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Abstract

This paper investigates the sources of current account imbalances accumulated within the European Monetary Union before the Great Recession. First, it documents that starting in 1996, before the actual introduction of the euro, countries in the euro area periphery experienced increasing current account deficits, appreciating real exchange rates and output growing faster than trends. Then, it develops and estimates a small open economy DSGE model which encompasses a variety of unanticipated and anticipated shocks. The main finding is that anticipated reductions in international borrowing costs can explain the observed evidence while productivity increases (anticipated or not) cannot: falling borrowing costs implies appreciation while increasing productivity implies depreciation. Quantitatively, anticipated shocks account for one third of output, half of real exchange rate and two third of current account fluctuations. In particular, anticipated fluctuations in international borrowing costs explain respectively 30 and 40 percent of current account and real exchange rate movements.

Keywords: Current Account, Business cycles, Anticipated Shocks

JEL Classification: E32, F32, F41

Résumé

Cet article étudie les sources des déséquilibres des comptes courants accumulés au sein de l'Union monétaire européenne avant la Grande Récession. Premièrement, il montre qu'á partir de 1996, et donc avant l'introduction de l'euro, les pays périphériques de la zone euro ont été caractérisés par une augmentation des déficits courant, une appréciation des taux de change réels et une croissance du PIB supérieure à la tendance. Ensuite, cet article développe et estime un modèle DSGE pour une petite économie ouverte, qui inclut différents chocs anticipés et non-anticipés. Le résultat principal est que la réduction anticipée des coûts des emprunts internationaux peut expliquer les faits observés, au contraire d'une augmentation de la productivité (anticipée ou pas): la baisse des coûts d'emprunt implique une appréciation du taux de change réel, alors que l'augmentation de la productivité implique une dépréciation. Quantitativement, les chocs anticipés expliquent un tiers des fluctuations du PIB, la moitié des fluctuations du taux de change réel et deux tiers des fluctuations de du compte courant. En particulier, les fluctuations anticipés des coûts d'emprunt internationaux expliquent respectivement 30 et 40 pour cent des variations du compte courant et du taux de change réel.

Mots clés: Compte Courant, Cycle Économique, Chocs anticipés

Classification JEL: E32, F32, F41

Non-technical summary

From 1996 to 2007 Ireland, Portugal and Spain (henceforth IPS) experienced increasing current account deficits, appreciating real exchange rates and output growing above trend. Current events in the euro area have shown that international imbalances have exacerbated the vulnerability of the EMU periphery countries. Accordingly, this paper investigates the sources of the current account imbalances experienced within the euro area before the Great Recession. Motivated by the timing of the widening of imbalances, which started before the actual introduction of the euro, anticipated shocks are at the core of the analysis. In particular, we asses both qualitatively and quantitatively the role of *unanticipated* and *anticipated* shocks for international variable fluctuations.

Using a structured estimated model we take the road started by Blanchard & Giavazzi (2002) and Blanchard (2007) of analyzing the imbalances within the EMU. Current account imbalances are different depending on their trigger (see for example Giavazzi & Spaventa (2010) and Eichengreen (2010)). Some are driven by growth differentials, that allow countries with better growth prospect to borrow money from abroad (which we proxy with anticipated increases in productivity) and others are triggered by other factors, as for example financial or demand changes. We therefore try to disentangle between different possible explanations focusing on the drivers of imbalances, *unanticipated and anticipated*, that can explain *jointly* the observed dynamics of current account, real exchange rate and GDP.

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 IPS imbalances. Three are the main results: first, the drop in the international yield spread is the only shock that can contemporaneously explain the three observed facts: current account deficit, real exchange rate appreciation and GDP, with its main components consumption and investment, above trends. Second, anticipated shocks account for a large portion of the fluctuations of international macroeconomic variables: 67 percent of the current account, 51 percent of the real exchange rate and 35 percent of output growth. Third, among anticipated shocks, anticipated yield spread shocks are the most important for international variable fluctuations: they account for 30 percent of total current account movements and 40 percent of changes in the real exchange rate. Our findings are robust to the introduction of different preferences and to a different modeling approach for anticipated shocks.

To conclude, in order to investigate 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 output allows us to distinguish between, otherwise identical, current account responses to different structural shocks.

1 Introduction

...there is no simple structural relation, in our economy, between the trade balance and the terms of trade. [...This] suggests that one cannot characterize the relation between trade and prices without specifying the source of fluctuations. (Backus et al. 1994)

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[1] of the European Monetary Union periphery (Ireland, Portugal and Spain).[2] Accordingly, it has become important to understand what caused these imbalances. The aim of this paper is twofold: first, to uncover the sources of the current account imbalances experienced in the euro area periphery before the Great Recession; second, to assess the importance of *anticipated vs unanticipated* shocks for current account, real exchange rate and output growth fluctuations.

Three macroeconomic facts are at the core of our analysis and their timing motivates our focus on anticipated shocks. First, significant flows of capital and diverging current account balances have characterized the members of 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)). Second, in periods of increasing deficits, IPS were growing above historical trend, augmenting investments and experiencing a persistent real exchange rate appreciation with respect to the rest of the EMU (Figure 1(b) and 1(d)).[3] Third, around 1996, the long term borrowing cost premium that the IPS had to pay with respect to the euro area core countries started a remarkable decrease. The average yield spread that Ireland, Portugal and Spain had to pay with respect to Germany on their government bond went from 3.7 percent in December 1995 to 0.02 percent in January 2005, (Figure 1(c)).

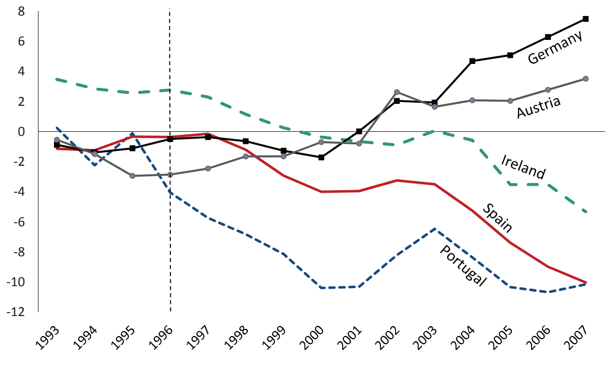
Investigating the causes of the euro periphery imbalances requires then to start the analysis before the actual introduction of the euro, as macroeconomic variables started to move around 1996. At beginning of 1996, residents of IPS learned that on January 1, 1999 their country would

[1]See Giavazzi & Spaventa (2010), OECD (2010) and Lane & Milesi-Ferretti (2011), among others. In the appendix, Figure .0.1 shows in fact that the link between the current account balance and the severity of the recession holds only for countries inside the EMU.

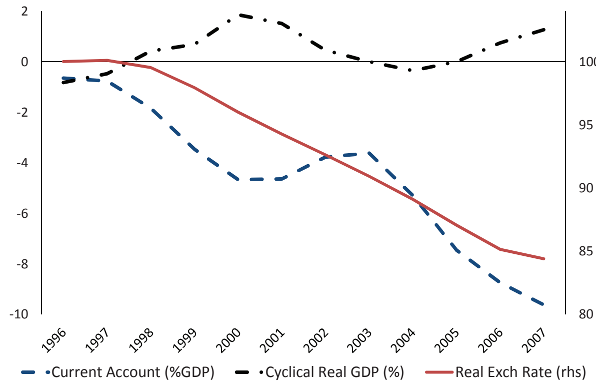
[2]Euro area periphery countries should also include Greece. However Greece is not listed as it will be discarded from the analysis of the paper. This is due to data unreliability for the 1996-2007 period: comparable time series are only partially available and there are non negligible inconsistency between databases which prevents us from merging different sources. Also Italy is often included among the countries in the euro area periphery. However this is mainly true when the focus is on government debt. 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 (1.7 percent of GDP at the end of 2007), Italy will not be included.

[3]Portugal stopped growing faster than trend after the year 2000. However, the 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)

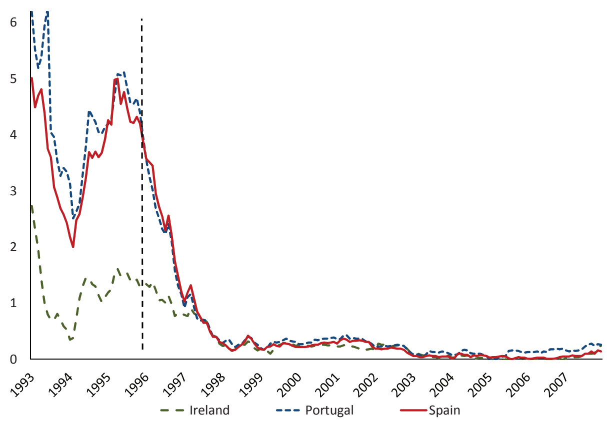
be part of the EMU (on December 15-16, 1995, the European Council meeting in Madrid, decided the exact timeline of the transition and the name of the common currency). Therefore, anticipations of changes due to the actual introduction of the euro cannot be discarded as a possible drivers of imbalances. Expectations are in fact key factors of international flows of capital. The current account balance, defined as the change in net foreign assets, captures, effectively, the inter-temporal feature of international trade. We account for this by including anticipated shocks in the analysis and by checking, to our knowledge for the first time in the euro area debate, qualitatively and quantitatively their relevance.



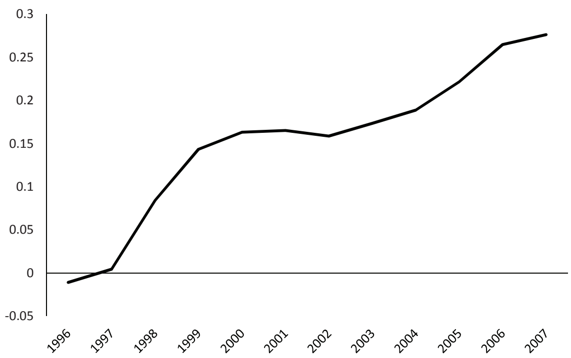
(a) Current Account Dynamics (% of GDP)



(b) Ireland, Portgual and Spain



(c) Bond Yield Spread



(d) IPS Investment

Figure 1: (a) Euro area current account (% of GDP) from 1993 to 2007 for Austria, Germany, Ireland, Portugal and Spain; (b) Current account (% of GDP), log deviation of GDP from the 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. GDP is log deviation from a deterministic linear trend which is consistent with the model assumptions, see section 3.1. The real effective exchange rate 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 investment from the GDP-implied trend derived in a model consistent way, see section 3.1. Source: Eurostat.

Using a structured estimated model we take the road started by Blanchard & Giavazzi (2002) and Blanchard (2007) of analysing the imbalances within the EMU. Current account imbalances are different depending on their trigger (see for example Giavazzi & Spaventa (2010) and Eichengreen (2010)). Some are driven by growth differentials, that allow countries with better growth prospect to borrow money from abroad (which we proxy with anticipated increases in productivity) and others are triggered by other factors, as for example financial or demand changes. We therefore try disentangle between different possible explanations focusing on the drivers of imbalances, *unanticipated and anticipated*, that can explain *jointly* the observed dynamics of current account, real exchange rate and GDP.

We lay out a New Keynesian DSGE small open economy model in a monetary union with two sectors, tradable and non tradable.[4] We combine different features of open economy general equilibrium models: habit persistence in consumption, nominal and real rigidities, monopolistic competition, tradable and non tradable sector, home bias, variable capital utilization, time varying markups and an incomplete international financial market. We then estimate the model on IPS data and, relying on Bayesian techniques, we use carefully selected priors to reduce the short sample limitations (see An & Schorfheide (2007) for a discussion on Bayesian estimation in DSGE models). Interestingly and in contrast to standard open-macro models, crucial parameters for international dynamics, like the trade and the tradable vs. non tradable elasticities, are estimated to be close to the micro-trade empirical estimates.

Unanticipated, one-year anticipated and long-term (10 quarters) anticipated innovations are included for each shock. We 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 of the estimated model.

Two main results emerge from our analysis. First, *anticipated* international yield spread shocks have been the crucial driver of the euro area periphery imbalances. Second anticipated shocks explain a large part of business cycle fluctuations, especially of international variables such as current account and real exchange rate.

We show, using impulse response analysis,[5]that international yield spread drops and anticipated increase in marginal efficiency of investment are the only sources that can generate the joint persistent dynamics of current account, real exchange rate and GDP. In contrast, anticipated labor augmenting and non tradable productivity shocks fail to generate an appreciation of the real exchange rate, given the estimated trade elasticity and persistency of shocks. Only anticipated tradable-specific productivity shocks can generate a sufficiently large Balassa-Samuelson effect that generates real exchange rate appreciation jointly with current account deficit and output growth.

[4]Elements of our framework are modeled as in Smets & Wouters (2003), Galí & Monacelli (2005), Galí & Monacelli (2008), Faia & Monacelli (2008), Rabanal (2009) and Burriel et al. (2010).

[5]Impulse responses are computed at the mean of the posterior distribution and displayed with HPD intervals, constructed using the 90% highest posterior density (HPD) of the posterior distribution.

However, this effect is temporary and when the shocks realize the real exchange rate depreciates and the current account turns to surplus.

Then, performing a variance decomposition analysis, we investigate what fraction of the fluctuations can be ascribed to unanticipated and anticipated shock. We find that anticipated shocks account for most of the predicted movements of our main variables: 67 percent of the current account, 51 percent of the real exchange rate and 35 percent of GDP. In particular, long-term anticipated international yield spread shocks play a major role for international variable fluctuations at business cycle frequency: 28 percent of the current account and 41 percent of the real exchange rate.

To check the robustness of the results we replicate the exercise under two different specifications of the model. We depart from the benchmark model first introducing Jaimovich and Rebelo preferences, estimating the size of the wealth effect on the labor supply.[6] Then we check if our main results hold if instead of having anticipated shocks that are certainly happening in the future (news shocks) we assign to them a degree of uncertainty (noise shocks).[7] Results are confirmed in both specifications of the model.

