The European Monetary Union and Imbalances: Is it an Anticipation Story?

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Abstract

This paper investigates the sources of the current account (CA) imbalances experienced within the EMU before the Great Recession by assessing the role played by anticipated shocks. Since 1996, before the actual introduction of the euro, widening of CA deficits occurred in countries with appreciating real exchange rates and output growing faster than trend. To understand the causes of these patterns, we develop and estimate a small open economy DSGE model encompassing plausible drivers of CA imbalances. Anticipated spread convergence, and not "catching-up", caused EMU imbalances. Quantitatively, anticipated shocks are important drivers of CA and real exchange rate fluctuations.

Keywords: Current Account, Real Exchange Rate, Anticipated Shocks

JEL Classification: F32, F41, E32

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1 Introduction

Current events in the euro area (EA) have shown that international imbalances, in particular current account and real exchange rate misalignments, have contributed to exacerbate the vulnerability of the European Monetary Union periphery (Ireland, Portugal and Spain).[1][2] Accordingly, it has become important to uncover their sources. Given that these imbalances started to arise in 1996, before the actual introduction of the euro, expectations are likely to have played an important role in driving flows of goods and capital. The aim of this paper is twofold: first, to uncover the causes of the current account imbalances experienced within the EA before the Great Recession; second, to assess the contribution of *unanticipated vs. anticipated* shocks to current account and real exchange rate fluctuations in an estimated open economy model.

Three facts are at the core of our analysis. First, diverging current account balances have characterized the European Monetary Union (EMU) up to the Great Recession. In 1996, Ireland, Portugal and Spain (henceforth IPS) started to increase current account deficits while other countries, such as Germany and Austria, began to raise surpluses (Figure 1(a)).[3] Notice that the dispersion of CA balances within the EA evolved in two phases. An initial one, between 1995 and 2000, where it increased by 179% and a second one, between 2003 and 2007, where it augmented by 59% (two shaded areas in Figure 1(e)). Second, in periods of increasing deficits, IPS output was growing above historical trend, augmenting investment and experiencing a persistent real exchange rate appreciation with respect to the rest of the EMU (Figure 1(b) and 1(d)).[4] Third, around 1996, the long term borrowing cost premium that IPS had to pay with respect to the EA core countries started a remarkable decrease, characterized again by two phases.[5] Phase one, from 1995 to 1999, with an almost linear

[1]See Giavazzi and Spaventa (2011) and Lane and Milesi-Ferretti (2011), among others.

[2]EA periphery countries should also include Greece. However Greece is not listed as it will be discarded from the analysis of the paper. This is due to data unreliability for the 1996-2007 period: comparable time series are only partially available and there are non-negligible inconsistencies between databases which prevent us from merging different sources. Also Italy is often included among the countries in the EA periphery. Given our focus on current account imbalances and the evidence that the maximum Italian current account deficit in the period considered (1996-2007) was significantly smaller than the one of Ireland, Portugal and Spain (2.4 percent of GDP at the end of 2007 compared to 9.6 IPS average), Italy will not be included.

[3]For a detailed analysis of the determinants of surplus countries, like Germany, see Kollmann *et al.* (2015)

[4]Portugal stopped growing persistently faster than trend after the year 2000. However, years of increasing current account deficits (1995-2000, figure 1(b)) were the ones characterized by high GDP growth and increasing investments. For a detailed analysis of Portugal see Reis (2013).

[5]Notice that the two phases are closely mimicking the evolution of the CA dispersion. Long term borrowing premium is measured as the average yield spread that IPS had to pay with respect to Germany on their government bond with a residual maturity of around 10 years on the secondary market. For a detailed analysis of the evolution of spreads in the EA after 1999, see Gilchrist and Mojon (2016)

decrease in the spread from 3.9 percent to 0.2 and phase two, from 2002 to 2005, with a smooth decrease from 0.2 to 0.03 (Figure 1(c)).

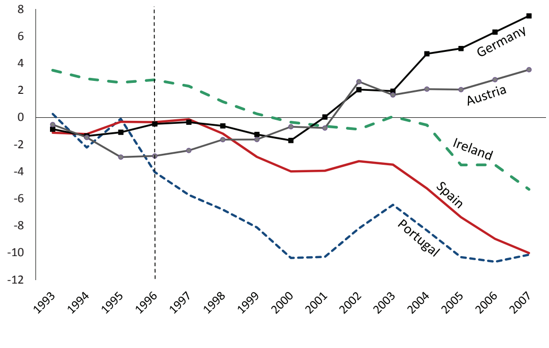
Motivated by the fact that the current account balance (defined as the change in net foreign assets) captures the *inter-temporal* feature of international trade and that EMU imbalances started to widen before the actual introduction of the euro, we introduce anticipated shocks in the analysis. While these shocks have been extensively studied as drivers of domestic business cycles, only few analyses focused on the international setting.[6] Our paper contributes to this literature by assessing, qualitatively and quantitatively, the impact of anticipated shocks as sources of current account imbalances. Related to our study, Hoffmann *et al.* (2017) investigate if productivity shocks (modelled as noise shocks) can explain the build-up of US current account imbalances.[7] Focusing on the EMU, this paper differs in four aspects: (i) it jointly (and crucially) analyzes the current account with the real exchange rate and GDP; (ii) it considers a broad variety of competing explanations, not only productivity; (iii) it estimates fundamental parameters for the international transmission of shocks, as the trade elasticity and shock persistence (see Corsetti *et al.* (2008)); (iv) it *quantifies* the contribution of anticipated shocks, as news shocks, for current account and real exchange rate fluctuations.

Using a structural estimated model, we take the road started by Blanchard and Giavazzi (2002) and Blanchard (2007) of analyzing the imbalances within the EMU. The main idea is that current account imbalances are different depending on their sources (e.g. Giavazzi and Spaventa (2011) and Eichengreen (2010)) but are observationally equivalent if looked separately from international prices and GDP components. We therefore consider all competing explanations, starting with growth differentials (relative "catching-up"), and we focus on those, *unanticipated* and *anticipated*, that can explain *jointly* the observed dynamics of the current account, the real exchange rate and GDP. More specifically, we lay out a New Keynesian DSGE small open economy model in a monetary union with two sectors (tradable and non tradable), that combines different features of open economy general equilibrium models.[8] We include unanticipated, one-year anticipated and long-term (10 quarters) anticipated

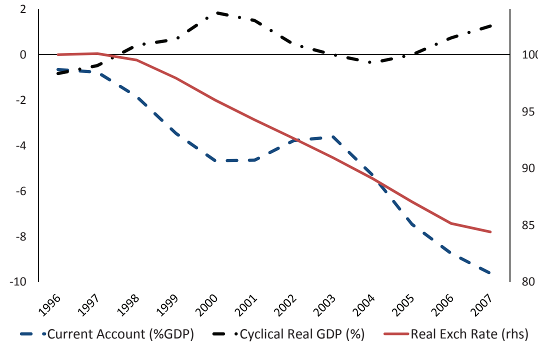
[6]See Beaudry and Portier (2014) for a comprehensive review of the literature on news and business cycles, which, on international environments, includes Jaimovich and Rebelo (2008), Corsetti *et al.* (2011), Beaudry *et al.* (2011), Sakane (2013), among others.

[7]Noise shocks are not properly anticipated shocks but Edge *et al.* (2007) show that they can be interpreted as swings in the formation of expectations of long-run productivity growth. This paper focuses on news shocks but results are robust to modeling changes in expectations as noise shocks (see section 5). A related work by Nam and Wang (2017) investigate if productivity news shocks can be reconciled with the US terms of trade appreciation.

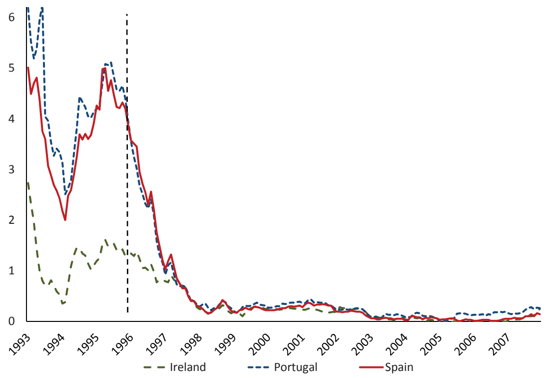
[8]The model features habit persistence in consumption, nominal and real rigidities, monopolistic competi-



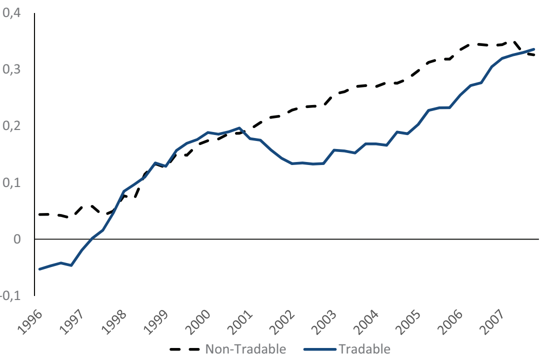
(a) Current Account Dynamics (% of GDP)



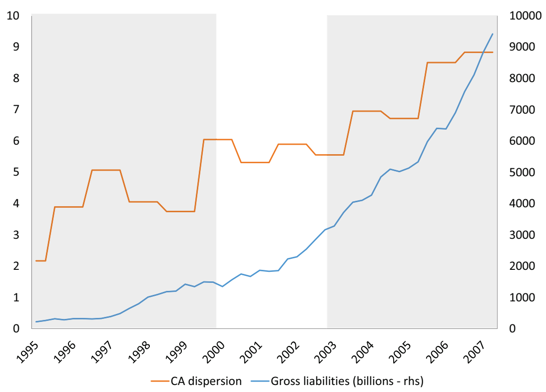
(b) Ireland, Portgual and Spain



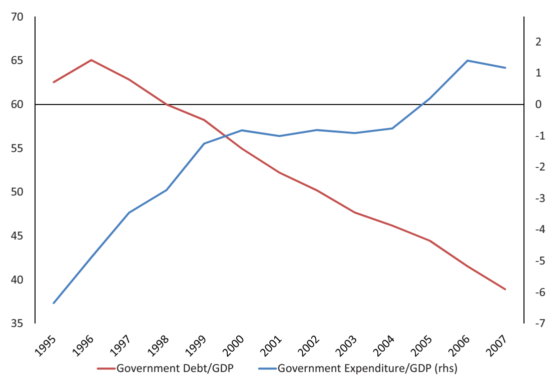
(c) Bond Yield Spread



(d) IPS Investment



(e) CA Dispersion and Gross Capital Flow



(f) Government Debt and Expenditure

Figure 1: (a) Euro area CA (% GDP) from 1993 to 2007 for Austria, Germany, Ireland, Portugal and Spain; (b) CA (% GDP), log deviation of GDP from a deterministic trend (%) and real effective exchange rate (vs. EU-12 countries) for the weighted average of Ireland, Portugal and Spain. As weights annual HICP (Harmonized Index of Consumption Prices) relative household consumption expenditure shares are used. The REER is an index (base year 1996 = 100) represented on the right y-axis. (c) Yield spread of long-term government bonds between Germany and Ireland, Portugal and Spain. The data are based on central government bond interest rates on the secondary market, gross of tax, with a residual maturity of around 10 years. (d) Log deviation of the average Ireland, Portugal and Spain tradable and non-tradable investment from the GDP-implied trend derived in a model consistent way, see section 3.1. (e) EA current account dispersion (standard deviation) and EA total claims in all sectors in millions of US dollars. The shaded area indicate the two periods of increasing dispersion. (f) Total consolidated gross debt at nominal value at the end of the year over GDP and net borrowing/net lending of general government as defined in the ESA 2010. Sources: Eurostat and BIS.

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tion, tradable and non tradable sector, home bias, variable capital utilization, time varying markups and an incomplete international financial market. Elements of our model are based on Galí and Monacelli (2008), Faia and Monacelli (2008), Rabanal (2009) and Burriel *et al.* (2010).

innovations for each shock and we estimate it on IPS data with Bayesian techniques (see An and Schorfheide (2007)). We then analyze the importance of productivity (sector-specific and common labor augmenting), preferences, investment, labor supply, markup, monetary policy and yield spread shocks, using impulse response functions and variance decompositions.

The model consciously mutes the role of fiscal policy and financial intermediation of external flows as possible sources of EA periphery CA imbalances. This choice, done in favor of simplification, is supported by two observations. First, as shown in Figure 1(f), IPS fiscal policy was consolidating, therefore unlikely to generate CA deficits. From 1996 to 2007, government debt in IPS went from 67% to 40% of GDP while the average spending decreased from a 5% deficit to a 1.1% surplus. In addition, average tax rate evolutions in IPS were similar to the rest of the EMU, acknowledging the large reduction of Irish corporate taxation to 12.5%, which however happened only in 2003.[9] Second, while the structure and dynamics of the European interbank market can explain the experienced financial fragility of the EA, caused for example by the intermediation role of banks in EA core countries of large gross capital flows from the rest of the world, it can be hardly considered the first driver of imbalances (see Hale and Obstfeld (2016) and de Ferra (2017)). Supporting this view, figure 1(e) shows unconditional evidence that the first phase of increase in CA dispersion (1995-2000) was not corresponding to a large increase in gross capital flows, which happened subsequently. We will therefore favor the simplest framework accounting for those potential drivers of EA periphery current account imbalances which could have been pivotal.

Two main results emerge from our analysis. First, anticipated reductions in international borrowing costs, and not "catching-up", have been the main drivers of the EA periphery imbalances. Second, quantitatively, overall anticipated shocks explain a large part of business cycle fluctuations, especially of international variables such as the current account and the real exchange rate.[10]

The estimation of the model assigns to *exogenous* and *far ahead* anticipated movements in yield spreads an important role. We claim that these were indeed two important characteristics of the experienced, smooth, yield convergence in EA periphery. The literature identifies four groups of possible drivers of yield spreads suppression: 1. Fall in policy risk (i.e. delegation to a credible monetary authority (Barro and Gordon (1983), Swanson (2008))

[9]Between 1996 and 2002, corporate tax rate decreased in Ireland and Portugal by respectively 56% and 17% and remained constant in Spain. However, notice that also in Germany, in the same period, corporate tax rate decreased by 30%.

[10]Results are robust to the choice of modelling anticipated shocks as news or noise, as shown in section 5.

and decreased political risk (Hale and Obstfeld, 2016)); 2. Harmonization of collateral treatment (Buiter and Sibert, 2005) and financial regulations (Kalemli-Ozcan *et al.*, 2010); 3. Fall in exchange rate risk and transaction costs (Martin and Rey, 2004) and (Hale and Spiegel, 2012); 4. Fiscal policy convergence (Swanson, 2008) and (ao *et al.*, 2017). All explanations, with a necessary remark for fiscal policy convergence, can be considered in large part exogenous to IPS macroeconomic conditions. As for fiscal convergence, Swanson (2008) argue that fiscal budget convergence can hardly explain more than 12.5% of spreads suppression while ao *et al.* (2017) assign to macro-fundamentals a marginal role in the observed covergence. We will therefore consider spread movements as exogenous. Moving to the dynamics, it can be shown that a single *far ahead* anticipated shock to the short-term spread (i.e. in January 1, 1996, agents learn that the short-term spread will be zero with the creation of the ECB in June 1, 1998) goes a long way in explaining the smooth dynamics of long-term spreads shown in Figure 1(c), even relying on the expectation hypothesis. Hence, the observed not abrupt convergence of spreads is consistent with an important role played by *far-ahead* anticipated fluctuations.

