Euro Currency Risk and the Geography of Debt Flows to Peripheral European Monetary Union Members

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Abstract

The pattern of debt flows to peripheral European Monetary Union members seems puzzling: they are mostly indirect and channeled through the large countries of the European Monetary Union. This paper examines to what extent the introduction of the euro and the elimination of the intra-area currency risk can explain this puzzle. A three-country dynamic stochastic general equilibrium framework with endogenous portfolio choice and two currencies is

developed. In the equilibrium, the core members of the European Monetary Union emerge as the main group of lenders to the peripheral European Monetary Union members. Outside lenders are pushed from the periphery debt markets because of currency risk. The model generates a pattern of debt flows consistent with the data despite the absence of any exogenous frictions or market segmentations.

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1. Introduction

Hale and Obstfeld (2016) and Hobza and Zeugner (2014) document an interesting and puzzling empirical fact: since the foundation of the EMU, the financing of peripheral EMU members' trade deficits versus the rest of the world was mostly indirect and intermediated by the large countries of the core EMU.¹ Peripheral EMU's debts were held mainly by Germany and France.² In turn, core EMU's debts were largely held by outside investors.

It is puzzling why investors outside the euro area are more reluctant to hold periphery bonds, and the core EMU countries hold an overwhelming portion of periphery bonds. Why do outsiders not lend to peripheral EMU directly? Using a stylized model, Hale and Obstfeld (2016) argue that this is because the transaction costs of lending to the peripheral EMU are lower for the core EMU than for the rest of the world. Coeurdacier and Martin (2009) find that preferential financial liberalization lowers transaction costs inside the Eurozone (relative to outside the Eurozone) by about 17% for bonds and 10% for stocks. Kalemli-Ozcan et al. (2010) consider three potential candidates to explain financial integration within the EMU: elimination of currency risk, legal harmonization and trade. They find that the elimination of currency risk is the primary explanation for the increasing integration.

In this paper, we theoretically investigate the role of currency risk, and its impact on the geographic pattern of debt flows to the peripheral EMU. We argue that the core EMU has a clear advantage compared to the outside lenders when lending to the peripheral EMU. Core countries share the same currency with the periphery and are not concerned about the currency risk. Due to this advantage, core EMU lenders can push outside lenders out of the periphery bond market.

However, we do not underestimate the importance of other factors that might have caused this market segmentation. Hale and Obstfeld (2016) argue that four main factors contributed to the comparative advantage of the core EMU in lending to the periphery: the decline in (perceived) risks of investing in the peripheral EMU, the decline in transaction costs and the elimination of the currency risk, the European Central Bank's policy of applying an identical collateral haircut to all euro area sovereigns, regardless of their varied credit ratings, and uniform financial regulations within the euro

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¹Peripheral EMU refers to Portugal, Italy, Ireland, Greece, and Spain. Core EMU refers to mainly Germany and France.

²Previous empirical studies such as Lane and Milesi-Ferretti (2005), Lane (2006), Spiegel (2009), De Santis and Grard (2009) and Haselmann and Herwartz (2010) ... also highlight the euro bias as an explanation to the euro area countries' increasing investments in other euro area countries after the formation of the EMU.

area. Another factor is zero risk weights. The current regulatory framework grants EMU banks a beneficial treatment of credit risk on their sovereign debt exposures by assigning 0% risk weights, essentially exempting sovereign exposure (Acharya and Steffen (2015)). In addition, the lack of large exposure rule for public debt allows core EMU banks to take on a very large position on peripheral debt. Banks outside the Eurozone, however, do not have that advantage. Information asymmetry might have also contributed to the observed geographic pattern of flows. Information asymmetry refers to the fact that the core EMU lenders know and understand the peripheral EMU borrowers better than outsiders. This is a possibility and can very well be true for private individuals and banks, but to a lesser extent for sovereign bonds.

In our paper, we focus on the role of the currency risk in shaping the direction of the debt flows. We show that in a calibrated three-country DSGE model, with the presence of euro currency risk and no other frictions, the core EMU lenders can hold a large part of the periphery's debt, pushing outsiders out of the peripheral EMU's debt markets. To the best of our knowledge, our paper is the first to analyze the geographic pattern of debt flows using a DSGE portfolio choice approach. Engel and Matsumoto (2009), Coeurdacier and Gourinchas (2011) and Bengui and Nguyen (2011) also study optimal portfolio choice in the presence of exchange rate risk. However, the issues they examine are different. Engel and Matsumoto (2009) and Coeurdacier and Gourinchas (2011) focus on explaining the equity home bias puzzle. In symmetric two-country setups, they show that not much equity diversification is required when agents can hedge their foreign exchange risk sufficiently. Bengui and Nguyen (2011) examine international debt dollarization in a small open economy setup. Our paper, on the other hand, investigates the pattern of debt flows as an optimal portfolio choice in a three-country setup.

Intuitively, there are two competing channels that influence the portfolio decisions of the core EMU and outside investors. The first channel is called the “currency channel”. It refers to the fact that the core EMU shares the same currency with the periphery. This currency advantage allows them to absorb the bad shocks to the periphery bonds' returns better than outside investors do. The mechanism works as follows. Consider the core EMU holders and the U.S. holders of the periphery bonds. If the euro depreciates against the U.S. dollar (for instance, because of an increase in the euro money supply), the dollar value of the periphery bond's return declines. This hurts both core EMU and U.S. bond holders. Furthermore, when the non-tradable good prices are sticky, the dollar value of the consumption expenditure of the core EMU bond holder is going to be lower compared to the U.S. bond holder.³ This helps the core EMU bond holders. Since the U.S. lenders only consume in dollars, they do not have this advantage. Even when the law of one price holds for tradable goods, the existence of non-tradable goods and nominal rigidity enable the “currency channel” to work in favor of the core EMU lenders.⁴ Simply put, being in the same monetary union with the periphery gives the core EMU an advantage over outside lenders in terms of lending to the peripheral EMU.

The second channel is called “the business cycle channel” and it discourages the core EMU lenders from lending to the peripheral EMU. It works as follows: core EMU countries' business cycles are

³For example, a 10 euro haircut previously cost 14 dollars. When the euro depreciates and dollar prices are sticky, a 10 euro haircut now costs only 12 dollars.