Recently, a number of empirical studies explored the potential causes of the increasing current account deficit in the euro area periphery before the crisis. On one hand, focusing on trade performance and international competitiveness, Bayoumi, Harmsen & Turunen (2011) show that intra-euro area trade is more elastic to changes in relative prices than extra-euro area trade and therefore a loss in competitiveness could generate persistent current account imbalances. Gaulier & Vicard (2012), however, argue that the losses in competitiveness were not a cause but rather a symptom: domestic demand shocks were responsible for higher prices in the non tradable sector and current account deficits. On the other hand, focusing on different possible explanations, Polito & Wickens (2013) argue that it was the inability of a single monetary policy to overcome persistent inflation differentials that generated over-borrowing in the periphery countries facing negative real interest rates. Lane & Pels (2012) show that the increase in expectations of future growth triggered lower savings, higher investments and current account deficits.

While our theoretical framework can be used to understand and test these explanations, two proposed explanations cannot be tested in our framework. The first is the importance of external trade shocks, introduced by Chen, Milesi-Ferretti & Tressel (2013). In this scenario, current account imbalances are mostly vis-a-vis the rest of the world but mainly financed by intra-euro area capital inflows. The second is the relevance of non-trade channels, like transfers and income balances, for

[6] Jaimovich & Rebelo (2009) constructed a specification of preferences that enables, through the introduction of a parameter, to control the wealth elasticity of labor supply. This type of preference is often used in the anticipated shock literature because, by minimizing the wealth elasticity of the labor supply as in Greenwood et al. (1988), allows to produce positive co-movement between output, hours worked, consumption and investment in response to permanent expected future changes in TFP.

[7] Noise shocks are shocks which are not fully observed by imperfectly informed agents. The signal-extraction problem that they face generates time-adjusting expectations (see Edge et al. (2007)).

intra-euro imbalances (see Kang & Shambaugh (2013)).

On the theoretical side, the present paper is closely related to the literature on the international transmission of shocks (e.g Backus et al. (1993), Kollmann (2005), Corsetti et al. (2008) and Enders & Muller (2009)) and to the research on the role of anticipated innovations for real business cycle fluctuations (e.g Jaimovich & Rebelo (2008), Jaimovich & Rebelo (2009) and Schmitt-Grohé & Uribe (2012)). In the New Open Economy literature, Bergin (2006) was the first to show, in an estimated two-country model, the importance of financial shocks for movements in the current account. Building on his findings, we test the real vs. financial origin of the current account deficit observed within the euro area before the Great Recession. As in Nam & Wang (2010) and Hoffmann, Krause & Laubach (2011) (henceforth NW and HKL), we investigate the role of anticipated productivity shocks for the reactions of international variables. Using calibrated models, NW find that productivity news shocks can be reconciled with the US terms of trade appreciation and HKL show that noise shocks can explain the build-up of the United States current account imbalances. On the contrary, we show that, once we estimate the model for the euro area periphery and we take into account contemporaneously the current account and the real exchange rate, anticipated productivity shocks cannot be the most important sources of the imbalances within the EMU.

Quantitatively, Schmitt-Grohé & Uribe (2012) were the first to document that productivity news shocks account for a large fraction of aggregate fluctuations when we assume that the economy is closed. Here we ask whether anticipated shocks are also an important driver of current account and real exchange rate movements. Our estimated small open economy DSGE model with both anticipated and unanticipated innovations makes it possible to understand what fraction of its variances can be ascribed to anticipated shocks.

The paper is organized as follows. Section 2 describes the economic environment in detail 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 international variable fluctuations. Section 5 checks the robustness of the results presenting different estimations and specifications of the model analyzed. Section 6 concludes.

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 euro area periphery as a small open economy allows us to account for the evidence that Ireland, Portugal and Spain together, between 1996 to 2007, represented 13 percent of the total euro area zone.[8]

[8] 13% is the weighted average of Ireland, Portugal and Spain between 1996 and 2007 in the euro area Harmonized Index of Consumer Prices (Eurostat).

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, supplies labor and decides the level of the capital to be used in production. The capital depreciates and investments are costly. The model features variable capital utilization and adjustment cost to investment in order to generate aggregate and sectoral co-movement in presence of anticipated shocks (see Jaimovich & Rebelo (2008), Jaimovich & Rebelo (2009) and Schmitt-Grohé & Uribe (2012)). 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, well-aware that therefore the purchasing power parity will not be necessarily 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 which 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. In addition prices are not fully flexible and follow a Calvo (1983) formulation with indexation.

There is a common monetary authority that fixes the nominal interest rate, targeting the average inflation inside the monetary union. The assumption that the domestic economy is small comes at the cost of inserting the monetary policy as exogenous to our small open economy[9]. The nominal exchange rate is fixed, given the membership in a monetary union, which implies that every price movement, in both sectors, are reflected in movements in inflation, real interest rate and real exchange rate. We allow for perfect risk-sharing within countries but incomplete international financial markets with only one internationally traded non contingent bond.

It is important to notice that there is no government in the model. The decision is due to the focus of the paper on the current account of the aggregate euro area periphery and it is supported by two observations. First, average tax policies in the IPS were in line with the rest of the monetary union[10] and second, from 1996 to 2007, government spending wasn't a major determinant of the increasing current account deficit. In fact, government debt to GDP actually decreased in Spain and Ireland and it just slightly increased in Portugal.[11] Between 1996-2007, aggregate government debt to GDP of the IPS went from 67% to 40% and the average spending went from a 5% deficit to a 1.1% surplus. Therefore, while specific fiscal policies may have played a role for individual country experiences (e.g. Ireland introduction from 1 January of 2013 of the 12.5% rate of corporate tax on trading income), it is not clear that government decisions on spending and taxes played any

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

[10]For example, in 2000, while Ireland had a low corporate income tax rate (24%), Spain and Portugal had higher than the EU average corporate income tax rates (respectively 35% and 35.2%; OECD data).

[11]Notice however that in Portugal government debt to GDP decreased from 58.2 to 50.4 in the period between 1996 and 2000, when most of the increase in current account deficit was registered (see figure 1(a)).

important role on the common and aggregate behavior of the euro area periphery.

In this section we introduce the detailed structure of the model. An appendix with the full set of equilibrium conditions, also de-trended and log linearized, is available upon request.

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:[12]

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

The parameter ψ^β determines the importance of average consumption in the discount factor and we set it to be low in order to reduce the interference with the dynamics of the model, as in Ferrero, Gertler & Svensson (2008). 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.

The preference of the household is represented by a utility function separable in consumption and hours worked which accounts for an h degree of habit persistence in consumption:

$$U(C_t, L_t) = \left\{ log(C_t - hC_{t-1}) - \epsilon_t^L \psi^L \frac{L_t^{1+\nu}}{1+\nu} \right\}. \tag{4}$$

ψ^L is a labor supply preference parameter, ν is the inverse of the Frisch elasticity of labor supply and ϵ_t^L denotes a labor supply shock with mean unity and law of motion:

$$\log \epsilon_t^L = \rho_{\epsilon^L} \log \epsilon_{t-1}^L + \zeta_t^L. \tag{5}$$

The representative household faces the following budget constraint:

$$C_t + \frac{B_t}{P_t} + \frac{A_t}{P_t} + I_t \leq W_t L_t + R_{t-1}\frac{B_{t-1}}{P_t} + R_{t-1} Sp_{t-1}^A \frac{A_{t-1}}{P_t} + \left(R_t^k u_t - \Psi(u_t)\right) K_{t-1}^p + \int_0^1 \Gamma_{N,t}(i) + \int_0^1 \Gamma_{h,t}(i). \tag{6}$$

[12]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 & 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.

$\Gamma_{j,t}(i)$ are real profits of the intermediate monopolistic competitive firms, in both the tradable and non tradable sectors,[13] W_t is the real wage in terms of the final good price and K_t^p is the physical capital owned by the household which accumulates according to

$$K_t^p = (1-\delta)K_{t-1}^p + \epsilon_t^I \left[1 - S\left(\frac{I_t}{I_{t-1}}\right)\right] I_t. \tag{7}$$

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_t^i is an investment specific shock with mean unity that evolves according to $\log \epsilon_t^I = \rho_{\epsilon^I} \log \epsilon_{t-1}^I + \zeta_t^I$. 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_t^k:

$$K_t = u_t K_{t-1}^p. \tag{8}$$

$\Psi(u_t)$ in equation (6) is the cost of use of capital in units of consumption and following Christiano, Eichenbaum & Evans (2005) we assume that $\Psi(u) = 0$ 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 portfolio of domestic state-contingent assets but we explicitly introduce a domestic *redundant* nominal bond B_t which has a gross return of R_t. On the international side, financial markets are incomplete and there is only one non-state contingent internationally traded asset A_t which pays $R_t Sp_t$. R_t denotes the nominal risk free interest rate inside the monetary union and Sp_t indicates the spread with respect to the risk free rate that the domestic household has to pay to access the international asset market. Sp_t is assumed to be exogenous with mean unity and follows:

$$\log Sp_t = \rho_{sp} \log Sp_{t-1} + \zeta_t^{Sp}. \tag{9}$$

The risk free rate R_t is governed by the monetary authority (the European Central Bank, ECB) which targets the union price index. As the rest of the monetary union is not modeled, the monetary policy rule follows an exogenous process:

$$\log R_t = (1-\rho_r)\log R + \rho_r \log R_{t-1} + \zeta_t^R \tag{10}$$

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 $\{P_t, W_t, R_t^k, R_t, R_t^B\}_{t=0}^{\infty}$ and the initial wealth B_0 and A_0, to maximize equation (1) subject to (2), (4),(6) and (7).

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:

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

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

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.[14] 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:

$$Y_{f,t}^{d} \equiv \left[\int_{n}^{1} (Y_{f,t}^{d}(i))^{\frac{\phi_t^T-1}{\phi_t^T}} di\right]^{\frac{\phi_t^T}{\phi_t^T-1}},\ Y_{h,t}^{d} \equiv \left[\int_{0}^{n} (Y_{h,t}^{d}(i))^{\frac{\phi_t^T-1}{\phi_t^T}} di\right]^{\frac{\phi_t^T}{\phi_t^T-1}},\ Y_{N,t}^{d} \equiv \left[\int_{0}^{1} (Y_{N,t}^{d}(i))^{\frac{\phi_t^N-1}{\phi_t^N}} di\right]^{\frac{\phi_t^N}{\phi_t^N-1}},$$

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.[15]

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:

$$Y_{j,t} = A_{j,t} K_{j,t}^{\alpha} \left[X_t L_{j,t}\right]^{1-\alpha}. \tag{11}$$

While X_t is the common labor-augmenting technology process, $A_{j,t}$ are the 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:

$$X_t = (1+z)^t \widetilde{X}_t, \text{ where } \log \widetilde{X}_t = \rho_X \log \widetilde{X}_{t-1} + \zeta_t^X. \tag{12}$$

The trend in labor augmenting can be disaggregated between a component common to the entire euro area z^{euro} and a component specific to IPS z^{IPS}. Sector-specific productivities also have a deterministic trend and an autoregressive process:

$$A_{j,t} = (1+g^j)^t \widetilde{A}_{j,t}, \text{ where } \log \widetilde{A}_{j,t} = \rho_{A_j} \log \widetilde{A}_{j,t-1} + \zeta_t^{A_j} \text{ for } j = N, h \tag{13}$$

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 $\zeta_t^X \sim N(0, \sigma_X^2)$. Labor-augmenting trend can be divided into a domestic and common EMU component:

[14] 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)).

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

$(1+z)^t \simeq (1+z^{euro})^t(1+z^{IPS})^t$. In addition, sectors' specific growth rates are included to allow the model to capture the different first moments in the tradable and in non tradable sector that characterized the IPS in the early 2000s,[16] These assumptions provide us a model-consistent based 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 in 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:

$$P_{j,t} = \left\{ (1-\theta^j) P_{j,t}(i)^{1-\phi_t^j} + \theta^j \left[P_{j,t-1} \left(\Pi_{j,t-1}\right)^{\varphi_j} \Pi_j^{1-\varphi^j} \right]^{1-\phi_t^j} \right\}^{\frac{1}{1-\phi_t^j}} \quad \text{for } j = \{N, h\} \tag{14}$$

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 sector 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:

$$\max_{P_t(i)} \sum_{k=0}^{\infty} \theta_j^k E_t \left\{ \frac{\lambda_{t+k}}{\lambda_t} \beta_{t+k-1} \left[\frac{P_{j,t}(i)}{P_{t+k}} \left[\frac{P_{j,t+k-1}}{P_{j,t-1}} \right]^{\varphi^j} \pi_j^{k(1-\varphi^j)} - MC_{j,t+k} \right] Y_{j,t+k}^d(i) \right\} \tag{15}$$

$$\text{s.t. } Y_{j,t}^d(i) = \left(\frac{P_{j,t}(i) \left[\frac{P_{j,t+k-1}}{P_{j,t-1}} \right]^{\varphi^j} \pi_j^{k(1-\varphi^j)}}{P_{j,t+k}} \right)^{-\phi_{j,t+k}^j} Y_{j,t+k}^d. \tag{16}$$

where $MC_{j,t}$ is the real marginal cost and $\frac{\lambda_{t+k}}{\lambda_t}$ is the discount factor of the household.

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 & Monacelli (2008) the tradable price index over the price of the domestic tradables can be written as a function of the terms of trade and parameters only:

$$\frac{P_{T,t}}{P_{h,t}} = g(S_t) = \left[\gamma_{h,t} + \gamma_{f,t} S_t^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}}, \qquad \text{with} \quad \frac{\delta g(S_t)}{\delta S_t} > 0. \tag{17}$$

$J_t \equiv \frac{P_{T,t}}{P_{N,t}}$ 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:

$$\frac{P_t}{P_{N,t}} = m(J_t) = \left[\gamma_{T,t} J_t^{1-\eta} + \gamma_{N,t}\right]^{\frac{1}{1-\eta}}, \qquad \text{with} \quad \frac{\delta m(J_t)}{\delta J_t} > 0. \tag{18}$$

[16] A similar approach in open-economy models has been followed by Lubik & Schorfheide (2005), Adolfson et al. (2007) and Rabanal (2009).