The existing literature that investigates current account deficits within the EA periphery can be grouped around two axes. Some studies, such as Gaulier and Vicard (2012) and Bayoumi *et al.* (2011), among others, focus on trade explanations linked to the international price competitiveness. Others, such as in 't Veld *et al.* (2014), Polito and Wickens (2014) and Lane and Pels (2012), focus on macro explanations (like asset bubbles and credit constraints, the loss of monetary policy independence or the change in growth expectations). Our paper narrows the gap between these two approaches considering these competing explanations in a parsimonious model.[11] The paper is finally related to the literature studying how credit spread shocks affect business cycle fluctuations, although our approach will mostly focus on international variables such as CA and real exchange rates (see Gilchrist and Zakrajsek (2012) among others and Gilchrist and Mojon (2016) for an analysis on the EA after 1999).

The paper is organized as follows. Section 2 describes the economic environment while section 3 illustrates the Bayesian estimation of the model. Section 4 investigates how structural shocks explain the current account imbalances and examines the importance of anticipated shocks for current account and real exchange rate fluctuations. Section 5 checks the robustness of the results. Section 6 concludes.

[11] It is worth mentioning, however, that our framework is not well suited to account for two additional channels: external trade shocks, introduced by Chen *et al.* (2013) and non-trade channels, like transfers and income balances, proposed by Kang and Shambaugh (2013).

2 The Model

We build a two-sector standard New Keynesian Dynamic Stochastic General Equilibrium (DSGE) small open economy model. The domestic economy is in a monetary union with the foreign economy which, for analytical simplicity, represents the rest of the monetary union and it is taken exogenously. Modeling the EA periphery as a small open economy allows us to account for the evidence that IPS together, between 1996 to 2007, represented 13 percent of the total EA zone.[12]

The model has three types of agents: households, final good producers and intermediate firms. The domestic representative household consumes, saves or borrows through domestic and foreign internationally traded bonds and supplies labor. The household owns physical capital, takes investment decisions and decides the amount of the owned capital to be given for production.

The model features variable capital utilization, adjustment cost of capital and preferences introduced by Jaimovich and Rebelo (2009) which can account for aggregate and sectoral co-movement in presence of anticipated shocks.[13] The consumption bundle is produced by perfectly competitive final good producers which aggregate non tradables with a combination of home and foreign tradable goods. There is no perfect substitutability between goods and we allow for home bias, aware that the purchasing power parity will therefore not necessarily be satisfied.

In addition, within each country, there are monopolistically competitive intermediate firms which produce different varieties of tradable and non tradable goods. They produce using labor and capital. These factors of production are freely mobile across sectors but not across countries. There are both common and sector-specific productivity dynamics which allows to generate an economy with permanent inflation differentials across countries and sectors. Prices are not fully flexible and follow Calvo (1983) formulation with indexation.

There is a common monetary authority that fixes the nominal interest rate. The assumption that the domestic economy is small comes at the cost of assuming that the monetary policy is exogenous to the dynamics of the small open economy[14]. The nominal exchange rate

[12] 13% is the weighted average of Ireland, Portugal and Spain between 1996 and 2007 in the EA Harmonized Index of Consumer Prices (Eurostat).

[13] Models featuring anticipated shocks sometimes fail to generate the aggregate co-movement between output, consumption, investment and hours worked observed in the data. The main reason is that anticipated changes in income can affect current labor supply.

[14] A semi-open small open economy in which IPS are responsible for 13% of the movements in average inflation has a too large region of model indeterminacy.

is fixed, given the membership in a monetary union. We allow for perfect risk-sharing within countries but incomplete international financial markets with only one internationally traded non-contingent bond. Therefore, household will be able to borrow-lend internationally only through a single bond which pays a spread on the nominal interest rate set by the common monetary authority. This assumption allows us to have a mechanism in the model to study the role of the experienced IPS spread convergence (Figure 1(c)).

As mentioned in the introduction, there is no government in the model. This choice is supported by two observations. First, government spending did not increase the overall debt of IPS (% of GDP) in the period under investigation. In fact, from 1996 to 2007, government debt went from 67% to 40% of GDP and the average spending went from a 5% deficit to a 1.1% surplus. Second, tax rate evolution was similar in IPS and in the EMU. Therefore, while specific fiscal policies may have played some role for the individual country experience (e.g., Ireland in 2003 set the corporate tax to 12.5%), government decisions on spending and taxes did not play an important role for the common dynamics of the EA periphery current account imbalances.

In this section we introduce the detailed structure of the model. Foreign variables are denoted by an asterisk (*). An appendix with the full set of equilibrium conditions, de-trended and log linearized, is available online.

2.1 Domestic Household

The domestic representative household maximizes the present value of his/her expected lifetime utility:

$$E_t \sum_{s=0}^{\infty} \chi_{t+s} \epsilon_t^d U(C_{t+s}, L_{t+s}). \tag{1}$$

E_t denotes the conditional expectation at date t and U is the instantaneous utility which is a function of final goods' consumption, C, and hours worked, L. χ denotes the household's endogenous discount factor. We assume that agents become more impatient when average de-trended consumption, $\overline{C_t}$, increases:[15]

$$\chi_t = 1 \quad \text{and} \quad \forall s \geq 0 \quad \chi_{t+s} = \beta_{t+s-1}\chi_{t+s-1} \quad \text{where} \quad \beta_{t+s-1} \equiv \frac{1}{1+\psi^{\beta}(\log \overline{C}_{t+s-1} - \chi^{\beta})}. \tag{2}$$

[15]This feature of the model ensures the presence of a stable non-stochastic steady state independent from initial conditions with incomplete financial markets. See Uzawa (1968), Schmitt-Grohé and Uribe (2003) and Bodenstein (2011) for a detailed discussion on the topic. The de-trended average consumption will be treated as exogenous by the representative household.

The parameter ψ^{β} determines the importance of average consumption in the discount factor and we set it to a low value in order to reduce the interference with the dynamics of the model, as in Ferrero *et al.* (2010). ϵ_t^D is an intertemporal preference shock with mean unity that obeys

$$\log \epsilon_t^d = \rho_{\epsilon^d} \log \epsilon_{t-1}^d + \zeta_t^d. \tag{3}$$

Notice that ζ_t^d, alike all other shocks introduced in the model, is a zero-mean i.i.d. random variable.

Preferences of the household are represented by the following utility function:

$$U(C_t, L_t) = \frac{\left\{(C_t - h^B \overline{C}_{t-1}) - \epsilon_t^L \psi^L L_t^{1+\nu} \Omega_t\right\}^{1-\sigma} - 1}{1-\sigma}, \tag{4}$$

where

$$\Omega_t = (C_t - h\overline{C}_{t-1})^{\mu} \Omega_{t-1}^{1-\mu} (1+z)^{1-\mu}. \tag{5}$$

where h^B is the degree of habit persistence in consumption, ψ^L is a labor supply preference parameter and ϵ_t^L denotes a labor supply shock with mean unity and law of motion:

$$\log \epsilon_t^L = \rho_{\epsilon^L} \log \epsilon_{t-1}^L + \zeta_t^L. \tag{6}$$

Utility depends on consumption at time t, C_t, a portion of average past consumption, $h^B \overline{C}_{t-1}$, and hours worked L_t. Past average consumption is perceived by the maximizing household as independent from his/her own choices. Ω_t controls the wealth effect on labor supply through the parameter $\mu \in [0, 1]$. As μ rises, the wealth elasticity of labor supply increases. This preference specification is due to Jaimovich and Rebelo (2009). By changing μ we can account for two important classes of utility functions used in the business cycle literature: King *et al.* (1988) types of preferences when $\mu = 1$ and Greenwood *et al.* (1988) when $\mu = 0$. We use Hoffmann *et al.* (2011) specification, which introduces habit persistence in consumption and a trend in the growth rate of the economy. The inclusion of $(1+z)^{1-\mu}$ allows us to preserve the compatibility with the long run balance growth path for the entire set $\mu \in [0, 1]$.

The representative household faces the following budget constraint:

$$C_t + \frac{B_t}{P_t} + I_t \leq$$
$$W_t L_t + R^W_{t-1}\frac{B_{t-1}}{P_t} + \left(R^k_t u_t - \Psi(u_t)\right) K^p_{t-1} + \int_0^1 \Gamma_{N,t}(i) + \int_0^1 \Gamma_{h,t}(i). \quad (7)$$

$\Gamma_{(N,h),t}(i)$ are real profits of the intermediate monopolistic competitive firms, in both the non tradable (N) and domestic tradable (h) sectors,[16] W_t is the real wage in terms of the final good price and K^p_t is the physical capital owned by the household which accumulates according to

$$K^p_t = (1-\delta)K^p_{t-1} + \epsilon^I_t \left[1 - S\left(\frac{I_t}{I_{t-1}}\right)\right] I_t. \quad (8)$$

I_t is investment in physical capital, δ is the depreciation rate and $S()$ is an adjustment cost function. We assume that $S(Z) = S'(Z) = 0$ and $S''(Z) = \eta_k > 0$, where Z is the economy's steady state growth rate and η_k is the capital adjustment cost elasticity. ϵ^i_t is an investment specific shock with mean unity that evolves according to $\log \epsilon^I_t = \rho_{\epsilon^I} \log \epsilon^I_{t-1} + \zeta^I_t$. The capital utilization rate, u_t, determines the amount of physical capital to be transformed in effective capital which is rented to firms at the real rate R^k_t:

$$K_t = u_t K^p_{t-1}. \quad (9)$$

$\Psi(u_t)$ in equation (7) is the cost of use of capital in units of consumption and $\Psi(u) = 0$ and $\frac{\Psi'(u)}{\Psi(u)} = \eta_u$ where, in steady state, $u = 1$.

We assume that there is full insurance within but not across countries, as only the domestic financial market is complete. To keep the notation to the minimum and help the exposition, we do not display the full portfolio of domestic state-contingent assets and we just introduce B_t, the single non-state contingent internationally traded asset. This bond pays R^W_t, which we decompose in the monetary union rate plus a spread. In log deviation from the steady state we can write it as $\widehat{r}^W_t = \widehat{r}_t + \widehat{sp}_t$. The presence of the spread indicates that the domestic household might have to pay a premium, but on average it does not, to borrow from the rest

[16] Shares of the monopolistic firm i are owned by domestic residents in equal proportions and are not traded internationally.

of monetary union.[17] Sp_t is assumed to be exogenous with mean unity and follows:

$$\log Sp_t = \rho_{sp} \log Sp_{t-1} + \zeta_t^{Sp}. \tag{10}$$

The risk-free rate, R_t, is governed by the monetary authority (the European Central Bank, ECB) which targets EA inflation. Given our small open economy assumption, aggregate EMU inflation is an exogenous variable. We therefore capture the monetary policy behavior of the ECB with the following exogenous process:

$$\log R_t = (1-\rho_r)\log R + \rho_r \log R_{t-1} + \zeta_t^R \tag{11}$$

The representative household chooses processes $\{C_t, L_t, B_t, A_t, u_t, K_t^p, I_t\}_{t=0}^{\infty}$ taking as given the set of prices $\{P_t, W_t, R_t^k, R_t, R_t^W\}_{t=0}^{\infty}$ and the initial wealth B_0 and A_0, to maximize equation (1) subject to (2), (4),(5),(7), (8) and (9).

2.2 Final good producer

The final good Y_t^d is produced by a perfectly competitive firm which buys and combines the varieties produced by intermediate firms. The tradable good, which is composed of goods both domestically $Y_{h,t}^d$ and foreign made $Y_{f,t}^d$, is aggregated with a non tradable good $Y_{N,t}^d$ by:

$$Y_t^d \equiv [\gamma_{T,t}^{\frac{1}{\eta}}(Y_{T,t}^d)^{\frac{\eta-1}{\eta}} + \gamma_{N,t}^{\frac{1}{\eta}}(Y_{N,t}^d)^{\frac{\eta-1}{\eta}}]^{\frac{\eta}{\eta-1}}, \qquad \text{where} \quad Y_{T,t}^d \equiv [\gamma_{h,t}^{\frac{1}{\epsilon}}(Y_{h,t}^d)^{\frac{\epsilon-1}{\epsilon}} + \gamma_{f,t}^{\frac{1}{\epsilon}}(Y_{f,t}^d)^{\frac{\epsilon-1}{\epsilon}}]^{\frac{\epsilon}{\epsilon-1}}.$$

where $\eta > 0$ is the elasticity of substitution between tradable and non tradable goods and $\epsilon > 0$ is the one between domestic and imported tradable goods. $\gamma_{T,t}$, $\gamma_{N,t}$, $\gamma_{h,t}$ and $\gamma_{f,t}$ are respectively the preference shares for tradable as a whole, non tradable, domestic tradable and foreign tradable goods.[18] We allow also for the presence of home bias in tradable goods.

Within each sector the firm aggregates among a continuum of different varieties of goods which are imperfectly substitutable following:

$$Y_{f,t}^d \equiv \left[\int_n^1 (Y_{f,t}^d(i))^{\frac{\phi_t^T-1}{\phi_t^T}} di\right]^{\frac{\phi_t^T}{\phi_t^T-1}}, \; Y_{h,t}^d \equiv \left[\int_0^n (Y_{h,t}^d(i))^{\frac{\phi_t^T-1}{\phi_t^T}} di\right]^{\frac{\phi_t^T}{\phi_t^T-1}}, \; Y_{N,t}^d \equiv \left[\int_0^1 (Y_{N,t}^d(i))^{\frac{\phi_t^N-1}{\phi_t^N}} di\right]^{\frac{\phi_t^N}{\phi_t^N-1}},$$

[17] As in McCallum and Nelson (1999), this is a way to introduce an exogenous and random international risk premium that reflects temporary, but persistent, deviations from uncovered interest parity condition.

[18] The shares can vary over time since they include deterministic preference shocks to guarantee the presence of a balance growth path with two sectors growing at different rates (see Rabanal (2009)).

where $\phi_t^T > 0$ and $\phi_t^N > 0$ are the exogenous random variables that determine the degree of substitutability between varieties produced by intermediate firms. They evolve as follows:

$$\log \phi_t^T = (1 - \rho_{\phi^T}) \log \phi^T + \rho_{\phi^T} \log \phi_{t-1}^T + \zeta_t^{\phi^T}$$
$$\log \phi_t^N = (1 - \rho_{\phi^N}) \log \phi^N + \rho_{\phi^N} \log \phi_{t-1}^N + \zeta_t^{\phi^N}$$

where ϕ^T and ϕ^N are steady state values, which are assumed to be the same. Hence, the final firm maximizes profits and by doing so, it takes as given the prices of the final good P_t, the consumer price index (CPI), and the price of the inputs.[19]

2.3 Intermediate firms

Production in both intermediate sectors is carried out by monopolistically competitive firms which employ both capital, K_t, and hours of labor L_t with the following production function:

$$Y_{j,t} = A_{j,t} K_{j,t}^{\alpha} \left[X_t L_{j,t} \right]^{1-\alpha}. \tag{12}$$

While X_t is the common labor-augmenting technology process, $A_{j,t}$ are the sector specific productivity innovations for the tradable and the non tradable sectors. From this section onwards, to lighten the notation, we introduce an indicator $j = \{N, h\}$ to denote those variables that are referring to both the tradable and the non tradable sector. The common labor-augmenting technology follows:

$$X_t = (1 + z)^t \widetilde{X}_t, \text{ where } \log \widetilde{X}_t = \rho_X \log \widetilde{X}_{t-1} + \zeta_t^X. \tag{13}$$

The trend in labor augmenting technology can be disaggregated between a component common to the entire euro area z^{euro} and a component specific to IPS z^{IPS}: $(1 + z)^t \simeq (1 + z^{euro})^t (1 + z^{IPS})^t$. Sector-specific productivities also have a deterministic trend and an autoregressive process:

$$A_{j,t} = (1 + g^j)^t \widetilde{A}_{j,t}, \text{ where } \log \widetilde{A}_{j,t} = \rho_{A_j} \log \widetilde{A}_{j,t-1} + \zeta_t^{A_j} \text{ for } j = N, h \tag{14}$$

where the shocks are *i.i.d.* normally distributed $\zeta_t^{AN} \sim N(0, \sigma_{AN}^2)$, $\zeta_t^{Ah} \sim N(0, \sigma_{Ah}^2)$ and $\zeta_t^X \sim N(0, \sigma_X^2)$. Sectors' specific trends are included to allow the model to capture the

[19] Notice that P_t can also be interpreted as the aggregate demand deflator.

different first moments in the tradable and in the non tradable sector that characterized IPS in the early 2000s.[20] These assumptions provide us a model-consistent method to detrend the data before proceeding with the estimation.

