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I find evidence that real interest rates differentials are key determinants of the evolution of real unit labor costs across Europe. Policy implications are significant as in the Eurozone the problem of divergent labor cost competitiveness cannot be separated from the one of differentials in monetary policy stance. Within this logic the reduction of State cross-differences in product and market frictions (structural reforms) are necessary but not sufficient for the elimination of labor cost imbalances. Other persistent sources of inflation differentials should be addressed as, for example, fiscal stance.

Keywords: Real Unit Labor Cost, Macroeconomic Imbalances, Euro Area.
JEL classification: E31, E44, E50

1 Introduction

The presence of macroeconomic imbalances in the euro area is at the center of the current debate over the macroeconomic stability of the currency union, generating great concern among European policy makers. Within the jargon of the European Central Bank and

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of the European Commission, imbalances do not involve only a country external position (current account) but also a number of other indicators which generally refer to the concepts of competitiveness (i.e. unit labour cost, real effective exchange rate, export market share), economic overheating (inflation, asset prices, unemployment) and indebtedness (public and private debt). The development of cross-european macrocosmic imbalances has become so pivotal in European policy circles to lead the European Commission to establish a Macroeconomic Imbalance Procedure now pairing the Excessive Deficit Procedure, foreseen in the art. 104 of the Growth and Stability Pact.

For their role in determining cross-country competitiveness differentials, labor costs are closely monitored within the assessment of macroeconomics imbalances in the euro area. It is often argued in European policy circles, that those countries more exposed to labor costs booms should realign with the rest of the Eurozone via internal devaluations. In this paper I focus on real labor costs, implicitly considering the wedge between labor and product inflation instead of simply nominal wage growth. What I show is that there is an important link relating relative monetary policy stance (real interest rates) and real labor costs when a restrictive assumption about production technology is dropped. Also, such link is not a purely nominal phenomenon but involves changes in the amount of capital of the economy. An important consequence of this is that real cost imbalances arise following cross-country differentials in the inflation rate.

This argument extents significantly the current literature on the determinants of the labor share, that focused mainly on factor and product markets frictions. It also implies that the accumulation of cross-country (real) cost imbalances is partly implicit in currency areas. The limit of the *physiological* degree of (real cost) differentials that characterize currency unions is defined by the magnitude and persistence of cross-regional inflation differences. This is what makes the case of the Eurozone different from the one of the US States. From a policy viewpoint implications are significant: first, frequently mentioned structural reforms, targeting labor markets and aiming at reducing real cost wedges, do not per se eliminate the possibility of accumulating real cost imbalances across euro area members. Second, persistent cross-country sources of inflation differentials might be enough to cause the accumulation of real cost imbalances. Among these sources, fiscal deficits should be particularly monitored, as impeding the implementation of an homogeneous monetary policy stance across all members of the currency union.

I begin the investigation by providing empirical evidence of significant differences in the relative tightness of monetary policy across euro area countries. Measuring relative monetary policy stance by both Taylor's residuals and real interest rates, I present evidence that, especially from 2003 to the beginning of the crisis in 2008, for some countries such as Spain, Greece and Ireland, monetary policy was relatively slack with respect to fundamentals.

The paper continues describing how real cost imbalances relate to relative monetary policy stance: I present a simple theoretical framework in which the real unit labor cost relates to monetary policy (real interest rates) through adjustments in the capital output ratio. This framework serves both as a theoretical support for the empirical analysis that follows and to clarify a crucial identification problem relating the labor share and inflation. After having proposed a solution to this empirical issue, I estimate an equation relating the labor share and real interest rates using data from individual euro area members. From a cross-sectional point of view, I find that in the euro area countries experiencing lower real interest rates witnessed higher increases in the real unit labor cost.

This work builds on a range of different research streams. First and foremost, the paper fits into the policy debate on real cost imbalances across Eurozone countries and more generally, in the literature on the determinants of real unit labor costs. In this stream of literature some key contributions are Bentolila and Saint Paul (2003), Arpaia et al. (2009), Lebrun and Perez (2011), Blanchard (1997), Blanchard and Katz (1992), Jones (2002), Blanchard and Giavazzi (2002), Kydland and Prescott (1990), Boldrin and Horvath (1995),Gomme and Greenwood (1995).