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:

$$Q_t = \frac{S_t}{g(S_t)} \frac{J_t}{m(J_t)} \frac{P^*_t}{P_{f,t}}, \qquad \text{with} \quad \frac{\delta Q_t}{\delta S_t} > 0 \ \frac{\delta Q_t}{\delta J_t} > 0. \tag{19}$$

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

$$NX_t + \frac{R_{t-1}B_{t-1}}{YP_t} + \frac{R_{t-1}Sp_{t-1}A_{t-1}}{YP_t} - \frac{B_t + A_t}{YP_t} = 0, \tag{20}$$

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

$$NX_t = \frac{J_t}{g(S_t)m(J_t)} \frac{(Y_{h,t} - C_{h,t} - S_t C_{f,t})}{Y}. \tag{21}$$

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

$$CA_t = \frac{(B_t - A_t)}{P_t Y} - \frac{(B_{t-1} - A_{t-1})}{P_t Y} \tag{22}$$

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

$$Y_t = Y^d_t + NX_t(Y). \tag{23}$$

Finally, it is important to recall that in equilibrium, due to the incompleteness of international financial markets, the risk-sharing equation is violated.[17]

2.5 Equilibrium in a Small Open Economy

In equilibrium intermediate and final goods' markets clear:

$$Y_{N,t} = Y^d_{N,t}, \tag{24}$$

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

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

Also the labor and the capital markets clear, implying:

$$L_t = L_{N,t} + L_{h,t}, \tag{27}$$

$$K_t = K_{N,t} + K_{h,t}. \tag{28}$$

[17] If we were in a model with perfect financial and insurance markets with constant nominal exchange 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, Dedola & Leduc (2010) provide a complete overview of the literature, from the work of Cole & Obstfeld (1991) to the most recent models.

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:

$$\widetilde{Y}_{N,t} = \frac{Y_{N,t}}{[(1+z)(1+g^N)]^t} = \widetilde{A}_{N,t}\widetilde{X}_t^{1-\alpha}(1+z)^{-\alpha}\widetilde{K}_{N,t}^{\alpha}L_{N,t}^{1-\alpha} \tag{29}$$

and

$$\widetilde{Y}_{h,t} = \frac{Y_{h,t}}{X_t(1+g^h)^t} = \widetilde{A}_{h,t}X_t^{1-\alpha}(1+z)^{-\alpha}\widetilde{K}_{h,t}^{\alpha}L_{h,t}^{1-\alpha}, \tag{30}$$

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 13 and 12. 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, to solve the model, we first order log linearize the model around the deterministic steady state.[18]

2.7 Anticipated shocks

Expectations are key drivers of international flows of capitals. 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's 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, the model is driven by nine shocks: 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.[19] Medium-term anticipated shocks have been shown, by Schmitt-Grohé & Uribe (2012), to be extremely important for domestic business cycle fluctuations. 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.[20]

[18]The full set of de-trended equations and log-linearized equilibrium conditions are in the appendix, available upon request.

[19]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.

[20]For an explanation of the chosen time frame please refer to section 3.1.

Following Schmitt-Grohé & 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:

$$\zeta_t^x = \zeta_{0,t}^x + \zeta_{4,t-4}^x + \zeta_{10,t-10}^x \tag{31}$$

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 & Uribe (2012).

3 Model Estimation

We rely on Bayesian techniques to estimate a subset of key parameters of the model over which there is both theoretical and empirical controversy. Two are the main goals of the estimation procedure: 1. Find the values of the goods' elasticities and persistency of shocks, which are crucial parameters for the theoretical behavior of international variables;[21] 2. Understand the importance of anticipated shocks for the euro area periphery's business cycle. Two are consequently the main findings of our estimation: first estimated tradable and non tradable elasticities are much closer to empirical micro-trade estimates than previously found using open-macro models. Second, anticipated shocks are important for the dynamics of international variables such as the current account and the real exchange rate in the euro area periphery.

In this section we start by describing the data used to estimate the model and the set of calibrated parameters. Subsequently, we present the prior distribution and compare it with the estimated posterior. Then, in the following section, we will analyze the implications of the model at the mean of the estimated parameters.

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[22], in which the exact timeline of the transition and the name of the common currency was decided, the EMU became a credible agreement. Therefore agents, in that date, started to act as if they were part of the EMU (Figure 1(a)).

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 future question which will not be addressed in this paper.

Ireland, Portugal and Spain experienced similar dynamics of the current account, the real exchange rate and the GDP during the period under investigation. Accordingly, throughout the

[21] Refer to section 4 for an explanation of the importance of estimating the persistency of shocks, the trade elasticity (ϵ) and the elasticity between tradable and non tradable goods (η).

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

estimation, we focus on these three countries jointly. A weighted average, using European Central Bank HCPI as weights, allows us to investigate the common sources of the experienced fluctuations in the euro area periphery, mitigating the peculiarities of each country.

Notice that also Greece is part of the euro area periphery and experienced, with some lag,[23] a similar dynamics of those three variables. Even though it should be included in the analysis, we decided to exclude it because of unreliability of the data available. In particular, the main obstacles we encountered were the lack of comparable time series data for the entire 1996-2007 period and the major incompatibility between databases that made aggregating different sources a risky discretionary exercise. Moreover, Italy is also often included among euro area 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. Real data and exchange rates are computed using the aggregate demand deflator, instead of the gdp deflator, to be model-consistent.[24]

Following Beltran & Draper (2008) we also include 3 time series for the behaviour of the foreign economy. We can do this because we assumed 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 (-IPS) tradable prices, the EMU (-IPS) non tradable prices and foreign real aggregate demand (-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 found 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. The full list of measurement equation is in the appendix.

3.2 Calibrated parameters

Table (1) summarizes the values and the sources of the calibrated parameters. We follow the estimation results of Smets & Wouters (2003) for different values: v, the inverse elasticity of work effort with respect to the real wage, is set equal to 1. The depreciation rate, δ, is 0.025 per quarter, implying a 10 per cent annual depreciation of capital. The degree of interest rate smoothing 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

[23]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.

[24]Details on the data are in the appendix available upon request.

Table 1: Calibrated Parameteres

Par	Value	Description	Source
v	1	Inverse elasticity of labor supply	Smets & Wouters (2003)
ψ^{β}	to set $\beta = 0.99$	Spillover effect of average de-trended consumption on the discount factor	
β	0.99	Discount factor	Quarterly interest rate $\approx 4\%$
ψ^{L}	to set $L = 0.236$	Labor supply preference parameter	
α	0.29	Capital Share	Smets & Wouters (2003)
δ	0.025	Depreciation of capital	Smets & 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 & 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	

it will have value $2.01 \cdot 10^{-5}$. We do this to ensure that the endogeneity of 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.

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 Ireland, Portugal and Spain, the average share of non tradable production for the period 1996:2007 is 77 per cent.[25] Focusing on the tradable goods sector we find that the share of imported goods is around 33.9 per cent for the IPS countries, displaying a relevant home bias.

3.3 Prior Distributions

Some structural parameters are central for shaping the responses of the model to shocks, in particular for the reaction of the current account and the real exchange rate to productivity shocks (Corsetti et al. 2008). Trade elasticity, the elasticity of substitution between tradable and non tradable goods and the shocks' persistency are the most important ones. For these, a wide range of values, provided by empirical and theoretical studies, fail to give us a precise and reliable calibration. Therefore we perform a Bayesian estimation using values found by previous studies as references for priors. Table 2 summarizes the prior of the parameters that we use in the estimation.

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. Broda & Weinstein (2006) show that for the U.S. the elasticity is decreasing over time and it ranges between

[25] 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.

6.8 and 4, when we consider three-digit goods. Cabral & Manteu (2011), focusing on the euro area periphery, finds that the average external demand elasticity of Ireland, Portugal and Spain, is 4. On the other side the international macroeconomic literature, which relies on aggregated data, finds much lower values. Taylor (1999) estimates a long run elasticity of 0.39. Imbs & Mejean (2009) try to reconcile disaggregated data with structural macro models showing how aggregation and theoretical assumptions can bias downwards macroeconomic estimates. Recently, the literature was enriched with theoretical studies showing that implied low trade elasticity could help explain the Backus and Smith puzzle[26] (Corsetti et al. (2008) and Benigno & Thoenissen (2008)) and the volatility of the real exchange rate (Thoenissen (2011)).[27] As a prior, we set a gamma distribution with mean 1.5 (the most widely used value in calibrated exercise) and standard deviation of 1, to consider the entire range of values proposed by previous studies.

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. Mendoza (1991), focusing on a set of industrialized countries, finds a value of 0.74, while Stockman & Tesar (1995) estimate a lower elasticity of 0.44. Rabanal & 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, Sala & Trigari (2008). We additionally estimate the parameter governing the discount factor, χ assuming a prior mean of -500 and a standard deviation of 200.

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 is 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 lvarez 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.

For the set of priors governing the persistency 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. Unanticipated sources of fluctuations are set to explain two third of the total variance of the shocks (Tab 3).

[26] Backus et al. (1993)

[27] The list of cited studies is far from being complete. Its only purpose is to give some important references and an idea of the boundaries of those estimates.

Table 2: Prior and Posterior Distribution - Parameters

		Prior			Posterior		
		Distr.	Mean	St. Dev	Mean	Lower	Upper
Estimated Parameters							
η	T Vs NT	*Gamma*	0.5	0.2	0.365	0.137	0.588
ϵ	home VS foreign	*Gamma*	1.5	1	3.102	2.686	3.501
h	habit formation	*Beta*	0.65	0.05	0.649	0.586	0.715
$\overline{\eta}_v$	Utilization rate elast	*Beta*	0.5	0.1	0.272	0.183	0.359
η_k	Capital adj cost elast	*Gamma*	10	5.5	23.403	15.410	31.127
θ	Good elasticity	*Norm*	7.5	1	8.279	6.796	9.717
θ_N	NT price rigidity	*Beta*	0.9	0.1	0.843	0.793	0.895
θ_h	T price rigidity	*Beta*	0.75	0.1	0.208	0.148	0.267
ϕ_N	NT indexation	*Beta*	0.5	0.05	0.491	0.409	0.573
ϕ_h	T indexation	*Beta*	0.5	0.05	0.435	0.354	0.517
χ	End discount weight	*Normal*	-500	200	-503.394	-817.568	-176.962
AR Coefficients							
ρ_{A_h}	T Techn	*Beta*	0.7	0.08	0.695	0.575	0.823
ρ_{A_N}	NT Techn	*Beta*	0.7	0.08	0.642	0.513	0.771
ρ_X	Labor Augmenting	*Beta*	0.4	0.1	0.399	0.234	0.564
ρ_ζ	Preference	*Beta*	0.7	0.1	0.848	0.768	0.929
ρ_{ϵ_L}	Labor	*Beta*	0.5	0.1	0.374	0.233	0.511
$\rho_{\epsilon_r b}$	Risk Prem	*Beta*	0.5	0.1	0.692	0.524	0.863
ρ_θ	NT Markup	*Beta*	0.3	0.1	0.215	0.086	0.336
ρ_ϕ	T Markup	*Beta*	0.3	0.1	0.300	0.135	0.460
ρ_{ϵ_I}	Invest	*Beta*	0.5	0.1	0.325	0.190	0.454
Foreign Block							
a_{11}	VAR, Y^{*d} to lag Y^{*d}	*Normal*	0.5	0.5	0.922	0.856	0.999
a_{12}	VAR, Y^{*d} to lag P_f^*	*Normal*	0	0.05	-0.016	-0.088	0.059
a_{13}	VAR, Y^{*d} to lag P_N^*	*Normal*	0	0.05	-0.047	-0.111	0.015
a_{21}	VAR, P_f^* to lag Y^{*d}	*Normal*	0	0.05	-0.008	-0.069	0.053
a_{22}	VAR, P_f^* to lag P_f^*	*Normal*	0.5	0.5	0.864	0.759	0.983
a_{23}	VAR, P_f^* to lag P_N^*	*Normal*	0	0.05	0.018	-0.044	0.082
a_{31}	VAR, P_N^* to lag Y^{*d}	*Normal*	0	0.05	0.098	0.050	0.147
a_{32}	VAR, P_N^* to lag P_f^*	*Normal*	0	0.05	0.037	-0.031	0.105
a_{33}	VAR, P_N^* to lag P_N^*	*Normal*	0.5	0.5	0.908	0.845	0.972
$100\sigma_u^{C^*}$	Foreign consump	*IGamma*	0.15	0.15	0.534	0.443	0.622
$100\sigma_u^{\pi^f}$	Foreign π_T	*IGamma*	0.15	0.15	0.484	0.404	0.562
$100\sigma_u^{\pi_N^*}$	Foreign π_{NT}	*IGamma*	0.15	0.15	0.302	0.246	0.356

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.

Finally, we allow for measurement errors in all the observable equations with the exceptions of nominal interest rate and foreign variables. As in Adolfson et al. (2007) and Christiano et al.