⁴Nominal shocks, such as currency risk, only work in the presence of nominal rigidity. If prices are completely flexible, nominal shocks would have no real impact.

more correlated with the peripheral EMU business cycles than with business cycles of the countries outside the Eurozone. Hence, periphery bonds might not be a good hedge for the core EMU lenders, as they do not want to receive low returns on their investment precisely when their economy worsens. This puts the core EMU in an inferior position compared to the outside lenders as the diversification benefits from investing in the Eurozone economies are small.

The two effects - the currency channel and the business cycle channel - influence the portfolio choice of the lenders in opposite ways. In particular, the currency channel encourages euro-denominated lending of the core EMU lenders, while the business cycle channel discourages this. On the contrary, the currency channel discourages euro-denominated lending of the outside lenders, while the business cycle channel encourages this. If we observe the core EMU does most of the lending to the peripheral EMU, it implies that the currency channel is stronger.

A natural question is why outside lenders are not pushed out of the core EMU's bond market too? This is a legitimate question because when it comes to holding core EMU bonds, the periphery investors also have the currency risk advantage compared to the outsider lenders. We argue that this effect is quantitatively small. First of all, the periphery is small and cannot saturate the core EMU's debt market. Second, since the inception of the euro, liabilities of the peripheral EMU have been increasing faster than their assets, and the peripheral EMU has been running a net deficit. Hence, we conclude that the periphery has little incentive to hold core bonds. Consequently, outside investors face less competition in the core bond markets than in the periphery bond markets, and end up investing most of their savings in the core bonds.

We describe our mechanism in detail using the framework of a DSGE model with incomplete markets. The model features three agents ('Periphery', 'Core', and a foreign lender called 'Outsider'), two sectors (tradable and non-tradable goods), two assets (periphery bond and core bond) with endogenous debt portfolio choices. In the model, the market segmentation arises endogenously based on optimal portfolio choice and does not rely on any exogenous market friction, such as information asymmetry or bailout discrimination. We adopt the new solution method developed by [Devereux and Sutherland \(2010\)](#) and [Tille and van Wincoop \(2010\)](#) to solve for the long run (i.e. zero-order) portfolio choice of countries.

The paper is organized as follows. Section 2 presents some empirical stylized facts on the geographic pattern of EMU debt flows. The model is described in section 3. Section 4 presents the solution method and the calibration of the model. Section 5 discusses the results from the analyses. Finally, section 6 concludes.

2. Stylized Facts

This section presents the stylized facts that motivate our theoretical model. As in [Hale and Obstfeld \(2016\)](#), we focus on the period between 1999 – when the Eurozone was formed – until before the crisis. This is to avoid the complications that the crisis might have caused.⁵

Figures 1 and 2 are taken directly from [Chen et al. \(2013\)](#). Figure 1 presents the decomposition of

⁵For 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.

Fig. 1. Net foreign assets of peripheral EMU. Source: Chen et al. (2013).

Fig. 2. Net foreign assets of core EMU. Source: Chen et al. (2013).

the peripheral EMU'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 the peripheral EMU's net liabilities since the beginning of 2000s. In 2001, the core held about 60 percent of the periphery's net liabilities. This share was about 75 percent by 2008. Figure 2 shows the decomposition of the core EMU's net foreign asset position versus other euro area countries and versus the rest of the world. Core EMU's net foreign assets were primarily versus the rest of the euro area (i.e. peripheral EMU), while their liabilities were mostly versus the rest of the world.

Hale and Obstfeld (2016) illustrate the changes in debt flows to core and periphery countries after the inception of the euro very clearly. Figure 3 is borrowed from their paper. They organize the countries to 4 groups: financial centers (FIN), core EMU (CORE), peripheral EMU (GIIPS) and the rest of the world (ROW)⁶. Data are from the Bank of International Settlement's consolidated banking

⁶FIN 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.

Fig. 3. Bilateral bank gross debt positions (left) and their change by 2007 (right). Source: Hale and Obstfeld (2016).

database. The left hand side panel 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 gross position. The right hand side panel 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, suggesting a concurrent increase in lending from FIN to CORE and from CORE to GIIPS.

Fig. 4. Borrowing and lending by selected large banks. Measured in billion dollars. Source: Hale and Obstfeld (2016).

In addition, using the Loan Analytics database, [Hale and Obstfeld \(2016\)](#) look into the geographical composition of borrowing and lending by some of the large banks in the core EMU. Figure 4 shows that the borrowing from FIN and lending to GIIPS increased dramatically after 1999, when the Eurozone

was formed, but collapsed during the 2008-2009 crisis. They find that there is a link between core EMU banks' borrowing from FIN and their lending to GIIPS during the pre-crisis period. This is as if the banks intermediated loans to the peripheral EMU. They do not find such a link for banks in different regions.⁷

It is interesting that both the lending from FIN to the core EMU banks and lending from the core EMU banks to GIIPS collapsed during the crisis. This phenomenon could be explained by an increase in risk aversion of all lenders during this time (Guiso et al. (2013)), and a perceived higher default risk, particularly of GIIPS countries. Higher risk aversion and higher default risk would cause capital to retrench. Currency risk during the crisis might have become secondary, and might have been overshadowed by these factors.

3. Model

We build a three-country, two-asset model to formalize our theory. The three countries are Periphery (denoted P), Core (denoted C) and Outsider (denoted O). P and C share the same currency (euros) while O uses dollars. The two assets are Periphery bonds and Core bonds, issued in euros. P only issues its Periphery bonds, and is assumed not to hold Core bonds. C can hold Periphery bonds, and issue its Core bonds. O has a choice of holding Periphery bonds and Core bonds. We also assume that the nominal bonds' returns are state contingent: they depend on the output realization.

We assume that country P does not hold Core bonds. This assumption not only makes the model more tractable, but also is aligned with the empirical evidence. It allows us to imitate the borrowing nature of the periphery countries since the inception of the euro. Therefore, we are able to focus on the competition between the Core and the Outsider lenders over the Periphery debt and hence analyze the currency risk and business cycle channels with more clarity. Similarly, we do not allow the outside country to issue debt, as it does not contribute to the answering of the question at hand.