Following Calvo (1983), intermediate firms are allowed to set prices only with probability $1-\theta^j$ independently on their previous history. The fraction θ^j of firms that cannot change their price is divided into a fraction φ_j that indexes it to past sector j's inflation, $\Pi_{j,t}$, and the remaining fraction $(1-\varphi_j)$ that sets it to j's steady state inflation, Π_j. The evolution of the price level in the tradable and non tradable sector can therefore be written as:

$$P_{j,t} = \left\{ (1-\theta^j) P_{j,t}(i)^{1-\phi_t^j} + \theta^j \left[P_{j,t-1} \left(\Pi_{j,t-1}\right)^{\varphi_j} \Pi_j^{1-\varphi^j} \right]^{1-\phi_t^j} \right\}^{\frac{1}{1-\phi_t^j}} \text{ for } j = \{N, h\} \tag{15}$$

where $P_{j,t}(i)$ is the price set in period t by the firm (i) which is allowed to re-optimize its price in sector (j).

Firms solve a two stage problem. In the first stage they minimize the real cost choosing in a perfectly competitive market the quantity of the two factors of production. In the second stage, individual firms in both sectors chose prices $P_{j,t}(i)$ in order to maximize the present discounted sum of future profits constrained by the sequence of demand constraints from final firms and by the fact that only a fraction $(1-\theta_j)$ of firms is allowed to reset freely their prices:

$$\max_{P_t(i)} \sum_{k=0}^{\infty} \theta_j^k E_t \left\{ \frac{\lambda_{t+k}}{\lambda_t} \beta_{t+k-1} \left[\frac{P_{j,t}(i)}{P_{t+k}} \left[\frac{P_{j,t+k-1}}{P_{j,t-1}} \right]^{\varphi^j} \pi_j^{k(1-\varphi^j)} - MC_{j,t+k} \right] Y_{j,t+k}^d(i) \right\} \tag{16}$$

$$\text{s.t. } Y_{j,t}^d(i) = \left(\frac{P_{j,t}(i) \left[\frac{P_{j,t+k-1}}{P_{j,t-1}} \right]^{\varphi^j} \pi_j^{k(1-\varphi^j)}}{P_{j,t+k}} \right)^{-\phi_{j,t+k}^j} Y_{j,t+k}^d. \tag{17}$$

where $MC_{j,t}$ is the real marginal cost.

2.4 Terms of trade, real exchange rate and current account

In this section we introduce some important variables: the terms of trade, the real exchange rate, the relative price of traded and non traded goods and the current account.

We start by defining the terms of trade as the price of imported over exported goods $S_t \equiv \frac{P_{f,t}}{P_{h,t}}$. Following Faia and Monacelli (2008) the tradable price index over the price of the

[20] A similar approach in open-economy models has been followed by Rabanal (2009), among others.

domestic tradables can be written as a function of the terms of trade and parameters only:

$$\frac{P_{T,t}}{P_{h,t}} = g(S_t) = [\gamma_{h,t} + \gamma_{f,t} S_t^{1-\epsilon}]^{\frac{1}{1-\epsilon}}, \qquad \text{with} \quad \frac{\delta g(S_t)}{\delta S_t} > 0. \tag{18}$$

$J_t \equiv \frac{P_{T,t}}{P_{N,t}}$ is the relative price of tradable over non tradable goods. The ratio of the CPI index to the price of non tradables thus can be written as:

$$\frac{P_t}{P_{N,t}} = m(J_t) = [\gamma_{T,t} J_t^{1-\eta} + \gamma_{N,t}]^{\frac{1}{1-\eta}}, \qquad \text{with} \quad \frac{\delta m(J_t)}{\delta J_t} > 0. \tag{19}$$

The small open economy is part of a Monetary Union, the law of one price holds $P_{f,t}(i) = P_{f,t}^*(i)\ \forall i \in [0,1]$ but the purchasing power parity (PPP) will not be satisfied given the presence of home bias in consumption. The real exchange rate is defined as $Q_t = \frac{P_t^*}{P_t}$ and it can be rewritten as a function of S_t, J_t and exogenous foreign prices:

$$Q_t = \frac{S_t}{g(S_t)} \frac{J_t}{m(J_t)} \frac{P_t^*}{P_{f,t}}, \qquad \text{with} \quad \frac{\delta Q_t}{\delta S_t} > 0 \ \frac{\delta Q_t}{\delta J_t} > 0. \tag{20}$$

Using the budget constraint, we can write the balance of payment condition (as share of mean level of output, Y) as:

$$NX_t + \frac{R_{t-1} Sp_{t-1} B_{t-1}}{YP_t} - \frac{B_t}{YP_t} = 0, \tag{21}$$

where NX_t denotes the real value of net exports as a ratio to steady state GDP and it is equal to

$$NX_t = \frac{J_t}{g(S_t) m(J_t)} \frac{(Y_{h,t} - C_{h,t} - S_t C_{f,t})}{Y}. \tag{22}$$

The current account is the net change in real bond holding scaled by the steady state level of GDP

$$CA_t = \frac{B_t}{P_t Y} - \frac{B_{t-1}}{P_t Y} \tag{23}$$

and total GDP is defined as the sum of aggregate demand and net export

$$Y_t = Y_t^d + NX_t(Y). \tag{24}$$

Finally, it is important to recall that in equilibrium, due to the incompleteness of international financial markets, the risk-sharing equation is violated.[21]

[21] If we were in a model with perfect financial and insurance markets with constant nominal exchange

2.5 Equilibrium in a Small Open Economy

In equilibrium intermediate and final goods' markets clear:

$$Y_{N,t} = Y^d_{N,t} \quad , \quad Y_{h,t} = Y^d_{h,t} + Y^{d*}_{h,t} \quad \text{and} \tag{25}$$

$$Y^d_t = C + I + \Psi(u_t)K^p_{t-1}. \tag{26}$$

Also the labor and the capital markets clear, implying:

$$L_t = L_{N,t} + L_{h,t} \quad \text{and} \quad K_t = K_{N,t} + K_{h,t}. \tag{27}$$

2.6 Detrending Equilibrium Conditions

The system of equilibrium conditions is non-stationary. The deterministic trends in the sector-specific productivities and in the labor-augmenting technology generate variables that grow as time elapses. To be able to use standard solution techniques, we first need to de-trend the model.

Focusing on those variables that grow in steady state we divide them by their trend generating a new stationary variable, denoted with a tilde, ex: $\widetilde{Y}_t$. For instance, the production in the two sectors, $Y_{N,t}$ and $Y_{H,t}$, can be made stationary as follows:

$$\widetilde{Y}_{N,t} = \frac{Y_{N,t}}{[(1+z)(1+g^N)]^t} = \widetilde{A}_{N,t}\widetilde{X}^{1-\alpha}_t(1+z)^{-\alpha}\widetilde{K}^{\alpha}_{N,t}L^{1-\alpha}_{N,t} \tag{28}$$

and

$$\widetilde{Y}_{h,t} = \frac{Y_{h,t}}{X_t(1+g^h)^t} = \widetilde{A}_{h,t}X^{1-\alpha}_t(1+z)^{-\alpha}\widetilde{K}^{\alpha}_{h,t}L^{1-\alpha}_{h,t}, \tag{29}$$

where $\widetilde{K}_{j,t} = \frac{K_{j,t}}{(1+z)^{t-1}}$ denotes de-trended capital and $\widetilde{A}_{j,t}$ and $\widetilde{X}_t$ are defined by equations (14) and (13). Notice that while real aggregate variables grow at rate $(1+z)^t$, sector-specific variables have an additional component introduced by the sector specific deterministic trend $(1+g^j)^t$. Finally, we log linearize the stationary model to the first order around the deterministic steady state (for the details see the online appendix).

rate, the risk-sharing condition would be satisfied. This equation states that a benevolent social planner would allocate consumption across countries in such a way that the marginal benefit from an extra unit of consumption equals its marginal costs. With a time separable preferences and CRRA utility function we would have a positive correlation between the relative consumption and the real exchange rate. The data show that this is not always the case (Backus-Smith puzzle, (Backus *et al.*, 1993)). Corsetti *et al.* (2010) provide a comprehensive review of the literature.

2.7 Anticipated shocks

Expectations are key drivers of international flows of capital. The current account balance, defined as the change in net foreign assets, captures the inter-temporal feature of international trade. Therefore, the investigation among plausible sources of current account imbalances should also consider the role played by swings in conditional expectations. In fact, changes in agents' knowledge of the future have consequences on borrowing and lending decisions and, therefore, on country's net foreign asset position. In order to account for this aspect, we include two possible anticipated components in all sources of fluctuation in our model.

Overall, nine shocks drive the model: preference shocks; tradable and non tradable technology shocks; labor augmenting productivity; investment specific shocks; labor supply shocks; cost-push shock; monetary policy and yield spread shocks. For each of these shocks we introduce unanticipated, medium term anticipated (one year) and long-term anticipated (10-quarters) innovations.[22] Medium-term anticipated shocks have been shown to be extremely important for domestic business cycle fluctuations by (Schmitt-Grohé and Uribe, 2012). To these, we add also long horizon anticipated shocks to capture the long-term motivations underlying current account imbalances. We pick the long-term to be exactly 10 quarters as it was the time that separated the beginning of our sample, January 1996, from June 1998, when the European Central Bank was created.

Following Schmitt-Grohé and Uribe (2012), if $\log x_t = \rho_x \log x_{t-1} + \zeta_t^x$ identifies a general exogenous process, we assume that the error term follows the structure:

$$\zeta_t^x = \zeta_{0,t}^x + \zeta_{4,t-4}^x + \zeta_{10,t-10}^x \tag{30}$$

where, for example, $u_{4,t-4}^x$ is today's realization of a shock that was acknowledged 4 quarters ago. For a full and detailed account of this method for introducing anticipated shocks we cross-refer to section 3 of Schmitt-Grohé and Uribe (2012).

3 Model Estimation

We calibrate a small subset of parameters and we rely on Bayesian techniques to estimate those over which there is both theoretical and empirical controversy. Particular attention is

[22]We do not include anticipated innovations in the monetary policy because those are already included in the fluctuations of future assets' return, which are accounted in the anticipated yield spread shocks.

devoted in finding the values of the elasticities and persistence of shocks, which are crucial parameters for the theoretical behavior of international variables (see section 4). Estimated values for tradable and non tradable elasticities are found to be much closer to empirical micro-trade estimates than previous open-macro estimations.

In this section we start by describing the data and the set of calibrated parameters. Subsequently, we present the prior distribution and compare it with the estimated posterior.

3.1 Data

We consider the first quarter of 1996 as the beginning of our sample. We assume, in fact, that with the European Council meeting, held on December 15-16, 1995 in Madrid, during which the exact timeline of the transition and the name of the common currency was decided,[23] the EMU became a credible agreement. Therefore agents, at that date, started to act as if they were part of the EMU.

We choose the last quarter of 2007, when we date the beginning of the Great Recession, as the end of our sample. We claim that it is important to focus on the pre-crisis period to understand why imbalances were actually accumulated, without being influenced by the peculiarities of the crisis episode. Understanding the link between the sources of the accumulating imbalances and the crisis is an interesting question which will not be addressed in this paper.

IPS experienced similar dynamics of current account, real exchange rate and GDP during this period, especially during phases of enlarging current account deficits.[24] Accordingly, we focus on these three countries jointly throughout the estimation. A weighted average, using European Central Bank HCPI as weights, allows us to investigate the common sources of the EA periphery imbalances, mitigating the peculiarities of each country.

While Greece is part of the EA periphery and experienced a similar dynamics of those three variables (even though with some lag),[25] we decided to exclude it from the analysis because of unreliability of the data available. In fact, Greece lacks comparable time series data with IPS for the entire 1996-2007 period and major incompatibilities between databases hindered the possibility of aggregating different sources. Moreover, Italy is also often included

[23] `http://www.europarl.europa.eu/summits/mad1_en.htm`

[24] For example, Portugal, which slowed down after the year 2000, experienced growing GDP, appreciating real exchange rate and current account deficits between 1995-2000 (see Figure 1(b)). For a detailed analysis of Portugal see Reis (2013).

[25] Greece was not part of the first list of countries adopting the Euro and joined the third stage of the EMU only on 1 January 2001.

among EA periphery countries but, given our specific focus on international imbalances and the fact that the current account deficit of Italy reached at maximum 1.7 percent of GDP in 1996-2007, we didn't include it in the study.

We estimate the model using quarterly observations for seven time series: real GDP, real consumption, real investment, average weekly hours worked, current account (% GDP), real exchange rate within EMU partners and 3-months Euro Interbank Offered Rate for euro area countries.[26] Real data and exchange rates are computed using the aggregate demand deflator, instead of the gdp deflator, to be model-consistent.

Following Beltran and Draper (2008), we also include three time series for the behaviour of the foreign economy. This is feasible because we assume that our open economy is small and does not affect the rest of the monetary union, implying that the foreign block is exogenous. We include, as unrestricted Vector Autoregression, the EMU (minus IPS) tradable prices, the EMU (minus IPS) non tradable prices and foreign real aggregate demand (minus IPS). The observables are assumed to follow the process $F_t^* = AF_{t-1}^* + \zeta_t^{*F}$ where $F_t^* = \left[Y_t^{*d} \ P_{f,t}^* \ P_{N,t}^*\right]'$, ζ_t^{*F} is a vector of iid random errors and A is a matrix of dimension (3x3).

The model implies that all the observable variables are non-stationary. Values of the trends are estimated imposing a trend stationary process to overall GDP and to sector specific output in the tradable and non tradable sector. The values of z, z^*, g^N and g^T are reported in table 1. All variables, with the exception of the nominal interest rate and the foreign VAR, are taken in log changes after having extracted the deterministic trend. Details on data and measurement equations are in the online appendix.

3.2 Calibrated parameters

Table (1) summarizes the values and the sources of the calibrated parameters. We follow Smets and Wouters (2003) for three values: α, the capital share, is set equal to 0.29; the depreciation rate, δ, is 0.025 per quarter, implying a 10 per cent annual depreciation of capital; ρ_r, the degree of interest rate persistence is 0.84.

