there was a strong repatriation of debt from foreign to domestic investors. This repatriation is particularly strong in crisis countries and for public debt.

whereas most of the Core Europe debts were held by non-Eurozone lenders. Figures 1 and 2 are taken directly from Chen, Milesi-Ferretti, and Tressel (2013). Figure 1 presents the decomposition of Peripheral Europe's net foreign asset position versus other euro area countries and versus the rest of the world. The figure shows that net liabilities versus other euro area countries accounted for the lion share of Peripheral Europe's net liabilities since the beginning of 2000s. In 2001, Core Europe held about 60 percent of Peripheral Europe's net liabilities. That figure in 2008 was about 75 percent. Figure 2 shows the decomposition of Core Europe's net foreign asset position versus other euro area countries and versus the rest of the world. Core Europe's net assets were primarily versus the rest of the Euro area (i.e. Peripheral Europe), while their liabilities were mostly against the rest of the world.

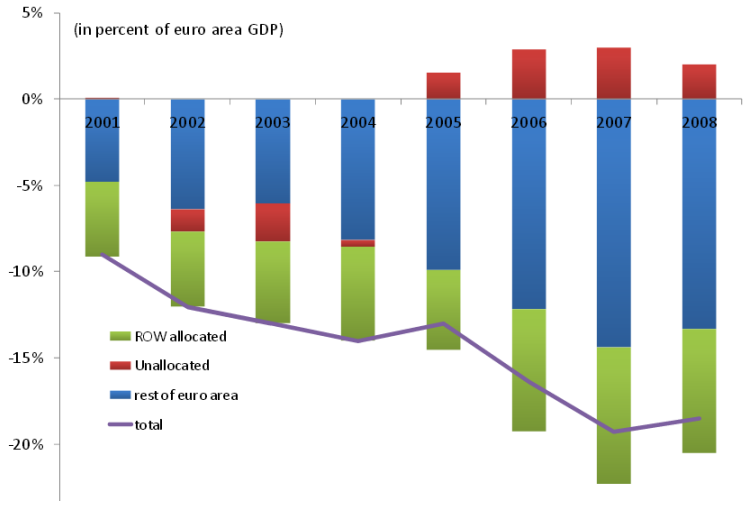

Figure 1: Net foreign assets of Peripheral Europe

Hale and Obstfeld (2014) illustrate nicely the changes of debt flows to Core and Peripheral Europe. Figure 3 below is borrowed from their paper. They organize the countries to 4 groups: financial centers (FIN), Core Europe (CORE), Peripheral Europ (GIIPS) and the rest of the world (ROW)[4]. Data are from the Bank of International Settlement's consolidated banking. The left hand side of the figure presents each region's gross bank debt holdings at the beginning of the Eurozone in 1999 versus another region, with the thickness of the lines reflecting holdings as a share of global

[4]FIN consists of Canada, Denmark, Japan, Sweden, Switzerland, UK, and US; CORE consists of Austria, Belgium, Finland, France, Germany, Netherlands, Luxembourg; GIIPS consists of Greece, Italy, Ireland, Portugal and Spain.

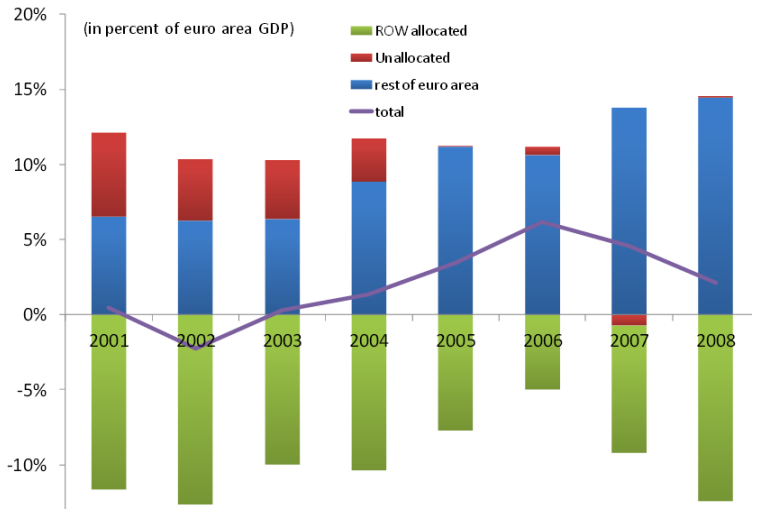

Figure 2: Net foreign assets of Core Europe

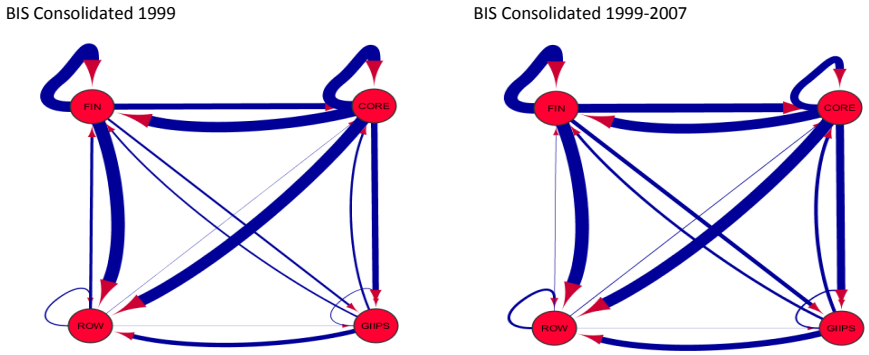

Figure 3: Bilateral bank's debt flows

gross position. The right hand side of the figure presents changes in gross positions from 1999 to 2007– before the financial crisis. The figure shows that most of the debt flows (by banks) to GIIPS between 1999 and 2007 were from CORE, and most of the debt flows to CORE were from FIN. The flows are significantly more than the gross debt positions in 1999. Please refer to Hale and Obstfeld (2014) for more detailed analysis with different data sources.