In each of the three economies, households provide labor and consume tradable and non-tradable goods. Firms produce non-tradable goods, and return profit to households. Households transfer wealth across time by holding or issuing bonds. While the country-specific non-tradable good is produced using labor, for simplicity, we assume that there is a single tradable good and each country receives an endowment of this good according to a country-specific stochastic process. The non-tradable goods' prices are sticky, while the tradable good's price is flexible. As a standard convention in the New Keynesian models, nominal rigidities in the non-tradable sector are modeled by dividing the sector into perfectly competitive retailers and monopolistically competitive intermediate good producers. In addition, in the model we assign Periphery and Core a higher discount rate to generate their borrowing from the Outsider in the equilibrium.

3.1. Notation

To be clear from the beginning, let us go through some of the key notation used in the paper. Superscripts P, C, and O denote country P (Periphery), C (Core), and O (Outsider).

⁷Refer to Hale and Obstfeld (2016) for more detailed analysis with different data sources.

$(c_{Tt}^P, c_{Nt}^P, c_t^P)$, $(c_{Tt}^C, c_{Nt}^C, c_t^C)$ and $(c_{Tt}^O, c_{Nt}^O, c_t^O)$ are the tradable, non-tradable, and *aggregate* consumption of Periphery, Core and Outsider countries, respectively.

$P_{Nt}^P, P_{Nt}^C, P_{Nt}^O$ are the nominal non-tradable good prices of Periphery, Core and Outsider countries, respectively.

P_{Tt}^E, P_{Tt}^O are the nominal tradable good prices of the Eurozone and Outsider countries, respectively.

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P_t^P, P_t^C, P_t^O are the nominal *aggregate* prices of Periphery, Core and Outsider countries, respectively.

b_{it}^j is country j 's holding of country i 's bond in units of the tradable good. We refer to them as the “real” bond holdings.

3.2. Periphery Country

The expected life-time utility of a representative Periphery household is given by:

$$E_0 \sum_{t=0}^{\infty} \psi_t^P \left[\frac{1}{1-\sigma} \left(c_t^P - \Phi \frac{l_t^{P1+\nu}}{1+\nu} \right)^{1-\sigma} + \chi \ln \left(\frac{M_t^P}{P_t^P} \right) \right]$$

Households derive utility from aggregate consumption (c_t^P), real money holdings ($\frac{M_t^P}{P_t^P}$) and experience disutility from working. The utility takes the form of GHH utility function to remove wealth effects and hence generate a decline in employment in bad times.⁹ Aggregate consumption consists of tradable and non-tradable consumption:

$$c_t^P = \frac{(c_{Tt}^P)^\gamma (c_{Nt}^P)^{1-\gamma}}{\gamma^\gamma (1-\gamma)^{1-\gamma}}.$$

Hence the aggregate price takes the form:

$$P_t^P = (P_{Tt}^E)^\gamma (P_{Nt}^P)^{1-\gamma},$$

$\psi_t^P \equiv (\phi_P \beta)^t \Pi_{k=0}^t c_{Tk}^{P-\mu}$ is country P's discount factor. It has two components. $(\phi_P \beta)^t$ is the standard discount factor component. ϕ_P is the coefficient reflecting country P's patience.¹⁰ The second component $\Pi_{k=0}^t c_{Tk}^{P-\mu}$ is the (uninternalized) endogenous discount factor that depends on the aggregate (economy-wide) level of households' tradable consumption. As in [Schmitt-Grohé 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 tradable consumption, which the representative household takes as given. In addition, $\mu = 0.001$ is set very small so that in the short run, the deviations of the endogenous discount factor from the standard discount factor β are negligible.

⁸Note that Periphery and Core share the same nominal tradable price, since they have the same currency.

⁹See [Greenwood et al. \(1988\)](#) for further details.

¹⁰Similarly, ϕ_C and ϕ_O are the patience coefficients for countries C and O. To ensure Outsider lends to Periphery and Core, we assume that O is more patient (i.e. $\phi_O > \phi_C$ and $\phi_O > \phi_P$).

Households face a sequence of budget constraints:

$$P_{Tt}^E c_{Tt}^P + P_{Nt}^P c_{Nt}^P + P_{Tt}^E b_{Pt}^P + M_t^P = y_{Tt}^P R_{t-1}^P P_{Tt-1}^E b_{Pt-1}^P + M_{t-1}^P + W_t^P l_t^P + P_{Tt}^E y_{Tt}^P + D_{t-1}^P, \quad (1)$$

where b_{Pt}^P is the “real” Periphery bond holdings of country P’s households (a negative b_{Pt}^P implies issuing). M_t^P is the money holding. $y_{Tt}^P R_{t-1}^P$ is the ex-post nominal return of the Periphery bond, which depends on P’s output and the nominal interest rate R_{t-1}^P , which was determined in the last period when the bond was issued. W_t^P is the nominal wage, y_{Tt}^P is the tradable endowment, and D_{t-1}^P is the profit from non-tradable production returned by firms at the end of the last period (since firms are owned by households).

The first-order conditions of the household’s problem are:

$$\frac{P_{Nt}^P}{P_{Tt}^E} = \frac{1 - \gamma}{\gamma} \frac{c_{Tt}}{c_{Nt}} \quad (2)$$

$$\Phi l_t^\nu = \frac{\gamma c_{Tt}^{\gamma-1} c_{Nt}^{1-\gamma}}{\gamma^\gamma (1-\gamma)^{1-\gamma}} \frac{W_t^P}{P_{Tt}^E} \quad (3)$$

$$U'_{c_{Tt}}(\cdot) = \phi_P \beta c_t^{-\mu} E_t r_{t+1}^P U'_{c_{Tt+1}}(\cdot) \quad (4)$$

$$U'_{c_{Tt}}(\cdot) = \chi \frac{P_{Tt}^E}{M_t^P} + \phi_P \beta c_t^{-\mu} E_t \frac{P_{Tt}^E}{P_{Tt+1}^E} U'_{c_{Tt+1}}(\cdot) \quad (5)$$