Table 3: Prior and Posterior Distribution - Standard Deviations

			Prior		Posterior		
		Distr.	Mean	St. Dev	Mean	Lower	Upper
Standard Deviation							
$100\sigma_{\zeta^{Ah}_{0,t}}$	T Techn	*IGamma*	0.15	0.15	2.201	1.546	2.846
$100\sigma_{\zeta^{An}_{0,t}}$	NT Tech	*IGamma*	0.15	0.15	0.149	0.045	0.258
$100\sigma_{\zeta^{X}_{0,t}}$	Labor Augmenting	*IGamma*	0.15	0.15	0.132	0.048	0.224
$100\sigma_{\zeta^{\zeta}_{0,t}}$	Preference	*IGamma*	0.15	0.15	3.997	2.624	5.348
$10\sigma_{\zeta^{I}_{0,t}}$	Invest	*IGamma*	0.15	0.15	4.695	2.926	6.452
$100\sigma_{\zeta^{L}_{0,t}}$	Labor	*IGamma*	0.15	0.15	0.138	0.048	0.225
$100\sigma_{\zeta^{r}_{0,t}}$	Int rate	*IGamma*	0.15	0.15	0.089	0.075	0.104
$100\sigma_{\zeta^{Sp}_{0,t}}$	Yield Spread	*IGamma*	0.15	0.15	0.131	0.047	0.215
$10\sigma_{\zeta^{\theta_N}_{0,t}}$	NT markup	*IGamma*	0.15	0.15	26.245	10.848	41.948
$100\sigma_{\zeta^{\theta_T}_{0,t}}$	T markup	*IGamma*	0.15	0.15	0.178	0.044	0.295
$100\sigma_{\zeta^{Ah}_{4,t}}$	Ant Ah	*IGamma*	0.075	0.075	0.072	0.023	0.129
$100\sigma_{\zeta^{An}_{4,t}}$	Ant An	*IGamma*	0.075	0.075	1.887	1.518	2.264
$100\sigma_{\zeta^{X}_{4,t}}$	Ant Labor Augmenting	*IGamma*	0.075	0.075	0.079	0.022	0.135
$100\sigma_{\zeta^{\zeta}_{4,t}}$	Ant Preference	*IGamma*	0.075	0.075	0.080	0.022	0.138
$100\sigma_{\zeta^{I}_{4,t}}$	Ant I	*IGamma*	0.075	0.075	0.069	0.023	0.117
$100\sigma_{\zeta^{L}_{4,t}}$	Ant L	*IGamma*	0.075	0.075	0.070	0.023	0.123
$100\sigma_{\zeta^{Sp}_{4,t}}$	Ant Yield Spread	*IGamma*	0.075	0.075	0.066	0.024	0.113
$100\sigma_{\zeta^{\theta_N}_{4,t}}$	Ant NT markup	*IGamma*	0.075	0.075	0.078	0.023	0.122
$100\sigma_{\zeta^{\theta_T}_{4,t}}$	Ant T markup	*IGamma*	0.075	0.075	0.072	0.023	0.127
$100\sigma_{\zeta^{Ah}_{10,t}}$	Ant Ah	*IGamma*	0.075	0.075	0.078	0.022	0.135
$100\sigma_{\zeta^{An}_{10,t}}$	Ant An	*IGamma*	0.075	0.075	0.090	0.022	0.155
$100\sigma_{\zeta^{X}_{10,t}}$	Ant Labor Augmenting	*IGamma*	0.075	0.075	0.069	0.023	0.120
$100\sigma_{\zeta^{\zeta}_{10,t}}$	Ant Preference	*IGamma*	0.075	0.075	0.079	0.022	0.137
$100\sigma_{\zeta^{I}_{10,t}}$	Ant I	*IGamma*	0.075	0.075	0.072	0.023	0.123
$100\sigma_{\zeta^{L}_{10,t}}$	Ant L	*IGamma*	0.075	0.075	7.501	5.941	9.022
$100\sigma_{\zeta^{Sp}_{10,t}}$	Ant Yield Spread	*IGamma*	0.075	0.075	1.270	0.414	2.057
$100\sigma_{\zeta^{\theta_N}_{10,t}}$	Ant NT markup	*IGamma*	0.075	0.075	0.065	0.023	0.109
$100\sigma_{\zeta^{\theta_T}_{10,t}}$	Ant T markup	*IGamma*	0.075	0.075	0.065	0.023	0.109

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 investment adjustment cost which are instead re-scaled by a factor of 10.

(2011) 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 50 percent of 500 thousands draws generated with 4 random walk Metropolis Hastings chains with average acceptance rate close to 30 percent.

It is interesting to notice that our estimated elasticities are, compared to previous macro-estimates, much closer to the values found in the micro-trade studies. First, the posterior mean of the trade elasticity, ϵ, is equal to 3.1. 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 & Manteu (2011), which used Euro Area micro-disaggregated data.[28] 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 the data is indeed informative for those parameters, especially for the trade elasticity, by comparing the prior and posterior density functions of the two elasticities.

Focusing on household parameters, the elasticity of capital utilization, 0.27, the capital adjustment cost elasticity, 23.4, and the habit formation in consumption, 0.65, are consistent with other studies (e.g. Burriel et al. (2010) which estimates a small open economy for Spain in a similar time period).

Prices are significantly more persistent in the non tradable sector than in the tradable sector. Average duration in the non tradable sector is of 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 13.7 percent.

The autoregressive parameters of the innovation processes tell us that shock are not particulary 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, 0.64.

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; steady state real exchange rate is positive in the model, given the higher average growth of the 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. Consumption more volatile than

[28] A potential explanation of the success of our model in capturing this aspect is that we focus on a monetary union in which, as pointed out by Lubik & Schorfheide (2005), the law of one price assumption of the model is not too far from reality.

Elasticities of Substitution

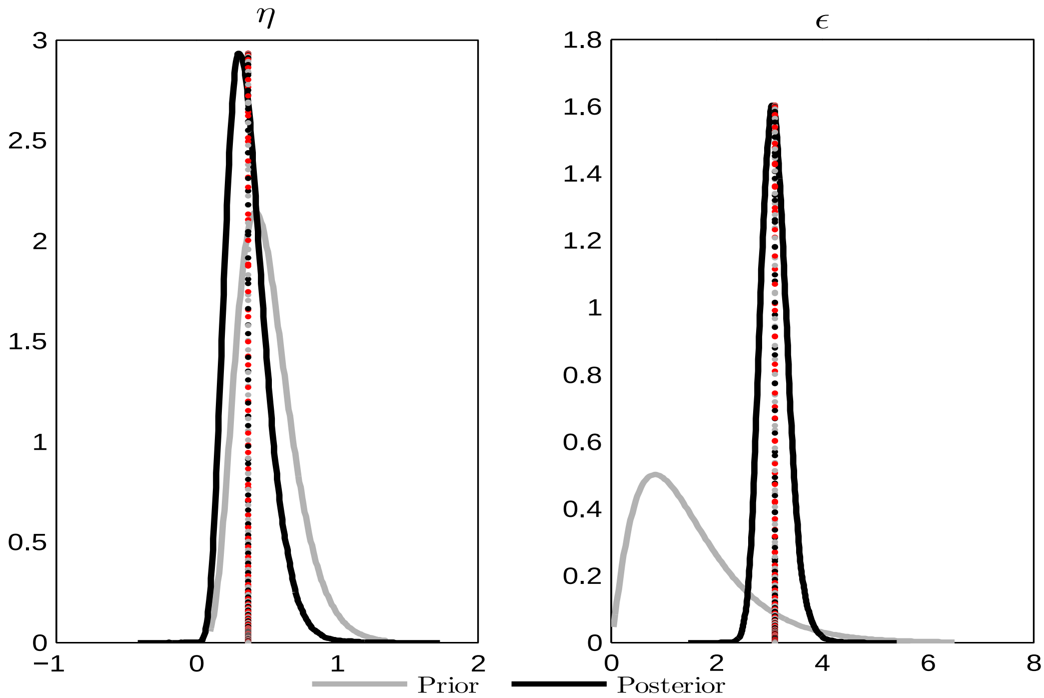


Figure 2: Prior and Posterior density

output and large current account fluctuations generate often problems. Aguiar & 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. However, given that qualitative results of the paper would not change, we continue to use the baseline estimation because we argue that it is at least as important to match consumption as output volatility to explain the experienced imbalances in the IPS.[29]

The estimation results are robust to standard test.[30] For all parameters and standard deviations the draws of the posterior sampling converged, 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, parameter governing the endogenous discount factor, for which the data seems uninformative and the posterior retrace the prior. 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. It is important to notice that the

[29]The estimated parameters and variance decomposition of the model excluding consumption as an observable variable are available upon request.

[30]Detailed test results and graphs are in the appendix available upon request

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	1.56	0	1.64
Δ ReR	-0.34	0.43	0.40	1.44	0.40	1.20
Δ Y	0.92	0.34	0.97	1.49	0.97	0.66
Δ I	1.72	1.81	0.97	2.91	0.97	2.84
Δ C	0.91	0.92	0.97	1.64	No cons	No cons
Δ L	-0.08	0.36	0	2.62	0	0.89
r	0.88	0.25	1.04	0.16	1.04	0.16
p^*_T	0	0.92	0	1.02	0	1.10
p^*_{NT}	0	0.98	0	1.48	0	1.58
Y^*_d	0	1.35	0	1.62	0	1.73

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 the consumption growth series.

estimation results do not change if, instead of estimating this parameter, we calibrate it to -500. In addition we control that parameters are locally identified at the posterior mean, following Iskrev (2010).

4 What explains current account imbalances in the Euro Area?

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 (see Giavazzi & Spaventa (2010), OECD (2010) and Lane & Milesi-Ferretti (2011), among others). 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. In particular, we start by learning from the impulse response functions what shocks can generate the experienced contemporaneous movement of current account, real exchange rate and GDP. Then we understand, through a variance decomposition of the estimated model, what fraction of international variable fluctuations can be ascribed to anticipated shocks.

As in Giavazzi & Spaventa (2010) and Eichengreen (2010), we have in mind a distinction between types of current account imbalances depending on their trigger. 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. We would define intertemporal efficient imbalances, the ones resulting from an increase in openess that allows countries with better growth prospect to borrow money from abroad using future growth to repay the international debt. If we believe in this definition, it is not difficult to understand why we think of anticipated productivity shocks as the main source of efficient imbalances.

The idea that capitals, inside the EMU, were flowing towards catching up countries with higher current or expected productivity growth has partially lost empirical support.[31] In this section we test theoretically which unanticipated and anticipated shocks are in fact important sources of the experienced imbalances of the euro area.

4.1 Impulse Responses

We study the dynamics of the model in response to a wide range of possible shocks at the posterior mean of parameters and standard deviations. 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 this shocks as anticipated shocks. In this section we look at the baseline model presented in section (2) in which we have separable utility function and anticipated shocks in the form of news shocks. Later we relax these two assumptions: in section 5.1 we show how the results change when we use a preference specification that makes it possible to control the wealth elasticity of labor supply and in section 5.2 we assume imperfect information and anticipated shocks in the form of noise shocks.

We consider 10 different sources of fluctuation: sector-specific technologies, labor augmenting technology, preference, investment adjustment cost, labor supply, sector-specific markups, monetary policy and yield spread. Our focus will be on the reaction of output, current account and real exchange rate to disclose which shock is capable of generating the experienced contemporaneous movement of those three variables (Figure 1(b)).

We start by analyzing the reaction of the economy to an unanticipated shock in the productivity of the tradable sector (Figure 3). This allows us to highlight some important mechanism triggered, in general, by productivity shocks. At the macro level, as the tradable technology jumps up, GDP, consumption and investment increase; the positive wealth effect, from the raise in current and future output, is behind consumption fluctuations while the improved marginal productivity of capital is moving investments. At the firm level, higher productivity combined with higher consumption pushes up firms' demand for labor and capital in the tradable sector, generating an increase in wages and in rental rate of capital. While this is not sufficient to increase the cost of production in the tradable sector, it triggers an increase in the marginal cost of the non tradable sector. Therefore, non tradable prices increase but less then the decrease in tradables. This leads to a drop in domestic

[31] Zemanek, Belke & Schnabl (2009) and Berger & Nitsch (2010) suggest that in fact capitals were flowing towards countries not only with higher per capita GDP growth but also with higher domestic distortions. See also Schmitz & von Hagen (2009), Sodsriwiboon & Jaumotte (2010), Barnes, Lawson & Radziwill (2010), Barnes (2010) and Belke & Dreger (2013) for the dynamics and consequences of large current account deficits in the euro area from a policy perspective.

Unanticipated Tradable Productivity Shock

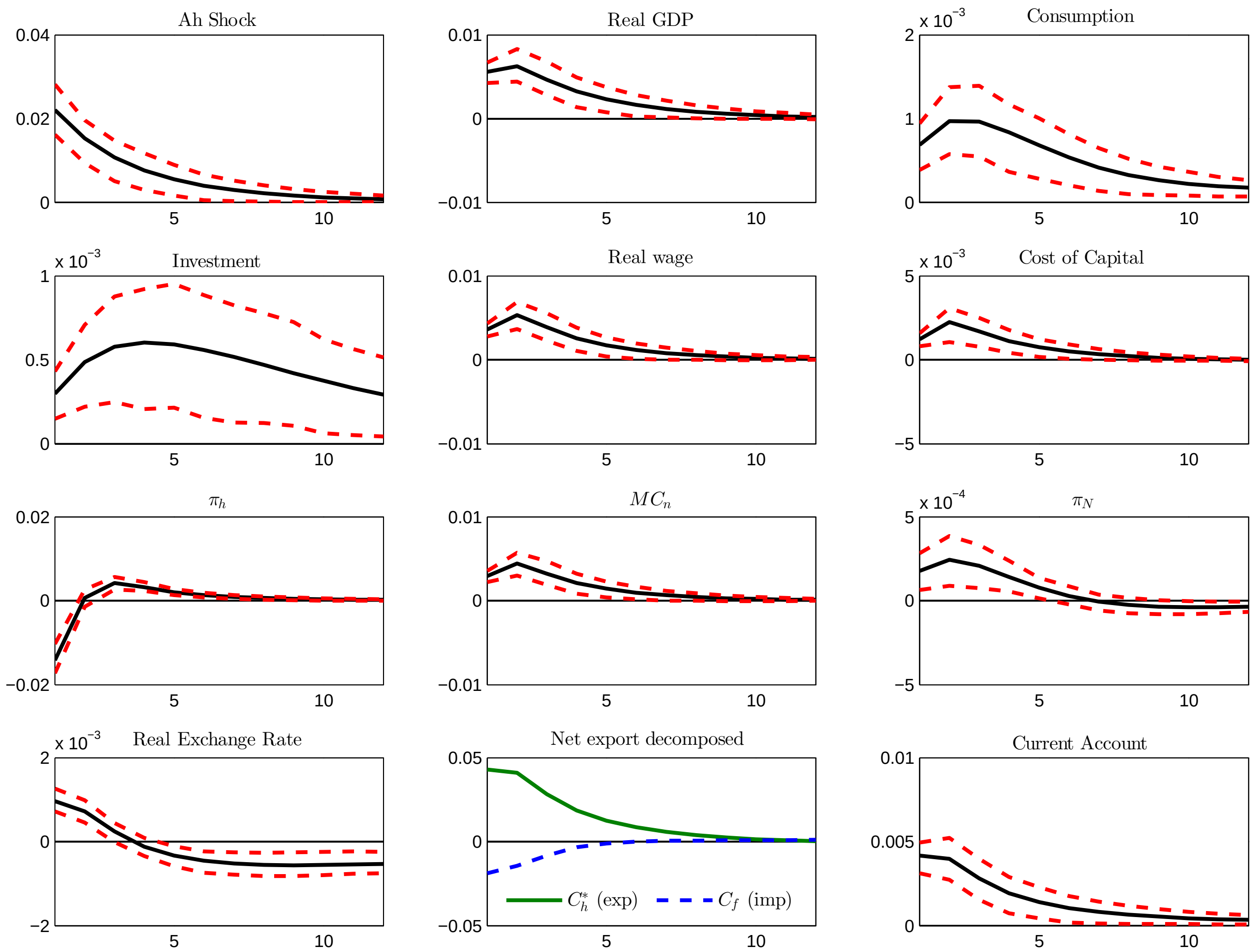


Figure 3: Impulse response to a positive unanticipated technology shock in the tradable sector. Note: an increase in the real exchange rate corresponds to a depreciation.

inflation and a real exchange rate depreciation.[32] As international competitiveness improves, net export increases, both for an increase in exports and a decrease in imports, and current account goes on surplus.