In addition, using Loan Analytics data base, Hale and Obstfeld (2014) also look into the geographical composition of borrowing and lending by individual banks. They find that for Core Europe's banks, there is an increased link between their borrowing from FIN and their lending to GIIPS during the pre-crisis period. This is as if the banks intermediate loans to Peripheral Europe. They do not find such a link for banks

in different regions. The figure below shows the borrowing and lending in billion dollars by some selected largest banks in Core Europe. The borrowing from FIN and lending to GIIPS increased dramatically after 1999, when the Eurozone was formed, but collapsed during the 2008-2009 crisis.

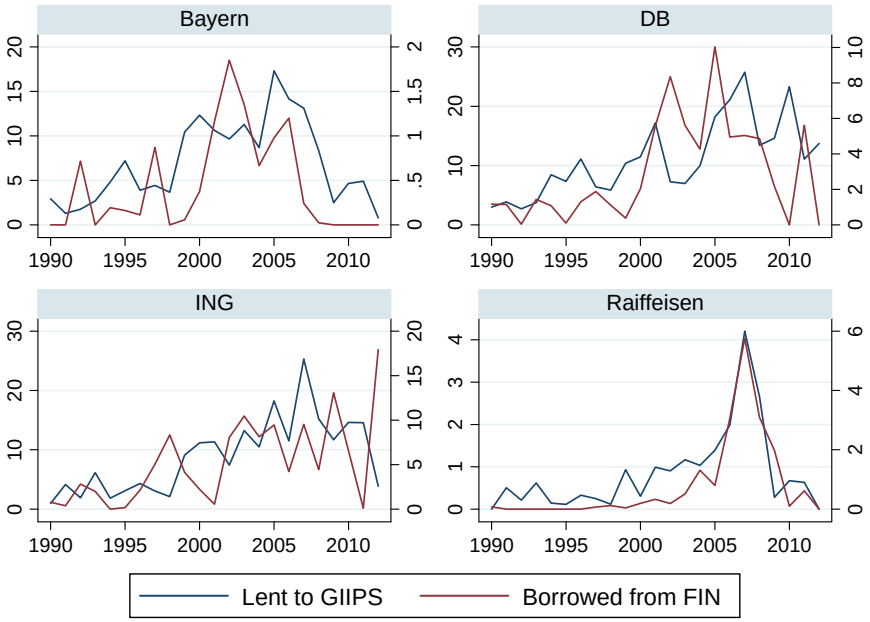

Figure 4: Borrowing and lending by selected large banks

3 Model

We build a model to formalize the intuition about the currency risk and the business cycle risk. The model features three countries: Peripheral Europe (denoted P) that issues Peripheral bonds, Core Europe (denoted C) that can buy Peripheral bonds, and issues its Core bonds, and an outsider (denoted O) that has a choice of investing between the Peripheral bonds and the Core bonds. The two assets in our model are the Peripheral bonds and the Core bonds. To capture sovereign risk without explicitly modeling default – which is difficult, we assume that the bonds' returns are state contingent: they depend on the output realization. The assumption is realistic, because in bad times, lenders usually negotiate and accept haircuts rather than suffer outright default. This assumption opens the door for Peripheral bonds' risk premium. Since

Peripheral output is more volatile, Peripheral bonds are riskier, and hence they carry a higher risk premium than Core bonds do.

The environment features *nominal rigidities* in the labor market and in the non-tradable good market, while the tradable good's price is flexible. The role of nominal rigidities is such that monetary shocks have real effects, hence currency risk matters. As a standard convention in New Keynesian models, nominal rigidities in the non-tradable sector are modeled by dividing the sector into competitive retailers and monopolistic intermediate good producers, who set price one period in advance. In addition, in the model we make Europe borrow by assigning them a higher discount rate. The details of the model are as follows:

3.1 The three economies

3.1.1 Peripheral Europe

We denote Peripheral Europe as country P. We will use P and Peripheral Europe interchangeably.

Country P's tradable output is an endowment, following an AR(1) process:

$$log(y_{Tt}^P) = \rho log(y_{Tt-1}^P) + \epsilon_t^P$$

To model nominal rigidities in the non-tradable market, we separate the non-tradable sector into intermediate good producers and retailers. Intermediate producer j produces a differentiated intermediate non-tradable good y_{Njt}^P using aggregate labor l_{jt}^P according to

$$y_{Njt}^P = A_{Nt}^P \left(l_{jt}^P\right)^{1-\alpha},$$

where A_{Nt}^P also follow the same AR(1) process as the tradable endowment:

$$A_{Nt}^P = y_{Tt}^P,$$

and α is the share of capital in intermediate non-tradable goods production. The labor input l_{jt}^P is purchased from a competitive employment agency and represents an aggregate of differentiated labor supplied by households. The producers sell their output to competitive retailers who combine these intermediate goods to produce a

final good using a constant elasticity of substitution (CES) production function

$$Y_{Nt}^{P} = \left[\int_{0}^{1} y_{Njt}^{P\frac{\omega-1}{\omega}} \right]^{\frac{\omega}{\omega-1}},$$

where ω is the elasticity of substitution between any two differentiated intermediate non-tradable goods.

The producers, who act as monopolistically competitive suppliers on the intermediate non-tradable goods market, set the price of their good one period in advance and commit to supply retailers at this price. In period t, the producers' production decisions consist of setting the price of their non-tradable intermediate good P_{Njt} one period in advance, and deciding how much to invest in capital.