This research also relates to the work by Fagan and Gaspar (2007), Brzoza-Brzezina (2010) and the ECB (2003) suggesting a role for real interest rate yield differentials as a primary source of imbalances among countries of the euro block. These authors stressed how, after joining the euro area, sovereign yields of some peripheral countries decreased significantly, while persistent differences in inflation at national level produced wedges in real yields which fueled current account deficits and a boom in private and public consumption. In this paper I refer more generally to monetary policy stance thus implicitly abstracting from sovereign risk considerations. More significantly the evidence developed in this paper relates to the work of Maddaloni and Peydro (2011) and Hau and Lai (2013), who also used Taylor residuals to characterize the relationship between monetary policy slack and (in order) loose credit standards and risk shifting.

The theoretical framework presented takes inspiration from the work of Carlstrom and Fuerst (2005), Kurizumi and Zandweghe (2008) and Khramov (2012). Many key references are also to the literature identifying a link between the labor share and inflation, most notably Gali and Gertler (1999), Sbordone (2002), Smets and Wouters (2003), Watson and King (2012).

The analysis follows this order: in the first section I briefly review the process of growing macroeconomic imbalances for some euro area countries; then in paragraph 3 I evaluate monetary policy stance for all major countries of the block since 1999. In the following paragraphs, I focus on the real unit labor cost and its relation with monetary policy. The last section concentrates on policy implications.

2 Imbalances in the Euro area: Some Facts

Within the terminology of European policymakers, the concept of imbalances is interpreted extensively; this conveys economic developments in a number of indicators that concern a country external position (current account and net asset position) but also its competitiveness (unit labour cost, real effective exchange rate, export market share) and indebtedness (public and private debt). This extensive interpretation has little in common with the existing literature on macroeconomic imbalances as this focuses mainly on the current account. Making reference to the actual debate on macroeconomic imbalances in European policy institutions, in this paper I will focus on one specific variable, the real unit labor cost. Before this however, in this paragraph I briefly review developments in a number of macroeconomic indicators, such as the real unit labor cost, the current account, export market share and credit to the private sector.

Figure 1 displays the evolution of the these indicators for major euro area countries since 1999. Cross-country divergence in some of these indicators is evident especially after 2003. So-called converging economies such as Spain, Ireland, Greece and (to a lesser extent) Portugal experienced until 2007 persistent and increasing current account deficits, a sizable increase in unit labor costs a significant real appreciation and losses in export market share.

Between 1999 to 2008 and especially after 2003, current accounts of converging economies have been persistently deviating from those of core countries of the union, with the former accumulating large deficits and the latter showing balances or surpluses (Figure **??**, first panel). Over the same period, a significant cross-country wedge also accumulates across real exchange rates (Figure **??**, second panel). Nominal unit labor costs, a proxy for labor competitiveness[1], in Ireland, Greece and Spain, increased dramatically since 1999, while in other countries like Germany and Austria it showed substantial stability or moderate increase (Figure **??**, third panel).

Few facts stand out from the panels presented:

1) Differences in all indicators considered existed at the time the Eurozone was created in 1999 and such differences tended to increase especially after 2003.

2) There appear to be correlation between the increase of wedges across all variables considered and some countries (notably Spain, Ireland and Greece fared worse than other in terms of current account deficits, real appreciation, wage inflation and credit growth.

Moving to the real unit labor cost which is the object of this paper. Figures **??** and **??**, focus specifically on the real unit labor cost and on its relationship with monetary policy. In figure **??** (first panel) I show the average increase in the labor share for euro area members since 1999 and up to 2008. Significant cross-country differences are evident: In countries such as Ireland, Italy Finland Greece and Portugal real labor cost of unit of output grew significantly more than in others. The second panel of figure of figure **??** shows a cross-country scatter plot between the average increase in the labor share and the average real interest rate. This is preliminary evidence suggesting the existence of a link between the two variables and thus between relative monetary policy stance and real labor costs. The figure shows a clear negative relationship, suggesting that those countries that accumulated higher increases in the labor share were also those characterized by lower real interest rates.

[1]Under the assumption that labor cost represents the most relevant share of firms cost structures. This indicator could be particularly ineffective in measuring companies' costs in periods or countries where credit scarcity is an issue, as it completely ignore financing costs.

In figure **??** I disentangle this relationship into two: the left panel shows the relationship between real interest rates and the capital output ratio. This simply expresses the link existing between cost of capital and capital accumulation: lower real interest rates relates to capital depending. The right panel shows the relationship between capital deepening and the labor share. It should be noted that this scatter plot displays a negative slope, this is crucially due to the elasticity of substitution among production factors.

Figure **??** is pivotal in understanding the economic reasoning suggested in this paper as basis for the relationship between gal unit labor cost and interest rates, and it represents the rough evidence around with the theoretical model presented later in this paper develops. If we depart from a unitary elastic factor substitution, or alternatively if we depart from a Cobb-Douglas production function, using instead a CES schedule, capital accumulation (triggered by relative monetary policy stance) has an effect of the labor share (real unit labor cost).