The discount factor is endogenous: we estimate χ^β and then calibrate ψ in order to ensure that the steady state value of the discount factor is equal to 0.99. At the mean of the prior distribution it will have value $1.99 \cdot 10^{-5}$. We do this to ensure that the endogeneity of

[26] Regarding the cost of borrowing, we therefore include as observable only R_t, the nominal monetary policy rate set by the European Central Bank. For the period 1996-1999 we therefore assume that IPS central banks where already acting as if monetary policy was conducted by a single monetary authority. This assumption allows us to estimate the spread and its role without forcing the model to exactly match its dynamics.

Table 1: Calibrated Parameteres

Par	Value	Description	Source
ψ^{β}	to set $\beta = 0.99$	Spillover effect of average de-trended consumption on the discount factor	
β	0.99	Discount factor	
σ	1	Curvature of utility	Schmitt-Grohé and Uribe (2012)
ψ^{L}	to set $L = 0.236$	Labor supply preference parameter	Eurostat 1996-2007
α	0.29	Capital Share	Smets and Wouters (2003)
δ	0.025	Depreciation of capital	Smets and Wouters (2003)
$\gamma_{N,t}$	0.77	Non tradable sector share in IPS GDP	Eurostat 1996-2007
$\gamma_{f,t}$	0.34	Average share of Imports on GDP	Eurostat 1996-2007
ρ_r	0.847	AR interest rate	Smets and Wouters (2003)
z	0.97	GDP trend - IPS	
z^*	0.57	GDP trend - EMU minus IPS	
$g^{NT} + z$	0.99	Non Tradable sector aggregate trend	
$g^{T} + z$	0.53	Tradable sector aggregate trend	

the discount factor does not significantly influence the medium term dynamics of the model. The labor supply preference parameter is set in order to ensure a steady state share of hours worked equal to 23.6% per week, based on IPS data.

For the share of tradable and non tradable goods, $\gamma_{N,t}$ and $\gamma_{T,t}$, we use the sectorial decomposition of the GDP in the Eurostat database. In IPS, the average share of non tradable production for the period 1996:2007 is 77 per cent.[27] Focusing on the tradable goods sector we find that the share of imported goods is around 33.9 per cent for IPS countries, displaying a relevant home bias.

3.3 Prior Distributions

Table 2 and 3 summarize the prior of the parameters used in the estimation. The two parameters determining the labor supply behavior (μ and v) are estimated. For μ, which determines the wealth elasticity of labor supply, we impose a uniform prior distribution over the entire interval $[0, 1]$. The prior for v, which is the inverse of the Frisch elasticity when $\mu = 0$, is set to a gamma prior distribution with mean 3.

Some structural parameters are central for shaping the responses of the model to shocks. Trade elasticity, the elasticity of substitution between tradable and non tradable goods and the shocks' persistence are the most important to determine the reaction of the current account and the real exchange rate to productivity shocks (Corsetti *et al.*, 2008). For these,

[27] The non tradable sector includes: construction; wholesale and retail trade; hotels and restaurants; transport; financial intermediation; real estate; public administration and community services; activities of households.

a wide range of values, provided by empirical and theoretical studies, fail to give us a precise and reliable calibration. Therefore we estimate them with Bayesian techniques using values found by previous studies as references for priors.

The elasticity of substitution between home and foreign produced tradable goods (the trade elasticity ϵ) is a parameter for which the literature provides a large range of estimates. On one side there are micro-trade studies that, using disaggregated data, estimate large values. Cabral and Manteu (2011), among others, find that the average external demand elasticity in the EA periphery is around 4. On the other side the international macroeconomic literature, which relies on aggregated data, finds much lower values. Taylor (1999), for example, estimates a long run elasticity of 0.39. Recent theoretical studies show in fact how implied low trade elasticity help macroeconomic models to overcome the Backus and Smith puzzle (Corsetti *et al.* (2008) and Benigno and Thoenissen (2008)) and allow to better match the volatility of the real exchange rate (Thoenissen (2011)). To capture this uncertainty while assigning slightly more probability on values closer to previous macro-estimates, we set a gamma prior distribution with mean 1.5 and standard deviation of 1.

The other central parameter is the elasticity of substitution between tradable and non tradable goods, η. Although the range of values suggested by previous studies is non trivial, there is more consensus on its actual value than on the trade elasticity. Mendoza (1991), focusing on a set of industrialized countries, finds a value of 0.74, while Stockman and Tesar (1995) estimate a lower elasticity of 0.44. Rabanal and Tuesta (2013), in a model made to understand the role of non tradable goods for the dynamics of the real exchange rate, estimate the parameter to be 0.13. Combining this information we set a gamma prior distribution with mean 0.5 and standard deviation of 0.2.

From the household side, three additional parameters are considered: consumption habit, capital adjustment cost elasticity and capital utilization rate elasticity. As habits in consumption choices can only take values between zero and one, we set a beta prior distribution with mean 0.65 and standard deviation of 0.05. Following Burriel *et al.* (2010), we assume that the capital adjustment cost elasticity, η_k, is normally distributed with mean 10 and a wide standard deviation of 5.5. Finally, for the capital utilization rate elasticity we define a variable $\overline{\eta}_v$ such as $\eta_v = \frac{1-\overline{\eta}_v}{\overline{\eta}_v}$ and estimate the new variable assuming a beta distribution with mean 0.5 and standard deviation 0.1, as in Gertler *et al.* (2008). We additionally estimate the parameter governing the discount factor, χ assuming a prior mean of -500 and a standard deviation of 200.

Table 2: Prior and Posterior Distribution - Parameters

		Distr.	Prior Mean	St. Dev	Posterior Mean	Lower	Upper
Estimated Parameters							
μ	Lab supply wealth eff	*Uniform*	0.5	0.29	0.947	0.883	1.000
v	Frisch elast (μ=0)	*Gamma*	3.0	0.5	4.005	3.018	4.993
η	T Vs NT	*Gamma*	0.5	0.2	0.369	0.140	0.583
ϵ	home VS foreign	*Gamma*	1.5	1.0	3.195	2.741	3.655
h	habit formation	*Beta*	0.7	0.1	0.697	0.627	0.770
$\overline{\eta}_v$	Utilization rate elast	*Beta*	0.5	0.1	0.242	0.157	0.325
η_k	Capital adj cost elast	*Gamma*	10.0	5.5	23.511	15.425	31.276
θ	Good elasticity	*Norm*	7.5	1.0	8.350	6.862	9.741
θ_N	NT price rigidity	*Beta*	0.9	0.1	0.848	0.791	0.913
θ_h	T price rigidity	*Beta*	0.8	0.1	0.188	0.131	0.243
ϕ_N	NT indexation	*Beta*	0.5	0.1	0.493	0.412	0.577
ϕ_h	T indexation	*Beta*	0.5	0.1	0.435	0.351	0.517
χ	End discount weight	*Normal*	-500.0	200.0	-503.470	-819.223	-176.014
AR Coefficients							
ρ_{A_h}	T Techn	*Beta*	0.7	0.1	0.704	0.585	0.828
ρ_{A_N}	NT Techn	*Beta*	0.7	0.1	0.646	0.522	0.776
ρ_X	Labor Augmenting	*Beta*	0.4	0.1	0.398	0.229	0.555
ρ_ζ	Preference	*Beta*	0.7	0.1	0.853	0.776	0.934
ρ_{ϵ_L}	Labor	*Beta*	0.5	0.1	0.529	0.372	0.681
$\rho_{\epsilon_r b}$	Risk Prem	*Beta*	0.5	0.1	0.757	0.609	0.905
ρ_θ	NT Markup	*Beta*	0.3	0.1	0.240	0.098	0.375
ρ_ϕ	T Markup	*Beta*	0.3	0.1	0.302	0.141	0.468
ρ_{ϵ_I}	Invest	*Beta*	0.5	0.1	0.329	0.191	0.457
Foreign Block							
a_{11}	VAR, Y^{*d} to lag Y^{*d}	*Normal*	0.5	0.5	0.925	0.861	0.999
a_{12}	VAR, Y^{*d} to lag P_f^*	*Normal*	0.0	0.1	-0.017	-0.091	0.056
a_{13}	VAR, Y^{*d} to lag P_N^*	*Normal*	0.0	0.1	-0.046	-0.109	0.017
a_{21}	VAR, P_f^* to lag Y^{*d}	*Normal*	0.0	0.1	-0.008	-0.070	0.056
a_{22}	VAR, P_f^* to lag P_f^*	*Normal*	0.5	0.5	0.854	0.767	0.950
a_{23}	VAR, P_f^* to lag P_N^*	*Normal*	0.0	0.1	0.022	-0.040	0.079
a_{31}	VAR, P_N^* to lag Y^{*d}	*Normal*	0.0	0.1	0.099	0.051	0.148
a_{32}	VAR, P_N^* to lag P_f^*	*Normal*	0.0	0.1	0.034	-0.035	0.099
a_{33}	VAR, P_N^* to lag P_N^*	*Normal*	0.5	0.5	0.912	0.852	0.977
$100\sigma_u^{C^*}$	Foreign consump	*IGamma*	0.15	0.15	0.533	0.438	0.624
$100\sigma_u^{\pi_f}$	Foreign π_T	*IGamma*	0.15	0.15	0.483	0.404	0.564
$100\sigma_u^{\pi_N^*}$	Foreign π_{NT}	*IGamma*	0.15	0.15	0.303	0.248	0.358

NOTE: Posterior estimates of structural parameters are presented at the mean and at the lower and upper bound of the 90% highest posterior density interval.

Focusing on the supply side, we impose an equal markup in the tradable and non tradable sector ($\phi_T = \phi_N = \phi$) of 15 percent, by setting the prior mean of the elasticities of substitution between varieties to 7.5. The dynamics of prices are controlled by the price indexation, φ_j, and the probability of resetting prices, θ_j. We allow for different average duration of prices in the two sectors: following Álvarez *et al.* (2005), we set a prior duration of 5 quarters in the tradable sector and of 10 quarters in the non tradable sector. The price indexation is set a priori to be equal in the two sector with a beta distribution of mean 0.5 and standard deviation of 0.1.

Table 3: Prior and Posterior Distribution - Standard Deviations

		Distr.	Prior Mean	Prior St. Dev	Posterior Mean	Posterior Lower	Posterior Upper
Standard Deviation							
$100\sigma_{\zeta_{0,t}^{Ah}}$	T Techn	*IGamma*	0.15	0.15	1.951	1.436	2.463
$100\sigma_{\zeta_{0,t}^{An}}$	NT Tech	*IGamma*	0.15	0.15	0.133	0.047	0.226
$100\sigma_{\zeta_{0,t}^{X}}$	Labor Augmenting	*IGamma*	0.15	0.15	0.136	0.048	0.236
$100\sigma_{\zeta_{0,t}^{\zeta}}$	Preference	*IGamma*	0.15	0.15	4.431	2.658	6.096
$10\sigma_{\zeta_{0,t}^{I}}$	Invest	*IGamma*	0.15	0.15	4.590	2.861	6.269
$100\sigma_{\zeta_{0,t}^{L}}$	Labor	*IGamma*	0.15	0.15	0.143	0.045	0.258
$100\sigma_{\zeta_{0,t}^{r}}$	Int rate	*IGamma*	0.15	0.15	0.089	0.075	0.104
$100\sigma_{\zeta_{0,t}^{Sp}}$	Yield Spread	*IGamma*	0.15	0.15	0.139	0.045	0.243
$10\sigma_{\zeta_{0,t}^{\theta_N}}$	NT markup	*IGamma*	0.15	0.15	30.903	9.736	55.214
$100\sigma_{\zeta_{0,t}^{\theta_T}}$	T markup	*IGamma*	0.15	0.15	0.148	0.046	0.268
$100\sigma_{\zeta_{4,t}^{Ah}}$	Ant Ah	*IGamma*	0.075	0.075	0.080	0.023	0.145
$100\sigma_{\zeta_{4,t}^{An}}$	Ant An	*IGamma*	0.075	0.075	1.967	1.587	2.330
$100\sigma_{\zeta_{4,t}^{X}}$	Ant Labor Augmenting	*IGamma*	0.075	0.075	0.073	0.023	0.126
$100\sigma_{\zeta_{4,t}^{\zeta}}$	Ant Preference	*IGamma*	0.075	0.075	0.071	0.023	0.124
$100\sigma_{\zeta_{4,t}^{I}}$	Ant I	*IGamma*	0.075	0.075	0.069	0.022	0.123
$100\sigma_{\zeta_{4,t}^{L}}$	Ant L	*IGamma*	0.075	0.075	0.075	0.022	0.149
$100\sigma_{\zeta_{4,t}^{Sp}}$	Ant Yield Spread	*IGamma*	0.075	0.075	0.067	0.023	0.114
$100\sigma_{\zeta_{4,t}^{\theta_N}}$	Ant NT markup	*IGamma*	0.075	0.075	0.069	0.023	0.122
$100\sigma_{\zeta_{4,t}^{\theta_T}}$	Ant T markup	*IGamma*	0.075	0.075	0.073	0.022	0.122
$100\sigma_{\zeta_{10,t}^{Ah}}$	Ant Ah	*IGamma*	0.075	0.075	0.075	0.023	0.137
$100\sigma_{\zeta_{10,t}^{An}}$	Ant An	*IGamma*	0.075	0.075	0.066	0.023	0.112
$100\sigma_{\zeta_{10,t}^{X}}$	Ant Labor Augmenting	*IGamma*	0.075	0.075	0.074	0.023	0.135
$100\sigma_{\zeta_{10,t}^{\zeta}}$	Ant Preference	*IGamma*	0.075	0.075	0.069	0.023	0.123
$100\sigma_{\zeta_{10,t}^{I}}$	Ant I	*IGamma*	0.075	0.075	0.066	0.024	0.114
$100\sigma_{\zeta_{10,t}^{L}}$	Ant L	*IGamma*	0.075	0.075	5.993	4.640	7.292
$100\sigma_{\zeta_{10,t}^{Sp}}$	Ant Yield Spread	*IGamma*	0.075	0.075	0.994	0.305	1.677
$100\sigma_{\zeta_{10,t}^{\theta_N}}$	Ant NT markup	*IGamma*	0.075	0.075	0.074	0.023	0.136
$100\sigma_{\zeta_{10,t}^{\theta_T}}$	Ant T markup	*IGamma*	0.075	0.075	0.156	0.021	0.513

NOTE: Posterior estimates of standard deviations are presented at the mean and at the lower and upper bound of the 90% highest posterior density interval. Standard deviations are presented in percentage, a part from those of unanticipated non tradable markup and capital adjustment cost which are instead re-scaled by a factor of 10.

For the set of priors governing the persistence of shocks we assume a beta distribution with means and standard deviations consistent with previous studies. An inverse gamma distribution is imposed to the standard deviation of shocks. In order not to impose to much weight on anticipated shocks a priori, we assume that unanticipated sources of fluctuations explain two third of the total variance of the shocks (Table 3).

Finally, we allow for measurement errors in all the observable equations with the exceptions of nominal interest rate and foreign variables. Similarly to Adolfson *et al.* (2008)

we calibrate the variance of each measurement error to 10 percent of the variance of the corresponding observable series.

3.4 Posterior Distribution

Table 2 and 3 present the posterior mean, standard deviation and 90 percent intervals for the estimated parameters and standard deviations. The statistics are computed using the last fifty percent of five-hundred thousand draws generated with two random walk Metropolis Hastings chains with average acceptance rate close to 30 percent.