The producers face a sequence of constraints given by retailers' demand for their non-tradable intermediate good

$$y_{Njt}^{P} = \left(\frac{P_{Njt}^{P}}{P_{Nt}^{P}} \right)^{-\omega} Y_{Nt}^{P}.$$

The budget constraint of producer j is:

$$PR_{jt}^{P} = P_{Njt}^{P} A_{Nt}^{P} (l_{jt}^{P})^{1-\alpha} - W_{t}^{P} l_{jt}^{P}, \tag{1}$$

where PR_{jt}^{P} is the nominal profit that the producer gives back to households at the end of the period, for use in the next period.

Household i supplies labor to competitive employment agencies that aggregate differentiated labor using a CES technology

$$l_{t}^{P} = \left[\int_{0}^{1} l_{it}^{P\frac{\xi-1}{\xi}} di \right]^{\frac{\xi}{\xi-1}},$$

where ξ is the elasticity of substitution between any two types of differentiated labor. Households i is a monopolistically competitive supplier of its individual labor and sets the nominal wage W_{it}^{P} one period in advance. Given the nominal wage they set in advance, they are committed to supply labor to meet the employment agencies'

demand for their labor type

$$l_{it}^P = \left(\frac{W_{it}^P}{W_t^P}\right)^{-\xi} l_t^P.$$

The utility of households i is

$$\Sigma\psi_t^P \left[ln(c_t^P) + \chi ln\left(\frac{M_t^P}{P_{Tt}^E}\right) + \mu ln(1 - l_{it}^P)\right],$$

where c_t is the aggregate consumption, consisting of tradable and non-tradable consumption: $c_t^P = (c_{Tt}^P)^\gamma (c_{Nt}^P)^{1-\gamma}$; l_{it}^P is the labor supply and $\frac{M_t^P}{P_{Tt}^E}$ is P's real euro holding. P_{Tt}^E is the euro nominal price of the tradable good. ψ_t^P is an endogenous discount factor: $\psi_{t+1}^P = (\phi_P\beta)^t \Pi_{k=0}^t (C_{Tk}^P)^{-\theta}$ where (C_{Tk}^P) is the aggregate country P's tradable consumption . The use of the *uninternalized* endogenous discount factor is to ensure stationarity. As in Schmitt-Grohe and Uribe (2003), this is a simple technical device to induce uniqueness of the deterministic steady state and stationary responses to temporary shocks. Specifically, the endogenous discount factor decreases with the aggregate consumption, which the representative entrepreneur takes as given. θ will be assigned a very small value ($\theta = 0.001$), so that the impact of the endogenous discount factor on the model's dynamics is minimal.

The budget constraint of household i is:

$$P_{Tt}^E c_{Tt}^P + P_{Nt}^P c_{Nt}^P + M_t^P = P_{Tt}^E y_{Tt}^P + W_t^P l_{it}^P + M_{t-1}^P - B_{Pt}^P + y_{Tt}^P R_t^P B_{Pt-1}^P + T_t^P + PR_{t-1}^P, \quad (2)$$

where capital letters denote nominal variables. In period t, each household chooses tradable and non-tradable consumption (c_{Tt}^P and c_{Nt}^P), and the nominal amount of Peripheral bonds to issue ($-B_{Pt}^P$), and the amount of money to hold (M_t^P). They also receive firms' profit PR_{t-1}^P in the last period and government lump sum tax or transfer T_t^P (which exactly offsets money supply on the aggregate). P_{Tt}^E and P_{Nt}^P are the euro nominal prices of the tradable and non-tradable goods. B_{Pt}^P indicates nominal Peripheral bond holdings by Peripheral Europe's households for the next period (the steady state B_P^P will be calibrated to be smaller than 0, which implies bond issuing). Note that the bond's nominal return depends on the realization of output: $y_{Tt}^P R_t^P$. This is to capture default and debt renegotiation: in bad times and with possibility of default, investors tend to accept haircuts of their bond holdings' returns.

For simplicity, we assume that country P does not hold C's bonds. This assumption greatly simplifies the model and enables us to more easily solve for countries' portfolio choices. Conceptually, as discussed in the introduction, Peripheral Europe has little incentive to hold Core Europe's debt, for two reasons. First, holding Core Europe's bond is not a good hedge for their income shocks. Since Peripheral Europe's output is more volatile than Core Europe's, it does not make sense for them to provide insurance to Core Europe (by holding Core Europe's bonds). Second, lending to Core Europe is costly because an additional euro lent to Core Europe has to be offset by an additional euro raised by issuing Peripheral bonds, which carry a higher interest premium.

By dividing the budget constraint by P^E_{Tt}, we obtain country P households' budget constraint in terms of the tradable good:

$$c^P_{Tt} + p^P_t c^P_{Nt} + \frac{M^P_t}{P^E_{Tt}} = y^P_{Tt} + w^P_t l^P_{it} + \frac{M^P_{t-1}}{P^E_{Tt}} - b^P_{Pt} + y^P_{Tt} R^P_t b^P_{Pt-1} \frac{P^E_{Tt-1}}{P^E_{Tt}} + t^P_t + pr^P_{t-1} \frac{P^E_{Tt-1}}{P^E_{Tt}}, \quad (3)$$

where the lower case letters indicate real variables (e.g. w, pr, b are real wage, profit and bond holdings respectively). p^P_t is the relative price of the non-tradable good to the tradable good in country P. The real return (in terms of the tradable good) for country P's bonds is: $y^P_{Tt} R^P_t \frac{P^E_{Tt-1}}{P^E_{Tt}}$. The real return of country P's bond depends on the realization of P's tradable output at time t, and the price levels. In particular, the real return will be lower with a lower realization of output, and with inflation. Note that the nominal return R^P_t is set at time $t-1$.