where, for brevity, the superscript P is dropped for consumption and labor variables. $r_{t+1}^P = R_t^P \frac{P_{Tt}^E}{P_{Tt+1}^E} y_{Tt+1}^P$ and $r_{t+1}^C = R_t^C \frac{P_{Tt}^E}{P_{Tt+1}^E} y_{Tt+1}^C$ denote the ex-post real returns of country P and country C’s bonds, respectively. In the first-order conditions, marginal utility with respect to tradable consumption is denoted as $U'_{c_{Tt}}(\cdot) \equiv \left(c_t - \Phi \frac{l_t^{1+\nu}}{1+\nu} \right)^{-\sigma} \frac{\gamma c_{Tt}^{\gamma-1} c_{Nt}^{1-\gamma}}{\gamma^\gamma (1-\gamma)^{1-\gamma}}$. Equation (2) is a static optimality condition describing the composition of the household’s consumption basket between tradable and non-tradable goods. Equation (3) is a static optimality condition describing the labor choice of the consumer. Equations (4) and (5) are Euler equations for Periphery bonds, and money holdings, respectively.

We now move to firms. Intermediate producer j produces a differentiated intermediate non-tradable good y_{Njt}^P using constant technology A_N and labor l_{jt}^P according to a linear production function

$$y_{Njt}^P = A_N l_{jt}^P$$

To model nominal rigidities in the non-tradable market, we separate the non-tradable sector into intermediate good producers and retailers. 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

$$Y_{Nt}^P = \left[\int_0^1 y_{Njt}^P \frac{\omega_F^{\omega_F-1}}{\omega_F} \right]^{\frac{\omega_F}{\omega_F-1}},$$

where ω_F is the elasticity of substitution between any two differentiated intermediate non-tradable goods, and $\frac{\omega_F}{1-\omega_F}$ is the firm’s markup.

The nominal profit of producer j is:

$$D_{jt}^P = P_{Njt}^P A_N l_{jt}^P - W_t^P l_{jt}^P \quad (6)$$

where D_{jt}^P is the profit that the producer distributes to households at the end of the period, for consumption in the next period.

In each period, only a fraction $1 - \kappa$ of the firms can adjust price. This means that for each firm, at the beginning of each period, there is a constant probability of $1 - \kappa$ that they can change their price if they want to. If the firm had fully flexible price ($\kappa = 0$), it would set the (hypothetical) price as a mark-up over marginal cost.

$$P_{Nt}^{*P} = \frac{\omega_F}{\omega_F - 1} MC_t^P = \frac{\omega_F}{\omega_F - 1} \frac{W_t^P}{A_N}$$

As is standard in New-Keynesian (NK) models, the aggregate non-tradable price for country P is governed by the following equation:

$$\begin{aligned} \log P_{Nt}^P - \log P_{Nt-1}^P &= (c_t^P)^{-\mu} \phi_P \beta E_t(\log P_{Nt+1}^P - \log P_{Nt}^P) \\ &+ \lambda_F \left(\log \left(\frac{W_t^P}{P_{Nt}^P A_N} \right) - \log \left(\frac{\bar{W}^P}{\bar{P}_N^P \bar{A}_N} \right) \right) \end{aligned} \quad (7)$$

where $\lambda_F = \frac{(1-\kappa)(1-(c_t^P)^{-\mu} \phi_P \beta \kappa)}{\kappa}$, and $\bar{X}$ denotes the steady state value of a variable.

3.3. Core Country and Outsider Country

The setup for country C and country O is quite similar to the setup for country P. The differences are (1) C and O have different discount factors, and (2) unlike P, who only can issue Periphery bonds, C can issue Core bonds and hold Periphery bonds, and O can hold both Periphery and Core bonds. For country C, the discount factor is $\psi_t^C \equiv (\phi_C \beta)^t \Pi_{k=0}^t c_{Tk}^{C-\mu}$. For country O, the discount factor is $\psi_t^O \equiv (\phi_O \beta)^t \Pi_{k=0}^t c_{Tk}^{O-\mu}$. Note that we assume $\phi_O > \phi_P$ and $\phi_O > \phi_C$ so that Outsider lends to Periphery and Core in the equilibrium.

The expected life-time utility of a representative Core household is given by:

$$E_0 \sum_{t=0}^{\infty} \psi_t^C \left[\frac{1}{1-\sigma} \left(c_t^C - \Phi \frac{l_t^{C1+\nu}}{1+\nu} \right)^{1-\sigma} + \chi \ln \left(\frac{M_t^C}{P_t^C} \right) \right]$$

Households face a sequence of budget constraints

$$\begin{aligned} P_{Tt}^E c_{Tt}^C + P_{Nt}^C c_{Nt}^C + P_{Tt}^E b_{Pt}^C + P_{Tt}^E b_{Ct}^C + M_t^C = \\ y_{Tt}^C R_{t-1}^C P_{Tt-1}^E b_{Ct-1}^C + y_{Tt}^P R_{t-1}^P P_{Tt-1}^E b_{Pt-1}^C + M_{t-1}^C + W_t^C l_t^C + P_{Tt}^E y_{Tt}^C + D_{t-1}^C \end{aligned} \quad (8)$$

where b_{Pt}^C is the “real” Periphery bond holdings of country C’s households, b_{Ct}^C is the “real” Core bond holdings of country C’s households (a negative b_{Ct}^C implies issuing).

The first-order conditions of the Core household's problem are:

$$\frac{P_{Nt}^C}{P_{Tt}^E} = \frac{1 - \gamma}{\gamma} \frac{c_{Tt}}{c_{Nt}} \quad (9)$$

$$\Phi l_t^\nu = \frac{\gamma c_{Tt}^{\gamma-1} c_{Nt}^{1-\gamma}}{\gamma^\gamma (1-\gamma)^{1-\gamma}} \frac{W_t^C}{P_{Tt}^E} \quad (10)$$

$$U'_{c_{Tt}}(\cdot) = \phi_C \beta c_t^{-\mu} E_t r_{t+1}^P U'_{c_{Tt+1}}(\cdot) \quad (11)$$

$$U'_{c_{Tt}}(\cdot) = \phi_C \beta c_t^{-\mu} E_t r_{t+1}^C U'_{c_{Tt+1}}(\cdot) \quad (12)$$

$$U'_{c_{Tt}}(\cdot) = \chi \frac{P_{Tt}^E}{M_t^C} + \phi_C \beta c_t^{-\mu} E_t \frac{P_{Tt}^E}{P_{Tt+1}^E} U'_{c_{Tt+1}}(\cdot) \quad (13)$$

where, for brevity, the superscript C is dropped for consumption and labor variables. Equation (9) is a static optimality condition describing the composition of the household's consumption basket between tradable and non-tradable goods. Equation (10) is a static optimality condition describing the labor choice of the consumer. Equations (11), (12) and (13) are Euler equations for Periphery bonds, Core bonds and money holdings, respectively.