Interestingly, and differently from the previous estimation performed by Schmitt-Grohé and Uribe (2012), the wealth elasticity of labor supply is estimated to be non negligible and close to 1. Wealth changes are indeed estimated to be an important driver of labor supply movements. The posterior mean of μ is 0.95 and v is estimated to be 4. This two parameters imply a Frisch elasticity of labor supply of 0.15. While this value is low for standard macroeconomic estimation, it is in line with micro evidence. One possible explantion is the high estimated elasticity of capital adjustment cost, which is 23.5. In fact, this value insures a positive correlation between consumption and hours worked in response to anticipated shocks independently on the size of the elasticity of the labor supply to wealth changes. Notice that this elasticity, like the one of capital utilization, 0.24, or the habit formation in consumption, 0.7, is in line with previous estimates (e.g. Burriel *et al.* (2010)).

Estimated trade and tradable vs. non tradable elasticities are also closer to values found in micro-trade studies, compared to previous macro-estimates. First, the posterior mean of the trade elasticity, ϵ, is equal to 3.2. This implies a degree of substitutability between home and foreign produced tradable goods significantly larger than previous macro-findings. It is in fact still below, but not too far, from the estimation results of Cabral and Manteu (2011), which use Euro Area micro-disaggregated data. Second, the elasticity of substitution between tradable and non tradable goods, η, is smaller than ϵ and it is equal to 0.37, in line with micro estimates. Figure 2 shows that data are indeed informative, especially for the trade elasticity. In fact, while the prior is skewed towards low values of ϵ, in line with previous macro-findings, the posterior sharply identifies a bigger trade elasticity.

Prices are significantly more persistent in the non tradable sector than in the tradable sector. Average duration in the non tradable sector is around 6 quarters while in the tradable sector prices change every 5 months. Past price indexation, on the other hand, is similar in both sectors. The estimated elasticity of substitution between varieties implies a markup of

Elasticities of Substitution

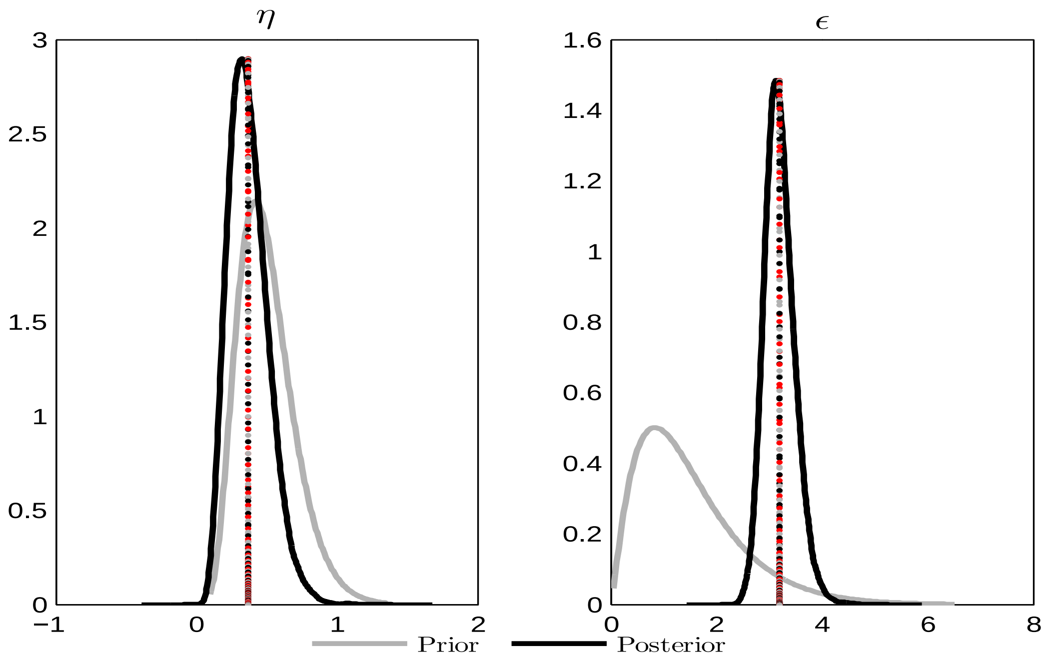

Figure 2: Prior and Posterior densities. Dotted line represent the posterior mean.

13.6 percent.

The autoregressive parameters tell us that shocks are not particularly persistent. Focusing on technology, an interesting result is that sector specific shocks are more persistent than common labor augmenting fluctuations. In particular, the estimated process for the productivity shock is slightly more persistent in the tradable, 0.7, than in the non tradable sector, 0.65. Preference and risk premium shocks are the most persistent fluctuations.

Table 4 compares the first and the second moments of the data with the one implied by the model. First moments are matched fairly well, given the calibrated deterministic trend, with some exceptions: current account is zero in steady state while it was on average negative in the sample period; investment was growing twice faster than output and therefore the model, which assigns the same trend to GDP, consumption and investment, fails to match investments' average growth; the steady state real exchange rate is positive in the model, given the higher average growth of IPS with respect to the rest of the EMU, but negative in the data. Looking at the second moments, while the model is doing a good job in matching standard deviation of the current account, it does less well in matching the volatility of the other variables. The possible explanation is linked to the characteristics of the sample period under investigation. Episodes in which consumption is more volatile than output and current account has large imbalances are often hard to reconcile with open economy models. Aguiar and Gopinath (2007) show how a standard small open economy model without trend growth is unable to match data moments. The hint that this low performance of the model is related to the higher relative volatility of consumption comes from the results of a second estimation we performed excluding consumption from the observable variables. Columns 6 and 7 of Table 4 show in fact that, without consumption as an observable, the model matches better the second moments of the data (estimated parameters and variance decomposition of the model are available in the online appendix). However, in the analysis, we use the baseline estimation because we argue that it is important to match the observed behavior of consumption in order to explain the experienced imbalances in IPS.

Table 4: Data and Model Moments

	Data		Model		Model no ΔC	
	Mean	Std dev	Mean	Std dev	Mean	Std dev
Δ CA	-0.34	1.33	0	1.51	0	1.70
Δ ReR	-0.34	0.43	0.40	1.43	0.40	1.22
Δ Y	0.92	0.34	0.97	1.37	0.97	0.45
Δ I	1.72	1.81	0.97	2.84	0.97	2.77
Δ C	0.91	0.92	0.97	1.70		
Δ L	-0.08	0.36	0	1.38	0.00	0.46
r	0.88	0.25	1.04	0.16	0	1.03
p_T^*	0	0.92	0	1.03	1.04	0.16
p_{NT}^*	0	0.98	0	1.52	0	1.52
Y_d^*	0	1.35	0	1.65	0	1.67

NOTE: Sample period Q1:1996-Q4:2007. Theoretical moments are displayed for the model. The last two columns are the moments of the same model estimated without consumption as an observable. Variable listed are, in order: current account (CA), real exchange rate (ReR), GDP (Y), investment (I), consumption (C), hours worked (L), short term nominal interest rate (r), foreign tradable and non tradable prices (p_T^* and p_{NT}^*), foriegn GDP (Y_d^*).

The estimation results are robust to standard tests and parameters are locally identified at the prior and posterior mean (Iskrev, 2010). For all parameters and standard deviations the draws of the posterior sampling converge, smoothed shocks are stationary and looking at the prior-posterior distributions we see that data are informative for all parameters. The only exception is χ, the parameter governing the endogenous discount factor, for which the data seem uninformative and the posterior retrace the prior (see the online appendix). This is not surprising as this parameter is chosen ad hoc in the literature and the specific value is not important as long as it ensures the presence of a stable non-stochastic steady state independent from initial conditions. Estimation results are robust if, instead of estimating this parameter, we calibrate it.

4 What explains current account imbalances in IPS?

Ireland, Portugal and Spain, from 1996 to 2007, accumulated current account deficit, experienced real exchange rate appreciation and grew above trend (Figure 1(b)). Current events in the euro area have shown that international imbalances, in particular current account and real exchange rate misalignments, have contributed to exacerbate the vulnerability of the European Monetary Union periphery. Accordingly, it has become important to understand what caused these imbalances. The purpose of this section is twofold: first, to uncover the sources of the current account imbalances experienced in the euro area periphery before the Great Recession through an impulse response analysis; second, to assess the importance of anticipated vs unanticipated shocks for current account, real exchange rate and GDP fluctuations exploiting the estimation results.

As in Giavazzi and Spaventa (2011) and Eichengreen (2010), we have in mind a distinction between types of current account imbalances depending on their underlying source. Some are driven by growth differentials, that allow surplus countries to invest in future growth of the borrowing countries, and others are triggered by other factors, as for example financial factors. The hypothesis that capital, inside the EMU, was flowing towards "catching-up" countries with higher current or expected productivity growth has been show, in recent empirical studies, to be unlikely.[28]

In section 4.1 we start by investigating if IPS current account imbalances were indeed the result of capital flowing towards "catching-up" euro area countries or instead were caused by other factors. We do that by first analyzing in details if unanticipated and anticipated productivity shocks (common or sector specific) are consistent with widening of current account deficits jointly with appreciating real exchange rate and growing GDP. Then, we check if other plausible sources can drive the observed joint dynamics of those three variables. The joint focus on the three variables and the use of an estimated model allow us to distinguish between otherwise observationally equivalent current account deficits. Next, in section 4.2, we quantify the role of unanticipated and anticipated shocks. This is done through a variance

[28]Zemanek *et al.* (2009) and Berger and Nitsch (2014), among others, suggest that in fact capital was flowing towards countries not only with higher per capita GDP growth but also with higher domestic distortions. See also Schmitz and von Hagen (2011), Sodsriwiboon and Jaumotte (2010), Barnes (2010) and Belke and Dreger (2013) for the dynamics and consequences of large current account deficits in the euro area from a policy perspective.

decomposition analysis by showing the percentage of the variance of each variable explained by each unanticipated and anticipated shock.

4.1 Impulse Responses

We study the dynamics of the model in response to a wide range of possible shocks at the posterior mean. For every source of fluctuation we consider the unanticipated component but we also allow for the possibility that agents learn in advance that a shock will realize in the future. We refer to these shocks as anticipated shocks. In this section we look at the baseline model presented in section (2) in which we have Jaimovich and Rebelo (2009) utility function and anticipated shocks in the form of news shocks. Later, in the robustness section, we will check the implications of these two assumption: section 5.1 presents the results assuming a separable utility function and section 5.2 introduces noise shocks instead of news shocks.

We consider 10 different sources of fluctuation: sector-specific technologies, labor augmenting technology, preference, investment efficiency, labor supply, sector-specific markups, monetary policy and yield spread. The focus is on the reaction of GDP, current account and real exchange rate. We aim at selecting the shocks capable of generating the experienced contemporaneous movement of those three variables (Figure 1(b)).

4.1.1 Productivity shocks

In order to highlight some important mechanism common to productivity shocks, we start by analyzing, in details, the reaction of the economy to unanticipated productivity shocks first in the tradable and then in the non tradable sector. This, jointly with the following analysis of the role of the trade elasticity (Figure 6), allows us to understand how current account and real exchange rate react to productivity shocks. The interaction between the shift in the supply curve, due to the decrease in marginal cost, and the movements in the domestic demand, generated by the change in wealth, will play the most important role.

When tradable technology jumps up (Figure 3), GDP, consumption and investment increase; the positive wealth effect, from the raise in current and future output, drives consumption fluctuations while the improved marginal productivity of capital moves investments. In the intermediate production sector, higher productivity, combined with higher demand for intermediate goods, pushes up firms' demand for labor and capital in the tradable sector, generating an increase in wages and in the rental rate of capital. While this is not sufficient

Unanticipated Tradable Productivity Shock

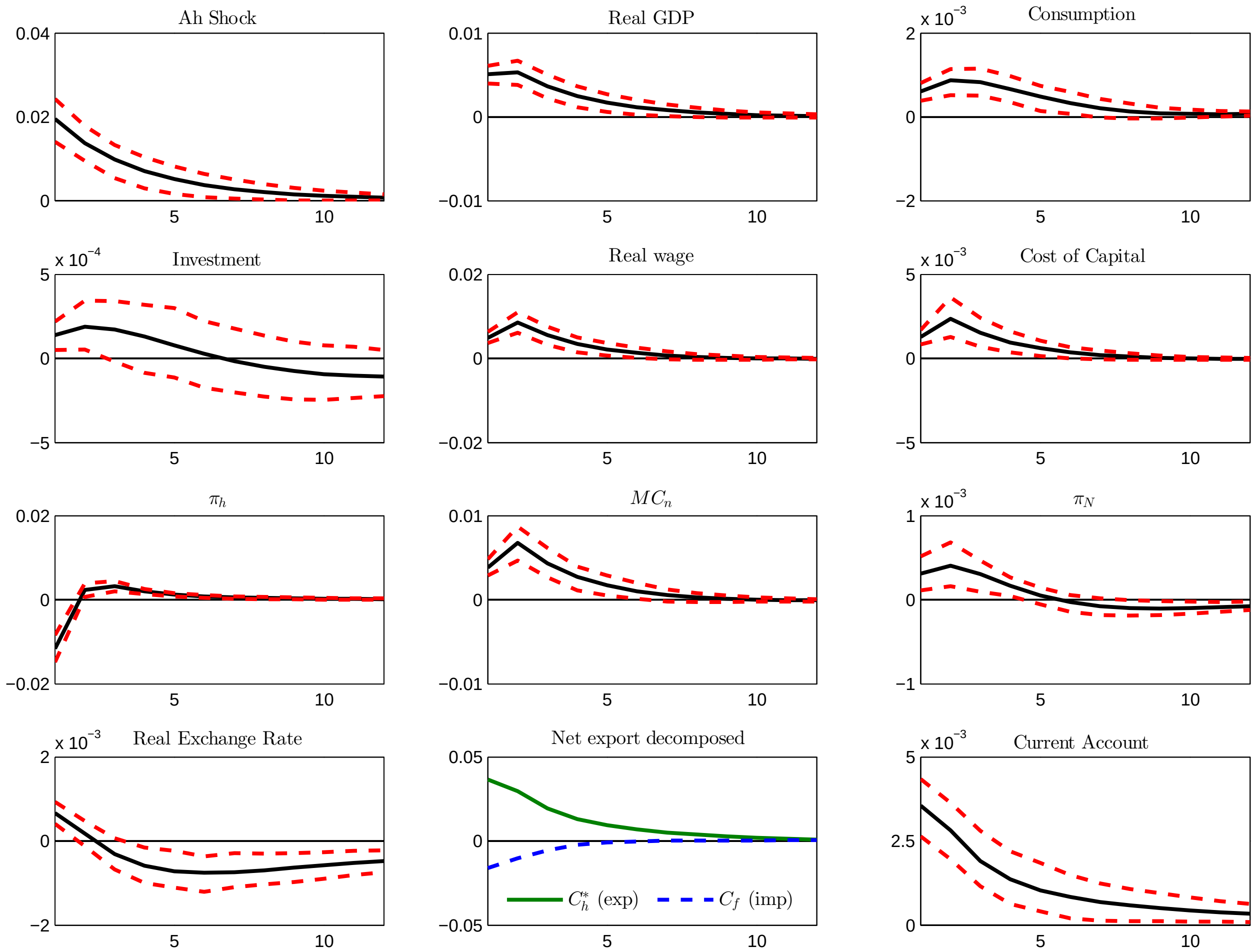

Figure 3: Impulse response to a positive one standard deviation unanticipated technology shock in the tradable sector. Note: an increase in the real exchange rate corresponds to a depreciation.

to increase the cost of production in the tradable sector, it triggers an increase in the marginal cost of the non tradable sector. As a result, non tradable prices increase but, differently from the classical Balassa-Samuelson set up, not sufficiently to compensate the decrease in prices in the tradable sector. This leads to a drop in the domestic aggregate price and a real exchange rate depreciation.[29] As international competitiveness improves, net export increases, both for an increase in export and a decrease in import, and current account goes on surplus.