Moving to non tradable sector productivity shocks, similarly to tradable ones, current account responds by going on surplus and real exchange rate depreciates. However, differently, GDP falls on impact (Figure 4, column 2). This is due to the fact that the underneath equilibrium dynamics is 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. Consumption and investment, exactly as in the previous case, increase. However, on impact, the increase in potential non tradable production is not followed by an equivalent increase

[32]Given the estimated trade elasticity and persistency of shocks, the positive wealth effect of the increase in production, mainly sold abroad, is more than offsetting the negative effect due to the terms of trade depreciation.

TFP shocks

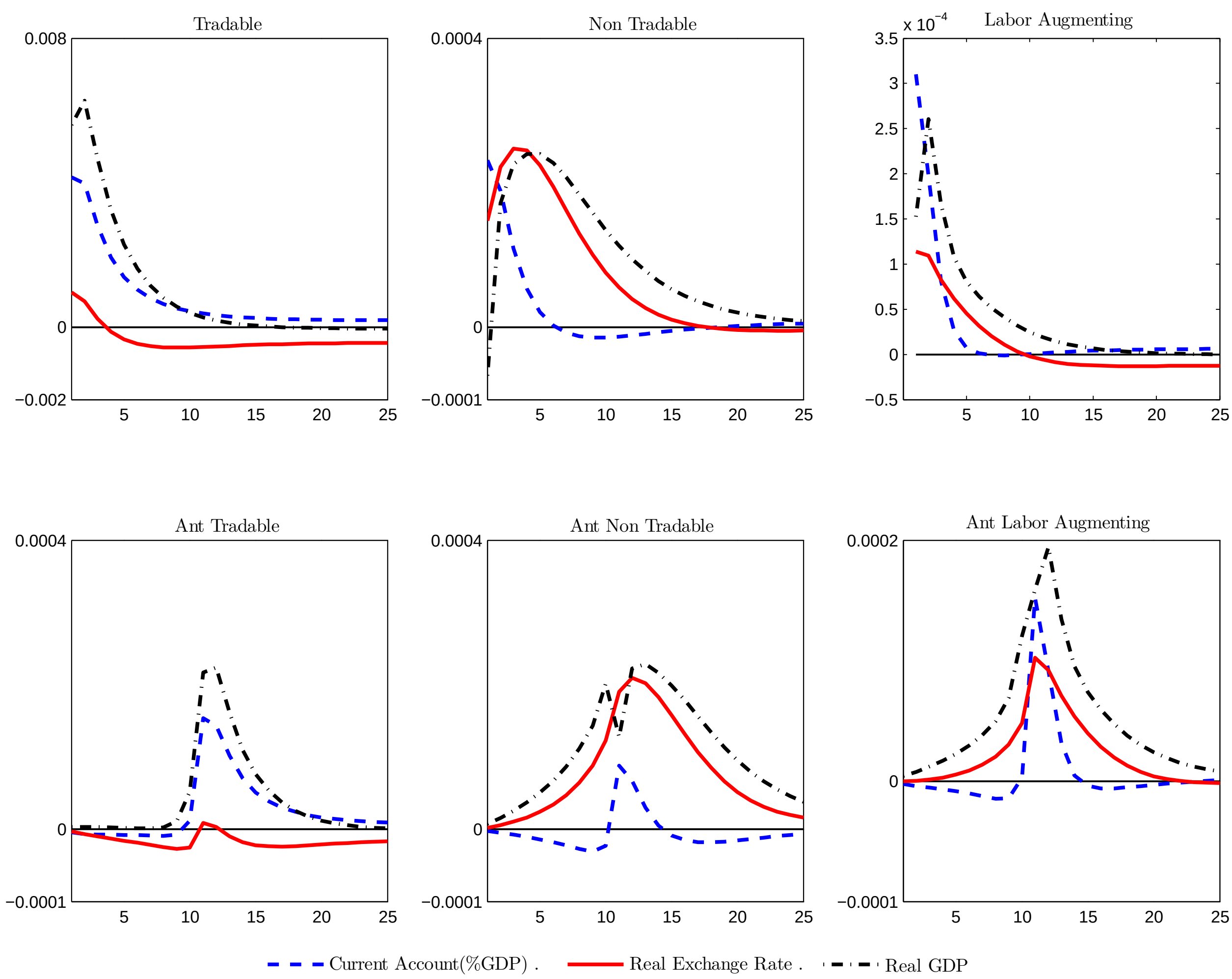


Figure 4: Impulse response of current account(% of GDP), real GDP and real exchange rate to sector specific and labor augmenting anticipated and unanticipated technology shocks. Note: an increase in the real exchange rate corresponds to a depreciation.

in non tradable demand, as it is partially complementary to tradable consumption. 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 sticky and therefore the non tradable firm needs to lower production by decreasing capital utilization and demand for labor. This lowers wages and the rental rate of capital with a 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 period, as prices adjust more, both tradable and non tradable sector productions increase.

Summarizing, an unanticipated shock both in the tradable and in the non tradable sector cannot match the observed evidence for Ireland, Portugal and Spain as it generates a current account surplus and a real exchange rate depreciation. The same happens in response to a common labor augmenting unanticipated productivity shock. Notice that while the Balassa-Samuelson sectorial prediction in response to a productivity shock in the tradable sector is satisfied, meaning an increase in the non tradable-tradable price ratio, this is not sufficient to generate a real exchange rate appreciation given our estimation. Therefore, we move to check if anticipated shocks can instead explain the observed evidence.

Figure 4 summarizes the response of GDP, current account and real exchange rate to one standard deviation positive shock in all anticipated and unanticipated productivity processes included in the model. The upper row shows the responses to unanticipated shocks while the lower row displays the ten-quarter anticipated shocks. We see that only tradable anticipated productivity shock can temporarily reproduce GDP increase characterized by real exchange rate depreciation and current account deficit. 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 increase 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. Increase in imports and decrease 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 Ireland, Portugal and Spain 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 increasingly larger anticipated shocks. This second scenario is extremely difficult to reconcile to Ireland, Portugal and Spain given that they experienced, since 1996, lowering tradable productivity. Figure (5) shows in fact the decreasing path of the tradable TFP with respect to the long run productivity average using the EUKLEMS database[33]

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 good and the persistency of shocks. As clearly explained in Corsetti et al. (2008), in presence of really low trade elasticity and home bias, real exchange rate appreciates and current account goes on deficit in response to productivity shocks. This is true because an appreciation, and the related

[33]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 Ireland, Portugal and Spain.

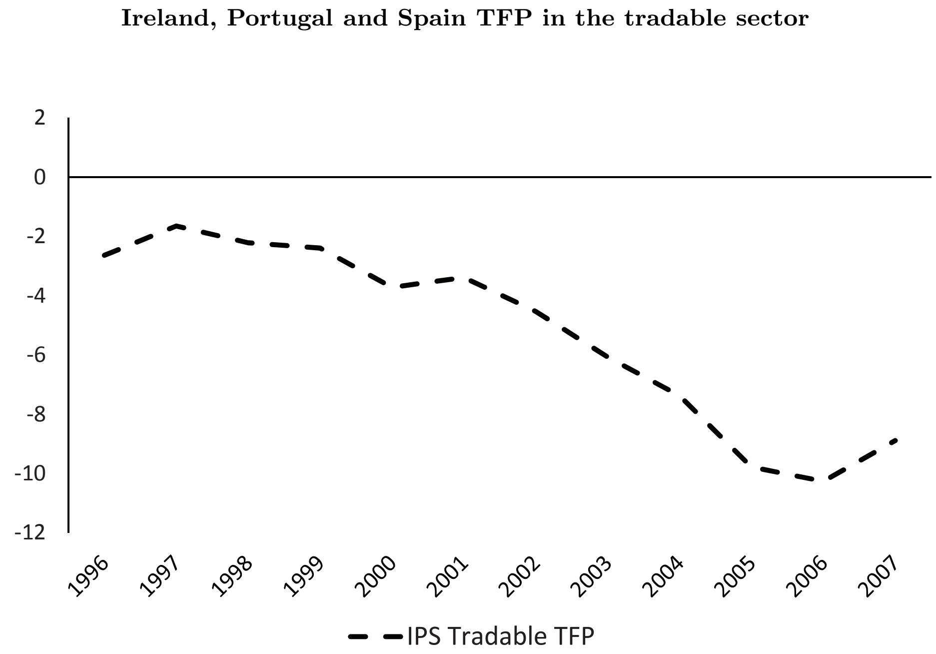


Figure 5: Total factor productivity path in the tradable sector calculated in percent deviation from the trend. The trend is calculated as the average TFP in 1981-2007 for Spain, in 1989-2007 for Ireland and in 1996-2007 for Portugal. Source EUKLEMS database and own calculations.

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 respond to a positive unanticipated tradable productivity shock when we allow the listed parameters to vary. First, the left panel of the Figure 6, shows that low values of trade elasticity, keeping the persistency of the shock and all other parameters at the estimated values, pushes the current account to deficit (and the real exchange rate to appreciation). We pick a 3D plot because it allows us to understand that higher values of the trade elasticities are also compatible with real exchange rate appreciation and a current account deficit if we increase the tradable vs. non tradable elasticity[34]. Second, the right panel of the 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 crucial to estimate these parameters within the model in order not to impose the desired results on the behavior of

[34]Notice that the range of parameters for which the current account goes on surplus in response to a positive tradable technology shock is pretty wide. As a rule of thumb, fixing the persistency of shocks, current account reacts positively when domestic and foreign goods are substitute and it reacts negatively if they are complements. Corsetti et al. (2008) show that in the presence of a marginal cost advantage with highly substitutable tradable goods, exports increase more than imports generating a surplus, while, in the case of complement goods, the wealth effect increases consumption above production generating current account deficit.

international variables by using specific parameterizations.

Trade elasticity, tradable vs non tradable elasticity and persistency

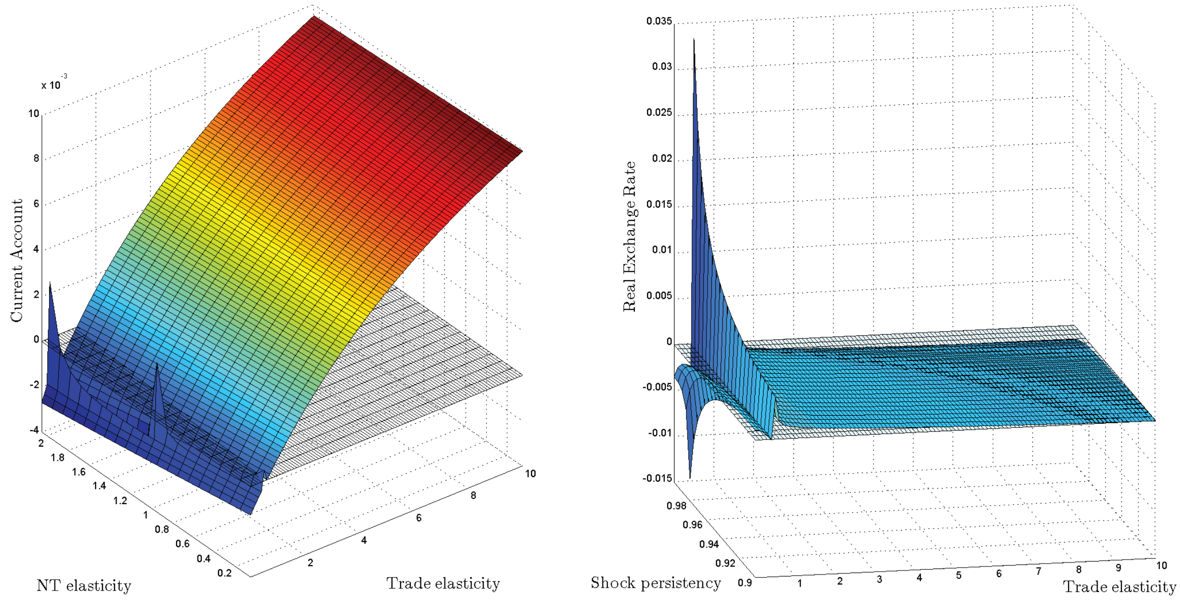


Figure 6: LHS: Impact of a tradable technology shock on current account(% of GDP) for different trade (ϵ) and tradable-non tradable elasticities (η). RHS: Different reaction of the real exchange rate for different values of the trade elasticity and the persistency of the tradable productivity shock (ρ_{A_h})

Having shown that none of the productivity shocks included in the model can generate the persistent observed contemporaneous movement, we study the reaction of the model to the other shocks. Figure 7 shows 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}.

