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AFRICAN DEVELOPMENT BANK GROUP

Overborrowing and Balance of Payments Imbalances in a Monetary Union

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Abstract

The sources of the balance of payments imbalances in the euro area can be characterized by a combination of four phenomena: *(i)* the credit imbalances between the core and the periphery of the EMU *(ii)* the credit misallocation between the tradable and the non tradable sectors in the periphery *(iii)* the rapid increase in the output and the price of non-tradable goods in the periphery since the beginning of the EMU and *(iv)* the current account imbalances within the EMU. This paper explains all four of these stylized facts within a single model as a result of the interaction between the common monetary policy, inflation heterogeneity and a relaxation of the credit constraint in the non-tradable sector of the periphery. When non-tradable goods are used as collateral, an increase in their prices can initiate an overborrowing spiral and lead to a balance of payment imbalances. Furthermore, the model endogenizes differences in unit labor costs between the core and the periphery of the euro area.

Keywords: Dutch disease, current account imbalances, monetary policy, euro area

JEL classification: E51, E58, F32, F41

1 Introduction

A current account deficit can be harmful if increased expenditure on nontradables squeezes the tradables sector by bidding up wages and drawing resources away from industries that have more scope for productivity growth. This is specially risky inside a currency union... Lane (2012)

The most prominent feature of the Euro area crisis has been the large current account deficits and the large amount of debt accumulated by countries at the periphery. These imbalances are commonly attributed to differences in competitiveness as manifested in persistent differences in the unit labor costs. This paper takes a different perspective in line with empirical evidences. It argues that in order to understand imbalances within the euro area, it is necessary to consider the lower real cost of credit for high inflation countries in a monetary union as well as the inflow of capital to the non-tradable sector this implies. These two effects, the credit channel of monetary policy and the Dutch disease syndrome, and their interaction are important to understand balance of payments imbalances within the euro area.

Within the euro area, countries that witnessed low real interest rates experienced the highest growth rates in credit. In return, the countries that have experienced the highest growth rates of credit showed the highest current account deficit. Therefore, the credit channel is likely to play an important role in explaining imbalances within the EMU. To explain the link between credit growth and the current account imbalances, this paper uses the theory of the Dutch disease. The reason for the increase in the real exchange rate in the periphery which causes a deterioration of their current account is the feedback loop between the borrowing limit and the consumption of non-tradable goods. This feedback loop occurs when non-tradable goods can be used as collateral because credit markets are imperfect.

When non-tradable goods can be used as collateral, lower real interest rates induce four effects. A *nominal debt effect*: higher inflation in the periphery relative to the center decreases the burden of debt if credit contracts are written in nominal terms. This induces a transfer of wealth from lenders to borrowers. A *wealth effect*: a fall in real interest rates induced by higher inflation increases the borrowing limit.

A *valuation effect*: as the non-tradable goods are used as collateral, the demand for non-tradable goods increases and therefore their prices as well. The increase in the price of non-

tradable goods allows borrowers to refinance their loans and therefore borrow more. *A monetary effect*: under the assumption that prices are sticky in the short run, monetary policy has real effects. Given that real interest rates are lower in the periphery than in the center, monetary policy will always have a more expansive effect in the former than in the latter. The real impact will therefore be stronger in the peripheral countries. All these effects work in the same direction: they generate a current account deficit in the periphery.

The effect of credit market imperfections and foreign borrowing by the non-tradable sector has been explored mainly for middle income countries. Tornell and Westermann (2004) for example analyze the effect of shocks on credit market conditions to the economy. The non-tradable sector in less developed countries is much more dependent on local banks. This leads to a differential effect of shocks to the credit market between countries at different levels of development. Tornell and Westermann (2005) complement this by showing how the liberalization of the credit market can lead to a credit boom in the non-tradable sector and a credit crunch.

Giavazzi and Spaventa (2011) analyze why the current account deficits and accumulating debt in the periphery were not a sign of a healthy convergence effect but rather an unsustainable credit boom. The authors point out that current account imbalances are irrelevant in a monetary union only when credit is used in a way that respects the intertemporal solvency constraint. This constraint is violated when the credit is used to produce non-tradable goods, because these cannot be used to pay back debt.

This allowed peripheral countries to borrow more and consume more of both types of goods. However, it also meant that the credit was not used in the sector in which it was offered the most productive use. For this reason the accumulated debt was unsustainable in the sense that the accumulated assets (non-tradable goods) could not easily be liquefied for repayment. Our model can explain the boom in credit which started in the periphery with the beginning of the EMU as a kind of bubble. The fact that the ECB's monetary policy is always more expansive in the periphery than in the center induced a rise in prices of non-tradable goods which is more pronounced in the periphery. The increased value of non-tradable goods could be used as collateral and thus loosened the credit constraint on these countries. As a consequence even more money flowed in and further increased non-tradable good prices. A positive feedback loop was thus created and considerably loosened the credit constraint for the periphery, thus detaching the amount of credit from corresponding changes in creditworthiness.

A number of recent papers have studied the sources of internal imbalances in the euro area. As noted by Chen, Milesi-Ferretti, and Tressel (2013), two traditional explanations have been put forward to explain internal imbalances in the euro area. The first one is based on the effects of financial integration following the adoption of the euro. The second is based on divergences in unit labor costs and market rigidities in the periphery.

The first hypothesis highlights that the cuts in the currency risk premium (Figure 6) should have led to real convergence between members of the monetary union. Free movement of capital induced by a low risk premium should have resulted in more productive investment. In principle, this mechanism conduces to a catch-up period for lagging countries. If the investments are used productively and level the playing field for the different economies, differences in current accounts are not worrying and must be transitional. This is, among others, the main idea developed by Blanchard and Giavazzi (2002) and Schmitz and von Hagen (2009). According to this view, *financial linkages* played a key role as a source of imbalances. The main mechanism of this approach is integrated in the theoretical model.

The second hypothesis is based on differences in unit labor costs. It highlights that the periphery experiences a rapid growth in wages while retaining low productivity. Since there is downward rigity in the nominal wages, this induced higher unit labor costs (Figure 7) and a loss in competitiveness. According to this view, *labor market frictions* inside the monetary union played a key role as a source of internal imbalances in the euro area. This is, among others, empirically shown by Biroli, Mourre, and Turrini (2010), Berger and Nitsch (2010) and theoretically (and beyond the euro area) by Ju and Wei (2007). We integrate this approach and explain the differences in unit labor costs endogenously.

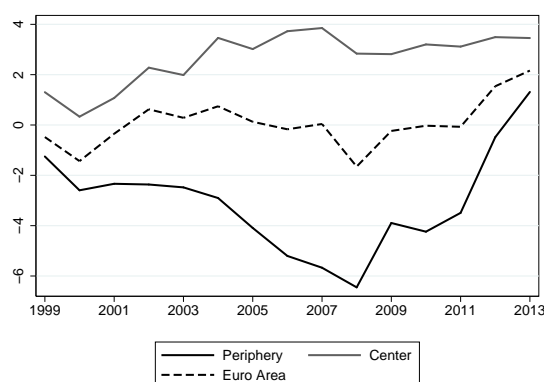
As already noted, this paper focuses on *monetary linkages* and shows how they can produce internal imbalances in the euro area when they are combined with the Dutch disease theory.

The remainder of the paper is organized as follows. Section 2 proposes new stylized facts to understand the sources of the internal imbalances in the euro area. Section 3 builds the two-country and two-sectors model which helps to understand the stylized facts. Section 4 estimates (and calibrates) the model and shows how the theoretical model can replicate the stylized facts. Section 5 concludes the paper.

2 Stylized Facts: Current Account Imbalances in the Euro-Area

Until the financial crisis began in 2007, the debate on current account imbalances has held the upper hand in the field of international macroeconomics. It focused mainly on the imbalances between Emerging Asia, oil producing countries and the United States¹. The euro area has been absent from this debate. The explanation is simple: from an aggregate viewpoint, until the european economic crisis starts in 2010, the current account of the euro area² was overall balanced. However, within the euro area, there were and are very large current account imbalances between the periphery and the center (Figure 1)³.

Figure 1: Illustration of Internal Imbalances within the Euro Area



Notes: The figure charts the current account imbalances (CA/GDP) within the EMU. "Center" refers to the core countries, *i.e.* Belgium, Germany, France, Netherlands, Austria and Finland while "periphery" refers to the peripheral countries, *i.e.* Ireland, Spain, Italy, Portugal and Greece. Current account deficits/surplus in each region are calculated by weighting each current account by national GDP.

Sources: World Economic Outlook (WEO, IMF).

These imbalances were accompanied by large movements in - gross and net - capital flows. 2007 marked a peak in gross capital movements in the euro area. Their level reached 40% of GDP (Lane (2013)). This period also coincides with the highest current account deficit recorded in peripheral countries. From the crisis, the current account adjustment was smooth instead of being abrupt thanks to the cross border liquidity flows – reflected in Target 2 balances (Auer

¹See among others Obstfeld and Rogoff (2007), Ferrero, Gertler, and Svensson (2007), Caballero, Farhi, and Gourinchas (2008) and Mendoza, Quadrini, and Rios-Rull (2009) and Iliopoulos (2009)

²This study focuses on the founding euro area members, *i.e.* the Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal and Spain which adopted the euro in 1999 and Greece which joined in 2001. Luxembourg is intentionally excluded because as highlighted by Blanchard and Giavazzi (2002): "Luxembourg is highly idiosyncratic; in particular, Luxembourg reports consistent current account surpluses of the order of 30% of GDP". Cyprus, Estonia, Malta, Slovakia and Slovenia which joined the euro area in 2007 or later are also excluded due to the lack of data.

³All the data that are used in this paper are presented in Table 1.

(2014), Lane (2013) and Sinn and Wollmershauser (2012)) – between the central banks of the EMU.

From the crisis, there is a consensus that Target 2 balances drive current account balances within the euro area. However, what about the sources of current account imbalances before the crisis? As already noted, the dominating positions attribute intra-european imbalances to the differences in competitiveness and the effect of financial integration. These explanations are correct but incomplete. This paper highlights an other channel, more consistent with a monetary union. The internal imbalances are attributed to the *heterogeneity* in real credit between the core and the periphery of the euro area and to the *misallocation* of this real credit across sectors in the periphery.

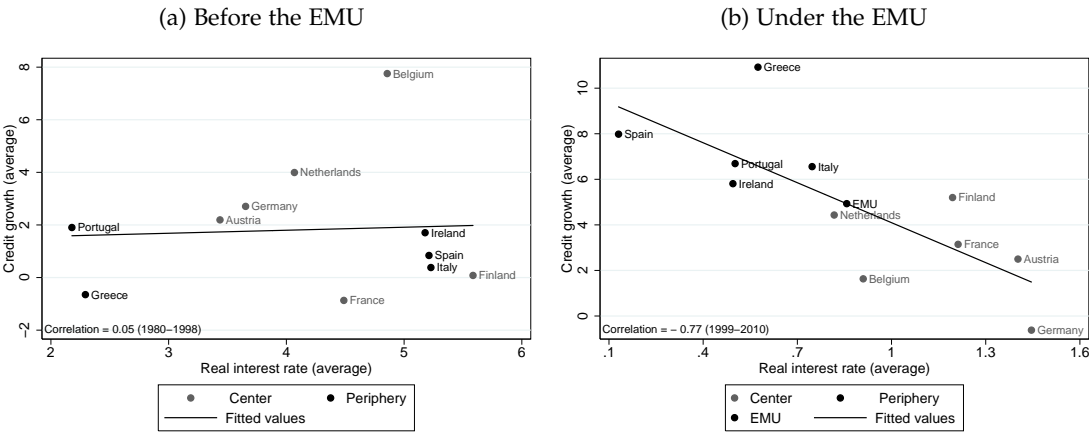
2.1 The Credit Channel in the EMU

Before the advent of the Economic and Monetary Union (EMU), each country had its own monetary policy. If the credit supply increased in a country, the central bank increased its nominal interest rates. As a consequence, real interest rates increased and with it the supply of credit. In the absence of a monetary union, there is no reason to expect a relationship between increasing rates of credit and real interest rates. This insight is confirmed in European countries before 1999. As shown by Figure 2a, there is no correlation between real interest rates defined as the difference between nominal interest rates and inflation and the growth rates of real credit.