3 Relative monetary policy stance in the Eurozone

The Eurozone being a currency union, a unique policy rate is set by the ECB, as a general rule, by looking euro area aggregated indicators. These variables however results from the aggregation of a possibly disperse set of country level data. Within the framework of price stability, the objective of keeping the harmonized euro area inflation rate below the 2 percent threshold (almost certainly) requires a subset of countries to have price growth rates higher and lower this fixed target. It is little surprising then to discover that a unique monetary policy stance might fit poorly single countries' fundamentals. If the possibility of achieving sub optimal monetary policy stance for a subset of countries is implicit in a currency union, this paper is concerned with the consequences of persistent relative monetary policy stance differentials in certain regions of a currency union and their connection with real cost imbalances.

The evidence presented in this section is definitely not new, however it will serve as a starting point for the analysis that follows. In the assessment of the effective monetary policy stance experienced by euro area countries since 1999 I will consider two conceptually equivalent indicators. The first is simply the real interest rate, the second is based on Taylor residuals. In this case I focus on a counterfactual analysis, considering the interest rate that would have prevailed in each country of the Eurozone, was a policy maker with the same preferences of the ECB able to implement monetary policy in those countries in isolation. The validity of this method is conditional on the assumption the policy reaction function estimated for the ECB are solely dependent on observable harmonized fundamentals for the Eurozone. I begin this exercise with the estimation of a simple monetary policy rule for the European Central Bank. In this case the instrument of monetary policy is the EONIA, the rate of uncollateralized interbank overnight lending for the euro area; this rate is taken as reference by the ECB when implementing Main Refinancing Operations (MRO).

The simple policy rule considered has the following specification:

$$i_t^* = i^* + \beta([E_t[\pi_{t+h}|\Omega_t] - \pi^*) + \gamma(E_t[\tilde{y}_{t+h}|\Omega_t]) \tag{1}$$

where i_t^* is the desired nominal EONIA rate π_{t+h} denotes the price change at time $t+h$ expressed in percentage points, π^* is the target inflation level and , $\tilde{y}_{t+h}$ is the output gap at time $t+h$ defined as the percent deviation of output from its natural level[2]. Ω_t denotes the information set available at time t and i^* the desired level for the EONIA when both output and inflation gaps are zero.

This analysis abstains from considering the period of the crisis (from the end of 2008 onward), because throughout this time the interest rate channel was severely disrupted and the EONIA a poor measure of the effective monetary policy stance. Abstracting from any judgment over the adequateness of the policy stance implemented by the European policy maker before 2008 over the union as a whole, I define as *desirable* for each country of the euro block the interest rate generated by a policy rule which best describes the behavior of the EONIA estimated with euro area harmonized indicators, but conditional on country specific fundaments (inflation and output gap). I will measure with deviations from these values the relative tightness of monetary policy.

Table **??** shows estimated coefficients for different specifications of equation **??**. Models differ for the forward specification of inflation and output gap and the use of a dummy for the central banker. All specifications presented produce similar results in terms of relative monetary policy tightness, however for the analysis that follows, model 4 is chosen as it is the one providing the best goodness of fit together with coefficients' signs which are consistent with theory.

Figures **??** to **??** display the actual and fitted values resulting from the estimation of equation **??** for the euro area as a whole and for subset of countries of the core and periphery. Confidence bands correspond to 5 percent significance level. From simply a graphical inspection and focusing on the euro area as a whole, predicted and actual policy rates have a good fit, with the only exception of a short time window between 2000 and 2001, this simple specification is able to explain almost 75 percent of the variation in the EONIA rate.

In figure **??** and **??** actual policy rates are compared with fitted values for selected countries of the union. Fitted values are computed using coefficients estimated for the Eurozone as a whole and courtly specific fundamentals. The first panel displays four major countries of the core, the second four economies of the periphery. Looking at the first panel, the predicted rate at 5 percent significance level matches the actual rate for most of the time sample for Germany, Austria and France, even in the case of the Netherlands the rate implemented by the policy maker fits reasonably well the desirable path, with a slight over tightening from the 2005 to 2006. Looking at figure **??** instead it can be noted

[2]Output gap is calculated using HP filter.

how the actual monetary policy was generally loose for Ireland, Greece and Spain. It was in average correct, but loose in the first part of the sample, for Portugal.