The expected life-time utility of a representative Outsider household is given by:

$$E_0 \sum_{t=0}^{\infty} \psi_t^O \left[\frac{1}{1-\sigma} \left(c_t^O - \Phi \frac{l_t^{O1+\nu}}{1+\nu} \right)^{1-\sigma} + \chi \ln \left(\frac{M_t^O}{P_t^O} \right) \right]$$

Households face a sequence of budget constraints

$$P_{Tt}^O c_{Tt}^O + P_{Nt}^O c_{Nt}^O + P_{Tt}^O b_{Pt}^O + P_{Tt}^O b_{Ct}^O + M_t^O = y_{Tt}^C R_{t-1}^C P_{Tt}^O b_{Ct-1}^O \frac{P_{Tt-1}^E}{P_{Tt}^E} + y_{Tt}^P R_{t-1}^P P_{Tt}^O b_{Pt-1}^O \frac{P_{Tt-1}^E}{P_{Tt}^E} + M_{t-1}^O + W_t^O l_t^O + P_{Tt}^O y_{Tt}^O + D_{t-1}^O \quad (14)$$

where b_{Pt}^O is the real Periphery bond holdings of country O's households, b_{Ct}^O is the real Core bond holdings of country O's households.

The first-order conditions of the Outsider household's problem are:

$$\frac{P_{Nt}^O}{P_{Tt}^O} = \frac{1 - \gamma}{\gamma} \frac{c_{Tt}}{c_{Nt}} \quad (15)$$

$$\Phi l_t^\nu = \frac{\gamma c_{Tt}^{\gamma-1} c_{Nt}^{1-\gamma}}{\gamma^\gamma (1-\gamma)^{1-\gamma}} \frac{W_t^O}{P_{Tt}^O} \quad (16)$$

$$U'_{c_{Tt}}(\cdot) = \phi_O \beta c_t^{-\mu} E_t r_{t+1}^P U'_{c_{Tt+1}}(\cdot) \quad (17)$$

$$U'_{c_{Tt}}(\cdot) = \phi_O \beta c_t^{-\mu} E_t r_{t+1}^C U'_{c_{Tt+1}}(\cdot) \quad (18)$$

$$U'_{c_{Tt}}(\cdot) = \chi \frac{P_{Tt}^O}{M_t^O} + \phi_O \beta c_t^{-\mu} E_t \frac{P_{Tt}^O}{P_{Tt+1}^O} U'_{c_{Tt+1}}(\cdot) \quad (19)$$

where for brevity, the superscript O is dropped for consumption and labor variables.

3.4. Exogenous Shocks

There are real and nominal shocks in the model. Real shocks are shocks to the tradable good endowments of the three countries:

$$\log(y_{Tt}^P) = \rho_P \log(y_{Tt-1}^P) + (1 - \rho_P) \log(\bar{y}^P) + \epsilon_t^P \quad (20)$$

$$\log(y_{Tt}^C) = \rho_C \log(y_{Tt-1}^C) + (1 - \rho_C) \log(\bar{y}^C) + \epsilon_t^C \quad (21)$$

$$\log(y_{Tt}^O) = \rho_O \log(y_{Tt-1}^O) + (1 - \rho_O) \log(\bar{y}^O) + \epsilon_t^O \quad (22)$$

Nominal shocks are the shocks to the supply of euros and dollars:

$$\log(M_t^E) = \rho_{ME} \log(M_{t-1}^E) + \varepsilon_t^{ME} \quad (23)$$

$$\log(M_t^O) = \rho_{MO} \log(M_{t-1}^O) + \varepsilon_t^{MO} \quad (24)$$

3.5. Market Clearings

Tradable good market clearing implies:

$$c_{Tt}^O + c_{Tt}^C + c_{Tt}^P = y_{Tt}^O + y_{Tt}^C + y_{Tt}^P \quad (25)$$

Both Periphery and Core bonds are in zero net supply. Market clearing for bond markets imply:

$$b_{Pt}^P + b_{Pt}^C + b_{Pt}^O = 0 \quad (26)$$

and

$$b_{Ct}^C + b_{Ct}^O = 0 \quad (27)$$

The first bond market clearing equation implies that Periphery issued bonds are entirely held by C and O. The second equation implies that Core issued bonds are entirely held by O.

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

$$M_t^E = M_t^P + M_t^C \quad (28)$$

4. Model Solution and Calibration

It is well-known that up to the first-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 complete asset market structures that make portfolio choice irrelevant. Since the focus of our paper is on the 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 portfolio bond holdings of the Core and Outsider lenders.

4.1. Solving for the Portfolio Holdings

We use the approach of [Devereux and Sutherland \(2010\)](#) and [Tille and van Wincoop \(2010\)](#) to solve the steady state portfolio choice problem. The portfolio choices of country C and country O

should satisfy the following:

$$E_t (r_{t+1}^P - r_{t+1}^C) (U'_{c_{O_{t+1}}}(\cdot) - U'_{c_{C_{t+1}}}(\cdot)) = 0 \quad (29)$$

Equation (29) means that C and O will choose an optimal bond portfolio so that the differential in their marginal utilities on average is not correlated to the return differential of their bond holdings. In other words, their consumption is on average insured against the monetary shocks and real shocks to P and C's tradable endowments.