With the advent of the EMU, the link between real interest rates and the growth rate of credit changed. The Maastricht Treaty required that EU countries would converge, have the same nominal interest rates and inflation levels. Countries were thus forced into these conditions during the decade preceding the introduction of the single currency. Indeed, there was a low level of inflation during this period. The convergence of inflation and nominal interest rates has thus generated the convergence of real interest rates, a dramatic change for some countries. By regrouping those countries that had converged in terms of the nominal requirements, the ECB could have imposed a single nominal interest rate (based on the average inflation rate) for all member countries. Instead, the common monetary policy led to diverging real interest rates. Indeed, in a monetary union, countries with inflation rates higher than the average have low real interest rates by definition. Countries with inflation rates below the average have high real interest rates. This real interest rate heterogeneity caused by the monetary policy is known as

the Walters¹ critique (Walters (1990)). This policy stimulates credit, which in turn drives up investment - productive or not - and leads to lower savings rates. Therefore economic activity is boosted and inflation rates increase in the first group of countries. In the second group of countries it reduces credit availability due to higher real interest rates².

Figure 2: Illustration of Monetary Policy and Credit Imbalances Nexus



Notes: Figure 2 charts the correlation between the (average) real interest rates and the (average) growth rate of credit before the EMU (panel a) and under the EMU (panel b). Credit is defined as the credit allocated to the private sector. The real interest rate is defined as the difference between the nominal interest rate and the inflation rate.
Sources: AMECO, WEO, WDI.

This argument is illustrated in figure 2b, which shows the negative relationship between the real interest rate and the average credit growth rate. The strong negative correlation is evident: countries with low real interest rates (periphery) have higher credit growth while countries with low real interest rates (center) experienced lower credit growth. What could be the effect of this credit growth? Figure 3 shows the correlation between credit growth and current accounts. Here too, the strong negative correlation is evident: the current account is lower (in the sense of a higher deficit) in countries with a higher rate of credit growth. The two strong and negative correlations highlighted by figures 2b and 3 illustrate what we called *monetary linkages* in the introduction and is the main message of this paper: to understand internal imbalances within the euro area, it is necessary to understand the *credit channel*, as introduced by Bernanke and Gertler (1995)³, of the common monetary policy.

¹Alan Walters was Margaret Thatcher’s economic advisor. He speculated that the economic and monetary union could be unstable due to the fact that divergent rates of inflation would lead to divergent real interest rates.

²The Walters’ critique that induces divergences in the EMU may be offset by the competitive channel through which higher inflation countries suffer from the rise in their unit labor costs and thus a lose in their competitiveness which tends to reduce inflationary pressure.

³In this seminal paper, Bernanke and Gertler (1995) distinguish between two views of the credit channel of monetary policy. The first one is known as the bank balance sheet or net worth channel and the second is the bank

Figures 2b and 3 show that countries in the periphery experienced a credit boom due to lower real interest rates. As a result of this credit boom they experienced current account deficits. A credit boom, however, is not *per se* enough to explain the balance of payment crisis that these countries face. Our main hypothesis is that these credit booms induced a balance of payment crisis due to their *misallocation* across sectors.

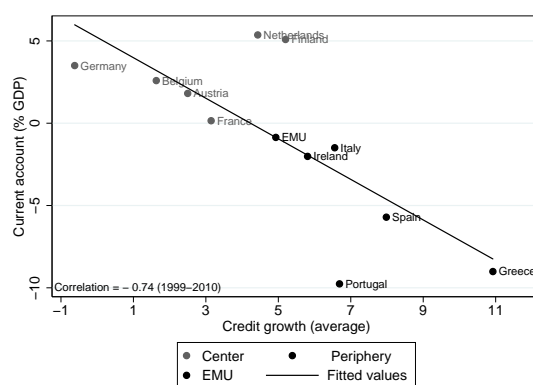
In the peripheral countries, credit booms induced by lower real interest rates were mainly used to finance the non-tradable sector, in other words: *credit booms gone wrong*¹. In this case, income generated by non-tradable goods cannot be used to pay back debt. This induced a violation of the intertemporal budget constraint of the country, *i.e.* a balance of payment crisis. When the money obtained through a credit boom is spent mainly in the non-tradable sector, it generates a *persistent* current account deficit. To explain this we rely on the concept of the Dutch disease as defined by Corden and Neary (1982)².

lending channel. The bank balance sheet channel refers to the fact that the external finance premium depends on the borrower's net worth. For example, following an expansive monetary policy, the external finance premium decreases if loans and bonds are imperfect substitutes. The bank lending channel refers to the fact that as intermediaries, banks can affect the supply of loans to firms (or households) by imposing a collateral. For example, an expansive monetary policy increases the value of the collateral and thus the ability of households to borrow. In this paper also, the authors highlight the fact that "An important goal of future research should be to give the role of consumers' balance sheets in monetary policy transmission the same attention that has been paid to the balance sheets of corporations". This is exactly what we do here.

¹The expression alludes to Schularick and Taylor (2012), "Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870-2008". The authors study the role of credit fluctuations on financial crises from an historical point of view (1870-2008) across 14 countries. In their paper, the economic crises are induced by a boom in the credit. In our paper, credit boom is not *per se* a problem. Economic crises are induced by credit misallocation across sectors.

²We rely on the modern interpretation of the Dutch disease which does not require the presence of natural resources in a country as in Corden and Neary (1982). Instead, it refers to any mechanism (capital inflows, foreign aid, foreign debt, windfall, etc.) that causes an appreciation of the real exchange rate through its impact on the price of non-tradable goods. See Yano and Nugent (1999) for more detail on the modern interpretation of the Dutch disease concept.

Figure 3: Illustration of Credit Imbalances and Internal Imbalances Nexus



Notes: Figure 3a charts the correlation between the (average) growth rate of credit and the (average) current account balance over GDP.
Sources: WEO, WDI.

2.2 The Dutch Disease in the EMU

When credit booms induced by lower real interest rates are mainly spent in the non-tradable sector, the real exchange rate appreciates through an increase in the price of non-tradable goods. The appreciation of the real exchange rate makes the domestic tradable goods more expensive with respect to the foreign tradable goods and, it leads to a current account deficit. The mechanism works as follow: when credit is mainly spent in the non-tradable sector, the available amount of non-tradable goods increases at the expense of tradable goods. Thus, it affects the allocation between tradable and non-tradable goods in the domestic economy.

This effect is more acute in a monetary union with strong trade and financial linkages like the euro area. Indeed, in a well integrated monetary union, the assumption of the law of one price is less restrictive (Cavallo, Neiman, and Rigobon (2014)) and in this case, it can be shown that the real exchange rate between the core and the periphery depends only on the ratio between their respective prices for non-tradable goods. Any difference in their prices of non-tradable goods induces a real exchange rate appreciation to the disadvantage of the country with the highest non-tradable price.

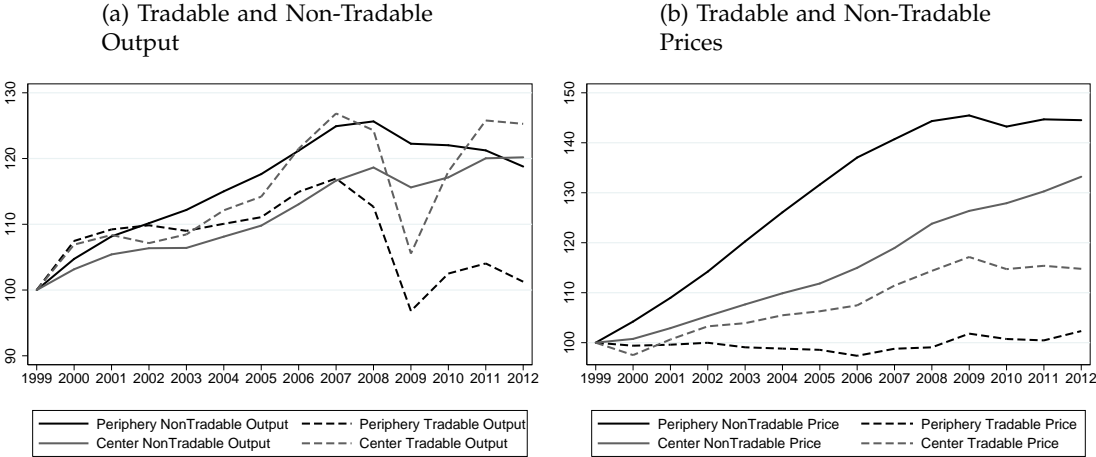
Figures 4a and 4b give a further evidence of the credit channel by highlighting the Dutch disease phenomenon in the EMU. Figure 4a shows the evolution of the output for the non-tradable and the tradable sectors in the core and in the periphery of the monetary union. Since the beginning of the EMU in 1999, the non-tradable sector has developed much stronger than the tradable sector in peripheral countries while we observe the opposit in the core countries.

We interpret this as the effect of the loosening of the credit constraint in the non-tradable sector in the periphery following the EMU.

Figure 4b shows the evolution of prices in the two sectors. The prices in the non-tradable sector in the periphery grow very rapidly, while the other three sectors record much slower inflation. Since the real exchange rate depends mainly on the ratio of prices for non-tradable between members in a monetary union, figures 4a and 4b explain the sources of current account imbalances in the euro area as illustrated in Figure 1.

Note that from the crisis, the current account adjustments occurred mainly through the adjustment of the tradable outputs due to the collapse of intra-trade in the euro area. The adjustments of the non-tradable output¹ and prices are quite small. These patterns of adjustment are in line with the evidences found by Lane (2013).

Figure 4: Illustration of Dutch Disease in the European Monetary Union



Notes: Figure 4a charts the output in the tradable and in the non-tradable sector for the "Center" and the "Periphery". Tradable sector output is the sum of gross value added of the manufacturing sector. Non-tradable sector output is the sum of gross value added of the construction and service sectors. This distinction follows Tornell and Westermann (2005). Figure 4b charts the price index of the tradable and non-tradable sector sectors.
Sources: AMECO (European Commission).

Therefore, any model treating the sources of the Euro-area imbalances, must rationalize these stylized facts. It also must rationalize why unit labor costs soared in the periphery.

¹This observation is only correct for services and not for real state as shown in figure 5. However services account for the bulk of the value added in the non-tradable sector.

3 Theoretical Framework

3.1 Overview of the Model

To reproduce the stylized facts above, a model with two countries and two sectors is built. Two sectors are introduced to account for the distinction between tradable and non-tradable goods. To account for the wealth, transfer, valuation and monetary effects, we introduce a collateral constraint for households in the peripheral countries. Figure 4 shows that both prices and production of non-tradable goods increased in the peripheral countries. From this we can conclude that the phenomenon is induced by a demand and not a supply shock. This is why the collateral constraint is imposed to households and not to firms.

To account for the credit channel of monetary policy, banks are introduced as financial intermediaries. Households in core countries consume the two types of goods and put their deposits in banks in exchange for a fee. Banks lend money to countries in the periphery by applying a markup. There is also an inter-bank market and the central bank of the monetary union affects the different interest rates by affecting the inter-bank rate. The banking sector provides a mechanism that link the interest rates between the two countries. However, it can be replaced by a financial market.