For the purpose of creating a synthetic indicator measuring relative monetary policy stance in each country of the union, with respect to the fitted values, and taking into account the persistency of the deviation, I construct an index which measures deviations between the two series plotted in Figures 2 and 3. This is done by measuring the area between the two lines representing the desirable and actual path for policy rates. From a computational point of view the index corresponds to the definite integral between the two curves having the following discrete counterpart for a general country j:

$$\widehat{MPAI}^{j} = \sum_{t=0}^{T} \left(x_t^j b^* - i_t \right) \tag{2}$$

b^* being a vector containing coefficients $\hat{\beta}$ and $\hat{\gamma}$ estimated for the Euro area and i_t the actual EONIA rate at time t. Finally T is the number of time observations. Note that if instead of considering a generic country j we consider the entire euro area (let's call x_t in this case $\bar{x}_t^J$, representing a weighted average of single euro area countries' fundamentals ($\bar{x}_t^J = \sum_{j \in J} w_j x_j$), where J is the set of Euro area countries thus $j \in J$) the index computed in equation **??** would simply be the sum of the estimation's residuals from equation **??**. Also note that here residuals are defined as the difference between the fitted and the actual values (and not the other way around as they are typically presented in literature), this is just to have a more intuitive interpretation of their signs, as in this case to a positive residual corresponds loose monetary policy. I will call this this index MPAI for Monetary Policy Adequacy Index. This measure is clearly stochastic, with variance depending directly from the variance of the estimated coefficients in b^*.

The Monetary Policy Adequacy Index (henceforth MPAI) as defined in equation **??** serves as a synthetic representation of the cumulated monetary policy deviations from the desirable path as defined by the estimated monetary policy rule in the euro area. A positive and statistically significant value for the index indicates that monetary policy for a specific country has been in average relatively expansionary over the time sample considered; conversely, a negative and statistically significant value for the same index is indication of a relatively contractionary monetary policy stance.

Figure **??** displays the MPAI for all countries of the Euro 13 block (with the exclusion of Estonia) using different forward specifications for the policy rule. Over the time sample considered (1999-2008) monetary policy stance is relatively expansionary in all major peripheral countries, specifically (in order of magnitude) in Ireland, Greece, Spain and Portugal and to a lower extent in Italy. On the other hand, monetary policy has been relatively adequate in all other countries with the notable exception of Germany, where policy rates were slightly higher than desirable. These results are significant at 1 percent significance level and robust to different forward specifications for the policy rule.

An indication of the average deviation of the policy rate from its desirable stance can be obtained by dividing the MPAI by the number of quarters in the sample. The resulting value represents the average interest rates deviation in each quarter Figure **??**). Considering the relevant border of the 99 percent confidence interval, interest rates were, in average from 50 to 75 Basis points (depending on the specification) lower in Ireland, from 30 to 50 Basis point in Greece, Spain and Portugal. There were marginally (10 Basis point) higher than desirable in Germany. The magnitude of these numbers might appear at a first glance low, however it should be noted that they are averages over a period of almost ten years and that interest rates compounding works in a multiplicative fashion.

This index can be further decomposed as follow:

$$\widehat{MPAI}^j = \sum_{t=0}^{T} \left(x_t^j b^* - i_t \right) \tag{3}$$

$$= \sum_{t=0}^{T} \left(x_t^j - \bar{x}_t^J \right) b^* + \sum_{t=0}^{T} \left(\bar{x}_t^J b^* - i_t \right) \tag{4}$$

The second term in equation **??** is the sum of estimation residuals from equation **??** which amounts to zero by construction; the first term represents deviations of country j output and inflation gaps from the euro area's weighted average multiplied by the estimated coefficients β and γ from equation **??**. This first term measures the business cycle difference of country j in comparison with the rest of the union.

It comes to reason that values for the index different from zero originate from values of this latter term; at each point in time t, the difference in fundamentals (inflation and output gap) between country j and the rest of the euro area can be further decomposed in order to highlight the role of the relative weight of the economy j in the currency union.

Thus after little reshuffling we can write:

$$x_t^j - \bar{x}_t^J = \left(1 - w^j \right) \left(x_t^j - \bar{x}_t^{J-j} \right) \tag{5}$$

The first term in brackets represents the (complement of the) relative size of a generic country j in the euro area, the second term how different are its fundamentals from the one of the union as a whole.

From the above formulation of this index two facts stand out: the appropriateness of the common monetary policy for a generic country j depends: i) positively on the similarity in the its business cycle with resect to the average for the currency union (magnitude of $x_t^j - \bar{x}_t^{J-j}$), ii) negatively on the size of the economy vis-a-vis with the rest of the currency area (low w^j) and on the magnitude of the coefficients β and γ representing the response of the policymaker to inflation and output gaps. These two factors also determine the *relative exogeneity* of a country to the centralized monetary policy process.