The first-order conditions for country P households' problem:

$$\begin{aligned}
\frac{P^P_{Nt}}{P^E_{Tt}} &= \frac{1-\gamma}{\gamma} \frac{c^P_{Tt}}{c^P_{Nt}} && (4)\\
\frac{1}{c^P_{Tt}} &= \phi_P \beta \left(c^P_{Tt}\right)^{-\theta} R^P_{t+1} P^E_{Tt} E_t \left(y^P_{Tt+1} \frac{1}{c^P_{Tt+1} P^E_{Tt+1}} \right) && (5)\\
\gamma \frac{1}{c^P_{Tt}} &= \chi \frac{P^E_{Tt}}{M^P_t} + \phi_P \beta \left(c^P_{Tt}\right)^{-\theta} P^E_{Tt} E_t \left(\frac{\gamma}{c^P_{Tt+1} P^E_{Tt+1}} \right) && (6)\\
E_t \left[\frac{\gamma(1-\xi)}{c^P_{Tt+1}} \frac{l^P_{t+1}}{P^E_{Tt+1}} \right] &= E_t \left[-\mu \xi \frac{l^P_{t+1}}{(1-l^P_{t+1}) W^P_{t+1}} \right] && (7)
\end{aligned}$$

(4) is the choice between tradable and non-tradable goods, (5) is the choice between consumption and bond issuing, (6) is the choice between consumption and money, (7) is the first order condition for the next period wage setting. (7) is obtained by replacing

$l_{it}^P = \left(\frac{W_{it}^P}{W_t^P}\right)^{-\theta} l_t^P$, taking the FOC with respect to W_{it+1}^P, and imposing symmetry. Note that W_{it+1}^P is the nominal wage for $t+1$ set at time t.

Intuitively, (7) can be explained as follows: for household i, they choose the nominal wage W_{it+1}^P in advance and commit to supply labor at this wage (and they know that the amount of labor supplied is a function of the nominal wage). The cost of supplying labor is the disutility from working, which is $E_t[\mu \frac{1}{1-l_{t+1}^P}(-\xi) l_{t+1}^P \frac{1}{W_{t+1}^P}]$ (note that we replace $l_{it+1}^P = \left(\frac{W_{it+1}^P}{W_{t+1}^P}\right)^{-\xi} l_{t+1}^P$ in the utility function). The benefit is the additional consumption obtained from the wage payment.

Now we go back to the producer's problem. We can rewrite the intermediate good producer's problem as follows:

$$max_{P_{Njt+1}^P} \Sigma \psi^P \frac{1}{P_{Tt}^E} \left[P_{Njt}^P A_{Nt}^P (l_{jt}^P)^{1-\alpha} - W_t^P l_{jt}^P\right]$$

The first order condition of the intermediate good producer with respect to P_{Njt+1}^P (after we substitute $y_{Njt+1}^P = \left(\frac{P_{Njt+1}^P}{P_{Nt+1}^P}\right)^{-\omega} y_{Nt+1}^P$, and $l_{jt+1}^P = \left(\frac{y_{Nt+1}^P}{A_{Nt}^P}\right)^{\frac{1}{1-\alpha}}$):

$$E_t \left[(1-\omega)\frac{y_{Nt+1}^P}{P_{Tt+1}^E} + \frac{W_{t+1}^P}{P_{Tt+1}^E}\frac{\omega}{1-\alpha}\left(\frac{y_{Njt+1}^P}{A_{Nt}^P}\right)^{\frac{1}{1-\alpha}} \frac{1}{P_{Nt+1}^P}\right] = 0$$

Since $\left(\frac{y_{Nt+1}^P}{A_{Nt}^P}\right)^{\frac{1}{1-\alpha}} = l_{t+1}^P$, we can rewrite the FOC as:

$$E_t \left[(1-\omega)\frac{y_{Nt+1}^P}{P_{Tt+1}^E} + \frac{\omega}{1-\alpha}\frac{W_{t+1}^P}{P_{Tt+1}^E}\frac{l_{t+1}^P}{P_{Nt+1}^P}\right] = 0 \tag{8}$$

3.1.2 Core Europe

We denote Core Europe as country C. Country C's tradable endowment follows an AR(1) process:

$$log(y_{Tt}^C) = \rho log(y_{Tt-1}^C) + \epsilon_t^C$$

Intermediate producer j produces a differentiated intermediate non-tradable good y_{Njt}^P using aggregate labor l_{jt}^P according to

$$y_{Njt}^C = A_{Nt}^C \left(l_{jt}^C\right)^{1-\alpha},$$

where A^C_{Nt} also follow the same AR(1) process as the tradable endowment:

$$A^C_{Nt} = y^C_{Tt}.$$

Household's utility function is:

$$\Sigma\psi^C_t \left[ln(c^C_t) + \chi ln\left(\frac{M^C_t}{P^E_{Tt}}\right) + \mu ln(1 - l^C_{it}) \right],$$

where ψ^C_t is an endogenous discount factor: $\psi^C_{t+1} = (\phi_C\beta)^t \Pi^t_{k=0}(C^C_{Tk})^{-\theta}$

Household's budget constraint:

$$\begin{aligned} P^E_{Tt}c^C_{Tt} + P^C_{Nt}c^C_{Nt} + M^C_t = W^C_t l^C_t + P^C_{Nt}y^{C_{Nt}} + M^C_{t-1} - B^C_{Ct} - B^P_{Ct} \\ + y^C_{Tt}R^C_t B^C_{Ct-1} + y^P_{Tt}R^P_t B^P_{Ct-1} + T^C_t + PR^C_{t-1}, \end{aligned} \tag{9}$$

where $-B^C_{Ct}$ is country C's bonds issuing, and B^P_{Ct} is P's bonds held by C this period.