Taking a second-order logarithmic approximation of the country C and country O portfolio first-order conditions and combining them yields:

$$E_t[(\hat{r}_{t+1}^C - \hat{r}_{t+1}^P)(co_{ct}^O \hat{c}_{t+1}^O + co_{cn}^O \hat{c}_{t+1}^O + co_l^O \hat{l}_{t+1}^O - co_{ct}^C \hat{c}_{t+1}^C - co_{cn}^C \hat{c}_{t+1}^C - co_l^C \hat{l}_{t+1}^C)] = 0, \quad (30)$$

where $\hat{x}$ denotes log deviations from the steady state value of the variable. co_j^i are the coefficients on variable j of country i and they are as follows: $co_{ct}^i = \gamma - 1 - \sigma\gamma \frac{c^i}{c_i - \Phi \frac{l^{i1+\nu}}{1+\nu}}$, $co_{cn}^i = 1 - \gamma - \sigma(1 - \gamma) \frac{c^i}{c_i - \Phi \frac{l^{i1+\nu}}{1+\nu}}$, $co_l^i = \sigma\Phi \frac{l^{i1+\nu}}{c_i - \Phi \frac{l^{i1+\nu}}{1+\nu}}$.

The details of the solution method are presented in Appendix A.

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 $\omega_F = 10$. We set the endogenous discount factor coefficient very small $\mu = 0.001$, 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, and the persistence of endowment to 0.8. We set κ equal to 0.75, implying that the average period between price adjustments is four quarters, as in Bernanke et al. (1999). The correlations of P, C and O's endowments are consistent with the data.¹¹

The steady state of the three-economy system is summarized in Table 2 and they seem quite reasonable. Overall, the share of the non-tradable good value is about two-thirds of total consumption 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 total output. The next section will discuss the steady state values of the bond portfolio holdings.

5. Results

In this section we introduce the results of the model. First, we present the steady state portfolio holdings. Using three exercises, we demonstrate the importance of the business cycle and the currency risk channels by studying the changes in the steady state portfolio holdings in response to the changes

¹¹Peripheral EMU consists of Italy, Spain, Portugal, Greece. Core EMU consists of France, Germany, Belgium. Outsider economies consist of United States, United Kingdom, Switzerland and Japan. Data is obtained from the OECD. For each group, we divide the total quarterly real GDP by the total population to obtain the group quarterly real GDP per capita. The moments are calculated from the series of the groups' quarterly real GDP growth.

Table 1
Baseline calibration

	Description	Value
γ	Share of tradable consumption	0.33
χ	Utility from money holdings	0.05
β	Discount factor	0.98
μ	Endogenous discount factor coefficient	0.001
A_N	TFP in intermediate non-tradable good production	1
ω_F	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
κ	Non-tradable good price stickiness	0.75
ρ^P	Persistence of P's tradable endowment	0.8
ρ^C	Persistence of C's tradable endowment	0.8
ρ^O	Persistence of O's tradable endowment	0.8
σ^P	Standard deviation of P's tradable endowment	0.01
σ^C	Standard deviation of C's tradable endowment	0.01
σ^O	Standard deviation of O's tradable endowment	0.01
$\rho(P, C)$	Correlation between P and C's tradable endowment	0.9
$\rho(P, O)$	Correlation between P and O's endowment	0.2
$\rho(C, O)$	Correlation between C and O's endowment	0.3
ν	Utility from leisure	0.6
Φ	Disutility from labor	3
ϕ_P	Patience parameter for Periphery	0.9999
ϕ_C	Patience parameter for Core	0.99999
ϕ_O	Patience parameter for Outsider	1

in the influence of each channel. Further, we discuss the mechanism in which these channels operate using the impulse responses to nominal and real shocks.

5.1. Steady State Portfolio Holdings

Under the baseline calibration displayed in Table 1, and using a value of 0.75 for the price stickiness parameter κ , we find that Core holds 65% of the Periphery debt and the remainder 35% of the Periphery liabilities is held by the Outsider investor. This is aligned with the data (see Figure 1).

To evaluate the relative importance of the business cycle and the currency risk channels on the portfolio holdings, we perform three exercises. In these exercises, we vary the value of the price stickiness parameter κ and the correlation between the three countries' endowments.

We change κ in order to capture varying degrees of currency risk exposure. A larger value for κ means higher degree of price stickiness in the non-tradable goods, which we interpret as higher exposure to currency risk. We predict that, everything else constant, when non-tradable good prices are sticky, a depreciation of the euro lowers the dollar value of Core household's non-tradable good consumption expenditure, which gives them an advantage over the Outsider household. In contrast, flexible non-tradable good prices could leave the dollar value of non-tradable good consumption expenditure unaffected, invalidating the currency risk.

The importance of the business cycle channel is adjusted by changing the endowment correlation between countries P and C, and between countries P and O. When a country's endowment is more correlated with country P's endowment, their incentive to lend to country P is weakened.

Table 2
Steady state values

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	0.302
y^P	Country P's total output in terms of the tradable good	3.02
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	1.77
a^C	Country C's NFA	1.28

Fig. 5. Periphery bond lending by Core and Outsider when $\rho(P, C) = 0.9$; $\rho(P, O) = \rho(C, O) = 0$. A larger value for κ means higher degree of stickiness in the price of nontradables.

In the first exercise, we keep cross-country tradable good endowment correlations between Core and Outsider, and between Periphery and Outsider at zero. The tradable good endowment correlation between Core and Periphery remains at its calibrated value of 0.90. This implies that, in terms of insuring against individual shocks, Outsider investor can achieve a better hedge by investing in a euro-denominated bond compared to the Core investor. We only vary the price stickiness parameter κ . All other parameters are as in the baseline calibration. We calculate the steady state bond holdings for various values of κ . They are shown in Figure 5.

At low degrees of price stickiness, Outsider holds a substantive portion of the Periphery debt. As κ increases, Outsider's position in Periphery bonds gets smaller while Core's position in Periphery bonds gets larger. This is in line with our prediction. For high levels of price stickiness, the euro currency risk becomes more prominent. A more prominent euro risk implies that Core has a significant advantage compared to the Outsider when it comes to purchasing euro-denominated Periphery bonds.