The final remark concerns the fact that the MPAI is strictly correlated to the average real interest rate prevailing in each country of the currency union from 1999 to 2008 (Figure ??).

4 Relative Monetary Policy Stance and the Real Unit Labor Cost

Relative monetary policy stance varied significantly across euro area countries between 1999 and the beginning of the crisis: peripheral economies such a Spain, Greece and Ireland experienced relatively loose monetary policy stance while, for countries of the core, policy interest rates were about right. This section links the evidence provided so far with the process of euro area real cost imbalances accumulation.

The intuition behind such link is simple and it entirely relies on dropping the assumption of unitary elastic substitution among factors, meaning moving from a Cobb-Douglass to a CES production schedule: a decline in the real interest rate leads households and/or firms to borrow more until the marginal return of capital equals the new level of the interest rate. This process implies capital accumulation. If output is produced via a CES production function, the ultimate effect of capital accumulation on the labor share (real unit labor cost) depends on the elasticity of factors substitution. To contextualize this reasoning in the recent experience of the Eurozone, countries like Spain, Ireland and Greece up to the beginning of the crisis (we saw) experienced lower real interests rates. As a consequence they went through capital deepening that, due to a lower than unity elasticity of substitution, produced an increase in the labor share.

An obvious flow to this reasoning would be that inflation (implicitly determining real interest rates) is not exogenous in the first place and in turn is determined by (under Cobb-Douglass assumption) by the labor share (Gali and Gertler (1999)). In the second part of this paragraph I will take into account the consequences of the endogeneity of inflation within the standard New Keynesian framework, while coming to the econometrics, I will deal with the identification problem using an instrument for inflation.

I start the exposition presenting a simple general equilibrium model without frictions in products or factor markets. This first exposition aims at showing that real unit labor cost and interest rate are related even in a frictionless model. This is a significant difference with respect to the existing literature and conventional wisdom about the accumulation of labor cost imbalances in the Eurozone. Then I modify the model introducing monopolistic competition for an intermediate good sector and thus price stickiness along with the standard NK paradigm. This modification allows to analyze the identification problem related to the target relationship.

The presented model mirrors the one by Carlstrom and Fuerst (2005) and discussed by Kurizumi and Zandweghe (2008) and Khramov (2012) with little ad hoc modifications, the main of which is the use of a CES production function which is used instead of a

Cobb-Douglass. The discussion of this model in the text will be limited to the features of interest to the analysis. While the purpose of this discussion is simply the derivation of an equation relating interest rates with the real unit labor cost, the model is presented in a more organic fashion in the appendix.

4.1 A Frictionless Model

A representative economy is populated by an large number of individual households whose preference are expressed by a standard utility function:

$$\sum_{t=0}^{\infty} \beta^t U(C_t, L_t) \tag{6}$$

Households in each period can purchase a one period bond B_t at a price Q_t. They can consume C_t at prices P_t and they can buy next period capital K_{t+1}. They earn a real wage $W_t L_t$ and a capital market rent $R_t K_t$. Household budget constraint is:

$$B_{t-1} + P_t[W_t L_t + R_t K_t] = Q_t B_t + P_t C_t + P_t K_{t+1} \tag{7}$$

and the non-Ponzi condition:

$$\lim_{T \to \infty} = E_t[B_T] \geq 0 \tag{8}$$

Firms produce output in a competitive setting via a CES production schedule:

$$Y_t = A\left[(\alpha) K_t^{\frac{\sigma-1}{\sigma}} + (1-\alpha) L_t^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \tag{9}$$

Where K_t, L_t and A are respectively capital, labor and an exogenous technological parameter, $\alpha \in (0, 1)$ is the factor share and σ represents factors' elasticity of substitution.

In each period firms maximize profits

$$Y_t - W_t L_t - R_t K_t \tag{10}$$

The two optimality conditions associated with firms' maximization problem are:

$$W_t = AF_l(K_t, L_t) \tag{11}$$

$$R_t = AF_k(K_t, L_t) \tag{12}$$

with R_t and W_t the real interest rate and wage.