In terms of the tradable goods:

$$\begin{aligned} c^C_{Tt} + p^C_t c^C_{Nt} + \frac{M^C_t}{P^E_{Tt}} = y^C_{Tt} + w^C_t l^C_t + \frac{M^C_{t-1}}{P^E_{Tt}} - b^C_{Ct} - b^P_{Ct} \\ + y^C_{Tt}R^C_t b^C_{Ct-1}\frac{P^E_{Tt-1}}{P^E_{Tt}} + y^P_{Tt}R^P_t b^P_{Ct-1}\frac{P^E_{Tt-1}}{P^E_{Tt}} + t^C_t + pr^C_{t-1}\frac{P^E_{Tt-1}}{P^E_{Tt}} \end{aligned} \tag{10}$$

The euro money supply is simply following an AR(1) process:

$$log(M^E_t) = \rho_m log(M^E_{t-1}) + \nu^E_t$$

The FOCs for households and firms' problems are given in the Appendix.

3.1.3 Outside Lenders

We denote the outsider lenders as country O. Country O's tradable endowment follows an AR(1) process:

$$log(y^O_{Tt}) = \rho log(y^O_{Tt-1}) + \epsilon^O_t$$

Intermediate producer j produces a differentiated intermediate non-tradable good

y^O_{Njt} using aggregate labor l^O_{jt} according to

$$y^O_{Njt} = A^O_{Nt} \left(l^O_{jt}\right)^{1-\alpha},$$

where A^O_{Nt} also follow the same AR(1) process as the tradable endowment:

$$A^O_{Nt} = y^O_{Tt}.$$

The representative household's utility is:

$$\Sigma \psi^O_t \left[ln(c^O_t) + \chi ln\left(\frac{M^O_t}{P^O_{Tt}}\right) + \mu ln(1 - l^O_{it}) \right]$$

ψ^O_t is an endogenous discount factor: $\psi^O_{t+1} = \beta^t \Pi^t_{k=0} (C^O_{Tk})^{-\theta}$. Note that country O's discount factor is higher than that of Europe, so that in the equlibrium, Outsiders will lend to Europe.

Household's budget constraint:

$$\begin{aligned} P^O_{Tt} c^O_{Tt} + P^O_{Nt} c^O_{Nt} + M^O_t = P^O_{Tt} y^O_{Tt} + W^O_t l^O_t + M^O_{t-1} - \frac{P^O_{Tt} B^C_{Ot}}{P^E_{Tt}} - \frac{P^O_{Tt} B^P_{Ot}}{P^E_{Tt}} \\ + \frac{P^O_{Tt} y^C_{Tt} R^C_t B^C_{Ot-1}}{P^E_{Tt}} + \frac{P^O_{Tt} y^P_{Tt} R^P_t B^P_{Ot-1}}{P^E_{Tt}} + T^O_t + PR^O_{t-1}, \end{aligned} \tag{11}$$

where B^C_{Ot} and B^P_{Ot} are the euro nominal Peripheral and Core bond holdings by country O this period. In terms of the tradable good:

$$\begin{aligned} c^O_{Tt} + p^O_t c^O_{Nt} + \frac{M^O_t}{P^O_{Tt}} = y^O_{Tt} + w^O_t l^O_t + \frac{M^O_{t-1}}{P^O_{Tt}} - b^C_{Ot} - b^P_{Ot} \\ + y^C_{Tt} R^C_t b^C_{Ot-1} \frac{P^E_{Tt-1}}{P^E_{Tt}} + y^P_{Tt} R^P_t b^P_{Ot-1} \frac{P^E_{Tt-1}}{P^E_{Tt}} + t^O_t + pr^O_{t-1} \frac{P^O_{Tt-1}}{P^O_{Tt}} \end{aligned} \tag{12}$$

The money supply is also AR(1):

$$log(M^O_t) = \rho_m log(M^O_{t-1}) + \nu^O_t$$

The FOCs for households and firms' problems are given in the Appendix.

3.2 Market clearing

Tradable market clearing implies:

$$c_{Tt}^{O} + c_{Tt}^{C} + c_{Tt}^{P} = y_{Tt}^{O} + y_{Tt}^{C} + y_{Tt}^{P} \tag{13}$$

(13) means that the sum of consumption and investment equals tradabe output. Bond market clearings for Peripheral bonds and Core bonds implies:

$$b_{Pt}^{P} + b_{Ct}^{P} + b_{Ot}^{P} = 0$$

and

$$b_{Ct}^{C} + b_{Ot}^{C} = 0$$

The first bond market clearing equation implies that bonds issued by P are entirely held by C and O. The second equation implies that C's bond is entirely held by O.

Euro money market clearing implies that euro holdings by country P and C add up to the total euro supply.

$$M_t^P + M_t^C = M_t^E$$

4 Model solution and findings

It is well-known that up to the 1st-order approximation, the values of the portfolio choices are indeterminate, because at this level of approximation, the two assets are perfect substitutes. Previous literature usually relies on perfect market structures that make portfolio choice irrelevant. Since the focus of our paper is on bond choices, we will adopt the solution method developed by Devereux and Sutherland (2010) and Tille and van Wincoop (2010) to solve for the steady state bond portfolio holdings of Core Europe and outside lenders.