Turning to non tradable productivity shocks, similarly to before, current account respond by going on surplus and real exchange rate depreciates (Figure 4). However, differently,

[29]Given the estimated trade elasticity, a big part of the increase in production is sold abroad. Therefore, even in the presence of home bias, we will have market clearing in the domestic tradable sector with depreciated real exchange rate. This holds true on impact because, in the domestic economy, the positive wealth effect coming from the increase in world demand for domestic goods more than offsets the negative effect due to the terms of trade depreciation.

GDP only slightly increases and aggregate domestic demand falls on impact. This is due to the fact that the underneath equilibrium dynamics are completely different for the two shocks. Two are the main distinctions: first, all non tradable production has to be consumed domestically and second, prices in the non tradable sector are relatively less flexible. In fact, while consumption and investment augment, the increase in potential non tradable production is not followed by an equivalent increase in non tradable demand. This is due to the price behavior and to the complementarity of non tradable to tradable goods. With full flexibility, prices would sufficiently decrease in order to generate a positive substitution effect towards non tradable goods to clear the higher production. However prices, especially in the non tradable sector, are extremely sticky and therefore non tradable firm decide to lower production by decreasing the demand for capital and labor. This lowers wages and the rental rate of capital with an additional twofold negative effect on non tradable demand: first it decreases the positive wealth effect on consumption (lower wages) and second, it drops the marginal cost in the tradable sector. Because prices in the tradable sector are relatively more flexible, their higher adjustment generates a substitution effect that additionally reduces the demand for non tradable goods. The final equilibrium effect is that on impact production increases in the tradables but decreases in non tradables contemporaneously to a drop in both sector prices. This generates a real exchange rate depreciation and a current account surplus. After the first two quarter, as prices adjust more, both tradable and non tradable sector production increases.

Summarizing, an unanticipated shock both in the tradable and in the non tradable sector cannot match the observed evidence for IPS as it generates a current account surplus and a real exchange rate depreciation. Therefore, not surprisingly, the same result is found in response to a common labor augmenting unanticipated productivity shock. The main idea is that while Balassa-Samuelson sectorial prediction is satisfied (in response to tradable productivity shocks), meaning an increase in the non tradable-tradable price ratio, this is not sufficient to generate a real exchange rate appreciation. We then move to check if anticipated shocks can instead explain the observed evidence.

Only tradable anticipated productivity shock can temporarily reproduce a GDP increase characterized by real exchange rate appreciation and current account deficit (Figure 4). In fact, before the actual realization of the shock, agents discount the future increase in wealth and smooth consumption. This pushes up home tradable and non tradable goods' prices generating a substitution towards relatively cheaper foreign imports. On one hand the in-

TFP shocks

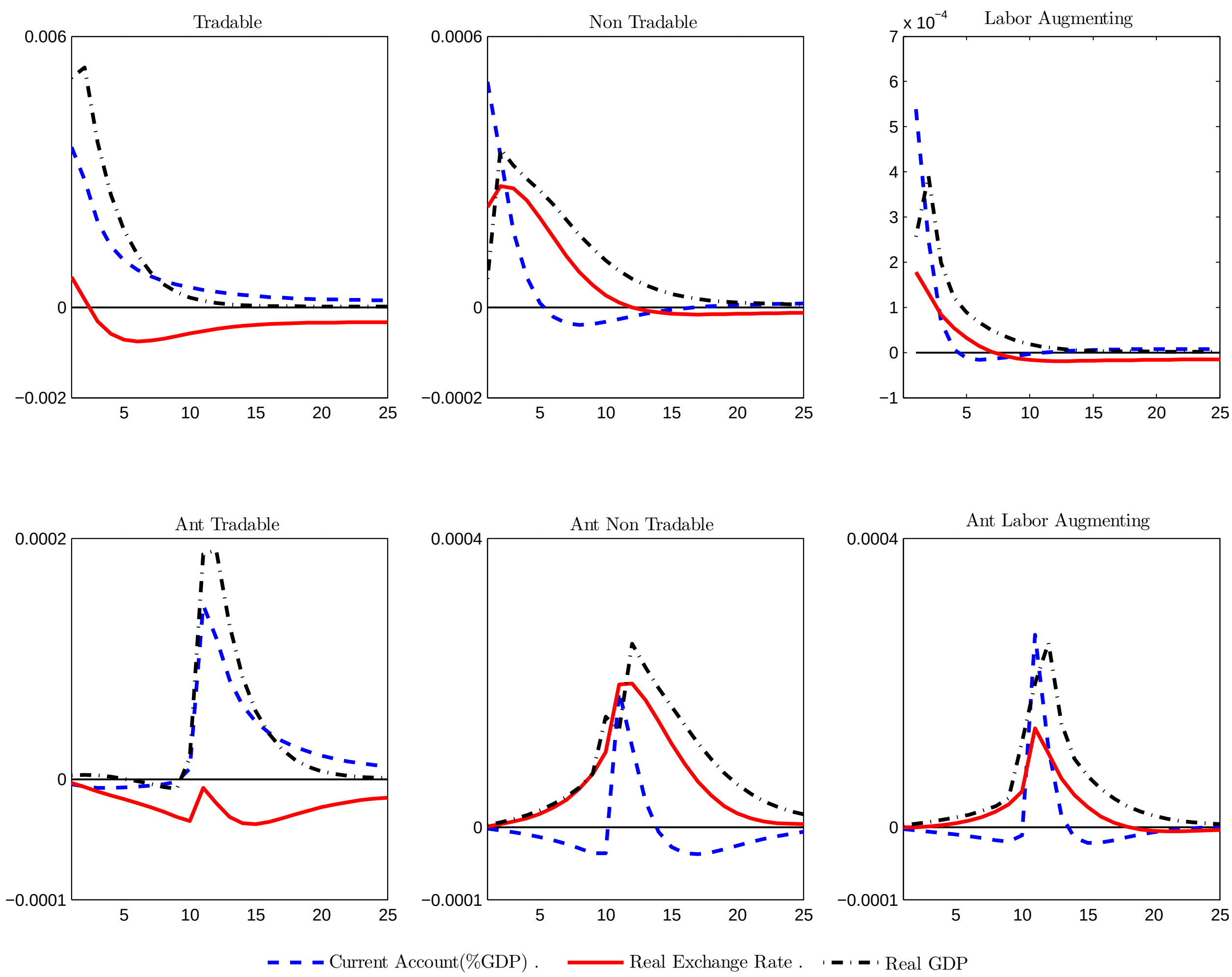

Figure 4: Impulse responses of current account(% of GDP), real GDP and real exchange rate to one standard deviation sector specific and labor augmenting anticipated and unanticipated technology shocks. Note: an increase in the real exchange rate corresponds to a depreciation.

crease in demand generates an increase in GDP, on the other hand the increase in prices leads to a real exchange rate appreciation and a decrease in exports. Increases in imports and decreases in exports lead to a current account deficit. This holds true until the shock actually realizes. Then, the economy follows the dynamic explained previously turning current account into persistent surplus and temporarily depreciated exchange rate. Therefore, to be able to explain IPS observed evidence in terms of anticipated productivity shock, it is necessary to assume that agents, starting in 1996, were anticipating tradable productivity to increase not earlier than 10 years later or were expecting always larger anticipated shocks in the tradable sector. This is extremely difficult to reconcile with IPS given that they experienced, since 1996, a lowering tradable productivity. Figure (5) shows in fact the decreasing path of tradable TFP with respect to the long run productivity average using the EUKLEMS database.[30]

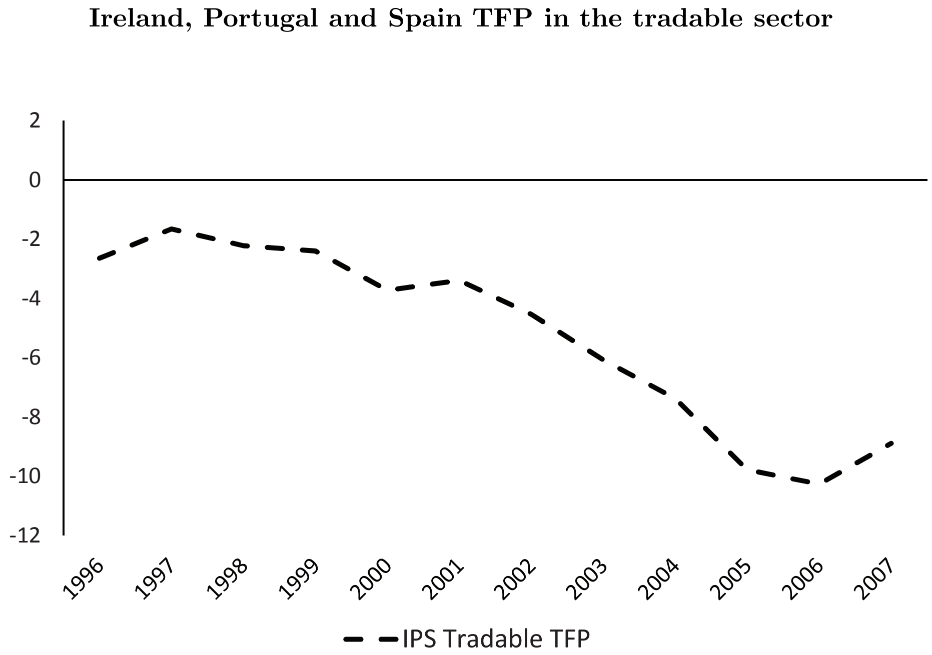

Figure 5: Total factor productivity path in the tradable sector calculated in percent deviation from the trend. The trend is calculated as the average TFP in 1981-2007 for Spain, in 1989-2007 for Ireland and in 1996-2007 for Portugal. Source EUKLEMS database and own calculations.

The inability of the estimated model to generate a lasting current account deficit and a real exchange rate appreciation in response to a positive technology shock depends strongly on the estimated values of three parameters: the trade elasticity, the elasticity of tradable and non tradable goods and the persistence of productivity shocks. As clearly explained in Corsetti *et al.* (2008), in presence of really low trade elasticity and home bias, the real exchange rate appreciates and the current account goes on deficit in response to productivity shocks. This is true because an appreciation, and the subsequent increase in wealth, is necessary to trigger a sufficient increase in demand for the home produced tradable goods, which are mostly domestically consumed and not highly substitutable with foreign goods. Figure 6 shows that our model is consistent with this finding if calibrated with parameter values different from the estimated one. In fact, it shows how the real exchange rate and the current account

[30]Note that the negative slope of tradable TFP is independent on the choice of the trend (average productivity). The TFP path is constructed using the EUKLEMS database and following the procedure suggested by Batini *et al.* (2009). Tradable sector is identified with "Manufacturing" while the non-tradable is constructed as a weighted average of "Wholesale and retail trade", "Electricity, gas and water supply", and "Transportation, storage, and communication". Relative value added, from the same database, are used as weights. Trends are computed using TFP country average using the entire time series. Annual HICP relative household consumption expenditure shares are used as weights for aggregating IPS.

Trade elasticity, tradable vs non tradable elasticity and persistence

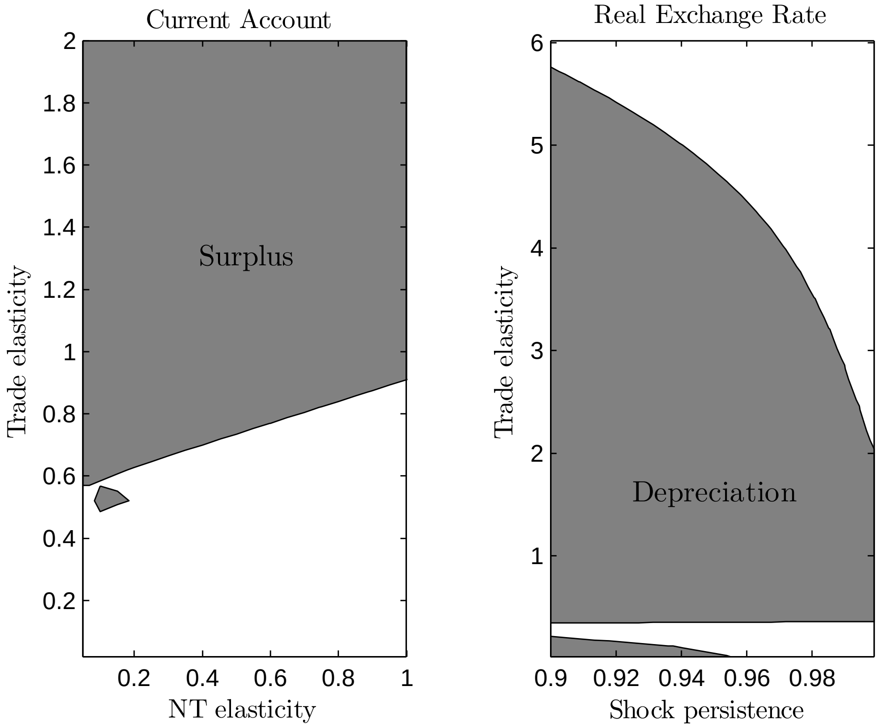

Figure 6: LHS: Impact of a tradable technology shock on current account(% of GDP) for different trade (ϵ) and tradable vs. non tradable elasticities (η). RHS: Different reaction of the real exchange rate for different values of the trade elasticity and the persistence of the tradable productivity shock (ρ_{A_h})

respond to a positive unanticipated tradable productivity shock when we allow the three crucial parameters to vary. First, the left panel of Figure 6, exhibits how trade and tradable vs. non tradable elasticities interact. In order to generate a current account deficit in the presence of high trade elasticity, the model needs to assume high tradable vs. non tradable elasticity. Second, the right panel of Figure 6, shows that in order to generate an appreciation with higher values of the trade elasticity, it is necessary to assume that productivity shocks are extremely persistent. This is necessary to generate a sufficiently large wealth effect to put upward pressure on prices. To conclude, we take this as evidence that it is important to estimate these parameters to assess the drivers of international imbalances.

4.1.2 Other shocks

Having shown that none of the productivity shocks included in the model can generate the persistent observed contemporaneous movement of the current account, the real exchange rate and GDP, we study the reaction of the model to all other shocks. Figure 7 highlights the responses to a drop in the yield spread, Sp_t, to an improvement in the investment technology, ϵ^I, to a positive labor supply shock, ϵ_t^L, and finally to a positive demand shock, ϵ^{ζ_t}.