We assume that households in the core of the euro area are more patient than households in the periphery. This assumption is derived from the fact that demographics differ within euro members. While peripheral countries have a young age profile with the exception of Italy, the population in core countries is much older on average (see Figure 8). This has obvious implications for the savings behavior. Center countries have significantly higher net savings. To reflect these empirical facts within the limits of this model, we introduce different discounting rates. The concept of two different discount rates in two country model has been introduced by Buiter (1981). Technically, this hypothesis assures that the borrowing constraint is binding in the steady state. Peripheral households are leveraged through the collateral constraint. They will therefore borrow more in order to increase their consumption following a positive monetary shock.

As tradable and non-tradable goods are normal goods, the consumption of both goods increases following a positive monetary shock. The current account of the peripheral countries

is therefore in deficit for two reasons. The first is that, in a two-country model, part of the increase in demand for tradable goods must come from abroad. This induces the deterioration of the current account. The second reason is that an increase in the consumption of non-tradable goods leads to an increase in their prices. The rising price of non-tradable goods deteriorates their real exchange rate and allows peripheral households to borrow more.

The two critical assumptions of this model are differences in discount rates and the collateral constraint for borrowers¹.

To streamline notation, dependence on current time period is dropped. The framework builds on Iacoviello (2005) and Monacelli (2009).

3.2 Households in the Monetary Union

3.2.1 Households in the Center

The representative household in the center maximizes her utility given by:

$$U_t = \mathbb{E}_t \sum_{t=0}^{\infty} \beta_c u_t . \quad (1)$$

Period utility u_t is given by:

$$u_t = C_c - \Theta_c^H \frac{(L_c^H)^{1+\varphi}}{1+\varphi} - \Theta_c^N \frac{(L_c^N)^{1+\varphi}}{1+\varphi} . \quad (2)$$

β_c is the discount factor, C_c the aggregate consumption bundle, L_c^i with $i = \{H, N\}$ are labor supply in the tradable and in the non-tradable sector respectively and Θ_c^i are the utility cost of working time in the tradable and in the non-tradable sectors respectively. The utility cost allows introducing differentiated types of labor in order to allow industry specific output to co-move positively following a monetary policy shock². Other authors who make this kind of labor market segmentation include Hristov, Hulsewig, and Wollmershauser (2010) and Calza,

¹This model studies balance of payment imbalances in the presence of tradable and non-tradable sectors in the economy. Given the assumptions that are introduced, the stylized facts that are presented and the model's framework adopted, we focus on the buildup of the crisis rather than the crisis itself. The reader interested in balance of payment crises in a two sectors economy can see Kalantzisi (2015).

²Because, if wages are equal across sectors, the relative price movements are dampened and the resulting cross sectoral substitution effects will not lead to a negative correlation between outputs of the two sectors. In term of mechanisms, this implied that following a positive shock, wages will increase in the two sectors while preferences that are specific to each sector will dampen the increase in labor supply so the increase in the production. This is more or less equivalent to assume that the supply is fixed.

Monacelli, and Stracca (2013). This hypothesis also allows to account for the fact that in both the center and the periphery of the EMU, the increase in the unit labor costs was higher in the non-tradable sector than in the tradable sector because international competition limit the rising costs in the tradable sector. For example, according to OECD data, in the periphery, the increases in the unit labor costs in the tradable and in the non-tradable sectors were respectively equal to 18% and 47% between 1999 and 2007. If the utility costs of working time were the same, with the assumption that labor is mobile across sectors, the nominal wage will be the same thus unit labor costs could not be differentiated across sectors¹.

The aggregate consumption index is a composite of tradable and non-tradable goods:

$$C_c = \frac{(C_c^T)^{v_c} (C_c^N)^{1-v_c}}{v_c(1-v_c)} \quad (3)$$

where v_c is the share of tradable goods in the consumption basket. Due to the Cobb-Douglas function aggregator, the elasticity of substitution between these two goods is equal to one. CES functions can be introduced to allow for a non-unitary elasticity of substitution but at expense of tractability². The tradable goods consumption index (C_c^T) is a weighted sum of home (C_c^H) and foreign (C_c^F) tradable goods:

$$C_c^T = \left[(\zeta_c)^{\frac{1}{\eta}} (C_c^H)^{\frac{\eta-1}{\eta}} + (1-\zeta_c)^{\frac{1}{\eta}} (C_c^F)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}. \quad (4)$$

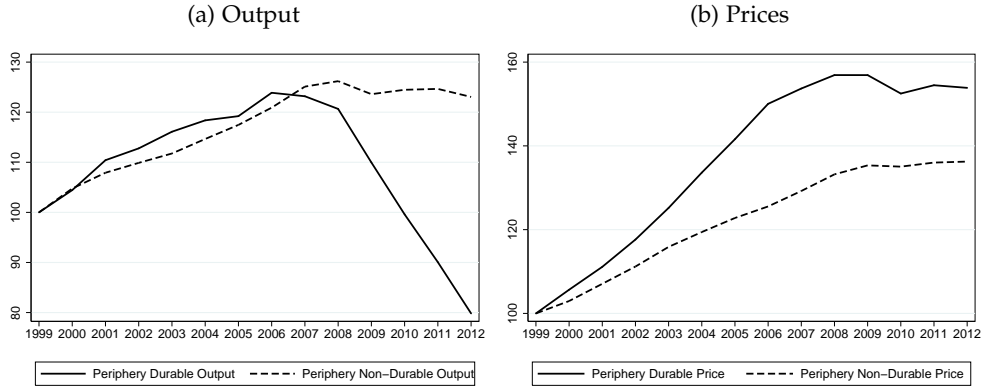
ζ_c measures the share of home tradable goods and η is the elasticity of substitution between home and foreign tradable goods.

It is assumed that the non-tradable goods can be durable as well as non-durable, because it includes construction as well as services. This hypothesis is inspired by Figure 4 which shows that the output and the price of non-tradable goods in the periphery increased dramatically. Figure 5 reveals that the movements in price and output for durable goods did not have the same pattern in the core and in the periphery of the euro area.

¹Schmillen (2013) offers in a cross-section basis, empirical evidences on labor markets heterogeneity between the tradable and the non-tradable sectors.

²Obstfeld and Rogoff (2007) argue that a unit elasticity is a good approximation.

Figure 5: Durable and Non-Durable Output and Prices in the Periphery



Notes: Figure 5 charts the output in durable and non-durable goods in the "Periphery". Durable output is the sum of the gross value added of the construction, non-durable output is the sum of gross value added in the service. Figure 4b charts the price index of durable and non-durable goods.

Sources: AMECO (European Commission).

To account for the differential development between durable and non-durable goods, non-tradable goods are further sub-divided into these two categories. Then the law of motion of non-tradable goods is:

$$I_c^N = C_c^N - (1 - \delta)C_{c,t-1}^N \quad \text{where if} \quad \begin{cases} \delta = 1 & \Rightarrow I_c^N = \text{non-durable} , \\ 0 < \delta < 1 & \Rightarrow I_c^N = \text{durable} . \end{cases} \quad (5)$$

δ is the depreciation rate of non-tradable goods and I_c^N the non-tradable goods purchased at time t . When $\delta = 1$ we have the usual definition of non-tradable goods while $0 < \delta < 1$ introduces a durability in non-tradable goods. The household budget constraint is:

$$P_c^T C_c^T + P_c^N \left[C_c^N - (1 - \delta)C_{c,t-1}^N \right] + B_c = R_{c,t-1} B_{c,t-1} + W_c^H L_c^H + W_c^N L_c^N + \Gamma_c^{\text{nominal}} \quad (6)$$

Where B_c represents deposit, R_c denotes the deposit rate, W_c^H and W_c^N denote respectively the nominal wages in the tradable and in the non-tradable sectors. $\Gamma_c^{\text{nominal}}$ represents nominal profits stemming from firms. We define the tradable good price, P_c^T , as the *numéraire* and use it to deflate the above constraint. This gives the following constraint in real terms:

$$C_c^T + p_c^N \left[C_c^N - (1 - \delta)C_{c,t-1}^N \right] + b_c = \frac{R_{c,t-1} b_{c,t-1}}{\pi_c^T} + w_c^H L_c^T + w_c^N L_c^N + \Gamma_c^{\text{real}} \quad (7)$$

where $p_c^N = P_c^N / P_c^T$ is the relative price of non-tradable goods. w_c^H and w_c^N represent respec-

tively the real wages, b_c represents the real deposit, and π_c^T represents inflation rate in the tradable sector. Households maximize utility (equation (1)) under the budget constraint (equation (7)). Some of the first-order conditions are:

$$U'(C_c^T) = \beta_c \mathbb{E}_t \left[\frac{R_c}{\pi_{c,t+1}^T} U'_{t+1}(C_c^T) \right] \quad (8)$$

$$p_c^N U'(C_c^T) = U'(C_c^N) + \beta_c (1 - \delta) \mathbb{E}_t \left[p_{c,t+1}^N U'_{t+1}(C_c^T) \right] \quad (9)$$

$U'(X)$ represents the derivatives of the utility function with respect to variable X . Equations (43) and (44) are the standard trade-off between labor and leisure: the marginal rate of substitution between consumption and leisure is equal to the real wage. Equation (8) is the usual consumption Euler equation. Equation (9) is the trade-off between tradable and non-tradable consumption: the marginal utility of tradable consumption (LHS) is equal to the shadow value of non-tradable consumption (RHS). When δ is equal to 1, as it is expected, the ratio of the two marginal utilities is equal to p_c^N , the relative price of non-tradable goods. For $0 < \delta < 1$, the trade-off between tradable and non-tradable consumption shows that non-tradable goods partially take the role of assets: the current price of non-tradable goods depends on its future expected price. This observation will play an important role in the mechanism of the model.

3.2.2 Households in the Periphery

The household in the periphery maximizes utility given by:

$$U_t = \mathbb{E}_t \sum_{t=0}^{\infty} \beta_p u_t . \quad (10)$$

Period utility u_t is given by:

$$u_t = C_p - \Theta_p^H \frac{(L_p^H)^{1+\varphi}}{1+\varphi} - \Theta_p^N \frac{(L_p^N)^{1+\varphi}}{1+\varphi} . \quad (11)$$

Total consumption splits between the consumption of tradable and non-tradable goods:

$$C_p = \frac{(C_p^T)^{v_p} (C_p^N)^{1-v_p}}{v_p(1-v_p)} . \quad (12)$$

The tradable consumption index results from a weighted sum between home (C_p^H) and foreign (C_p^F) tradable goods:

$$C_p^T = \left[(\zeta_p)^{\frac{1}{\eta}} \left(C_p^H \right)^{\frac{\eta-1}{\eta}} + (1 - \zeta_p)^{\frac{1}{\eta}} \left(C_p^F \right)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}. \quad (13)$$

ζ_p measures the degree of home bias in domestic tradable goods. As in the center, non-tradable goods can depreciate at the same rate δ . In the periphery, non-tradable goods provide utility services and are used as collateral to obtain loans. In the center they provide only utility services. Since non-tradable goods can be used as collateral, their consumption is more sensitive to movements in real interest rates compared to tradable consumption.

The budget constraint in nominal terms is:

$$P_p^T C_p^T + P_p^N \left[C_p^N - (1 - \delta) C_{p,t-1}^N \right] + B_p = R_{p,t-1} B_{p,t-1} + W_p^H L_p^H + W_p^N L_p^N + \Gamma_p^{nominal}. \quad (14)$$

where B_p represents the amount borrowed and R_p represents the rate charged. W_p^H and W_p^N are respectively the nominal wages in the tradable and in the non-tradable sectors. $\Gamma_p^{nominal}$ are profits stemming from firms.