From the first order condition of the consumer maximization problem, we obtain the inter-temporal condition relating the nominal interest rate to expected real interest rate:

$$i_t - E_t[\pi_{t+1}] = E_t[AF_k(K_{t+1}, L_{t+1})] \quad (13)$$

or equivalently (using the Fisherian equation)

$$r_t = E_t\{AF_k(K_{t+1}, L_{t+1})\} \quad (14)$$

Given perfect competition in product and factors markets, the real unit labor cost (or labor income share) is defined as:

$$RULC_t = \frac{W_t L_t}{Y_t} = \frac{L_t AF_l(K_t, L_t)}{Y_t} \quad (15)$$

Where W_t is the real wage and MPL_t is the marginal product of labor. Thus in case of a CES production function we have:

$$RULC_t = (1-\alpha)\left(\frac{Y_t}{L_t}\right)^{\frac{1-\sigma}{\sigma}} = 1 - \alpha\left(\frac{K_t}{Y_t}\right)^{\frac{\sigma-1}{\sigma}} \quad (16)$$

For $\sigma = 1$ equation **??** collapses to $1-\alpha$ and the production schedule becomes Cobb-Douglas. The Cobb-Douglas production function represents a limiting case[3] in which output elasticities are equal to one and the labor income share is constant and equal to $1-\alpha$. However it is clear that this specification is not fitted for explaining changes in output factor shares and in the following analysis I will relax the hypothesis of unit substitutability, assuming σ to be a finite number greater than zero.

Equation **??** is interesting because it establishes a relationship between the real unit labor cost and the capital output ratio. The sign of this relationship depends crucially on the magnitude of the parameter σ: for values between 0 and 1 (low factor elasticity of substitution) the relationship is positive, for values higher than one it is negative.

Also:

$$\frac{K_t}{Y_t} = \left(\frac{R_{t-1} + v_t}{\alpha}\right)^{-\sigma} \quad (17)$$

where $v_t = F_k(K_t, L_t) - E_{t-1}\{F_k(K_t, L_t)\}$ is the forecasting error at time t of the one step ahead expectation for the marginal product of capital at time $t-1$. Finally substituting into **??** the following equilibrium relationship between the real unit labor cost and real interest rate can be obtained:

[3] Among the reasons of the success of Cobb-Douglas production functions in theoretical modeling there is the fact that such production schedule is the only able to insure a constant elasticity of substitution, homogeneity of degree one and constant factor shares overtime. This latter characteristic contributed largely to the diffusion of Cobb-Douglas production functions as (relatively) constant shares of factors on output overtime was among the Kaldor's stylized facts of economic growth.

$$RULC_t = 1 - \alpha \left(\frac{R_{t-1} + v_t}{\alpha} \right)^{1-\sigma} \tag{18}$$

Denoting with lower cases the percentage deviations from the steady state **??** becomes:

$$s_t = \phi r_{t-1} + \epsilon_t \tag{19}$$

where s_t is the (log) real unit labor cost, $\phi = \frac{s}{1-s}(\sigma - 1)$ and $\epsilon_t = \frac{s}{1-s}(\sigma - 1)v_t$. Under rational expectations the forecasting error v_t is orthogonal to the information set at date $t-1$, thus the identification of equation is achieved yielding the OLS estimator of ϕ.

Equation **??** establishes a linear relation between the real unit labor and the real interest rate s and it represents the theoretical base for the empirical investigation previously developed concerning the real unit labor cost.

The economic interpretation of the above relation is the following: when the world interest rate declines, borrowing increases with capital accumulation until the marginal return of capital equals the new real interest rate. The final effect on the real unit labor cost depends critically on the elasticity of substitution: for $\sigma > 1$, capital accumulation results in a decrease of the labor share; the real unit labor cost increases instead for $\sigma < 1$.

What is noteworthy of equation **??** is that it establishes a link between relative monetary policy stance, measured with differentials in real interest rates, and differentials in the real unit labor cost, in a completely frictionless framework. This is to say that wedges in real unit labor cost in currency unions can arise, consequence of a non-unitary elastic factor substitution, even if economies are not affected by different market frictions.

The model presented in this paragraph abstracts from price stickiness. The empirical investigation of equation **??** however clashes with one crucial fact of the New Keynesian Economics: real marginal costs (closely related to the real unit labor cost in a Cobb-Douglas framework) are a key short run determinant of price dynamics. The New Keynesian Phillips Curve in models with price stickiness features, in fact, inflation as determined by current and expected firms' marginal costs. To the extent real interest rates are implicitly determined by the difference between the nominal rate and the level of inflation, it comes to reason that an empirical estimation of equation **??**, might be affected by endogeneity.

The problem however is more complex: the standard NKPC is typically derived under the assumption of a production function only comprising labor and featuring Cobb-Douglass technology. These two assumptions obviously clash with key aspects on which the relationship between the labor share and real interest rates presented in this paper is based. A formally more correct investigation of the this relationship in conjunction with a NKPE should consider these two equations as resulting form the same general equilibrium model, this is what I do in the next paragraph. There I will explore in more analytic fashion the simultaneity bias between the NKPC and equation **??**, by modifying the presented model to include price stickiness (and thus a feedback from real marginal costs to inflation).