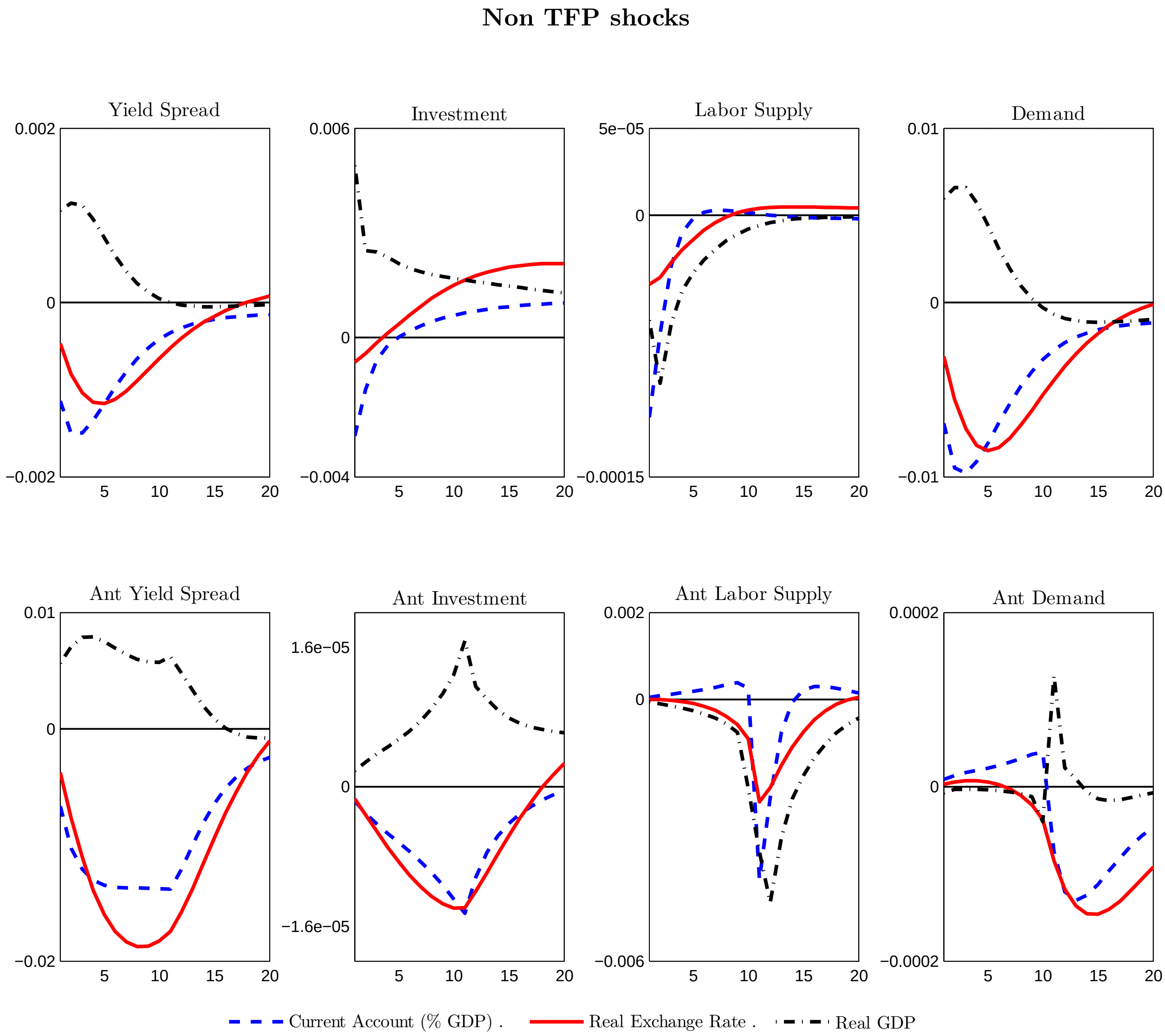

Figure 7: Impulse response of current account(% of GDP), real GDP and real exchange rate to one standard deviation unanticipated and anticipated drop in the yield spread, increase in the investment efficiency, positive labor supply shock and positive demand shock. Note: an increase in the real exchange rate corresponds to a depreciation.

Five shocks generate a simultaneous deterioration of the current account, appreciation of the real exchange rate and increase in GDP: unanticipated and anticipated yield spread drops, unanticipated and anticipated investment efficiency increases and unanticipated positive demand shocks.[31] Unanticipated positive investment specific shock, however, can explain only a short-lived real exchange rate appreciation. Instead, labor supply and anticipated demand

[31] Also monetary policy shock are able to replicate the observed dynamics. The figure however is similar to unanticipated yield spread and it is not going to be shown. Notice that in this small open economy, it is difficult to disentangle between the two shocks a priori. Only through the estimation, thanks to the fact that the ECB rate is included as a data series, the two can be disentangled.

shock fail to explain the joint behavior as they respectively imply co-movement between GDP and depreciation and recessionary pressures between the news and the realization of the shock.

Not surprisingly, the dynamics generated by an unanticipated drop in the yield spread and an increase in demand are somehow similar but for one variable, investment. Both shocks lead to an increase in consumption that generates an increase in the demand for both tradable and non tradable goods. This pushes up prices in both sectors (but less than optimally, given the stickiness of prices) and firms respond with an increase in the demand for labor and capital. Wages and the rental rate of capital go up, leading to an increase in marginal costs. The result is an appreciation of the terms of trade and of the real exchange rate. The current account deteriorates both because of the increase in demand but also because of the lower price competitiveness of exportable goods. So far the dynamics implied by a decrease in the cost of borrowing and a pure shift in preferences are similar. However, the two shocks imply opposite reactions of real investment: a drop in the cost of borrowing leads to an increase of investments while a demand shock leads to a decrease of it (crowding out).[32] Between 1996 and 2007, IPS experienced a persistent increase in real investment, as shown in Figure 1(d), allowing us to conclude that the demand shocks cannot be alone the main driver of the imbalances in the euro area periphery.

Similarly, an anticipated increase in investment efficiency fails to match the dynamic of one variable, consumption. In this case, the increase in output is entirely driven by the immediate and slow increase in investment which, in the periods between the news and the realization of the shock, results in increasing marginal costs for firms. Firms respond by increasing prices and consumption decreases. Therefore, even though an anticipated investment shock leads to a real exchange rate appreciation and a current account deficit, it cannot be the main driver of the observed imbalances: in IPS periods of current account deficits were often characterized by raising consumption.[33]

Differently, unanticipated and anticipated drops in the yield spread can match contemporaneously the behavior of all macro variables: increasing GDP, raising consumption and investment, current account deficit and real exchange rate appreciation. In fact, a decrease in the yield spread generates a decrease in the cost of borrowing which shifts current aggregate demand through an increase in consumption and investment. This pushes up domestic

[32]For picture legibility investment responses are shown in the online appendix and not in Figure 7.

[33]Notice, in fact, that unlike investment, consumption in IPS oscillated around its steady state.

tradable and non tradable prices and results in a real exchange rate appreciation.[34] The appreciated exchange rate and the increase in import demand turn net exports and current account into deficit. Following the same mechanism, anticipated yield spread shocks imply the same economic response but more persistent in time. This is due the fact that household prefer to adjust smoothly (due to habit persistence and large adjustment costs) and therefore start consuming and investing at the acknowledgment of the news. Therefore, from the impulse response analysis, we conclude that unanticipated and anticipated drops in the yield spread are the only sources that alone could explain the experienced current account imbalances. In line with this result there is the evidence that between 1996 and 2007 IPS experienced a large and unprecedented decrease in the relative cost of borrowing (Figure 1(c)). Notice that this decrease happened in two phases: an abrupt decrease between 1996 and 1997 and a slower but persistent decrease in the period between 2002 and the third quarter of 2006.[35]

4.2 The importance of anticipated shocks

This section adds quantitative estimation results to the qualitative impulse-response analysis of the previous section. First, it quantifies the role of unanticipated vs. anticipated shocks for current account, real exchange rate and output fluctuations. Second, it assess the role of yield spread shocks, among other shocks, as a driver of the experienced imbalances.

Anticipated shocks have been estimated to be important drivers of closed-economy business cycle fluctuations. In this section we check if these shocks are also important for movements of open-economy macroeconomic variables such as the current account and the real exchange rate. Through a variance decomposition analysis (Schmitt-Grohé and Uribe, 2012) we assess the relative importance of unanticipated vs. anticipated shocks for output growth, current account changes and real exchange rate movements.

Table 5 displays the aggregate share of unconditional variance explained by unanticipated and anticipated shocks. The latter is displayed separating the short from the long horizon. Anticipated shocks account for 62 percent of current account movements, 48 percent of real exchange rate fluctuations and 35 percent of GDP growth variability. The role of anticipated

[34]This results are in line with empirical estimates of responses of inflation and industrial production to an exogenous increase in the spread (see Gilchrist and Mojon (2016)).

[35]Even though interest rate spread is not among our observable variables in the estimation, the smoothed values of the spread implied by the model does a reasonable job in matching the mean (model 0.87, data 0.51) and the variance (model 0.102, data 0.138) of the observed changes in the spread.

Table 5: Share of Variance Explained by Anticipated Shocks

Shock	Δ GDP	Δ Current Account(% of GDP)	Δ Real Exchange rate
Unanticipated	65.39	37.65	51.63
4-Quarters Anticipated	11.40	22.97	7.21
10-Quarters Anticipated	23.15	38.60	41.09

Note: Unanticipated and anticipated shocks grouped by the length of anticipation. The unconditional variance decomposition is computed at the mean of the posterior distribution.

shocks is therefore even more pronounced for current account and real exchange rate fluctuations than for GDP growth. This is consistent with the idea that the current account, defined as the change in net foreign asset, captures indeed the inter-temporal feature of international trade and that swings in expectations are crucial drivers of international relative prices.

Moving to more detailed results, Table 6 presents the disaggregated contribution of all shocks to the variance of the three variables. First, we focus on GDP growth. Seven shocks are almost equally responsible for its fluctuations: unanticipated tradable and anticipated non tradable productivity, unanticipated demand, anticipated labor supply, unanticipated investment specific, anticipated yield spread and unanticipated tradable markup. On top of some results in line with the literature, such as the importance of investment specific productivity shocks (Justiniano *et al.* (2010)[36]) or of labor supply and preferences for countries like Spain (Burriel *et al.* (2010)), we learn that 17% of GDP growth movements are explained by the reaction of the economy to anticipated shocks in the spread. A sizable fraction of GDP growth fluctuations is explained by TFP shocks: 15 % by unanticipated tradable shocks and 11% by anticipated non tradable shocks.

Current account changes are explained almost entirely by four shocks: anticipated yield spread (26%), unanticipated demand (25%), anticipated non tradable productivity (23%) and anticipated labor supply (12%). The remaining part is explained by unanticipated tradable productivity and investment specific shocks. In line with the impulse response analysis, anticipated yield spread and unanticipated demand shocks are important sources of the experienced current account deficit as they imply a contemporaneous real exchange rate appreciation and GDP growth. For yield spread shocks, the variance decomposition analysis helps us to assign to the anticipated component, with respect to the unanticipated one, the main explanatory power of current account fluctuations. Demand shifts also explain one fourth of current account fluctuations but, as we saw in the impulse response analysis, they

[36]However notice that we do not include in the set of observable variables the relative price of investment which can be a reason of why we find investment specific shocks important for output growth fluctuations.

Table 6: Unconditional Variance Decomposition

Shocks		Δ GDP	Δ Current Account(% GDP)	Δ Real Exchange rate
Tradable tech.	$u_{0,t}^{AH}$	14.9	5.3	0.4
	$u_{4,t}^{AH}$	0.0	0.0	0.0
	$u_{10,t}^{AH}$	0.0	0.0	0.0
	Σu^{AH}	15.0	5.4	0.4
Non tradable tech.	$u_{0,t}^{AN}$	0.0	0.1	0.0
	$u_{4,t}^{AN}$	11.3	22.8	7.1
	$u_{10,t}^{AN}$	0.0	0.0	0.0
	Σu^{AN}	11.3	22.9	7.1
Labor augmenting prod.	$u_{0,t}^{X}$	0.0	0.1	0.0
	$u_{4,t}^{X}$	0.0	0.0	0.0
	$u_{10,t}^{X}$	0.0	0.0	0.0
	Σu^{X}	0.0	0.1	0.0
Demand	$u_{0,t}^{\zeta}$	21.2	25.3	13.3
	$u_{4,t}^{\zeta}$	0.0	0.0	0.0
	$u_{10,t}^{\zeta}$	0.0	0.0	0.0
	Σu^{ζ}	21.2	25.3	13.3
Labor supply	$u_{0,t}^{L}$	0.0	0.0	0.0
	$u_{4,t}^{L}$	0.0	0.0	0.0
	$u_{10,t}^{L}$	5.8	12.4	1.8
	Σu^{L}	5.8	12.4	1.8
Investment specific	$u_{0,t}^{I}$	14.4	4.2	0.5
	$u_{4,t}^{I}$	0.0	0.0	0.0
	$u_{10,t}^{I}$	0.0	0.0	0.0
	Σu^{I}	14.4	4.2	0.5
Monetary Policy	u_{t}^{r}	0.6	0.6	0.3
Yield spread	$u_{0,t}^{Spread}$	0.5	0.5	0.3
	$u_{4,t}^{Spread}$	0.1	0.2	0.2
	$u_{10,t}^{Spread}$	17.4	26.2	39.3
	Σu^{Spread}	18.0	26.9	39.7
Markup - tradable	$u_{0,t}^{\theta}$	12.6	1.4	34.0
	$u_{4,t}^{\theta}$	0.0	0.0	0.0
	$u_{10,t}^{\theta}$	0.0	0.0	0.0
Markup - Non tradable	$u_{0,t}^{\phi}$	0.0	0.0	0.0
	$u_{4,t}^{\phi}$	0.0	0.0	0.0
	$u_{10,t}^{\phi}$	0.0	0.0	0.0
	Σu^{I}	12.6	1.4	34.0
Foreign Tradable price	$u_{t}^{\Pi_T *}$	1.0	0.2	0.0
Foreign Non Tradable price	$u_{t}^{\Pi *}$	0.0	0.0	2.5
Foreign consumption	u_{t}^{c*}	0.1	0.0	0.3
	Σu^{*}	1.1	0.2	2.8

Note: The unconditional variance decomposition is computed at the mean of the posterior distribution.

cannot be the only driver of the deficit as they fail to generate an increase in investment. Moving to anticipated labor supply shocks, the important role for current account and GDP fluctuations is explained by the lack of a properly modeled demographic evolution for IPS. In fact a labor supply shock, as it reduces hours worked for the given wages, resemble an increase in population (Burriel *et al.*, 2010).

Focusing on the real exchange rate, table 5 shows that anticipated shocks play an important role as they explain half of its variability. This is almost entirely imputable to anticipated shocks to the yield spread. In fact, as shown in the impulse response analysis, anticipated decrease in the spread generate persistent real exchange rate appreciations, which matches the observed evidence for IPS. Two are the main unanticipated component explaining changes in real exchange rate movements: demand and cost-push shock in the tradable sector, which roughly account for half of the unconditional variance.

The results from the variance decomposition analysis confirm and strengthen the previous findings. Yield spread shocks are the main driver of the experienced imbalances in IPS. In particular, anticipated long run fluctuations in the risk premium are behind the joint dynamics of the current account, the real exchange rate and GDP.

5 Robustness checks

In this section we propose two different specifications of the model to check the robustness of our results. First, we remove Jaimovich and Rebelo type of preferences and we estimate the model using preferences separable in consumption and leisure. Second, we substitute certain with uncertain anticipated shocks (news vs. noise) to check the role of the chosen structure of anticipated shocks. The results of the paper hold in both model specifications.