Normalizing the household budget constraint by P_p^T yields:

$$C_p^T + p_p^N \left[C_p^N - (1 - \delta) C_{p,t-1}^N \right] + b_p = \frac{R_{p,t-1} b_{p,t-1}}{\pi_p^T} + w_p^H L_p^H + w_p^N L_p^N + \Gamma_p^{real} \quad (15)$$

where p_p^N is the relative price of non-tradable goods. w_p^H and w_p^N denote respectively real wages. b_p represents real debt and Γ_p^{real} real profit. π_p^T represents the inflation in the tradable sector.

Households in the periphery are collateral constrained in order to prevent indefinite accumulation of debt. To borrow from financial intermediaries, they use the stock of durable goods as collateral. This collateral constraint is in nominal terms:

$$R_p B_p \leq (1 - \delta)(1 - \chi) C_p^N \mathbb{E}_t \left[P_{p,t+1}^N \right]. \quad (16)$$

χ represents the fraction of the non-tradable goods that cannot be used as a collateral. The net (expected) future value of the durable stock (RHS) pledged as a collateral must be greater than the amount that will be repaid (LHS). When deflated by the price of tradable goods, it can be

written in real terms:

$$R_p b_p \leq (1 - \delta)(1 - \chi) C_p^N \mathbb{E}_t \left[p_{p,t+1}^N \pi_{p,t+1}^T \right]. \quad (17)$$

Any new borrowing depends on the expected value of the relative price of non-tradable goods, on the expected inflation rate in the tradable sector and on the interest rate used to discount the value of the credit. Furthermore, it depends on the rate at which non-tradable goods depreciate, the stock of non-tradable goods and to the loan-to-value ratio $(1 - \chi)$.

This theoretical assumption has an empirical foundation. Home purchases involve borrowing from banks in many countries. As shown by the IMF (2011), the average mortgage loan carries a loan-to-value ratio of 71% in industrial countries and to 80% in our five peripheral countries according to the ECB (2009). Real estate is thus mainly what we have in mind when modeling non-tradable goods as collateral. This induces an opportunity to build up a highly leveraged position. It also induces an accelerator mechanism where borrowing capacity is amplified by monetary policy shocks that in turn influence house prices. Chen, Milesi-Ferretti, and Tressel (2013) document that the worsening external position of peripheral countries is to a significant extent associated with a worsening in the financial balance sheet of households which in turn is mostly explained by an increase in purchases of housing. For evidences on a positive link between house prices and credit see Ramcharan and Crowe (2013).

In section 3.2.1 it was supposed that households of the core countries are not subject to a borrowing constraint. Since they are more patient than households in the periphery, they are net savers in the steady state, so that the borrowing constraint is irrelevant because it never binds.

The representative household in the periphery maximizes utility as given in equation (10) under the budget constraint (15) and the collateral constraint (17). Some of the first-order conditions are:

Equations (45) and (46) are the same as in the previous household maximization problem. The consumption Euler equation however is different here:

$$\psi = \frac{1}{R_p} - \beta_p \mathbb{E}_t \left[\frac{1}{\pi_{p,t+1}^T} \frac{U'_{t+1}(C_p^T)}{U'(C_p^T)} \right]. \quad (18)$$

It comprises the additional term ψ , the marginal value of relaxing the collateral constraint. When $\psi = 0$, we have the usual Euler equation. The trade-off between consumption today and consumption in the future $\left(U'_{t+1}(C_p^T) / U'(C_p^T) \right)$ is set by the real interest rate $\left(R_p / \pi_{p,t+1}^T \right)$. When

$\psi \neq 0$, the shadow value of the borrowing constraint creates a wedge between the marginal utility of current consumption ($U'(C_p^T)$) and the marginal utility of shifting consumption intertemporally ($\beta_p \mathbb{E}_t [U'_{t+1}(C_p^T) R_p / \pi_{p,t+1}^T]$). For example, an expansive monetary policy induces a decrease in the shadow value of the borrowing constraint, an increase in credit and thus an increase in current consumption.

The trade-off between tradable and non-tradable consumption is given by:

$$p_p^N U'(C_p^T) = U'(C_p^N) + \beta_p (1 - \delta) \mathbb{E}_t [p_{p,t+1}^N U'_{t+1}(C_p^T)] + \psi (1 - \chi) (1 - \delta) p_p^N U'(C_p^T) \mathbb{E}_t [\pi_{p,t+1}^T] \quad (19)$$

Compared to equation (9), non-tradable goods still partially take a role of asset but there is an additional term which depends on the Lagrange multiplier of the collateral constraint, ψ . The next part will analyze the role of ψ in detail.

How Does Monetary Policy affect the Current Account through the Borrowing Constraint?

Monetary policy affects the current account through its effect on the shadow value of the borrowing constraint. Without durable goods, the current account is the difference between output and its permanent level. This is the base model of the intertemporal approach of the current account. First presented by Sachs (1982), it simply says that the country runs a current account deficit when output is below its permanent level through foreign borrowing. In this model, this occurs for example when there is a temporary reduction in the terms-of-trade or a temporary reduction in domestic productivity. Without durable goods ($\delta = 1$), only the mechanism described by Sachs (1982) affects the current account. Under the assumption that prices are sticky, monetary policy affects real variables through the standard mechanisms of the neo-Keynesian model.¹

When we make the distinction between durable and non-durable goods, as it has been presented by Obstfeld and Rogoff (1996), monetary policy affects the current account through its effect on the accumulation of durable goods *via* the user cost. The consumption of durable goods provides a utility that lasts several periods. This makes a monetary shock more persistent and the current account becomes more volatile. Since durable goods partially take the role of assets

¹See Sheffrin and Woo (1990) for a test and Ferrero, Gertler, and Svensson (2007) for an application of this kind of model. However, this framework is not able to explain the boom in credit or the sharp rise in the price of non-tradable goods.

(see equation (9)), it becomes possible to explain a moderate increase in the price of non-tradable goods but not the boom in credit. In this framework, we can only explain a moderate current account deficit.¹

When durable goods can be used as collateral, monetary policy affects the current account through its effect on the shadow value of the borrowing constraint. For example, an expansive monetary policy induces a rise in the price of non-tradable goods. This induces an appreciation of the real exchange rate and therefore a current account deficit. An increase in the price of non-tradable goods also induces a relaxation of the shadow value of the credit constraints. The reason is that the increase in the price of non-tradable goods induces higher expected inflation. Higher expected inflation induces a decrease in the shadow value of borrowing constraint because real interest rates are lower. The relaxation of credit constraints allows agents to borrow more.

By borrowing more, they consume more of both goods. Since we are in an open economy, part of the increase in demand for tradable goods must come from abroad. This induces a further deterioration of the current account. By increasing the consumption of non-durable goods, their prices rise. This induces a further reduction in the shadow value of the borrowing constraint and thus a new increase in credit. This self-reinforcing mechanism can induce an overborrowing spiral and a balance of payments imbalances.

3.3 Production

There is a continuum of monopolistically competitive firms in both sectors and in both regions. Firms in each sector are indexed by $i = \{H, N\}$. Since the production technology is the same across countries, the regions are not indexed and we present the firm maximization problem in general terms. In each country, firms are owned by households.

3.3.1 Final Good Producers

In each sector the final good is produced using a continuum of intermediate goods of mass 1 through the following technology:

$$\int_0^1 \mathcal{G}(Y_i(j)/Y_i) dj = 1 \quad (20)$$

¹See Mansoorian and Mohsin (2008) for an application of this kind of model and Iscan (2002) for a test.

where \mathcal{G} is increasing, strictly concave and $\mathcal{G}(1) = 1$. $Y_i(j)$ represents the input used to produce good j in sector i . This constant return technology stems from Kimball (1995). It is a generalization of the well known aggregator of Dixit and Stiglitz (1977) popularized by Blanchard and Kiyotaki (1987). In each sector, the final good sector is perfectly competitive.

When modeling a New Keynesian model under an open economy, the Kimball (1995) aggregator is more suitable. Under the standard New Keynesian framework, *i.e.* with the aggregator of Dixit and Stiglitz (1977), there is no role of the degree of the openness of the economy as a source of real rigidity. The Kimball (1995) aggregator allows to introduce real rigidities (*kinked demand*) by altering the dependence of price to marginal cost. In the formulation of Kimball, the elasticity of substitution between goods is endogenous and is not constant (depends inversely on the relative market share).

The representative producer maximizes profits subject to the production function, equation (20):

$$\Pi_i = \max_{Y_i(j), Y_i} P_t Y_i - \int_0^1 P_i(j) Y_i(j) dj . \quad (21)$$

P_t and $P_i(j)$ are the prices of the final and the intermediate good j , respectively. This maximization problem yields the following demand function:

$$Y_i(j) = Y_i \mathcal{G}'^{-1} \left(\frac{P_i(j)}{Y_i \lambda} \right) , \quad (22)$$

where λ is the Lagrange multiplier associated with the technology constraint (20). Since the final good market is perfectly competitive, the zero profit condition implies the following aggregate price:

$$P_t = \frac{\int_0^1 P_i(j) Y_i(j) dj}{Y_i} . \quad (23)$$

3.3.2 Intermediate Good Producers

There is a continuum of intermediate goods producers. In each sector $i = \{H, N\}$, each producer uses labor as the only input. The production function is represented by the following technology:

$$Y_i^N(j) = A_i L_i(j) . \quad (24)$$

Productivity in each sector and in each country, is modeled as a first auto-regressive and stationary process:

$$A_i = (A_{i,t-1})^{\rho_{A_i}} \exp(\epsilon^{A_i}) \quad (25)$$

where ϵ^{A_i} is the productivity shock and ρ_{A_i} the auto-correlation of the productivity process in each sector.

Producers choose the price that maximizes their discounted real profit. We assume that prices are sticky in order to illustrate the nexus between the monetary policy and current account imbalances. Following Calvo (1983), in each period, there is a probability ρ that firms keep prices unchanged. The optimal price setting of firms is a static indexing rule *i.e.* they apply the following price updating:

$$P_i(j) = \bar{\pi}_i P_{i,t-1}(j) , \quad (26)$$

where $\bar{\pi}_i$ represents the inflation rate in the steady state in each sector.

With probability $(1 - \rho)$, firms receive a signal that they can choose the price P^* that maximizes their profits:

$$\mathbb{E}_t \sum_{t=0}^{\infty} \beta_i \rho^j [P^* Y_{t+j}(k) - \Psi_{t+j}(k)] . \quad (27)$$

$Y_{t+j}(k) = A_i L_{i,t+j}$ is output and $\Psi_{t+j} = W_i L_{t+j}$ is total cost.

To continue the maximization program, we need to give an explicit formulation of \mathcal{G} . For this, we follow Dotsey and King (2005) and Levin, Lopez-Salido, and Yun (2007):

$$\mathcal{G}(Y_i(j)/Y_i) = \frac{\omega}{1 + \vartheta} [(1 + \vartheta)(Y_i(j)/Y_i) - \vartheta]^{1/\omega} - \left[\frac{\omega}{1 + \vartheta} - 1 \right] , \quad (28)$$

where $\omega = \frac{\epsilon(1+\vartheta)}{\epsilon(1+\vartheta)-1}$ and ϵ represents the elasticity among varieties. ϑ determines the degree of curvature of the demand curve. If $\vartheta = 0$ then $\omega = \frac{\epsilon}{\epsilon-1}$ and we get the usual Dixit and Stiglitz (1977) constant elasticity of substitution. ω represents the markup. It can be shown that the first order condition leads to the following optimal price as in Adjemian and Juillard (2011):

$$\mathbb{E}_t \sum_{k=0}^{\infty} \rho^k \beta_i^k \bar{\pi}^k \frac{\lambda_{i,t+k}}{\lambda_i} \Pi'_{t+k} (\bar{\pi}^k P^*) = 0 . \quad (29)$$

Π' represents the derivative of profits with respect to the optimal price. The first-order

conditions are a little bit technical¹.