However there is still a possibility to estimate directly or indirectly equation **??** without incurring in a identification problem: this is by considering a long run relationship. In fact, to the extent the identification of equation **??** is put into jeopardy by the short term link between marginal costs and inflation (the Phillips curve), in the long run the same equation should be identifiable.

4.2 The Long Run

Equation **??** can be estimated directly or indirectly, I choose this second possibility. In fact the long run counterpart of equation **??** can be consistently estimated and after taking logs would be[4]:

$$ln(1 - RULC_t) = \sigma log(\alpha) + (1 - \sigma)r_{t-1} + \epsilon_t \tag{20}$$

It should be noted that the coefficient relating the real interest rate with the labor share solely depends on the elasticity of substitution σ while the constant depends on both σ and α. However a more intuitive way of estimating these two parameters in the long run is by estimating equation **??**. This mean estimating the (long run) relationship between the real unit labor cost and output per worker (labor productivity), after taking logs:

$$s_t = \gamma_1 + \gamma_2 y_t \tag{21}$$

where $\gamma_1 = log(1-\alpha)$, $\gamma_1 = \frac{\sigma-1}{\sigma}$ $y_t = \frac{Y_t}{N_t}$ (output per worker). Note that the estimation of this relationship also corresponds to a test on the elasticity of factor substitution: for values of γ significantly different from 0, σ is significantly different from 1.

I estimate the long run relationship represented by equation **??** with a panel VECM for 13 countries of the Eurozone (the initial block of 12 and Greece), the time sample is from 1999 to 2008 and the frequency quarterly. The first step in to verify wether the variables considered effectively are integrated of order one. I run a battery of unit root tests for output per worker and the real unit labor cost. The Fisher-type unit-root tests using both Phillips-Perron and Dickey-Fuller specifications fail reject the null hypothesis of unit roots in all panel variables[5] and for all variables considered. Having established that the real unit labor cost and real interest rates are integrated, I perform the Westerlund error-correction-based panel cointegration tests. Tests statistics reject the null hypothesis of no cointegration among real interest rates and the real unit labor cost at panel level[6].

The autoregressive distributed lag model corresponding to **??** is:

[4] So far I have considered only a frictionless model; however considering a product market markup will not modify the discussion developed below, in this case the long run counterpart of equation **??** would it would be convenient to estimate: $ln(RULC_t) = log(\frac{1-\alpha}{\mu}) + (\frac{1-\sigma}{\sigma})\frac{Y_t}{L_t}$

[5] 4 lags are inserted for the computation of the test statistics. Results are robust to different lags number and the introduction of trends.

[6] P-values for the Pt statistics is 0.05 and for Pa 0.074.

$$\Delta s_{it} = \lambda_i s_{i,t-1} + \delta_{1i} y_{i,t-1} + \delta_{2i} y_{i,t-2} + \mu_i + \eta_{it} \tag{22}$$

The error correction re-parametrization is:

$$\Delta s_{it} = \psi_i (s_{it-1} - \gamma_{1,i} - \gamma_{2,i} y_{it-1}) + \delta_{1i} \Delta y_{it-1} + \eta_{it} \tag{23}$$

where $\psi_i = -(1 - \lambda_i)$ is the parameter indicating the speed of adjustment. $\gamma_{1,i} = \frac{\mu_i}{1-\lambda_i}$ and $\gamma_{2,i} = \frac{\delta_{1i}+\delta_{2i}}{1-\lambda_i}$ are the long run coefficients that we seek to estimate. As the time dimension of the data is large enough, I estimate independent models for each country and contract the MG (Mean Group) estimator proposed by Pesaran and Smith (1995), which simply consist in arithmetic averages across groups. This produce consistent estimates even in the precedence of heterogeneity across countries.

Estimation results are presented in table **??**: the first column shows coefficients for the short and long run relationship between the labor share output per worker considering a coincident specification for the ECM; the second column reports the same estimates when one additional lag of output per worker and the labor share are added to the specification. Considering the first model the implied long run parameters for the elasticity of substitution and the factor shares are 0.69 and 0.30. This first result is significant as it confirms the hypothesis of a non unitary elasticity of substitution. A key implication of this result is the support of a CES production function specification. Having obtained estimates for λ and sigma σ the implied coefficients for equation **??** are:

$$ln(1 - RULC_t) = -0.831 + 0.31 \quad r_{t-1} \tag{24}$$

implying a negative relationship between the real unit labor cost and lagged real interest rates. The sign of this relationship directly depends on the magnitude of the elasticity of substitution: for a value lower than unity (in this case 0.69) factors are relative complements and a negative relationship exists between the labor share and the real unit labor cost. In this case capital accumulation is crucially related to increases in the labor share.