4.1 Solving for the portfolio holdings

We use the approach of Devereux and Sutherland (2010) and Tille and van Wincoop (2010) methodology to solve the steady state portfolio choice problem. We will compute near non-stochastic portfolio holdings:

The portfolio choices of country C and country O should satisfy the following:

$$E_t\left(R_t^P\frac{P_{Tt}^E}{P_{Tt+1}^E}y_{Tt+1}^P-R_t^C\frac{P_{Tt}^E}{P_{Tt+1}^E}y_{Tt+1}^C\right)(c_{Tt+1}^O-c_{Tt+1}^C)=0 \tag{14}$$

The equation means that C and O will choose an optimal bond portfolio so that their consumption differential (i.e. $c_{Tt+1}^O - c_{Tt+1}^C$) on average is not correlated to any return differential of their bond holdings (i.e. $R_t^P\frac{P_{Tt}^E}{P_{Tt+1}^E}y_{Tt+1}^P - R_t^C\frac{P_{Tt}^E}{P_{Tt+1}^E}y_{Tt+1}^C$). In other words, their consumption is on average insured against the monetary shocks and real shocks to P and C's tradable endowment.

To solve for the non-stochastic steady state portfolio holdings, we take the second order approximation of the above equation and the first order approximation of the rest of the equations of the log linearized model.

4.2 Baseline calibration and the Steady State

The value of the discount factor is set for quarterly data: $\beta = 0.98$. The share of tradable consumption is a third of total consumption: $\gamma = \frac{1}{3}$. Following Chugh (2006), we set χ equal 0.05, the elasticities of substitution ω equal 10 and ξ equal 21. We set the endogenous discount factor coefficient very small $\theta = 0.001$, so that it does not have a significant impact on the model's dynamics. We also set the persistence of money supply to 0.9.

We estimate different moments of the technology and output process using real quarterly GDP data from OECD. Data span from quarter 1, 1999 – the beginning of the Euro to quarter 4, 2006 – before the financial crisis. Peripheral Europe consists of Italy, Spain, Portugal, Greece. Core Europe consists of France, Germany, Belgium. Outsider economies consist of United States, United Kingdom, Switzerland and Japan. We divide each group' total real quarterly GDP by the group' total population to obtained the group' real quarterly GDP per capita. The moments are calculated from the HP-filtered cyclical components of the regions' real quarterly GDP. The moments are the persistence of output, the standard deviations of output, and the correlations between three countries' output. Table 1 shows that the correlation between Peripheral Europe's output and Core Europe's output is very high, much higher than other correlations. This will have an important impact on the equilibrium choice of debt, as the business

	Description	Value
γ	Share of tradable consumption	0.33
χ	Utility from money holdings	0.05
β	Discount factor	0.98
θ	Endogenous discount factor coefficient	0.001
A_N	TFP in intermediate non-tradable good production	1
α	Share of labor in intermediate non-tradable good production	0.33
ξ	Elasticity of subs. betw. labor	21
ω	Elasticity of subs. betw. intermediate non-tradable goods	10
ρ_m	Persistence of money supply	0.9
σ_m	Standard deviation of money supply	0.001
ρ^P	Persistence of P's output	0.7785
ρ^C	Persistence of C's output	0.8866
ρ^O	Persistence of O's output	0.7547
σ^P	Standard deviation of P's output	0.004586
σ^C	Standard deviation of C's output	0.00421
σ^O	Standard deviation of O's output	0.004741
$corr(P, C)$	Correlation between P and C's output	0.9153
$corr(P, O)$	Correlation between P and O's output	0.2733
$corr(C, O)$	Correlation between C and O's output	0.3578
μ	Utility from leisure	2.2
ϕ^P	Patience parameter for Periphery	0.9999
ϕ^C	Patience parameter for Core	0.99999
ϕ^O	Patience parameter for Outsider	1

Table 1: Baseline parametrization

cycle risk for Core Europe is strong.

Finally, we calibrate the coefficient of leisure in the utility $\mu = 2.2$ so that total employment time at the steady state is about one-third. We calibrate the discount factors for P and C so that in the steady state, P's NFA equals 100% of P's total output, consistent with the data for Peripheral Europe. Table 1 presents all the values for the parameters.

The steady state of the 3-economy system is summarized at Table 2 and they seem quite reasonable. Overall, the share of the non-tradable good value is about two-third in all the economies. Country P's net foreign asset position is negative (which means P is borrowing) and about -100 % of its total output , whereas the size of countries O and C's NFA position ranges from about 40% to 60% of their output. The next

Parameter	Variable	Value
R	Interest rate	1.0204
y_T^P	Country P's tradable output	1
y_N^P	Country P's nontradable output	0.28
y^P	Country P's total output in terms of the tradable good	2.90
y^O	Country O's total output in terms of the tradable good	3.10
y^C	Country C's total output in terms of the tradable good	3.08
b^P	Country P's NFA	-3.05
a^O	Country O's NFA	1.78
a^C	Country C's NFA	1.27

Table 2: Steady state values

section will discuss the steady state values of the bond portfolio holdings. We leave the discussion about the steady state portfolio holdings to the next section.

4.3 Long run (steady state) Portfolio Holdings

In this section, we study the currency risk and business risk in a different angle. We do a comparative statics exercise: we examine the impact on the steady debt holdings when we vary the country P-country C output correlation, and when we vary γ - the consumers' preference towards tradable goods.

In the first exercise, we vary the correlation between country P and country C's output. The idea is to show the impact of business cycle risk. Our intuition predicts that at low levels of correlation between countries P and C's output, we should observe country C hold more of P's bonds. This is because when the business cycle risk becomes more muted, the euro currency risk becomes more dominant. A more dominant euro risk implies that country C has a significant advantage compared to country O when in holding Peripheral bonds. As the correlation gets larger, the business cycle risk becomes more problematic for C, hence C's position in P's bonds should get smaller.