The evolution of the aggregate price index in each sector is such that:

$$P = \left[(1 - \rho) (P^*)^{\frac{1}{1-\epsilon}} + \rho (\bar{\pi} P_{t-1})^{\frac{1}{1-\epsilon}} \right]^{1-\epsilon}. \quad (30)$$

where P^* is the price sets by firms that can adjust their prices.

3.4 Closing the Model

3.4.1 Unit Labor Costs

Let $\omega = Y^T/Y$ the size of the tradable sector in the economy. Then the total unit labor costs (ULC) in the economy can be written as:

$$ULC = \underbrace{\left(\frac{W^H L^T}{Y^T} \right)^\omega}_{\text{ULC in the Tradable sector}} \underbrace{\left(\frac{W^N L^N}{Y^N} \right)^{1-\omega}}_{\text{ULC in the Tradable sector}} \quad (31)$$

i.e. a weighted average of unit labor costs in the tradable sector and in the non-tradable sector respectively. After some basic manipulation, it can be show that the unit labor cost can be rewritten as:

$$ULC = \left(\frac{W^H}{A^H} \right) \left(\frac{W^N}{W^H} \right)^{1-\omega} \left(\frac{A^H}{A^N} \right)^{1-\omega} \quad (32)$$

Through international competition, the first term (W^H/A^H) in equation (32) can not be very different between the core and the periphery. All differences in total ULC (Figure 7) between the core and the periphery must be explained by the ratio of the two wages *i.e.* by the term (W^N/W^H) unless we make an additional assumption on the relative sectoral productivity within a country *i.e.* the term (A^H/A^N) . Such an additional assumption would give rise to the Balassa-Samuelson effect (Balassa (1964) and Samuelson (1964)).

¹And are available upon request.

3.4.2 Monetary Policy

For the monetary policy, we assume that the ECB uses a Taylor rule and targets only the average inflation rate of the monetary union:

$$\frac{R^{IB}}{\bar{R}} = \left(\frac{R_{t-1}^{IB}}{\bar{R}} \right)^{\rho_r} \left(\left(\frac{\pi^{EMU}}{\bar{\pi}} \right)^{\phi_\pi} \right)^{(1-\rho_r)} \exp(\epsilon^m) . \quad (33)$$

where ρ_r measures the degree of the interest rate smoothing as in Clarida, Gali, and Gertler (2000). With this formulation, volatility in the nominal interest rate is much lower. \bar{R} represents the interest rate in the steady state, ϕ_π denotes the degree of inflation stabilization *i.e.* measure the sensitivity of interest rate to current inflation and ϵ^m represents the monetary policy shock. The monetary union price index is:

$$P^{EMU} = (P_p)^\varrho (P_c)^{(1-\varrho)} . \quad (34)$$

Inflation of the monetary union is defined as $\pi^{EMU} = P^{EMU} / P_{t-1}^{EMU}$ thus $\bar{\pi}$ is the inflation target in the EMU. The size of the peripheral economy in the euro area is given by ϱ .

3.4.3 Market Clearing

Market clearing in the tradable sector implies:

$$Y_p^H = C_p^H + C_c^F \quad (35)$$

$$= \zeta_p \left(\zeta_p + (1 - \zeta_p)(T_p)^{1-\eta} \right)^{\frac{\eta}{1-\eta}} C_p^T + (1 - \zeta_c) \left(\zeta_c (T_c)^{-(1-\eta)} + (1 - \zeta_c) \right)^{\frac{\eta}{1-\eta}} C_c^T \quad (36)$$

where T_p and T_c are the terms-of-trade in the the periphery and in the center respectively. The same condition applies to the clearing condition in the tradable market in the center.

Market clearing in the non-tradable sectors implies:

$$Y_p^N = C_p^N - (1 - \delta)C_{p,t-1}^N , \quad (37)$$

$$Y_c^N = C_c^N - (1 - \delta)C_{c,t-1}^N . \quad (38)$$

Since labor is mobile across sectors and not across countries, labor markets clear when:

$$L_p = L_p^H + L_p^N, \quad (39)$$

$$L_c = L_c^H + L_c^N. \quad (40)$$

The world market resources constraint is satisfied when:

$$C_p^T + C_c^T = \left(\frac{P_p^H}{P_p^T} \right) Y_p^H + \left(\frac{P_c^H}{P_c^T} \right) Y_c^H. \quad (41)$$

4 Calibration and Estimation of the Model

4.1 Estimation of the Model

4.1.1 Estimation Methodology

This section addresses the dynamic properties of the model following a monetary policy innovation. The model equations are linearized around the non-stochastic steady state (see appendix 6.1.2). This approximation is accurate for small exogenous shocks that are bounded within a neighborhood of this steady state.

Bayesian methods are used to estimate the key parameters related to the monetary policy transmission. To do this, we use the following observables: the nominal interest rate set by the ECB and the average inflation in the euro area. We use quarterly data ranging from 1999q1 to 2010q4. This sample is quite short for the use of Bayesian techniques. However, we can not go back before 1999 due to institutional constraints. We choose to restrict the number of estimated parameters and to focus on parameters related to monetary policy shocks. This restriction makes the optimization algorithm more stable. Since two observables are used in the estimation procedure, we need to introduce at least two shocks in the model to avoid the occurrence of a singularity. In addition to the monetary shock, we introduce productivity shocks in each sector. This induces a total five shocks in the model. All these shocks are stationary $AR(1)$ processes.

Let \mathcal{S}_Z be the sample of our observables with length Z and Ω be the set of parameters of interest. Bayesian estimation is based on the construction of the posterior distribution $\mathcal{P}(\Omega|\mathcal{S}_Z)$

of the DSGE parameters. The posterior distribution is such that:

$$\mathcal{P}(\Omega|\mathcal{S}_Z) \propto \mathcal{L}(\mathcal{S}_Z|\Omega)\mathcal{P}(\Omega) \quad (42)$$

where $\mathcal{L}(\mathcal{S}_Z|\Omega)$ denotes the DSGE model likelihood and $\mathcal{P}(\Omega)$ denotes the priors of the DSGE model parameters.

We use the Metropolis-Hasting algorithm to update Ω and the likelihood of our linearized model, computed *via* its state-space representation, is evaluated by using the Kalman filter.

4.1.2 Prior and Posterior Distributions

We assume a beta distribution for the interest rate persistence parameter (ρ_r) because it must be bounded between zero and one, and a gamma distribution for the inflation stabilization parameter, (ϕ_π) in order to keep it in positive values. These two parameters are crucial to identify the real effects of monetary policy shocks.

We assume an inverse gamma distribution for the standard deviations of the shocks in order to assure that the support of these shocks is in an open interval that excludes zero and is unbounded. Since we make no assumption on the relative sectoral productivity within a country (see equation (32)), all productivity processes have the same mean of 0.01. As mentioned, productivity processes are introduced for technical reasons: to avoid the occurrence of a singularity. They do not play a role in the mechanism of the model since the shocks are orthogonal by construction.

The characteristics of the prior and the posterior distributions are reported in table 2. The value of the prior distributions closely follows Smets and Wouters (2003). The estimation delivers plausible parameters for the long-run reaction function of the monetary authorities. According to the data, between 1999 to 2010, the ECB's interest rate persistence parameter ranges from 1.8 to 2.6. This induces an aggressive inflation targeting. The interest rate smoothing parameter is about 0.76. The size of the monetary shock is about 0.64.

4.2 Calibration of the Model

4.2.1 Calibrated Parameters

The remaining parameters are calibrated because the set of monetary variables that we used above does not provide sufficient information to estimate them. Only key parameters are described here. The value of all parameters can be found in table 3. The discount rate of the household in the core (saver) is set to 0.99 and the discount factor of the household in the periphery (borrower) is set to 0.97. This assures that the collateral constraint binds ($\psi = 0.02$) in the steady state. The Frisch elasticity of substitution for the labour supply, φ , is set to 1. Following Monacelli (2009), the annual depreciation rate of non-tradable goods is set to 4 percent, hence $\delta = 0.01$. χ is set to 0.25 which implies a loan-to-value ratio equal to 75 percent. This value is used by Iacoviello (2005). Following Aslam and Santoro (2008), the elasticity of substitution between loans, ζ is set to 150. We assume zero reserve requirement and set κ to zero in order to focus on the role of conventional monetary policy. When κ is strictly positive, a macro-prudential policy could be introduced into the model. We follow the literature (Monacelli (2009) and Ferrero (2012)) by assuming that the prices of non-tradable (durable) goods are more flexible than the prices of tradable (non-durable) goods. Difference in price flexibility between these two type of goods are documented by Bils and Klenow (2004). ρ^T and ρ^{NT} are set to 0.65 and 0.25 respectively. These values imply an average frequency of price adjustment of 9 months in the non-durable sector and of 4 months in the durable sector. The elasticity of substitution among varieties, ϵ is set to 6, a standard value. This implies that in each sector, markups are equal to 17% in the steady state. Following Kimball (1995) and Chari, Kehoe, and McGrattan (2000) the elasticity of demand with respect to the relative price of a good *i.e.* ϑ is set to 33 percent. The values of ϵ and ϑ imply that the degree of curvature of the firm's demand curve, *i.e.* ω is equal to 1. The share of non-tradable goods in aggregate spending, ν_c and ν_p , are such that in the steady state, households spend 80 percent of their income in tradable (non-durable) goods. This is the value in industrial countries. It implies that ν_c and ν_p are equal to 0.82 and 0.75, respectively. The steady state level of hours worked is normalized to 33 percent in each country. This implies that the marginal disutility from working, Θ_i^j with $i = \{c, p\}$ and $j = \{H, N\}$, is endogenously determined to ensure that $L_p = 0.3 = L_p^T + L_p^N$ and $L_c = 0.3 = L_c^T + L_c^N$. The remaining parameters are very standard and their values can be found in the table 3.

4.3 Empirical Results

Figure 9 shows the dynamics of the variables following an expansive monetary policy¹. The key results are the following. Households in the periphery are leveraged through the collateral constraint. This induces a credit-cycle following a positive shock as in Kiyotaki and Moore (1997), Iacoviello (2005), and Monacelli (2009). An expansive monetary policy makes the collateral constraint (equation(17)) of the borrower less tight. This induces a decrease in the shadow value of the borrowing constraint. The tightness of the collateral constraint allows households to increase debt (9e). This new borrowing has several dynamic effects.

First, since both tradable and non-tradable goods are normal goods, households increase consumption on both goods (9g and 9h), following the wealth effect² induced by the expansive monetary policy. Then, the increase in non-tradable good consumption induces an increase in their price. But since households in the periphery are leveraged, the increase in the real price of non-tradable goods is more pronounced in the periphery than in the core countries (9f).

The strong increase in the real price of non-tradable goods in the periphery induces a valuation effect since non-tradable goods can be used as collateral: following an increase in the real price, household can borrow more, thus consume more on both goods and so on. Following a common and positive monetary shock, demand is stronger in the periphery than in the center due to the valuation effect. This in turn induces a monetary effect: inflation is higher in the periphery than in the center. Inflation is higher in the tradable sector of the periphery (9a)³ but the difference in inflation rates is more pronounced in the non-tradable sectors (9b) as predicted by the stylized facts (4b).