Four shocks can generate a simultaneous deterioration of the current account, appreciation of the real exchange rate and increase in GDP: unanticipated and anticipated yield spread drops[35], anticipated investment adjustment cost and finally unanticipated positive demand shocks. On the other hand, from Figure 7, we see that unanticipated investment shocks do not generate a lasting real exchange rate appreciation, labor supply shocks generate GDP growth with real exchange rate depreciation and finally anticipated demand shock generate recessionary pressure on GDP in the period before the realization of the shock.

Not surprisingly, the dynamics generated by an unanticipated drop in the yield spread and an unanticipated increase in demand are somehow similar, but for one variable. 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

[35] 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 disentangle.

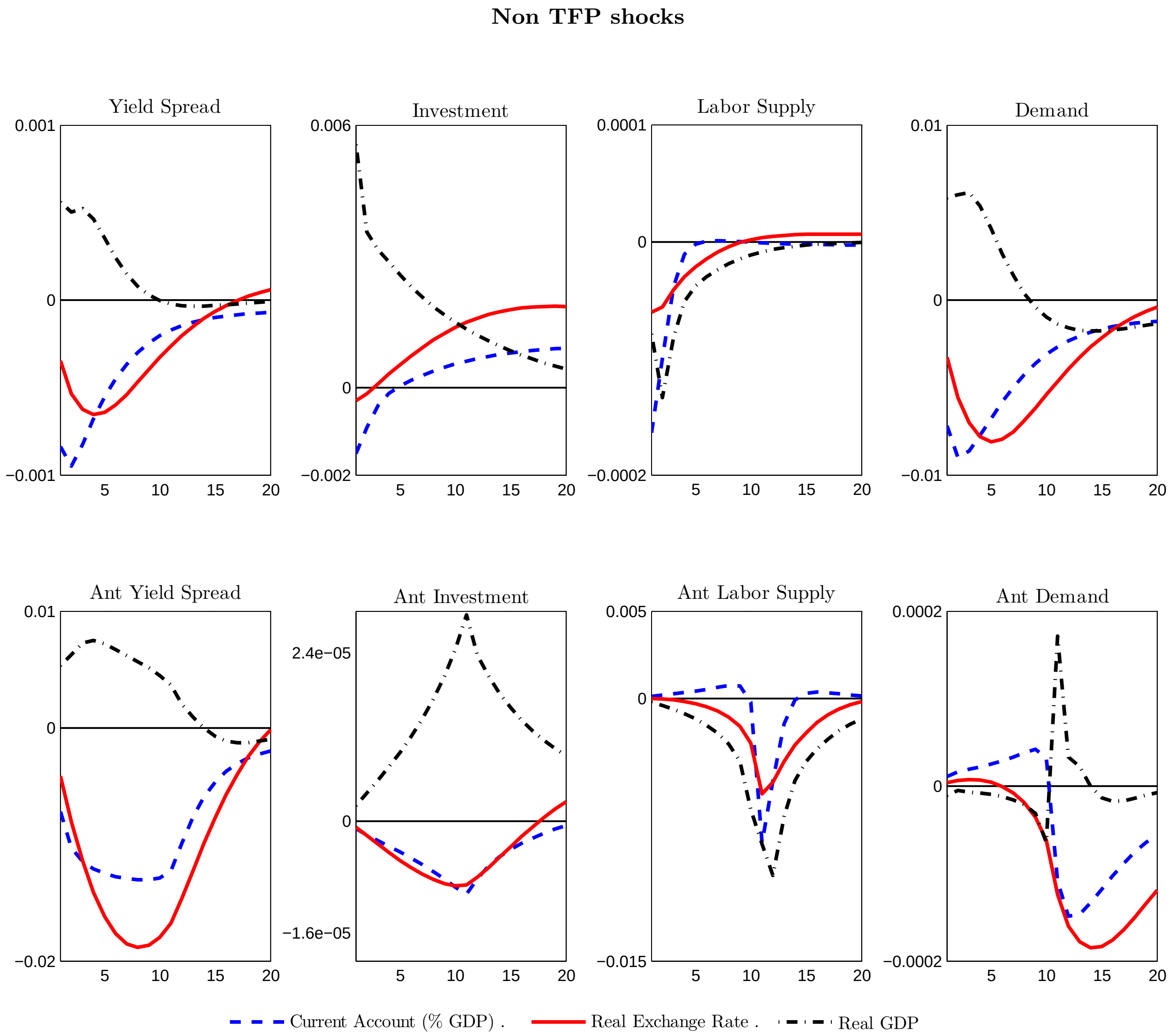


Figure 7: Impulse response of current account(% of GDP), real GDP and real exchange rate to unanticipated and anticipated drop in the yield spread, improvement in the investment technology, positive labor supply shock and positive demand shock. Note: an increase in the real exchange rate corresponds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

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 decrease in the cost of borrowing leads to an increase in the amount of investment, while the pure demand shock crowds out investments. Between 1996 and 2007 Ireland, Portugal and Spain experienced a persistent increase in real investment, as shown in Figure 1(d), permitting us to conclude that the demand shocks cannot be alone the main driver of the imbalances in the euro area periphery.

Similarly, anticipated decrease in investment costs fail to match the dynamic of one variable: consumption. In this case, the increase in output is entirely driven by the immediate and long lasting increase in investment which, in the period preceding the realization of the shock, results in increasing marginal costs for firms. Firms respond by increasing prices and consumption decreases. The consequent appreciation of the real exchange rate leads to negative net exports and current account deficit. In Ireland, Portugal and Spain, periods of current account deficits were characterized by increase in consumption. It is worthed to notice, however, that differently from investment that was increasing through the entire sample, the de-trended consumption pattern for Ireland, Portugal and Spain was oscillating around the steady state.

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 imbalance inside the EMU by matching the behavior of all macro variables: increasing GDP, consumption and investment are matched with current account deficit and real exchange rate appreciation. Supporting this qualitative result, we saw in Figure (1(c)) that Ireland, Portugal and Spain, in the same period, experienced a large and unprecedented decrease in the relative cost of borrowing. The next step is to support the qualitative analysis from the impulse response with quantitative results coming from the estimated model. First we are interested to quantify the role of yield spread shocks for current account, real exchange rate and output fluctuations. Second we want to understand if anticipated or unanticipated shocks in the yield played the dominant role. We therefore proceed with a variance decomposition analysis to understand to which shock the estimation assigns the ability of explaining the current account and real exchange rate fluctuations.

4.2 The importance of anticipated shocks

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

Table 5: Share of Variance Explained by Anticipated Shocks

Shock	Δ GDP	Δ Current Account(% of GDP)	Δ Real Exchange rate
Unanticipated	65.04	31.94	49.10
4-Quarters Anticipated	5.97	3.49	3.25
10-Quarters Anticipated	28.94	63.84	47.57

Note: Sum of all shocks grouped by the length of anticipation. The unconditional variance decomposition is computed at the mean of the posterior distribution of the estimated structural parameters.

Table 5 displays the aggregate share of unconditional variances explained by unanticipated and anticipated shocks. The latter is displayed separating the short and long horizon. Anticipated shocks account for 67 percent of current account movements, 51 percent of real exchange rate variability and 35 percent of output growth fluctuations. We see that the role of anticipated shocks is even more considerable for current account and real exchange rate fluctuations than for GDP movements.

Table 6: Unconditional Variance Decomposition

Shocks		Δ GDP	Δ Current Account(% GDP)	Δ Real Exchange rate
Tradable tech.	$u^{AH}_{0,t}$	15.2	7.0	0.6
	$u^{AH}_{4,t}$	0.0	0.0	0.0
	$u^{AH}_{10,t}$	0.0	0.0	0.0
	Σu^{AH}	15.2	7.0	0.6
Non tradable tech.	$u^{AN}_{0,t}$	0.0	0.0	0.0
	$u^{AN}_{4,t}$	5.9	3.4	3.2
	$u^{AN}_{10,t}$	0.0	0.0	0.0
	Σu^{AN}	5.9	3.4	3.2
Labor augmenting prod.	$u^{X}_{0,t}$	0.0	0.0	0.0
	$u^{X}_{4,t}$	0.0	0.0	0.0
	$u^{X}_{10,t}$	0.0	0.0	0.0
	Σu^{X}	0.0	0.0	0.0
Demand	$u^{\zeta}_{0,t}$	17.2	22.2	10.9
	$u^{\zeta}_{4,t}$	0.0	0.0	0.0
	$u^{\zeta}_{10,t}$	0.0	0.0	0.0
	Σu^{ζ}	17.2	22.2	10.9
Labor supply	$u^{L}_{0,t}$	0.0	0.0	0.0
	$u^{L}_{4,t}$	0.0	0.0	0.0
	$u^{L}_{10,t}$	14.4	36.0	6.0
	Σu^{L}	14.4	36.0	6.0
Investment specific	$u^{I}_{0,t}$	15.3	1.2	0.2
	$u^{I}_{4,t}$	0.0	0.0	0.0
	$u^{I}_{10,t}$	0.0	0.0	0.0
	Σu^{I}	15.3	1.2	0.2
Monetary Policy	u^{r}_{t}	0.3	0.5	0.3
Yield spread	$u^{Spread}_{0,t}$	0.1	0.2	0.1
	$u^{Spread}_{4,t}$	0.1	0.1	0.1
	$u^{Spread}_{10,t}$	14.5	27.8	41.5
	Σu^{Spread}	14.7	28.1	41.7
Markup - tradable	$u^{\theta}_{0,t}$	15.8	0.2	34.3
	$u^{\theta}_{4,t}$	0.0	0.0	0.0
	$u^{\theta}_{10,t}$	0.0	0.0	0.0
Markup - Non tradable	$u^{\phi}_{0,t}$	0.0	0.0	0.0
	$u^{\phi}_{4,t}$	0.0	0.0	0.0
	$u^{\phi}_{10,t}$	0.0	0.0	0.0
	Σu^{I}	15.8	0.2	34.3
Foreign Tradable price	$u^{\Pi_T *}_{t}$	1.0	0.5	0.0
Foreign Non Tradable price	$u^{\Pi *}_{t}$	0.0	0.0	2.4
Foreign consumption	u^{c*}_{t}	0.1	0.0	0.3
	Σu^{*}	1.1	0.5	2.8

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

Moving to more detailed results, table 6 presents the disaggregated contribution of all the shocks to the variance of the three variables. First, we focus on output growth. Unanticipated tradable and anticipate non tradable productivity, demand, anticipated labor supply, unanticipated investment specific, anticipated yield spread and unanticipated tradable markup are the shocks that almost equally contribute to output growth fluctuations. On top of some results in line with the literature, like the importance of investment specific productivity shocks (Justiniano, Primiceri & Tambalotti (2010)[36]) or of labor supply and preferences for countries like Spain (Burriel et al. (2010), we learn that 15% of output movements are explained by the reaction of the economy to anticipated fluctuations in the cost of borrowing. A sizable fraction of output fluctuation, as in Schmitt-Grohé & Uribe (2012), is explained by TFP shocks: 15 % by unanticipated tradable shocks and 6% by anticipated non tradable shocks.

Current account changes are explained almost entirely by 3 shocks: anticipated yield spread (28%), unanticipated demand (22%) and anticipated labor supply (35%). The remaining part is explained by productivity shocks: unanticipated in the tradable sector and anticipated in the non tradable one. In line with the impulse response analysis, anticipated yield spread and unanticipated demand shocks are important sources of the experienced current account deficit characterized by a real exchange rate appreciation and output growing. The variance decomposition helps us to assign to the anticipated component of the yield spread shock, with respect to the unanticipated one, the main explanatory power of current account fluctuations. Demand shifts also help explaining one fifth of current account fluctuations even though, as we saw in the impulse response analysis and it is confirmed here, they cannot be the only driver of the deficit as they fail to generate an increase in investment. The important role of anticipate labor supply shock, as in GDP, can be explained by the lack of a properly modeled demographic evolution which played an important role in Ireland, Portugal and Spain.

Focusing on real exchange rate changes, table 5 shows that anticipated shocks play a crucial role, by explaining half of its variability. Ten-quarter anticipated drop in the yield spread accounts for 80% of the anticipated component. We saw in the impulse response analysis that an anticipated decrease in the spread is the only shock that can generate a persistent real exchange rate appreciation, matching the observed evidence for the IPS. The main unanticipated component explaining changes in real exchange rate movements is tradable specific cost-push shocks, which roughly account for a third 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 Ireland, Portugal and Spain. In particular, anticipated long run fluctuations in the risk premium, for the estimated small open economy, are crucial driver of the joint GDP, current account and real exchange rate dynamics. Unanticipated and anticipated increase in productivity, both labor augmenting or sector specific, played only a marginal role in the accumulation of imbalances.

[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 the importance of investment specific shocks for output growth fluctuations.

5 Robustness checks

In this section we propose two different specifications of the model to check the robustness of our results. First, we introduce Jaimovich and Rebelo type of preferences to estimate and understand the importance of the wealth elasticity of the labor supply. 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 Jaimovich and Rebelo preferences

Business cycle data feature aggregate co-movement between output, consumption, investment and hours worked. Barro & King (1984) showed that standard business cycle models sometimes fail to generate this co-movement. This is often the case also for models featuring anticipated shocks. In fact, anticipated permanent shocks in technology can generate a negative correlation between consumption and hours worked if agents anticipate the increase in wealth and consequently increase demand for leisure and consumption. A proposed solution is to separate the wealth of agents from labor supply decisions. A way of doing so is by using the utility function proposed by Greenwood et al. (1988) which completely eliminates wealth effects on labor supply. We use a more flexible version, proposed by Jaimovich & Rebelo (2009), which allows us to estimate the importance of those wealth effects.

We start by noticing that our baseline scenario does not suffer from the counterfactual reaction of hours worked to anticipated shocks in productivity. In fact, capital adjustment cost elasticity, if sufficiently large,[37] triggers an immediate positive adjustment in investment and hours worked.