Table 3 shows the percentages of Peripheral bonds held by Core Europe and Outsiders. When the correlation is zero, Core Europe holds 127 percent of the Peripheral bonds. What it means is that the currency risk is so strong that Core Europe lends more than Peripheral Europe's NFAs, and consequently, Peripheral Europe lends to outsiders. Obviously, outsider borrowing from Peripheral Europe in Peripheral bonds is not realistic. This is only possible in our model because we do not place a restriction

$Corr(P,C)$	$Core$	$Outside$
0	127%	-27%
0.1	126%	-26%
0.2	125%	-25%
0.3	124%	-24%
0.4	122%	-22%
0.5	119%	-19%
0.6	115%	-15%
0.7	108%	-8%
0.8	94%	6%
0.9	54%	46%
0.95	-22%	122%

Table 3: Percent share of Peripheral debt held by Core and Outsider investors under benchmark parametrization for varying values of $Corr(P,C)$.

on the direction of the lending. If we restrict that Peripheral Europe does not lend to anyone else, or equivalently, countries' lending to Peripheral Europe does not exceed Peripheral Europe's NFAs, we would have Core Europe lending hit the constraint of 100 percent. In any case, the results show that when there is no business cycle risk, the euro currency risk would make Core Europe do all of the lending to Peripheral Europe. Outsiders, being pushed out from Peripheral bond market, have to park their savings in Core bonds. See Table 5 in the Appendix for the value of bilateral bond holdings.

When the correlation increases, the business cycle risk becomes more important. This implies that outsiders gradually lend more to Peripheral Europe, because their output is not as correlated to country P's. At the empirical value of 0.915, outsiders hold 61 percent of Peripheral bonds, and Core Europe only holds 39 percent. What this shows is that the business cycle risk is also a very important force to consider in any attempt to explain the pattern of capital flows to Europe. Figure 5 below visualizes the shares of Peripheral bonds held by C and O, corresponding to different values of $corr(P,C)$.

In the next exercise, we vary γ– which proxies consumers' preference toward tradable consumption. The idea is that we vary the relative size of the non-tradable sector, and hence the influence of the currency risk. When γ is small, the non-tradable sector is large, and so is the role of non-tradable consumption in the consumption basket.[5]

[5]Note that since the consumption aggregator is a Cobb-Douglas function, γ is also the share of

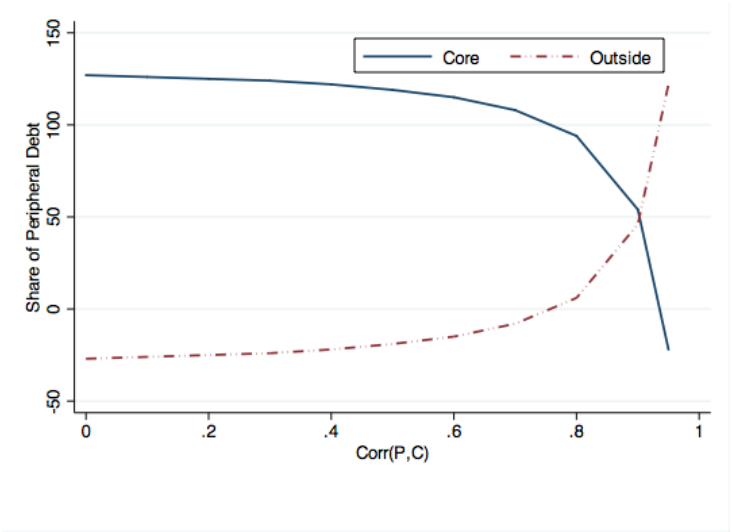

Figure 5: Share of Peripheral debt holding

The advantage of Core Europe is stronger. When γ is larger, the non-tradable sector shrinks, the currency risk advantage becomes smaller.

γ	*Core*	*Outside*
0.01	82%	18%
0.1	41%	59%
0.2	39%	61%
0.3	39%	61%
0.4	39%	61%
0.5	39%	61%
0.6	38%	62%
0.7	38%	62%
0.8	38%	62%
0.9	38%	62%
0.99	38%	62%

Table 4: Percent share of Peripheral debt held by Core and Outside investors under benchmark parametrization for varying values of γ.

Table 4 shows the percentages of Peripheral bonds held by Core Europe and Outsiders, corresponding to different values of γ. When γ equals 0.01, the currency risk channel is very important, Core Europe do most of the lending, even at the presence of the business cycle risk. With larger γ, the currency risk becomes less important,

consumption expenditure spent on tradable goods.

Outsiders with their business cycle advantage start to lend more to Peripheral Europe. The increases are quite small for large γ (as seen in Table 6 in the Appendix). The rounded percentages hence are unchanged. The table suggests that when γ approaches 1 and the currency risk is tiny, business cycle risk is almost entirely responsible for the 38 v.s. 62 percent distribution of Peripheral bonds.

5 Conclusion

This paper examines to what extent euro currency risk can explain why outsiders' lending to Peripheral Europe seems to be intermediated by the Core Europe. We illustrate that the euro currency risk can go a long way in explaining why Core Europe can push outside lenders out of the Peripheral bond market. In our model equilibrium, when only the currency risk is present, Core Europe can emerge as the only lender to Peripheral Europe ,despite the absence of exogenous frictions and market segmentation. In addition, we also show that the business cycle risk is strong and should be considered in any attempt to explain capital flows to Europe. In the calibrated version of our simple model, when both the currency risk and the business cycle risk are present, Core Europe only holds 39 percent of the Peripheral bonds. Given that in the data, Core Europe constitutes about two-thirds to three-quarters of the lending, the result implies that other factors, such as asymmetric information or bailout discrimination, might be also at play.