These differences in inflation rates generate differences in real interest rates (9c) under a common shock as predicted by the stylized facts (figures 2a and 2b). These inflation differentials induce also a nominal debt effect since debt contracts are in nominal terms. This mechanism is symmetrical to the one described by Fisher (1933). Higher inflation in the periphery induces a decrease in the real debt burden. In turn, this induces an increase in consumption of both goods. In a general equilibrium framework like the model developed here, the decrease in the

¹We simulate an expansive because it was fairly accommodative for country in the periphery and mainly for Spain as shown by Jimenez, Ongena, Peydro, and Saurina (2014)

²See Skudelny (2009) for an econometric evidence of the wealth effect in the case of the euro area and Case, Quigley, and Shiller (2011) in the case of Unites States

³The law of one price holds but PPP does not. Thus tradable prices are different in the two regions.

real interest rate encourages household in the periphery to increase their current consumption of tradable goods through the Euler equation (18). But the increase in current tradable consumption is very pronounced through its effect on the shadow value of the collateral constraint comparing to household in the center for whom tradable consumption decreases.

The decrease in the tradable consumption of households in the center is induced by the decrease in the relative price of non-tradable goods in the center. The positive co-movement between these two variables is documented by Barsky, House, and Kimball (2007) and confirmed by Aslam and Santoro (2008) and Monacelli (2009). This is due to the fact that when credit markets are perfect, the shadow value of non-tradable goods ($p_c^N U'(C_c^T)$) in equation (9) is quasi-constant.

The deterioration of the current account can be seen in (9i). It can be traced back to two channels. First, following the positive monetary shock, households increase the demand for domestic and foreign tradable goods (8n). This induces *ceteris paribus* higher current account deficits. Second, the increase in the prices of non-tradable goods is higher in the periphery than in the center (8m). The reason for this is that households in the periphery are leveraged. In a monetary union, the real exchange rate depends mainly on the ratio of these two prices. The expansive monetary policy shock therefore induces an appreciation of the real exchange rate. This, in turn, further deteriorates the current account in the periphery.

Finally, we can analyze the role of unit labor costs (ULC). As explained in the introduction, the sharp rise in ULC is at the heart of the arguments offered to explain current account divergences in the Economic and Monetary Union (EMU) of the European Union. In this literature, however, it is not endogenously explained why ULC soared. This paper, in contrast, explains the rise in ULC endogenously. We explain the increase in the relative price of non-tradable goods and in ULC (both explaining the over-valuation of the real exchange rate) due only to a monetary shock when credit markets are imperfect.

As already shown above, following a monetary shock, the model endogenously generates a higher demand in the countries of the periphery than in the center. This induces an upward pressure on wages which is higher in the countries of the periphery. As shown by the ECB (2007) and Giavazzi and Spaventa (2011), the GDP growth for countries at the periphery relies almost entirely on employment growth and not on total factor productivity growth. In this case, the increases in ULC are mainly explained by the growth of nominal wages (see equation

(32)). This explain the sharp increase in the ULC of countries in the periphery (8p) relative to the increase in the ULC in the center. Figures 8q and 8r go beyond the literature and show that it is mainly the ULC in the non-tradable sector which rose sharply. The increase in the ULC in the tradable sector remained moderate and of similar magnitude in both regions due to international competition.

5 Conclusion and Policy Implications

This paper has proposed, both empirically and theoretically, a general framework in which the roots of imbalances within the euro area are identified.

The origin of current account deficits in the euro area has often been attributed to differences in unit labor costs. This paper proposed an explanation that is much more consistent with an economic and monetary union. The current account imbalances are firstly attributed to real interest rates heterogeneity and secondly, to the ability of peripheral countries to use non-tradable goods as collateral.

Our stylized facts are strongly supportive of this explanation. Our two country and two sector model helps to understand the underlying transmission mechanism. We have shown that the proposed framework is much more suited as an explanation of internal imbalances within the EMU. We were able to place the explanation based on unit labor costs in a more general context.

In terms of economic policy, this raises questions concerning the appropriate monetary policy for the EMU. Monetary authorities should have effective tools in order to avoid divergences which can arise when there is only one common nominal interest rate. The tools should in particular be capable of preventing credit imbalances between countries and within sectors. This is open for future research.

References

- Adjemian, S., and M. Juillard (2011): "Accuracy of the Extended Path Simulation Method in a New Keynesian Model with Zero Lower Bound on the Nominal Interest Rate," Cepremap, mimeo.
- Aslam, A., and E. Santoro (2008): "Bank Lending, Housing and Spreads," Discussion Papers 08-27, University of Copenhagen. Department of Economics.
- Auer, R. A. (2014): "What drives TARGET2 balances? Evidence from a panel analysis," *Economic Policy*, 29(77), 139–197.
- Balassa, B. (1964): "The Purchasing-Power Parity Doctrine: A Reappraisal," *Journal of Political Economy*, 72, 584.
- Barsky, R. B., C. L. House, and M. S. Kimball (2007): "Sticky-Price Models and Durable Goods," *American Economic Review*, 97(3), 984–998.
- Berger, H., and V. Nitsch (2010): "The Euro's Effect on Trade Imbalances," IMF Working Papers 10/226, International Monetary Fund.
- Bernanke, B. S., and M. Gertler (1995): "Inside the Black Box: The Credit Channel of Monetary Policy Transmission," *Journal of Economic Perspectives*, 9(4), 27–48.
- Bils, M., and P. J. Klenow (2004): "Some Evidence on the Importance of Sticky Prices," *Journal of Political Economy*, 112(5), 947–985.
- Biroli, P., G. Mourre, and A. A. Turrini (2010): "Adjustment in the Euro Area and Regulation of Product and Labour Markets: An Empirical Assessment," CEPR Discussion Papers 8010.
- Blanchard, O., and F. Giavazzi (2002): "Current Account Deficits in the Euro Area: The End of the Feldstein-Horioka Puzzle?," *Brookings Papers on Economic Activity*, 33(2), 147–210.
- Blanchard, O. J., and N. Kiyotaki (1987): "Monopolistic Competition and the Effects of Aggregate Demand," *American Economic Review*, 77(4), 647–66.
- Buiter, W. H. (1981): "Time Preference and International Lending and Borrowing in an Overlapping-Generations Model," *Journal of Political Economy*, 89(4), 769–97.

- Caballero, R. J., E. Farhi, and P.-O. Gourinchas (2008): "An Equilibrium Model of Global Imbalances and Low Interest Rates," *American Economic Review*, 98(1), 358–93.
- Calvo, G. A. (1983): "Staggered prices in a utility-maximizing framework," *Journal of Monetary Economics*, 12(3), 383–398.
- Calza, A., T. Monacelli, and L. Stracca (2013): "Housing Finance And Monetary Policy," *Journal of the European Economic Association*, 11, 101–122.
- Case, K. E., J. M. Quigley, and R. J. Shiller (2011): "Wealth Effects Revisited 1978-2009," Working Paper 16848, National Bureau of Economic Research.
- Cavallo, A., B. Neiman, and R. Rigobon (2014): "Currency Unions, Product Introductions, and the Real Exchange Rate," *The Quarterly Journal of Economics*, 129(2), 529–595.
- Chari, V. V., P. J. Kehoe, and E. R. McGrattan (2000): "Sticky Price Models of the Business Cycle: Can the Contract Multiplier Solve the Persistence Problem?," *Econometrica*, 68(5), 1151–1180.
- Chen, R., G. M. Milesi-Ferretti, and T. Tressel (2013): "External imbalances in the eurozone," *Economic Policy*, 28(73), 101–142.
- Clarida, R., J. Gali, and M. Gertler (2000): "Monetary Policy Rules And Macroeconomic Stability: Evidence And Some Theory," *The Quarterly Journal of Economics*, 115(1), 147–180.
- Corden, W. M., and J. P. Neary (1982): "Booming Sector and De-Industrialisation in a Small Open Economy," *Economic Journal*, 92(368), 825–48.
- Dixit, A. K., and J. E. Stiglitz (1977): "Monopolistic Competition and Optimum Product Diversity," *American Economic Review*, 67(3), 297–308.
- Dotsey, M., and R. G. King (2005): "Implications of state-dependent pricing for dynamic macroeconomic models," *Journal of Monetary Economics*, 52(1), 213–242.
- ECB (2007): "Output growth differentials in the euro area: sources and implications," in *Economic Bulletin 04*. European Central Bank.
- (2009): "Housing Wealth and Private Consumption in the Euro Area," in *Economic Bulletin 01*. European Central Bank.

- Ferrero, A. (2012): "House price booms, current account deficits, and low interest rates," Staff Reports 541, Federal Reserve Bank of New York.
- Ferrero, A., M. Gertler, and L. Svensson (2007): "Current Account Dynamics and Monetary Policy," in *International Dimensions of Monetary Policy*, NBER Chapters, pp. 199–244. National Bureau of Economic Research, Inc.
- Fisher, I. (1933): "The Debt-Deflation Theory of Great Depressions," *Econometrica*, 1(4), 337–357.
- Gerali, A., S. Neri, L. Sessa, and F. M. Signoretti (2010): "Credit and Banking in a DSGE Model of the Euro Area," *Journal of Money, Credit and Banking*, 42(s1), 107–141.
- Giavazzi, F., and L. Spaventa (2011): "Why the current account may matter in a monetary union: Lessons from the financial crisis in the euro area," in *The Euro Area and the Financial Crisis*, ISBN-13: 9781107014749. Cambridge University Press.
- Hristov, N., O. Hulsewig, and T. Wollmershauser (2010): "Financial Frictions and Inflation Differentials in a Monetary Union," CESifo Working Paper Series 3235, CESifo Group Munich.
- Iacoviello, M. (2005): "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle," *American Economic Review*, 95(3), 739–764.
- Iliopoulos, E. (2009): "External imbalances and collateral constraints in a two-country world," Universite Paris1 Pantheon-Sorbonne (Post-Print and Working Papers) halshs-00429600, HAL.
- IMF (2011): "Chapter 3: Housing Finance and Financial Stability - Back to Basic?," in *Global Financial Stability Report (GFSR): Durable Financial Stability: Getting There from Here*. International Monetary Fund.
- Iscan, T. B. (2002): "Present value tests of the current account with durables consumption," *Journal of International Money and Finance*, 21(3), 385–412.
- Jimenez, G., S. Ongena, J. Peydro, and J. Saurina (2014): "Hazardous Times for Monetary Policy: What Do Twenty-Three Million Bank Loans Say About the Effects of Monetary Policy on Credit Risk-Taking?," *Econometrica*, 82(2), 463–505.
- Ju, J., and S.-J. Wei (2007): "Current Account Adjustment: Some New Theory and Evidence," NBER Working Papers 13388, National Bureau of Economic Research, Inc.

- Kalantzi, Y. (2015): "Financial fragility in small open economies: firm balance sheets and the sectoral structure," *The Review of Economic Studies*, forthcoming.
- Kimball, M. S. (1995): "The Quantitative Analytics of the Basic Neomonetarist Model," *Journal of Money, Credit and Banking*, 27(4), 1241–77.
- Kiyotaki, N., and J. Moore (1997): "Credit Cycles," *Journal of Political Economy*, 105(2), 211–48.
- Lane, P. (2012): "The European Sovereign Debt Crisis," *Journal of Economic Perspectives*, 26(3), 49–68.
- Lane, P. R. (2013): "Capital Flows in the Euro Area," European Economy - Economic Papers 497, Directorate General Economic and Financial Affairs (DG ECFIN), European Commission.
- Levin, A., J. D. Lopez-Salido, and T. Yun (2007): "Strategic Complementarities and Optimal Monetary Policy," CEPR Discussion Papers 6423.
- Mansoorian, A., and M. Mohsin (2008): "Durable Goods, Time Preference and The Dynamics of the Current Account," *Open Economies Review*, 19(3), 337–354.
- Mendoza, E. G., V. Quadrini, and J.-V. Rios-Rull (2009): "Financial Integration, Financial Development, and Global Imbalances," *Journal of Political Economy*, 117(3), 371–416.
- Monacelli, T. (2009): "New Keynesian models, durable goods, and collateral constraints," *Journal of Monetary Economics*, 56(2), 242–254.
- Obstfeld, M., and K. Rogoff (1996): "Dynamics of Small Open Economies," in *Foundations of International Macroeconomics*. Cambridge, Massachusetts: MIT Press.
- (2007): "The Unsustainable U.S. Current Account Position Revisited," in *G7 Current Account Imbalances: Sustainability and Adjustment*, NBER Chapters, pp. 339–376. National Bureau of Economic Research, Inc.
- Ramcharan, R., and C. Crowe (2013): "The Impact of House Prices on Consumer Credit: Evidence from an Internet Bank," *Journal of Money, Credit and Banking*, 45(6), 1085–1115.
- Sachs, J. (1982): "The Current Account in the Macroeconomic Adjustment Process," *Scandinavian Journal of Economics*, 84(2), 147–59.