As in Hoffmann et al. (2011), we introduce two new features with respect to the standard Jaimovich & Rebelo (2009) formulation: habit persistence in consumption and the presence of a trend in the growth rate of our economy. We substitute the utility function (equation 4) with the following:

$$U(C_t, L_t) = \frac{\left\{(C_t - h\overline{C}_{t-1}) - \epsilon_t^L \psi^L L_t^{1+\nu} \Omega_t\right\}^{1-\sigma} - 1}{1-\sigma}, \tag{32}$$

where

$$\Omega_t = (C_t - h\overline{C}_{t-1})^{\mu} \Omega_{t-1}^{1-\mu} (1+z)^{1-\mu}. \tag{33}$$

Utility depends on consumption at time t, C_t, a portion of average past consumption, $h\overline{C}_{t-1}$, and hours worked L_t. Notice that 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 $\mu \in [0, 1]$. By changing μ we can account for two important classes of utility functions used in the business cycle literature: King, Plosser & Rebelo (1988) types of preferences (KPR henceforth) when $\mu = 1$ and Greenwood et al. (1988) when $\mu = 0$ (GHH henceforth). The inclusion

[37] In our estimated model, capital adjustment cost elasticity needs to be above 2.42 approximately to ensure positive response of hours worked in face of a labor augmenting productivity shock anticipated 10 quarters in advance.

of $(1+z)^{1-\mu}$ allows us to maintain the assumption of a deterministic trend in the labor augmenting productivity.[38]

The representative agent will then maximize his/her utility function subject to (2), (4), (6), (7) and to the new utility function (32, 33).[39] The remaining part of the model is equivalent to the baseline specification presented in section 2.

The model features three new parameters: σ, μ and v. σ, the intertemporal elasticity of substitution, is calibrated to 1, as in baseline model. μ, the degree of the wealth elasticity of the labor supply, and v, the elasticity of labor supply when μ is equal to zero, are estimated. We assign to μ a gamma prior distribution within 0 and 1 with mean 0.5 and to v a gamma prior distribution with mean 1 and standard deviation of 0.5. Tables 7 and 8 summarize the prior mean, posterior mean and the 90-percent lower and upper bound for all the estimated parameters. The statistics are computed using the last 50 percent of 250 thousands draws generated with two random walk Metropolis Hastings chains.

Interestingly, and differently from previous estimation performed by Schmitt-Grohé & Uribe (2012), the wealth elasticity of labor supply is estimated to be non negligible and close to 1. Wealth effects on labor supply indeed play an important role in explaining the behavior of Ireland, Portugal and Spain. The posterior mean of μ is 0.9 and v is estimated to be 4.2. 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. All other estimated parameters and standard deviations are not statistically significant from the baseline estimation (3), as shown in table 7 and 8. The only exception is the persistency of labor supply shocks which is significantly more persistent now that we estimate the Frisch elasticity. Estimation results are robust to standard tests presented at the end of section 3.3.

Using parameters and standard deviations at the mean of their posterior distribution, we analyze the impulse response to all shocks. Figure 8 plots the reaction of GDP, current account and real exchange rate to a 10-quarters positive one-standard deviation anticipated productivity shock in both sectors and to an anticipated drop in the yield spread. As for the baseline model, both shocks are able to generate on impact a current account deficit but only the yield spread matches the contemporaneous appreciation of the real exchange rate. A complete impulse response analysis confirms that all the results are robust under the model specification with the Jaimovich and Rebelo types of preferences. Also the variance decomposition analysis confirms the important role played by anticipated yield spread shocks for changes in current account (26%), in real exchange rate (39%) and in real GDP growth (17%)

To summarize, the role of anticipated shocks, and in particular of yield spread fluctuations, is confirmed in a model with estimated wealth elasticity of the labor supply. [40]

[38] Jaimovich & Rebelo (2009) imposed $\mu > 0$ in order to add some weight to the KPR preferences which are growth consistent. Introducing $(1+z)^{1-\mu}$ we avoid problems coming from highly persistent deviations from the steady state growth path, allowing us to consider the entire set $\mu \in [0,1]$ in the estimation.

[39] The first order necessary conditions for this new maximization problem are in the appendix available upon request.

[40] Detailed tables and extended results are available on request.

Table 7: Prior and Posterior Distribution with JR preferences

		Distr.	Prior Mean	Prior St. Dev	Posterior Mean	Posterior Lower	Posterior Upper
Estimated Parameters							
μ	Lab supply wealth eff	*Gamma*	0,5	0,2	0,901	0,781	1,000
v	Frisch elast (μ=0)	*Gamma*	1,0	0,5	4,237	2,245	6,226
η	T Vs NT	*Gamma*	0,5	0,2	0,386	0,132	0,623
ϵ	home VS foreign	*Gamma*	1,5	1,0	3,222	2,768	3,652
h	habit formation	*Beta*	0,7	0,1	0,697	0,623	0,774
$\overline{\eta}_v$	Utilization rate elast	*Beta*	0,5	0,1	0,237	0,154	0,320
η_k	Capital adj cost elast	*Gamma*	10,0	5,5	23,636	15,799	31,475
θ	Good elasticity	*Norm*	7,5	1,0	8,266	6,729	9,641
θ_N	NT price rigidity	*Beta*	0,9	0,1	0,845	0,785	0,904
θ_h	T price rigidity	*Beta*	0,8	0,1	0,189	0,134	0,243
ϕ_N	NT indexation	*Beta*	0,5	0,1	0,494	0,413	0,582
ϕ_h	T indexation	*Beta*	0,5	0,1	0,437	0,356	0,520
χ	End discount weight	*Normal*	-500,0	200,0	-481,785	-805,519	-163,981
AR Coefficients							
ρ_{A_h}	T Techn	*Beta*	0,7	0,1	0,704	0,584	0,827
ρ_{A_N}	NT Techn	*Beta*	0,7	0,1	0,642	0,514	0,770
ρ_X	Labor Augmenting	*Beta*	0,4	0,1	0,396	0,225	0,557
ρ_ζ	Preference	*Beta*	0,7	0,1	0,856	0,777	0,934
ρ_{ϵ_L}	Labor	*Beta*	0,5	0,1	0,532	0,371	0,689
$\rho_{\epsilon_r b}$	Risk Prem	*Beta*	0,5	0,1	0,747	0,589	0,904
ρ_θ	NT Markup	*Beta*	0,3	0,1	0,238	0,099	0,375
ρ_ϕ	T Markup	*Beta*	0,3	0,1	0,304	0,134	0,456
ρ_{ϵ_I}	Invest	*Beta*	0,5	0,1	0,326	0,192	0,455
Foreign Block							
a_{11}	VAR, Y^{*d} to lag Y^{*d}	*Normal*	0,5	0,5	0,923	0,861	0,999
a_{12}	VAR, Y^{*d} to lag P_f^*	*Normal*	0,0	0,1	-0,018	-0,091	0,052
a_{13}	VAR, Y^{*d} to lag P_N^*	*Normal*	0,0	0,1	-0,045	-0,112	0,018
a_{21}	VAR, P_f^* to lag Y^{*d}	*Normal*	0,0	0,1	-0,011	-0,070	0,053
a_{22}	VAR, P_f^* to lag P_f^*	*Normal*	0,5	0,5	0,853	0,765	0,950
a_{23}	VAR, P_f^* to lag P_N^*	*Normal*	0,0	0,1	0,021	-0,037	0,078
a_{31}	VAR, P_N^* to lag Y^{*d}	*Normal*	0,0	0,1	0,099	0,049	0,147
a_{32}	VAR, P_N^* to lag P_f^*	*Normal*	0,0	0,1	0,036	-0,033	0,105
a_{33}	VAR, P_N^* to lag P_N^*	*Normal*	0,5	0,5	0,907	0,843	0,971
$100\sigma_u^{C^*}$	Foreign consump	*IGamma*	0,15	0,15	0,536	0,441	0,628
$100\sigma_u^{\pi f}$	Foreign π_T	*IGamma*	0,15	0,15	0,481	0,403	0,555
$100\sigma_u^{\pi_N^*}$	Foreign π_{NT}	*IGamma*	0,15	0,15	0,301	0,246	0,352

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.

5.2 Imperfect Information

Eventually, we check if our results hold assuming a different structure and *ratio* for anticipated shocks. We move away from a setup where all agents had full and perfect information, and therefore

Table 8: Prior and Posterior Distribution with JR preferences

			Prior		Posterior		
		Distr.	Mean	St. Dev	Mean	Lower	Upper
Standard Deviation							
$100\sigma_{\zeta^{Ah}_{0,t}}$	T Techn	*IGamma*	0,15	0,15	1,921	1,407	2,463
$100\sigma_{\zeta^{An}_{0,t}}$	NT Tech	*IGamma*	0,15	0,15	0,130	0,048	0,225
$100\sigma_{\zeta^{X}_{0,t}}$	Labor Augmenting	*IGamma*	0,15	0,15	0,127	0,049	0,220
$100\sigma_{\zeta^{\zeta}_{0,t}}$	Preference	*IGamma*	0,15	0,15	4,532	2,659	6,367
$10\sigma_{\zeta^{I}_{0,t}}$	Invest	*IGamma*	0,15	0,15	4,691	2,938	6,395
$100\sigma_{\zeta^{L}_{0,t}}$	Labor	*IGamma*	0,15	0,15	0,143	0,046	0,250
$100\sigma_{\zeta^{r}_{0,t}}$	Int rate	*IGamma*	0,15	0,15	0,090	0,074	0,103
$100\sigma_{\zeta^{Sp}_{0,t}}$	Yield Spread	*IGamma*	0,15	0,15	0,119	0,048	0,198
$10\sigma_{\zeta^{\theta_N}_{0,t}}$	NT markup	*IGamma*	0,15	0,15	28,663	10,285	49,608
$100\sigma_{\zeta^{\theta_T}_{0,t}}$	T markup	*IGamma*	0,15	0,15	0,129	0,045	0,224
$100\sigma_{\zeta^{Ah}_{4,t}}$	Ant Ah	*IGamma*	0,075	0,075	0,096	0,021	0,177
$100\sigma_{\zeta^{An}_{4,t}}$	Ant An	*IGamma*	0,075	0,075	1,952	1,583	2,308
$100\sigma_{\zeta^{X}_{4,t}}$	Ant Labor Augmenting	*IGamma*	0,075	0,075	0,065	0,024	0,107
$100\sigma_{\zeta^{\zeta}_{4,t}}$	Ant Preference	*IGamma*	0,075	0,075	0,062	0,024	0,109
$100\sigma_{\zeta^{I}_{4,t}}$	Ant I	*IGamma*	0,075	0,075	0,072	0,023	0,132
$100\sigma_{\zeta^{L}_{4,t}}$	Ant L	*IGamma*	0,075	0,075	0,075	0,023	0,129
$100\sigma_{\zeta^{Sp}_{4,t}}$	Ant Yield Spread	*IGamma*	0,075	0,075	0,063	0,023	0,106
$100\sigma_{\zeta^{\theta_N}_{4,t}}$	Ant NT markup	*IGamma*	0,075	0,075	0,065	0,025	0,111
$100\sigma_{\zeta^{\theta_T}_{4,t}}$	Ant T markup	*IGamma*	0,075	0,075	0,071	0,024	0,134
$100\sigma_{\zeta^{Ah}_{10,t}}$	Ant Ah	*IGamma*	0,075	0,075	0,065	0,025	0,108
$100\sigma_{\zeta^{An}_{10,t}}$	Ant An	*IGamma*	0,075	0,075	0,066	0,025	0,113
$100\sigma_{\zeta^{X}_{10,t}}$	Ant Labor Augmenting	*IGamma*	0,075	0,075	0,070	0,024	0,127
$100\sigma_{\zeta^{\zeta}_{10,t}}$	Ant Preference	*IGamma*	0,075	0,075	0,062	0,024	0,106
$100\sigma_{\zeta^{I}_{10,t}}$	Ant I	*IGamma*	0,075	0,075	0,065	0,025	0,106
$100\sigma_{\zeta^{L}_{10,t}}$	Ant L	*IGamma*	0,075	0,075	6,167	4,356	8,004
$100\sigma_{\zeta^{Sp}_{10,t}}$	Ant Yield Spread	*IGamma*	0,075	0,075	1,084	0,313	1,867
$100\sigma_{\zeta^{\theta_N}_{10,t}}$	Ant NT markup	*IGamma*	0,075	0,075	0,142	0,024	0,336
$100\sigma_{\zeta^{\theta_T}_{10,t}}$	Ant T markup	*IGamma*	0,075	0,075	0,066	0,024	0,105

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 investment adjustment cost which are instead re-scaled by a factor of 10.

shocks were anticipated with certainty, and we introduce imperfect information. We are interested in understanding if imperfectly anticipated movements in productivity can explain Ireland, Portugal and Spain imbalances. In fact, Hoffmann et al. (2011) showed that imperfectly anticipated productivity shocks can explain fairly well the accumulated current account deficit experienced inside the United States.

TFP and Yield Spread shocks with Jaimovich and Rebelo utility

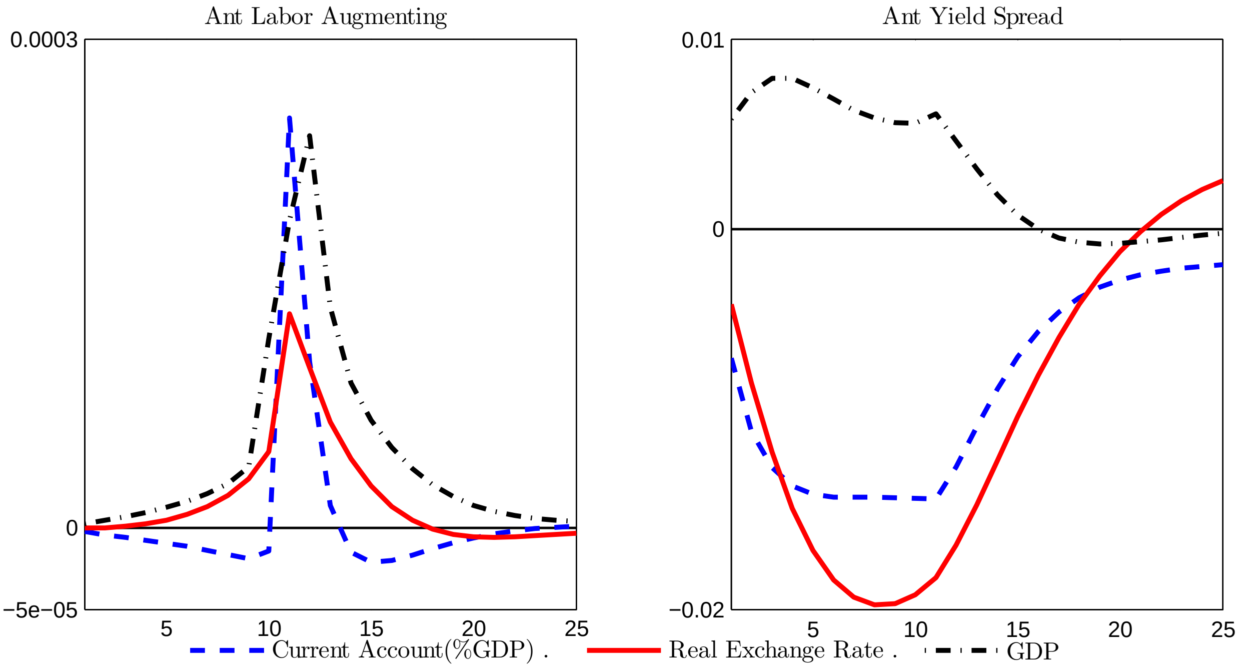


Figure 8: Impulse response of current account(% of GDP), real GDP and real exchange rate to a drop in the yield spread for the model specification with the Jaimovich and Rebelo types of preferences. Note: an increase in the real exchange rate corresponds to a depreciation.