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6 Appendix

FOCs for country C's household i

$$p_t^C = \frac{1-\gamma}{\gamma}\frac{c_{Tt}^C}{c_{Nt}^C} \tag{15}$$

$$\frac{1}{c_{Tt}^C} = \phi_C\beta\left(c_{Tt}^C\right)^{-\theta} R_{t+1}^P P_{Tt}^E E_t\left(y_{Tt+1}^P \frac{1}{c_{Tt+1}^C P_{Tt+1}^E}\right) \tag{16}$$

$$\frac{1}{c_{Tt}^C} = \phi_C\beta\left(c_{Tt}^C\right)^{-\theta} R_{t+1}^C P_{Tt}^E E_t\left(y_{Tt+1}^C \frac{1}{c_{Tt+1}^C P_{Tt+1}^E}\right) \tag{17}$$

$$\gamma\frac{1}{c_{Tt}^C} = \chi\frac{P_{Tt}^E}{M_t^C} + \phi_C\beta\left(c_{Tt}^C\right)^{-\theta} P_{Tt}^E E_t\left(\frac{\gamma}{c_{Tt+1}^C P_{Tt+1}^E}\right) \tag{18}$$

$$E_t\left[\frac{\gamma(1-\xi)}{c_{Tt+1}^C}\frac{l_{t+1}^C}{P_{Tt+1}^E}\right] = \left[-\mu\xi\frac{l_{t+1}^C}{(1-l_{t+1}^C)W_{t+1}^C}\right] \tag{19}$$

In addition, the FOCs of the intermediate good producers is:

$$E_t\frac{1}{c_{Tt+1}^C}\left[(1-\omega)\frac{y_{Nt+1}^C}{P_{Tt+1}^E} + \frac{\omega}{1-\alpha}\frac{W_{t+1}^C}{P_{Tt+1}^E}\frac{l_{t+1}^C}{P_{Nt+1}^C}\right] = 0 \tag{20}$$

FOCs for country O's household i

$$p_t^O = \frac{1-\gamma}{\gamma}\frac{c_{Tt}^O}{c_{Nt}^O} \tag{21}$$

$$\frac{1}{c_{Tt}^O} = \beta\left(c_{Tt}^O\right)^{-\theta} R_{t+1}^P P_{Tt}^E E_t\left(y_{Tt+1}^P \frac{1}{c_{Tt+1}^O P_{Tt+1}^E}\right) \tag{22}$$

$$\frac{1}{c_{Tt}^O} = \beta\left(c_{Tt}^O\right)^{-\theta} R_{t+1}^C P_{Tt}^E E_t\left(y_{Tt+1}^C \frac{1}{c_{Tt+1}^O P_{Tt+1}^E}\right) \tag{23}$$

$$\gamma\frac{1}{c_{Tt}^O} = \chi\frac{P_{Tt}^O}{M_t^O} + \beta\left(c_{Tt}^O\right)^{-\theta} P_{Tt}^O E_t\left(\frac{\gamma}{c_{Tt+1}^O P_{Tt+1}^O}\right) \tag{24}$$

$$E_t\left[\frac{\gamma(1-\xi)}{c_{Tt+1}^O}\frac{l_{t+1}^O}{P_{Tt+1}^O}\right] = \left[-\mu\xi\frac{l_{t+1}^O}{(1-l_{t+1}^O)W_{t+1}^O}\right] \tag{25}$$

In addition, the FOC of the intermediate good producers is:

$$E_t\frac{1}{c_{Tt+1}^O}\left[(1-\omega)\frac{y_{Nt+1}^O}{P_{Tt+1}^O} + \frac{\omega}{1-\alpha}\frac{W_{t+1}^O}{P_{Tt+1}^O}\frac{l_{t+1}^O}{P_{Nt+1}^O}\right] = 0 \tag{26}$$

$$\tag{27}$$

$Corr(P,C)$	b_C^P	b_O^P	b_O^C
0	3.8803	-0.8325	2.6086
0.1	3.8518	-0.8040	2.5801
0.2	3.8163	-0.7684	2.5445
0.3	3.7706	-0.7228	2.4989
0.4	3.7098	-0.6620	2.4381
0.5	3.6249	-0.5771	2.3532
0.6	3.4979	-0.4501	2.2262
0.7	3.2873	-0.2394	2.0155
0.8	2.8698	0.1781	1.5980
0.9	1.6467	1.4011	0.3750
0.95	-0.6741	3.7219	-1.9458

Table 5: Portfolio holdings under benchmark parametrization for varying values of $Corr(P,C)$. Correlation between Euro Area economies' output and outsider's output is set at their empirical values. b_C^P is country C's holdings of P's bonds, b_O^P is O's holdings of P's bonds, and b_O^C is O's holdings of C's bonds. Positive numbers mean lending, negative number means borrowing. Units are in numbers of tradable goods.

γ	b_C^P	b_O^P	b_O^C
0.01	2.4963	0.5515	1.2246
0.1	1.2534	1.7944	-0.0183
0.2	1.2016	1.8462	-0.0701
0.3	1.1850	1.8628	-0.0867
0.4	1.1768	1.8710	-0.0949
0.5	1.1719	1.8759	-0.0998
0.6	1.1687	1.8791	-0.1030
0.7	1.1664	1.8814	-0.1053
0.8	1.1647	1.8831	-0.1070
0.9	1.1633	1.8845	-0.1084
0.99	1.1624	1.8854	-1.1094

Table 6: Portfolio holdings under benchmark parametrization for varying values of γ. Cross-country correlations are set at their empirical values. b_C^P is country C's holdings of P's bonds, b_O^P is O's holdings of P's bonds, and b_O^C is O's holdings of C's bonds. Positive numbers mean lending, negative number means borrowing. Units are in numbers of tradable goods.