- Samuelson, P. A. (1964): "Theoretical Notes on Trade Problems," *The Review of Economics and Statistics*, 46(2), pp. 145–154.
- Schmillen, A. (2013): "Are wages equal across sectors of production?," *The Economics of Transition*, 21(4), 655–682.
- Schmitz, B., and J. von Hagen (2009): "Current Account Imbalances and Financial Integration in the Euro Area," CEPR Discussion Papers 7262.
- Schularick, M., and A. M. Taylor (2012): "Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870-2008," *American Economic Review*, 102(2), 1029–61.
- Sheffrin, S. M., and W. T. Woo (1990): "Present value tests of an intertemporal model of the current account," *Journal of International Economics*, 29(3-4), 237–253.
- Sinn, H.-W., and T. Wollmershauser (2012): "Target loans, current account balances and capital flows: the ECB's rescue facility," *International Tax and Public Finance*, 19(4), 468–508.
- Skudelny, F. (2009): "Euro area private consumption - Is there a role for housing wealth effects?," Working Paper Series 1057, European Central Bank.
- Smets, F., and R. Wouters (2003): "An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area," *Journal of the European Economic Association*, 1(5), 1123–1175.
- Tornell, A., and F. Westermann (2004): "The Credit Channel in Middle Income Countries," in *Financial Market Development in Latin America*. Stanford University Press.
- (2005): *Boom-Bust Cycles and Financial Liberalization*, vol. 1 of *MIT Press Books*. The MIT Press.
- Walters, A. A. (1990): *Sterling in Danger: Economic Consequences of Fixed Exchange Rates*. Fontana Press.
- Yano, M., and J. B. Nugent (1999): "Aid, Nontraded Goods, and the Transfer Paradox in Small Countries," *American Economic Review*, 89(3), 431–449.

6 Appendix for Monetary Union Imbalances

6.1 Simple Derivations

6.1.1 First Order Conditions

$$\frac{U'(L_c^H)}{U'(C_c^T)} = w_c^H \quad (43)$$

$$\frac{U'(L_c^N)}{U'(C_c^T)} = w_c^N \quad (44)$$

$$\frac{U'(L_p^H)}{U'(C_p^T)} = w_p^H \quad (45)$$

$$\frac{U'(L_p^N)}{U'(C_p^T)} = w_p^N \quad (46)$$

6.1.2 Steady State

The steady state is computed explicitly. The interest rate is determined by the household's Euler equation in the core countries (equation (8)):

$$R_c = 1/\beta_c . \quad (47)$$

The Lagrange multiplier of the collateral constraint is determined by the household's Euler equation in the periphery, equation (18), and equation (47)

$$\psi = \beta_c - \beta_p . \quad (48)$$

To determine the consumption of non-tradable goods, its relative consumption is first computed by using equations (19) and (48). This leads to the following equation:

$$\frac{C_p^T}{C_p^N} = \left(\frac{v_p}{1 - v_p} \right) p_p^N [1 - (1 - \delta)(\beta_p + (1 - \chi)(\beta_c - \beta_p))] . \quad (49)$$

We thus computed the expression of the collateral constraint (17):

$$\frac{b_p}{C_p^N} = \beta_c(1 - \delta)(1 - \chi)p_p^N \quad (50)$$

and the budget constraint (15) in the steady-state:

$$\frac{L_p}{C_p^N} = \frac{C_p^T}{C_p^N} + \delta p_p^N + (R_p - 1) \frac{b_p}{C_p^N}. \quad (51)$$

By using equations (49), (50) and (51), it can be shown that:

$$C_p^N = \frac{wL_p}{p_p^N \left[\frac{v_p}{1-v_p} [1 - (1 - \delta)(\beta_p + (1 - \delta)(1 - \chi)(\beta_c - \beta_p))] + (1 - \delta)(1 - \chi)(1 - \beta_c) \right]}. \quad (52)$$

By using (50) and (52), the unique steady state level of debt is:

$$b_p = \beta_c p_p^N (1 - \delta)(1 - \chi) C_p^N. \quad (53)$$

By using (49) and (52), the consumption of tradable goods by the household in the periphery is:

$$C_p^T = \frac{v_p}{1 - v_p} p_p^N [1 - (1 - \delta)(\beta_p + (1 - \chi)(\beta_c - \beta_p))] C_p^N. \quad (54)$$

The tradable/non-tradable consumption trade-off from equation (9) can be used to determine the relative consumption of the tradable goods by the household in the center:

$$\frac{C_c^T}{C_c^N} = \left(\frac{v_c}{1 - v_c} \right) p_c^N [1 - \beta_c(1 - \delta)]. \quad (55)$$

From the market clearing in the tradable sector (36) we have:

$$y_p^H = \mathcal{S}L_p^H = \zeta_p C_p^T + (1 - \zeta_c) C_c^T. \quad (56)$$

Labor at steady state is given by

$$L_p^N = \delta C_p^N, \quad (57)$$

$$L_p^H = L_p - \delta C_p^N. \quad (58)$$

Tradable good consumption by the households in the center is:

$$C_c^T = \frac{L_p - \delta C_p^N - \zeta_p C_p^T}{(1 - \zeta_c)}. \quad (59)$$

By using (55) and (59), the non-tradable goods consumption by the households in the center is:

$$C_c^N = \left(\left(\frac{v_c}{1 - v_c} \right) p_c^N [1 - \beta_c(1 - \delta)] \right)^{-1} C_c^T. \quad (60)$$

In the steady state we have:

$$w = w_p^H = w_p^N = w_c^H = w_c^N = \frac{\epsilon - 1}{\epsilon}. \quad (61)$$

The remaining steady state variables are easy to compute. They are available upon request. The values of the utility cost of working time (Θ_i^j) are determined by the various labor/leisure trade-offs *e.g.* equations (43), (44), (45) and (46) with $i = \{c, p\}$ and $j = \{H, N\}$:

$$\Theta_i^j = \frac{v_i w_i^j c_i^j}{(L_i^j)^\varphi c_i} \quad (62)$$

6.2 Financial Intermediaries

The banking sector builds on Aslam and Santoro (2008) and Gerali, Neri, Sessa, and Signoretti (2010). We assume that both loan and deposit contracts are done under flexible prices. The loan contracts between banks and borrowers are done with banks under monopolistic competition.

Final Banking Sector: Let $R_p(j)$ the interest rate charged by the j th bank to the j th borrower and $b_p(j)$ the amount borrowed. The borrower chooses $b_p(j)$ to minimize the following program:

$$\min_{b_p(j)} \int_0^1 R_p(j) b_p(j) dj \quad (63)$$

subject to

$$b_p = \left(\int_0^1 (b_j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}. \quad (64)$$

ς is the elasticity of substitution between loans. It determines the markup of each bank. Profit maximization leads to the following loan demand:

$$b_j = \left(\frac{R_j}{R_p} \right)^{-\varsigma} b_p, \quad (65)$$

where b_p is the aggregate demand. The average loan rate, R_p , is given by:

$$R_p = \left(\int_0^1 (R_j)^{1-\varsigma} dj \right)^{\frac{1}{1-\varsigma}} \quad (66)$$

The Inter Bank Market: The profit of the j th bank, Π_j^B can be written as:

$$\Pi_j^B = R_j b_j + R^{IB} B_j^{IB} - R_c D_j. \quad (67)$$

B_j^{IB} is interbank net lending, R^{IB} is the inter-bank rate and b_j is the volume of credit allocated by the j th bank to the representative household in the periphery at the rate R_j . D_j is the volume of deposits by the j th household in the center which is compensated by the j th bank at the rate R_c . The representative intermediate bank maximizes Π_j^B by choosing $\{b_j, D_j, B_j^{IB}\}$. The bank budget constraint is:

$$b_j + B_j^{IB} + \Phi_j = D_j, \quad (68)$$

where Φ_j is the reserve requirement at the central bank. It is defined as¹:

$$\Phi_j = \kappa D_j \quad (69)$$

where κ is the reserve requirement rate. Equation (68) thus becomes:

$$b_j + B_j^{IB} = (1 - \kappa) D_j. \quad (70)$$

It is assumed that the loan rate is perfectly flexible. Since the interbank market is not under monopolistic competition, it can be shown that in equilibrium the interbank rate is:

$$R^{IB} = \frac{R_c}{1 - \kappa}. \quad (71)$$

¹This hypothesis implicitly assumes that there is no excess reserves. In this case, reserves are held in order to meet the reserve requirement of the Central bank.

The rate charged to the borrowers is:

$$R_p = \frac{\zeta}{\zeta - 1} R_c . \quad (72)$$

6.3 Tables

Table 1: Data Sources and Definitions

Variables	Definitions	Sources
Current account (% GDP)	Current account balance, ratio to GDP	World Economic Outlook (2011)
Private credit (% GDP)	Domestic credit to private sector	World Development Indicators (2011)
Inflation	Annual % change of consumer prices	World Economic Outlook (2011)
ST nominal interest rate	3-month "European Interbank Offered Rate"	Ameco database, European Commission
Tradable Output	Aggregation of the gross value added of the manufacturing industry	Author's construction using Ameco database, European Commission
Non-Tradable Output	Aggregation of the gross value added of the construction and service industries	Author's construction using Ameco database, European Commission
Tradable Prices	Weighted average of price deflator gross value added of the manufacturing industry	Author's construction using Ameco database, European Commission
Non-Tradable Prices	Weighted average of price deflator gross value added of the construction and service industries	Author's construction using Ameco database, European Commission

Table 2: Prior and Posterior Distributions

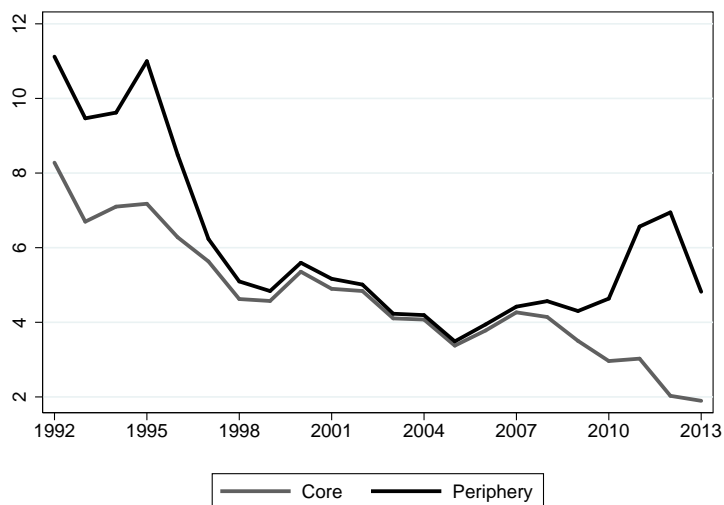
	Distribution	Prior		Posterior		
		Mean	St. Dev	Mean	Lower	Upper
ρ_r	Gamma	0.7	0.1	0.760	0.694	0.834
ϕ_π	Beta	1.5	0.25	2.152	1.791	2.647
ϵ^m	Inverse Gamma	0.5	Inf	0.638	0.459	0.815
ϵ_c^{AH}	Inverse Gamma	0.010	Inf	0.008	0.003	0.013
ϵ_c^{AN}	Inverse Gamma	0.010	Inf	0.007	0.003	0.012
ϵ_p^{AH}	Inverse Gamma	0.010	Inf	0.728	0.528	0.906
ϵ_p^{AN}	Inverse Gamma	0.010	Inf	0.015	0.003	0.032