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. These are due to temporary or strongly persistent growth rate shocks that can be respectively interpreted as one time permanent change in the level of productivity or as persistent change in the trend of productivity growth. Agents are able to observe actual levels of productivity but they do not know their underline sources. 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:

$$lnX_t - lnX_{t-1} = z + u_t^X + \widetilde{A}_t \quad (34)$$

$$\text{with} \quad (35)$$

$$\widetilde{A}_t = \rho_A \widetilde{A}_{t-1} + u_t^A. \quad (36)$$

Both $u_t^A \sim N(0, \sigma_A^2)$ and $u_t^X \sim N(0, \sigma_X^2)$ are independent and identically distributed random

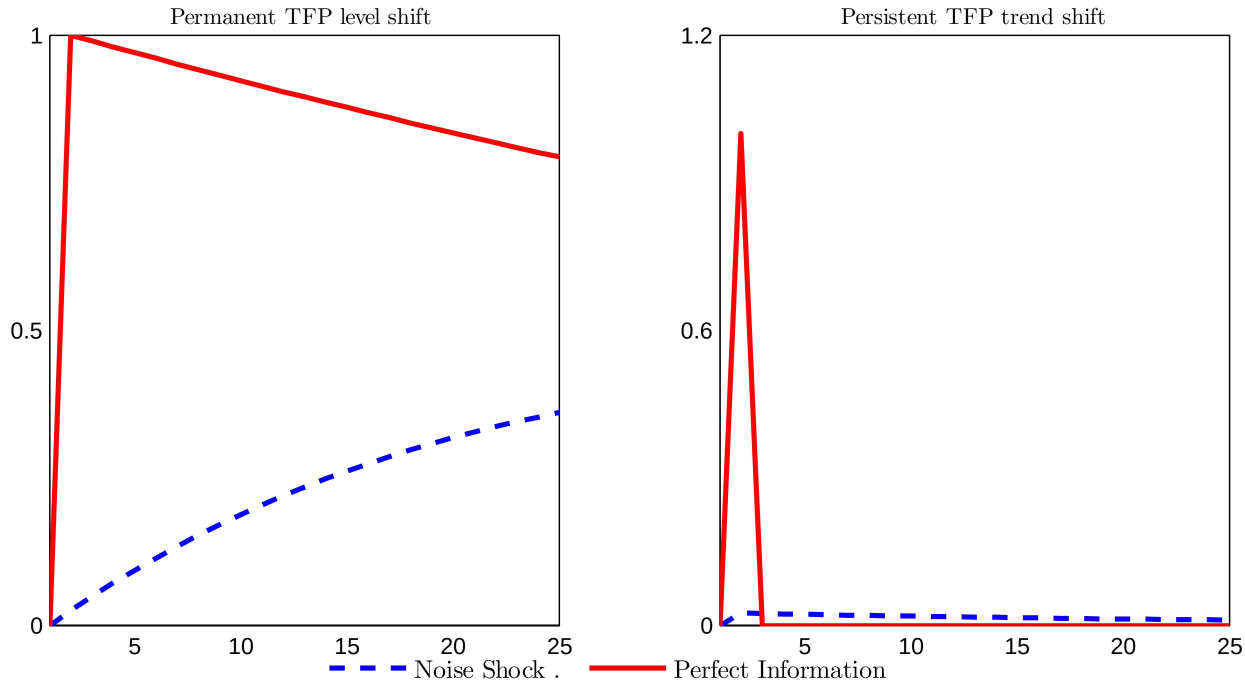


Figure 9: Productivity growth under perfect and imperfect information.

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 movement is generated by the one time or the persistent shock.[41] 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:

$$\widetilde{A}_{j,t|t} = (1-\kappa)\rho_{A_j}\widetilde{A}_{j,t-1|t-1} + \kappa z_t, \qquad \text{where} \quad z_t = ln(Z_t). \tag{37}$$

κ represents the Kalman gain which we set to 0.025, following Hoffmann et al. (2011).[42] $\rho_{A_j} = 0.99$ in order to be as close as possible to one without breaking stationarity. Figure 9 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 de-trended considering the unit root and parameters are set at the mean of posterior distribution of the baseline estimation (section 3). Figure 10 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

[41] For the formulation of the learning process we follow Boz, Daude & Durdu (2011) and Hoffmann et al. (2011).

[42] Results are similar if we use instead the median unbiased estimator based on Stock & Watson (1998) found by Garnier & Wilhelmsen (2009) for the euro area.

Noise TFP shocks

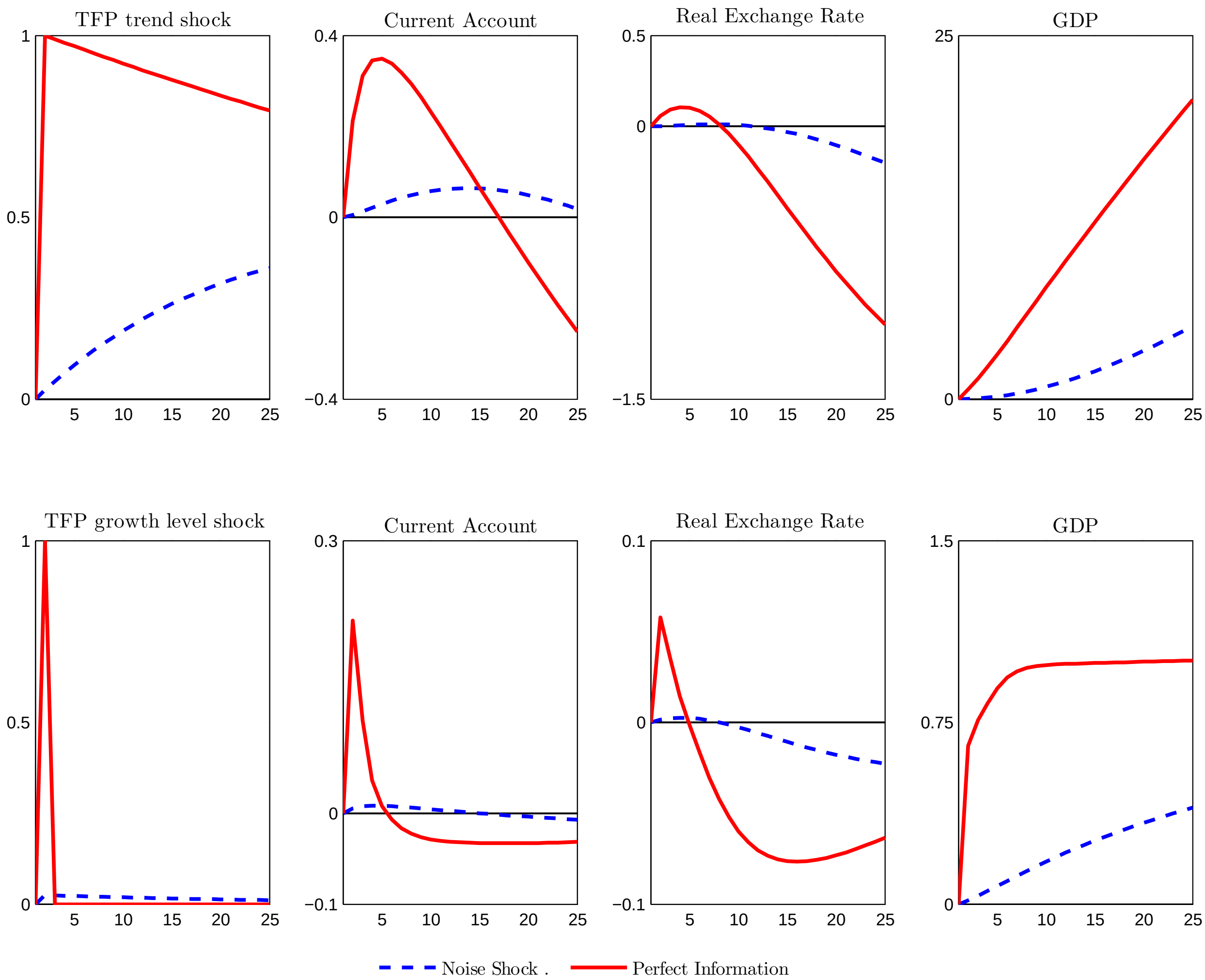


Figure 10: Impulse responses to a positive anticipated technology shock in the tradable sector. The Figure compares responses of the baseline specification with the framework in which agents have imperfect information on the shocks. The first row shows the responses to a trend growth rate shock, ζ_t^A, while the second row depicts the responses to a permanent level shock, ζ_t^X

agents. Qualitatively the result are similar but in the imperfect information setup responses are less pronounced and more persistent than under complete information.

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.

We conclude that even if modeling anticipated shocks as imperfectly expected changes in productivity can be seen as an improvement, we cannot explain Ireland, Portugal and Spain imbalances only with productivity shocks, even if anticipated with some noise.

6 Conclusions

From 1996 to 2007 Ireland, Portugal and Spain experienced three common facts: increasing current account deficits, appreciating real exchange rates and output growing above trend. Current events in the euro area have shown that current account imbalances have exacerbated the vulnerability of the European Monetary Union (EMU) periphery. Accordingly, the main purpose of our research is twofold: first to uncover the sources of the current account imbalances experienced within the euro area before the Great Recession; second, motivated by the timing of the three facts, to understand the qualitative and quantitative role of *unanticipated* and *anticipated* shocks for international variable 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 Ireland, Portugal and Spain.

The idea that capital was flowing towards "catching-up" euro area countries with high current or expected productivity growth has lost empirical support. This paper shows that theoretically anticipated as well as unanticipated productivity shocks, either in the tradable or in the non-tradable 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 current account, real exchange rate and GDP.

Three are the main results: first, the decrease in the international yield spread is the main source of the imbalances experienced by Ireland, Portugal and Spain. Yield spread drops are the only shocks that can contemporaneously explain the three observed facts: current account deficit, real exchange rate appreciation and GDP, with its main components consumption and investment, above trends. Second, anticipated shocks account for a large portion of the fluctuations of international macroeconomic variables: 67 percent of the current account, 51 percent of the real exchange rate and 35 percent of output growth. Third, among anticipated shocks, anticipated yield spread shocks are the most important for international variable fluctuations: they account for 30 percent of total current account movements and 40 percent of changes in the real exchange rate.

Our findings are robust to the introduction of Jaimovich and Rebelo type of preferences and to the weakening of the certainty assumption behind anticipated shocks. In fact, the impulse response and quantitative results are confirmed when we use preferences (Jaimovich and Rebelo) that allow us to estimate the degree of the wealth effect on the labor supply. Furthermore, results hold when, instead of modeling anticipated shocks as news shocks, we model them as adjustments in expectations in an imperfect information framework (signal-extraction models of news - noise shocks).

To conclude, in order to investigate 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 output growth 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 imbalances and under what conditions they could be labeled as “excessive”.

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Appendix

During the Great Recession the euro area countries that experienced a deeper and longer economic contraction were those that accumulated negative current account balances. Figure .0.1 shows that indeed this is true only for countries in the EMU. In fact, the positive correlation between the current account balance of 2007 and the real GDP growth rate of the period 2007/11 is lost when we consider 13 different developed countries that were having a similar pattern in the dispersion of the current account balances.

ΔGDP 07/11 vs. 2007 Current Account Position

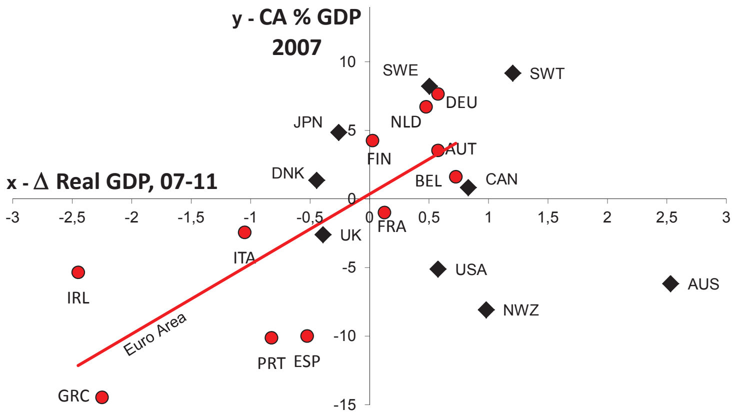

Figure .0.1: (a) Euro Area current account from 1990 to 2007 for Austria, Germany, Ireland, Portugal and Spain; (b) Average real GDP growth between 2007 and 2011 (x-axis) on the current account position in 2007 (y-axis). Dots represent countries within the European Monetary Union and rhombi represent countries outside the EMU. The red line is a linear regression line constructed using only euro area data points. Source: Eurostat (2012).

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