Fig. 6. Periphery bond lending by Core and Outsider when $\rho(P, C) = 0.9$, and $\rho(C, O) = 0.3$. Note that $\kappa = 0.75$.

Accordingly, we observe that as the euro risk gets more pronounced, the Outsider investor gets pushed out of the Periphery bond market due to increased competition by the Core investor.

In the second exercise, we investigate the importance of the business cycle channel. Keeping κ at 0.75, we only alter the correlation between Periphery and Outsider tradable endowments. Figure 6 demonstrates that, at low levels of correlation, Outsider holds almost 100% of the Periphery bonds. As correlation increases, this share goes down. Our intuition is that, at low levels of correlation, the Outsider investor has a greater incentive to hold Periphery bonds because the bond's return is not much correlated to Outsider's business cycle. At a higher level of correlation, the incentive to hold Periphery bond is lower, so much that the holding becomes negative. Note that since we do not restrict the Periphery bond held to be always positive, for large values of the correlation, country P lends to country O.

In the third exercise, we continue to investigate the importance of the business cycle channel this time by varying the correlation between Periphery and Core tradable endowments. As shown in Figure 7, at zero cross-correlation, Core holds 90% of the Periphery debt. This share declines as the two country business cycles become more correlated. The intuition for this result is the same as above. At lower levels of correlation, Core investor has a greater incentive to hold Periphery bonds, which serves as a good insurance against shocks to Core tradable endowment. As the endowment correlation increases, the return on the Periphery bond also becomes more correlated with the Core tradable endowment, which reduces the insurance quality of the asset.

5.2. Impulse Responses

In this section we present impulse responses of various relative prices, consumption and labor choice to an increase in the euro supply and to a negative shock to the Periphery tradable endowment. We aim at explaining the precise mechanism of the currency risk channel on the portfolio holdings of the

Fig. 7. Periphery bond lending by Core and Outsider when $\rho(P, O) = 0.2$, and $\rho(C, O) = 0.3$. Note that $\kappa = 0.75$.

countries.

We first consider a 1% increase in the euro money supply as shown in Figure 8. We investigate the impulse responses from this shock under flexible and sticky non-tradable prices separately. The blue dotted line represents the flexible price world, while the red dashed line represents the sticky price world.

As the supply of euro increases, the euro price of the tradable good goes up (since the tradable good price is always flexible). This is equivalent to a euro depreciation. When non-tradable prices are flexible (the blue dotted lines), nominal shocks have no real impact. For that reason, consumption, labor and the relative price of non-tradable goods (i.e. the real exchange rate) of all countries remain unchanged.

When non-tradable prices are sticky (the red dashed lines), the relative prices of non-tradable goods decline in both the EMU and in the Outsider country. Since non-tradable firms cannot change prices immediately, they boost non-tradable good production in response to the increase in demand. However, the non-tradable good prices do not increase as much as the tradable good price: the relative price of the non-tradable good goes down in each of the countries.

This has implications for the portfolio choice. Following the shock, euro depreciates, and the real returns on both of the euro bonds decline. The depreciated euro reduces the dollar equivalent of the Outsider investor's portfolio investment. In the meanwhile, with sticky prices, the non-tradable good's relative price falls more in Core compared to the Outsider country. This brings an advantage to Core compared to Outsider lenders, because Core non-tradable good expenditure is now lower. This implies that Core can be more tolerating (compared to Outsider) to the decline in the real return of the euro bond, because their non-tradable good price is relatively lower compared to the Outsider following an increase in the supply of euros.

Next we consider a 1% decrease in the Periphery country's tradable endowment. Since the cross-

Fig. 8. A 1% increase in the euro supply. Blue dotted line represents the flexible price world, where we fixed κ to 0.01. The dashed red line represents the sticky price world, where κ is set to 0.99. The y-axis is the percentage deviations from the steady state value of the variable.

country endowment correlations are non-zero, we observe spillover effects on the Core and Outsider country endowments as well (see the first row of Figure 9). The correlation between the Periphery and Core tradable good endowments is higher than the correlation between Periphery and Outsider's tradable good endowments, and hence, on impact, the endowment of Core declines more than the Outsider's endowment.

Following a temporary negative endowment shock, Periphery country smooths consumption by importing tradable goods. Similarly, Core also imports tradable goods from the Outsider. This causes higher demand for foreign tradable goods. Hence, the tradable good prices rise both in the EMU and abroad.

Under the flexible price scenario, non-tradable good prices also go up on impact, even though not as much as the tradable good prices. This leads to a decrease in the relative prices of non-tradable goods in all three countries. Aggregate consumption in all three countries decline. When the non-tradable good prices are sticky, the relative price of non-tradable goods decline more significantly. Since non-tradable good prices can not immediately be adjusted, non-tradable good production increases. Higher non-tradable output boosts non-tradable consumption and hence aggregate consumption. In other words, the increase in non-tradable consumption more than offsets the decrease in tradable endowment.

We can see that in both flexible price and sticky price scenarios, the relative price of non-tradable goods in all three countries move in a very similar manner, both qualitatively and quantitatively. Similarly the tradable good prices move in a similar manner, leaving the nominal exchange rate roughly unchanged. What this means is that Core lenders do not enjoy an extra benefit from relatively lower non-tradable prices from endowment shocks, unlike the case following the nominal shock.

Fig. 9. A 1% decrease in the Periphery country tradable good endowment. Blue dotted line represents the flexible price world, where we fixed κ to 0.01. The dashed red line represents the sticky price world, where κ is set to 0.99. The y-axis is the percentage deviations from the steady state value of the variable. We assumed that cross-country endowment correlations are zero.

6. Conclusion

This paper quantitatively examines the role of currency risk in explaining why outsiders' lending to the EMU seems to be intermediated by the core EMU. The results of our model indicate that, in an otherwise frictionless environment, the lack of currency risk dominates the diversification motive and hence gives core EMU investors an advantage to push outside lenders out of the periphery bond market. As a consequence, outside lenders have no choice, but only the core EMU bond market to park their savings. Despite the absence of exogenous frictions and market segmentation, the core EMU does emerge as the main lender to the peripheral EMU in the equilibrium of our model.