Table 3: Parameters calibration

Description	Symbol	Value
Households		
Discount factor (Center)	β_c	0.99
Discount factor (Periphery)	β_p	0.97
Rate of depreciation of NT goods	δ	0.01
Loan-to-value ratio	χ	0.25
Inverse of elasticity of labor supply	φ	1
Preference share for NT goods (Periphery)	v_p	0.75
Preference share for NT goods (Center)	v_c	0.82
Preference share for home tradable	ζ_p	0.55
Preference share for home tradable	ζ_c	0.45
Elasticity of substitution between home and foreign T	η	2
Producers		
Elasticity of substitution between varieties	ϵ	6
Fraction of T firms that cannot adjust their prices	ρ^T	0.65
Fraction of NT firms that cannot adjust their prices	ρ^N	0.25
Degree of curvature of the firms demand curve	ω	1
Banking sector		
Elasticity of substitution between loans	ζ	150
Reserve requirement by the central bank	κ	0

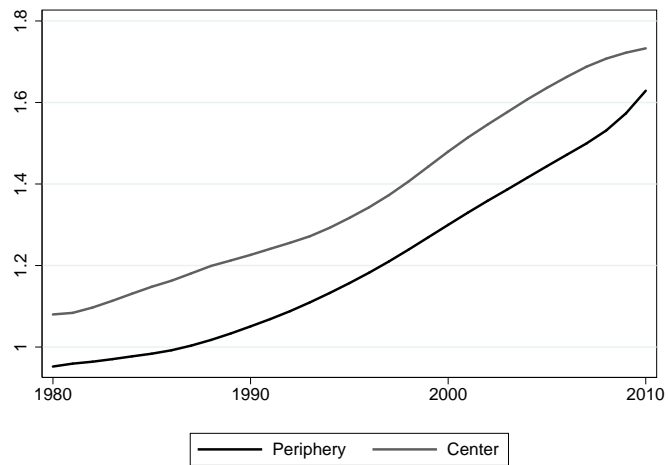
6.4 Graphical Appendix

Figure 6: 10-year government bond yields in the European Monetary Union



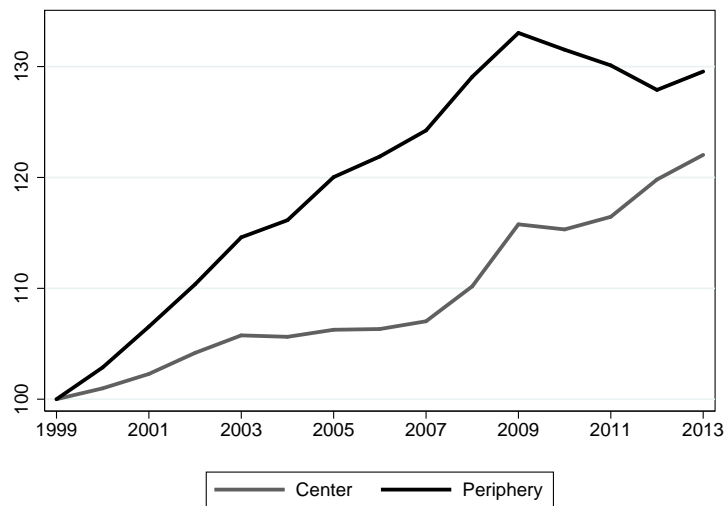
Notes: Bond yield in each region are calculated by weighting each yield by national GDP.
Sources: Datasteam and WEO.

Figure 8: Ratio of old to young



Sources: OECD.

Figure 7: Unit Labor Costs in the European Monetary Union



Sources: OECD.

Figure 9: Impulse response of selected variables to an *expansive* monetary shocks

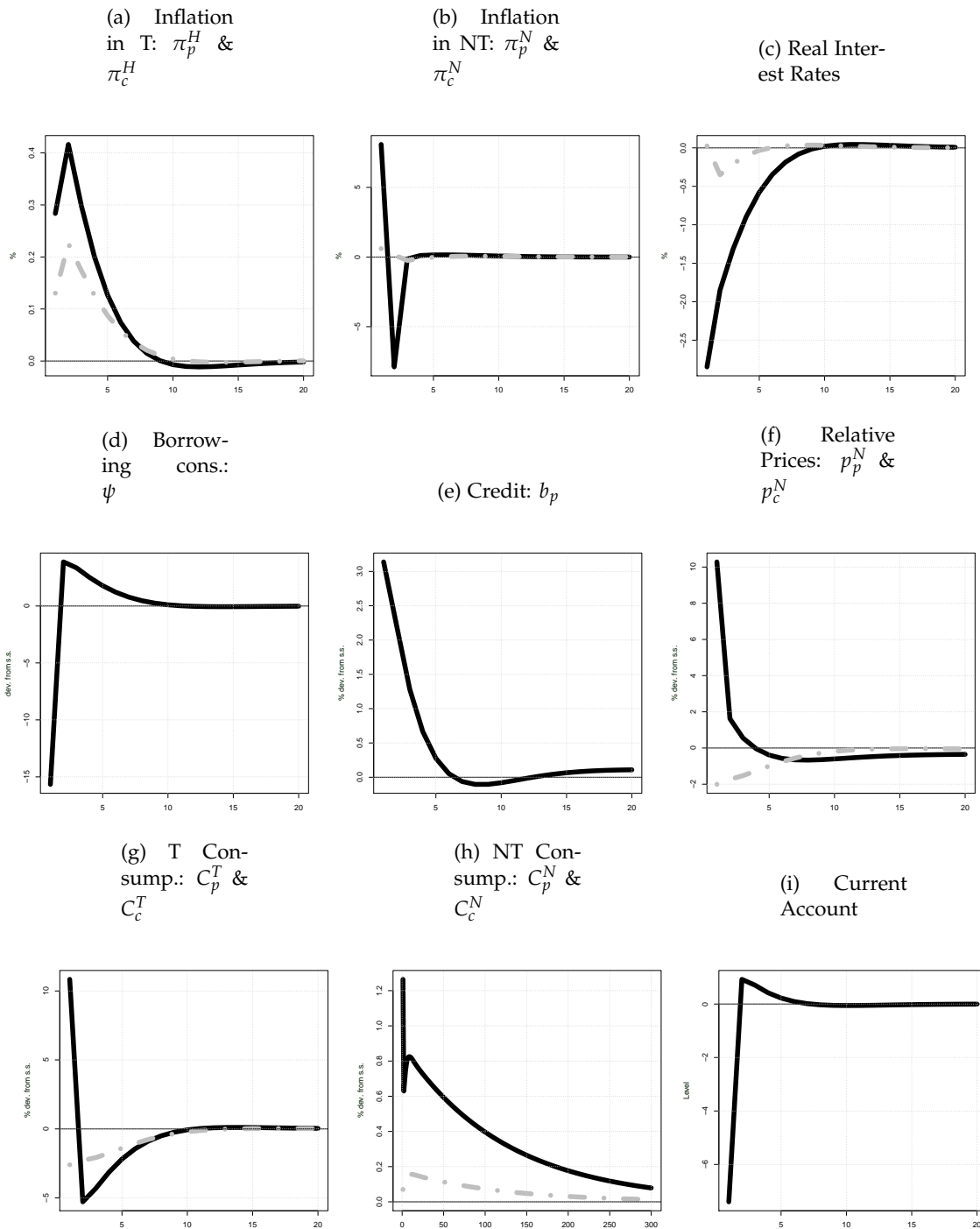
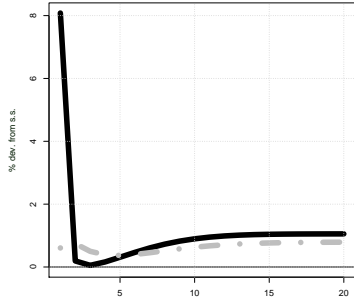
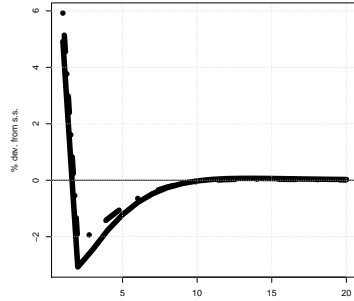


Figure 8: continued

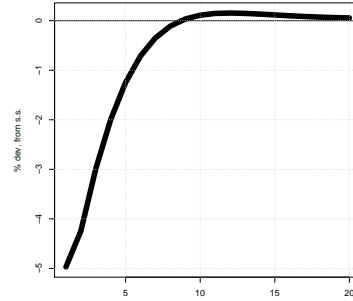
(j) RER: P_p^N & P_c^N



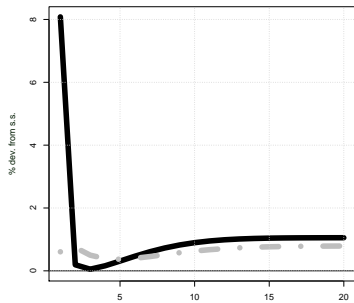
(k) T Con-
sump.: C_p^H & C_p^F



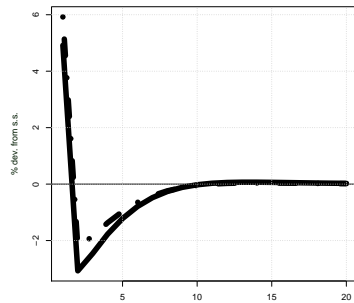
(l) Terms-of-
Trade



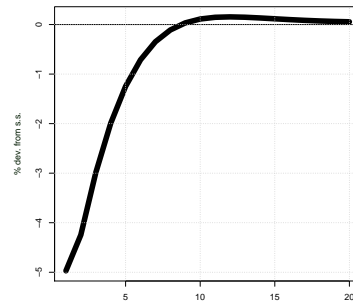
(m) RER: P_p^N & P_c^N



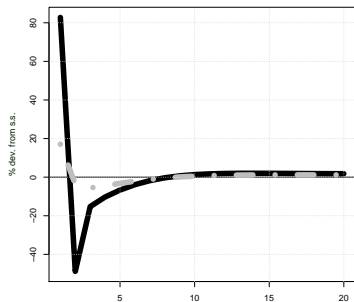
(n) T Con-
sump.: C_p^H & C_p^F



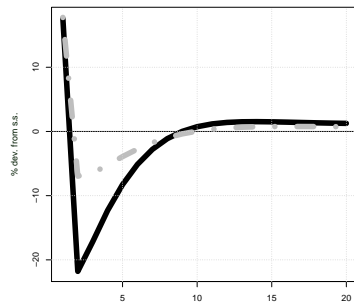
(o) Terms-of-
Trade



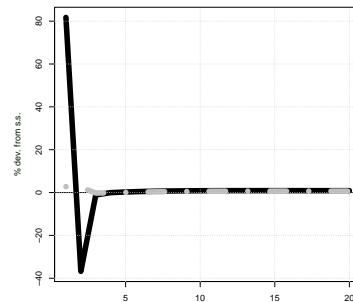
(p) ULC (To-
tal Economy)



(q) ULC
(Tradable)



(r) ULC
(Non-
Tradable)



— Periphery - - - - Core

Notes: T and NT stand respectively for Tradable and Non-Tradable.

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