5.1 Separable preferences

In order to make sure that our estimation and main results are not driven by the choice of the Jaimovich and Rebelo (2009) utility function, which allowed us to directly estimate the wealth elasticity of the labor supply, we substitute it with preferences separable in consumption and hours worked:

$$U(C_t, L_t) = \left\{ log(C_t - h^B C_{t-1}) - \epsilon_t^L \psi^L \frac{L_t^{1+\nu}}{1+\nu} \right\}. \tag{31}$$

ψ^L is a labor supply preference parameter, ν is the inverse of the Frisch elasticity of labor supply and, as before, ϵ_t^L denotes a labor supply shock. The representative agent will then maximize his/her utility function (1) subject to (2), (7), (8), (9) and to the utility function (31) (see the online appendix for the details). The remaining part of the model is equivalent to the baseline specification presented in section 2.

We calibrate v, the inverse elasticity of work effort with respect to the real wage, to 1 (Smets and Wouters, 2003) and keep the calibration of the other parameters as in the baseline model. We estimate the model and generate statistics using the last 50 percent of five hundred thousands draws generated with four random walk Metropolis Hastings chains. Estimated parameters and standard deviations, shown in the online appendix, are not statistically different from the baseline estimation. The only two exceptions are the persistence of labor supply shocks which is significantly less persistent and the standard deviation of the anticipated labor supply shock which is larger.

Using parameters and standard deviations at the mean of their posterior distribution, we analyze the impulse response to all shocks and perform the variance decomposition of GDP growth, current account changes and real exchange rate fluctuations. Results from the impulse-response analysis are confirmed: only unanticipated and anticipated yield spread shocks can jointly account for current account deficit, real exchange rate appreciation and GDP above trend. Interestingly, the variance decomposition analysis validate the important role played by anticipated shocks, and in particular by yield spread shocks for changes in current account (26%), in real exchange rate (39%) and in real GDP growth (17%), but assigns a bigger role of current account fluctuations to anticipated labor supply shocks (36%). The reason is the ability of the Jaimovich and Rebelo (2009) preferences to control better the behavior of the labor supply. However, the confirmation of the importance of anticipated labor supply shocks for current account fluctuations pushes for a model with a more detailed labor market sector which allows to properly understand the role of demographic flows in the build up of current account in IPS.

To summarize, we take this results as a confirmation that anticipated shocks, and in particular yield spread shocks were important sources of the experienced current account imbalance in IPS.

5.2 Imperfect Information

We check also if our results hold assuming a different structure and rationale for anticipated shocks. We move away from a setup where all agents have full and perfect information, and therefore shocks were anticipated with certainty, and we introduce imperfect information. We are interested in understanding if imperfectly anticipated movements in productivity can explain IPS imbalances. In fact, Hoffmann *et al.* (2017) showed that imperfectly anticipated productivity shocks can explain fairly well the accumulated current account deficit experienced inside the United States.

We modify the setup of the model and we concentrate on labor productivity movements because we assume that those are the only imperfectly observed elements in our economy.

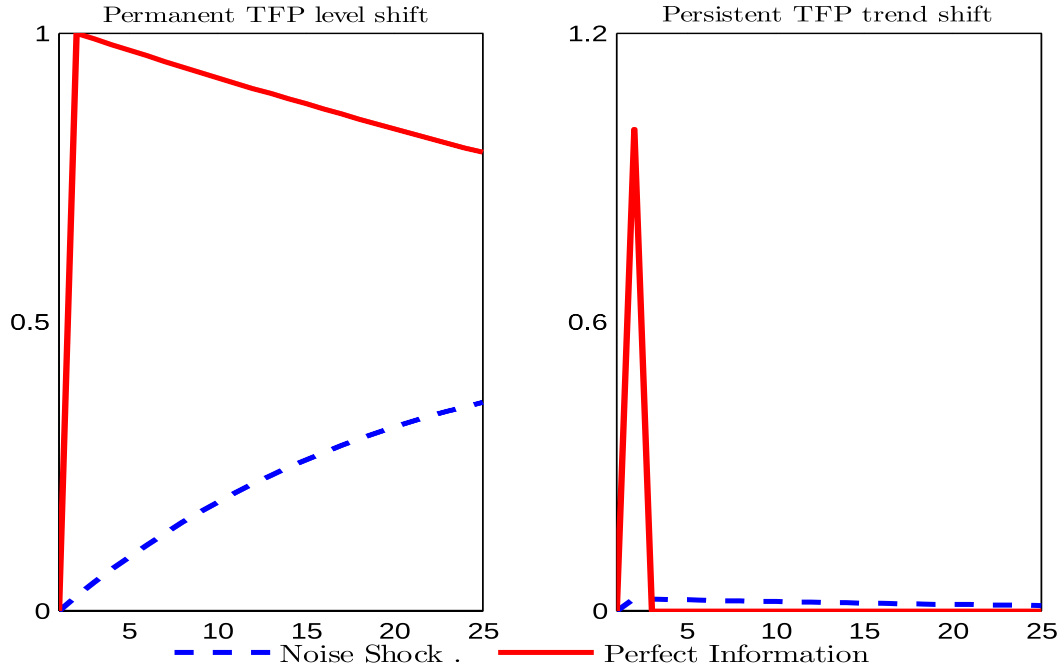

Figure 8: Productivity growth under perfect and imperfect information.

These are due to temporary or strongly persistent growth rate shocks that can be respectively interpreted as a one time permanent change in the level of productivity or as a persistent change in the trend of productivity growth. Agents are able to observe actual levels of productivity but they do not know their underline source. At each point in time they use all the new information to update their estimation of the true nature of the shock. Edge *et al.* (2007) showed that this learning feature of the model is a way of modeling the formation of expectations of long-run productivity growth. Therefore, we are interested in understanding if our results are robust when using these imperfectly anticipated shocks.

The main modification of the model, with respect to the baseline, concerns the exogenous process for technology. We remove the two sector-specific productivities (presented in section 2.3) and we introduce two novelties in the labor augmenting productivity process:

$$lnX_t - lnX_{t-1} = z + u_t^X + \widetilde{A}_t \quad \text{with} \quad \widetilde{A}_t = \rho_A \widetilde{A}_{t-1} + u_t^A. \tag{32}$$

Both $u_t^A \sim N(0, \sigma_A^2)$ and $u_t^X \sim N(0, \sigma_X^2)$ are independently and identically distributed random variables. The model now features a unit root: a shock u_t^X leads to a permanent shift in the level of the labor augmenting technology, while the new shock u_t^A, generates an additional and persistent change in the growth rate of technology.

Agents, at the beginning of time t, observe $Z_t = \frac{X_t}{X_{t-1}}$ but cannot distinguish if the

Noise TFP shocks

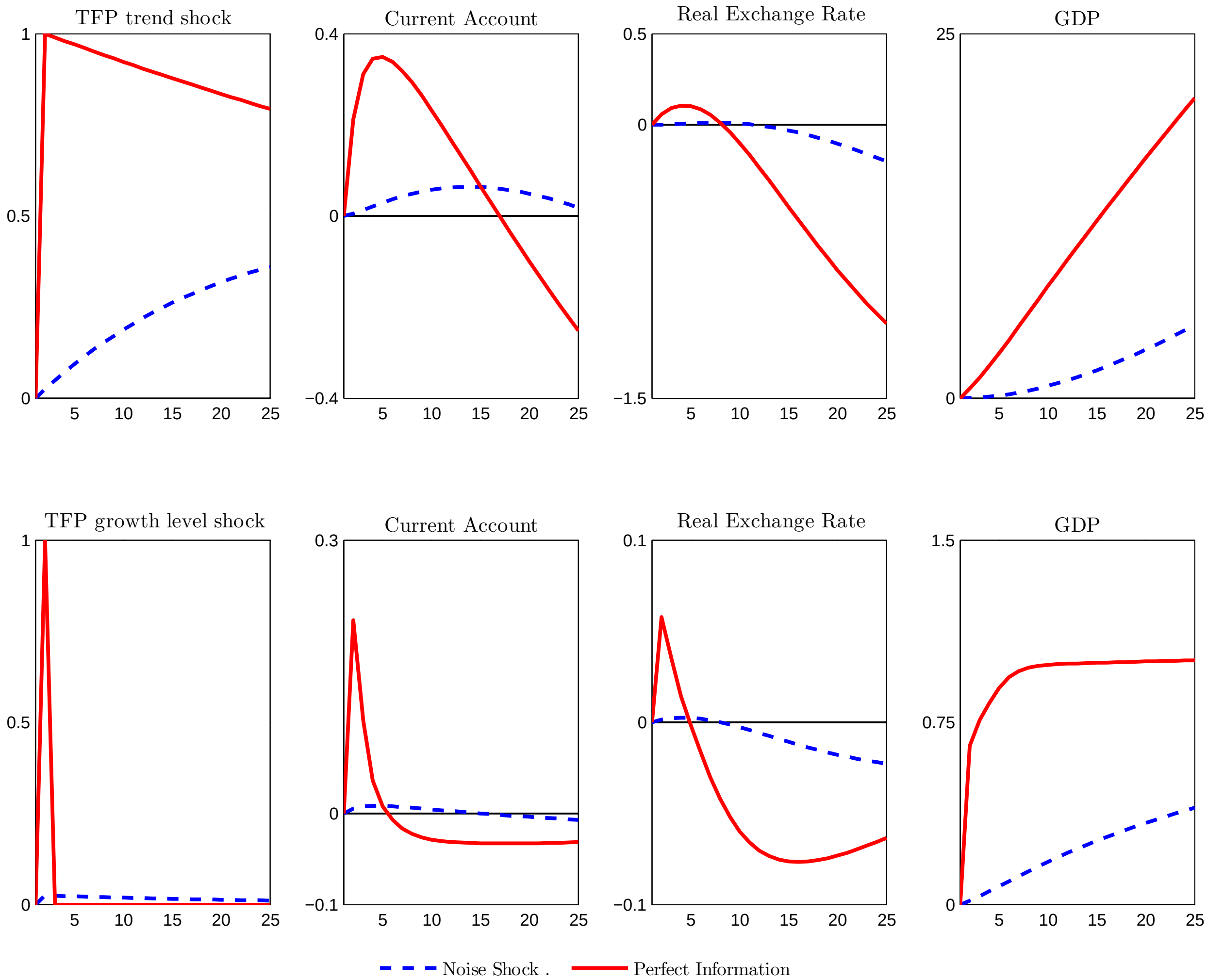

Figure 9: Impulse responses to a one standard deviation positive anticipated technology shock in the tradable sector. The Figure compares responses of the baseline specification with the framework in which agents have imperfect information on the shocks. The first row shows the responses to a trend growth rate shock, ζ_t^A, while the second row depicts the responses to a permanent level shock, ζ_t^X

movement is generated by the one time or the persistent shock.[37] They know the entire history of TFP shocks up to time t and the underlying distribution of both the trend and the cyclical component. This, jointly with the linearity of our solution, makes the Kalman filter the best estimator available to agents:

$$\widetilde{A}_{j,t|t} = (1-\kappa)\rho_{A_j}\widetilde{A}_{j,t-1|t-1} + \kappa z_t, \qquad \text{where} \quad z_t = ln(Z_t). \tag{33}$$

κ, which represents the Kalman gain, is set to 0.025 and ρ_{A_j}, the persistence of the shock,

[37]For the formulation of the learning process we follow Boz *et al.* (2011) and Hoffmann *et al.* (2011).

equals 0.99.[38] Figure 8 shows the difference between the true dynamics of the two 1-percentage point shocks to technology and the dynamics perceived by the agents.

The rest of the model is identical to the baseline specification. The model is now detrended considering the presence of the unit root and parameters are set at the mean of posterior distribution of the estimation with separable preferences (section 5.1). Figure 9 shows the impulse responses of the current account, the real exchange rate and GDP to the trend growth rate shock and to the permanent level shock. For both shocks we compare the reactions of the model assuming perfect and imperfect information of agents. Results are less pronounced and more persistent but in line with the baseline specification.

Imperfectly anticipated shocks, as perfectly anticipated productivity shocks, fail to generate contemporaneously current account deficit, real exchange rate appreciation and increasing GDP. A positive increase in TFP generates a current account surplus and real exchange rate depreciation, even if temporarily. However notice that in this framework labor productivity TFP level shocks succeed in matching a positive co-movement between current account and real exchange rate. This can be explained by the fact that productivity, even if imperfectly forecasted, starts to move contemporaneously with expectations, while in the presence of pure anticipated shocks productivity does not move before the forecasted realization.

Even if modeling anticipated shocks as imperfectly expected changes in productivity can be seen as an improvement, we cannot explain IPS imbalances only with productivity shocks, even if anticipated with some noise.

6 Conclusions

From 1996 to 2007 Ireland, Portugal and Spain have experienced three common facts: increasing current account deficits, appreciating real exchange rates and GDP growing above trend. Current events in the euro area have shown that current account imbalances have exacerbated the vulnerability of the EMU periphery. Accordingly, it has become important to uncover their sources. Given that the current account balance captures the inter-temporal feature of international trade and that EMU imbalances started to arise in 1996, before the actual introduction of the euro, expectations are likely to have played an important role in the build up of imbalances. We account for this by including anticipated shocks in the analy-

[38] Results are similar if instead 0.025 we use the estimation proposed by Garnier and Wilhelmsen (2009) for the euro area.

sis and by checking qualitatively and quantitatively their relevance. The contribution of this paper is twofold: first, we uncover the causes, *unanticipated and anticipated*, of the current account imbalances experienced by Ireland, Portgual and Spain before the Great Recession. Second, we assess the role of anticipated shocks for current account and real exchange rate fluctuations. Using an estimated small open economy DSGE model, we show that *anticipated* shocks and in particular *yield spread* anticipated shocks have been the main driver of the experienced imbalances in IPS.

The idea that capital was flowing towards "catching-up" euro area countries with high current or expected productivity growth has been shown, in recent empirical studies, to be unlikely. This paper provides a theoretical explanation of why unanticipated and anticipated productivity shocks, either in the traded or in the non-traded sector, cannot be the relevant sources of the current account deficits observed inside the EMU. The reason is the inability of productivity shocks to generate the experienced contemporaneous movement of the current account, the real exchange rate and GDP.

Ruling out fiscal policy and financial intermediation as main drivers of IPS imbalances, given that the initial and largest widening of current account dispersion happened in period of fiscal consolidation and slow increase in gross capital flows, we highlight two main results of the paper: first, the decrease in the international yield spread is the main source of the imbalances experienced in IPS. Yield spread drops are the only shocks that can contemporaneously explain the 3 observed facts: current account deficit, real exchange rate appreciation and GDP, with its main components consumption and investment, above trend. Second, anticipated shocks account for a large portion of the fluctuations of international macroeconomic variables: 62 percent of the current account, 48 percent of the real exchange rate and 35 percent of output growth. Among anticipated shocks, anticipated yield spread shocks are the most important for current account and real exchange rate fluctuations. Our findings are robust to the substitution of Jaimovich and Rebelo type of preferences with standard separable utility and to the weakening of the certainty assumption behind anticipated shocks.

To conclude, when investigating the sources of current account imbalances, we should keep in mind two considerations: first, an important fraction of current account fluctuations is due to shocks which are anticipated; second, the joint analysis of the current account with the real exchange rate and the GDP allows us to distinguish between otherwise identical current account responses to different structural shocks. Future research should go in the direction of studying the implications of different sources of current account fluctuations in order to identify the conditions under which they generate "excessive" imbalances.

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