The result has important policy implications. We show that the lack of currency risk within the EMU, combined with other factors, can route debt inflows via the core EMU. Since the core EMU's intermediation of capital inflows puts pressure on the countries' financial stability, this geographic pattern of capital flows poses challenges to the Eurozone (Hale and Obstfeld (2016)). The problem is that, unlike other home-preferential treatments that can be eliminated, the lack of currency risk within the EMU is built-in and cannot be removed.

Appendix A. Solving for portfolio choices of countries

This appendix presents the solution for the zero-order portfolio choices of the model. Define country i 's real net foreign asset position as $a_t^i \equiv b_{Pt}^i + b_{Ct}^i$, i.e. the real net foreign asset position equals country i 's real holdings of Periphery and Core bonds. The only equilibrium conditions of

the model where these bonds and net asset positions appear are the households' budget constraints. Consider the budget constraints of country C and O's households:

$$c_{Tt}^C + \frac{P_{Nt}^C}{P_{Tt}^E} c_{Nt}^C + a_t^C + m_t^C = r_t^P a_{t-1}^C + (r_t^C - r_t^P) b_{Ct-1}^C + y_{Tt}^C + w_t^C l_t^C + d_{t-1}^C + m_{t-1}^C \quad (\text{A.1})$$

$$c_{Tt}^O + \frac{P_{Nt}^O}{P_{Tt}^O} c_{Nt}^O + a_t^O + m_t^O = r_t^P a_{t-1}^O + (r_t^P - r_t^C) b_{Ct-1}^O + y_{Tt}^O + w_t^O l_t^O + d_{t-1}^O + m_{t-1}^O \quad (\text{A.2})$$

where the lowercase letters indicate the real values of variables, and recall $r_t^P \equiv y_{Tt}^P R_t^P \frac{P_{Tt-1}^E}{P_{Tt}^E}$ and $r_t^C \equiv y_{Tt}^C R_t^C \frac{P_{Tt-1}^E}{P_{Tt}^E}$. Denote the first-order components of the excess return of country C as $u_t \equiv b_{Cr}^C (\hat{r}_t^P - \hat{r}_t^C)$, where b_j^i and r represent steady state values of the bond holdings and the rate of return. $\hat{y}$ denotes log deviations from the steady state value of variable y . Since $b_{Ct-1}^O = -b_{Ct-1}^C$, we have $b_{Cr}^O (\hat{r}_t^C - \hat{r}_t^P) = -u_t$. Following the approach of Devereux and Sutherland (2010), we initially consider u_t as an exogenous state variable. From this we can solve for the first-order approximation of the model, with u_t as an *iid* state variable. The first-order accurate solution for the excess return is:

$$\hat{r}_{t+1}^P - \hat{r}_{t+1}^C = \theta_r^u u_{t+1} + \theta_r^\varepsilon \varepsilon_{t+1} \quad (\text{A.3})$$

where ε_{t+1} is the vector of the exogenous shocks. θ_j^i is the log-linearized solution coefficient for variable j with respect to the exogenous shock i . Differences in marginal utilities of country O and C's households are:

$$co_{ct}^O \hat{c}_{t+1}^O + co_{cn}^O \hat{c}_{t+1}^O + co_l^O \hat{l}_{t+1}^O - co_{ct}^C \hat{c}_{t+1}^C - co_{cn}^C \hat{c}_{t+1}^C - co_l^C \hat{l}_{t+1}^C = \theta_c^u u_{t+1} + \theta_c^\varepsilon \varepsilon_{t+1} + \theta_c^x \hat{x}_t \quad (\text{A.4})$$

where $\hat{x}_t$ is the vector of the endogenous state variables.

Substituting $u_{t+1} = b_{Pr}^C (\hat{r}_{t+1}^P - \hat{r}_{t+1}^C)$ to (A.3), one can derive:

$$\hat{r}_{t+1}^P - \hat{r}_{t+1}^C = \frac{\theta_r^\varepsilon \varepsilon_{t+1}}{1 - \theta_r^u b_{Pr}^C} \quad (\text{A.5})$$

Similarly, substitute $u_{t+1} = b_{Pr}^C (\hat{r}_{t+1}^P - \hat{r}_{t+1}^C)$ to (A.4) to get

$$co_{ct}^P \hat{c}_{t+1}^P + co_{cn}^P \hat{c}_{t+1}^P + co_l^P \hat{l}_{t+1}^P - co_{ct}^O \hat{c}_{t+1}^O - co_{cn}^O \hat{c}_{t+1}^O - co_l^O \hat{l}_{t+1}^O = \frac{\theta_c^u b_{Cr}^C \theta_r^\varepsilon \varepsilon_{t+1}}{1 - \theta_r^u b_{Pr}^C} + \theta_c^\varepsilon \varepsilon_{t+1} + \theta_c^x \hat{x}_t \quad (\text{A.6})$$

The idea is to substitute (A.5) and (A.6) into the second-order approximations of the combined bond Euler equations of the households:

$$E_t[(\hat{r}_{t+1}^P - \hat{r}_{t+1}^C)(co_{ct}^O \hat{c}_{t+1}^O + co_{cn}^O \hat{c}_{t+1}^O + co_l^O \hat{l}_{t+1}^O - co_{ct}^C \hat{c}_{t+1}^C - co_{cn}^C \hat{c}_{t+1}^C - co_l^C \hat{l}_{t+1}^C)] = 0 \quad (\text{A.7})$$

After substituting (A.5) and (A.6) to (A.7), one gets:

$$[rb_P^C(\theta_c^u\theta_r^\varepsilon - \theta_r^u\theta_c^\varepsilon) + \theta_c^\varepsilon]\Sigma\theta_r^{\varepsilon'} = 0 \quad (\text{A.8})$$

where $\Sigma = E_t\varepsilon_{t+1}\varepsilon'_{t+1}$.

Hence, the steady state Periphery bond holdings of the Core investor could be written as:

$$b_P^C = -\frac{1}{r} \frac{\theta_c^\varepsilon \Sigma \theta_r^{\varepsilon'}}{(\theta_c^u \theta_r^\varepsilon - \theta_r^u \theta_c^\varepsilon) \Sigma \theta_r^{\varepsilon'}}$$

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