4.3 Introducing Price Stickiness: Labor Share, Real Interest Rates and Inflation

The real unit labor cost plays a key role in the determination of prices in the standard NK framework. In the analysis presented in this paper, real interest rates are considered in their link with fluctuations in the labor share. However in the short run price stickiness is a key determinant of inflation and within the standard[7] framework of the New Keynesian Economics, the real unit labor cost is an important determinant of prices changes. As the relationship presented in this paper involves the real interest rate, which is implicitly defined by the inflation level, the short run estimation of such relationship poses some

[7]Meaning when a standard Cobb-Douglass production function is used.

issues. In this paragraph I formalize the short run relationship between the real unit labor cost and real interest rates when a CES production function is used. I will do so by extending the model presented above with the introduction price stickiness. Again the model is presented in some detail in the appendix while in this paragraph I will focus only on the aspects which are relevant for the discussion.

Let's modify the framework presented introducing an intermediate good sector characterized by monopolistic firms that set prices in a staggered fashion a la Calvo. This development follows strictly the derivation of standard NK models. The intermediate goods producers cost minimization problem yields the two conditions:

$$w_t = Z_t MPL_t \tag{25}$$

$$r_t = Z_t MPK_t \tag{26}$$

Where W_t and R_t are the real wage and interest rate and Z_t is the marginal cost. The real unit labor cost then becomes:

$$RULC_t = Z_t \left[1 - \alpha \left(\frac{R_{t-1} - v_t}{\alpha Z_t} \right)^{1-\sigma} \right] \tag{27}$$

R_{t-1} in this case is the real interest rate computed with the actual inflation rate $i_{t-1} - \pi_t$ as the forecasting error for the inflation rate is included in v_t. Again for $\sigma = 1$ and perfect competition $z_t = 1$, this equation collapses to $1 - \alpha$, the constant labor share in case of a Cobb-Douglas. Considering deviations from the steady state this relation becomes:

$$s_t = \gamma z_t + \phi r_{t-1} + \eta_t \tag{28}$$

Where lower cases indicate deviations from the steady state, s_t is the real unit labor cost and $\gamma = \frac{\mu}{s}[1 - \alpha\sigma(\frac{1}{\beta\mu\alpha})^{1-\mu} + \mu(\sigma - 1)(\frac{1}{\beta\mu\alpha})^{1-\sigma}\frac{1}{\mu}]$, $\phi = (\sigma - 1)\frac{1}{\beta s}(\frac{1}{\beta\alpha\mu})^{-\sigma}$ and $\eta_t = v_t \frac{1}{\mu}(\sigma - 1)(\frac{1}{\beta\alpha\mu})^{-\sigma}$. It could be noted that, as in the previous case, the existence and the sign of the relationship between the RULC and the real interest rate depends solely on the elasticity of substitution σ.

Due to the fact that marginal costs are not directly observable, the above equation has the following empirical counterpart:

$$s_t = \phi r_{t-1} + \upsilon_t \tag{29}$$

Where $\upsilon_t = \gamma z_t + \eta_t$. This equation can be read together with the NKPE which originates directly from the Calvo price setting:

$$\pi_t = \lambda z_t + \beta E_t[\pi_{t+1}] \tag{30}$$

where z_t is the marginal cost.

Using the first of this conditions to substitute for the real interest rate in equation **??** we have:

$$s_t = \phi(i_{t-1} - \pi_t) + \upsilon_t \tag{31}$$

Then using the NKPC we can write the inflation level at time t as a function of the marginal cost:

$$s_t = \phi \underbrace{(i_{t-1} - \lambda z_t - \beta E_t[\pi_{t+1}])}_{r_t} + \upsilon_t \tag{32}$$

It is evident that equation **??** cannot be directly estimated due the bias originating from $E(r_t, \upsilon_t) \neq 0$ as υ_t depends on the marginal cost at time t ($\upsilon_t = \gamma z_t + \eta_t$).

However equation **??** could be estimated if we find an instrument for the level of inflation. Let's consider the following equation:

$$s_t = \phi(i_{t-1} - E_{t-1}[x_t]) + \eta_t \tag{33}$$

where $\eta_t = \phi_1 z_t - \phi_2 \upsilon_t$ and x_t is a variable such that $E(x_t, \pi_t) \neq 0$ and $E(x_t, z_t) = 0$, meaning an instrument for the inflation rate that is not correlated with marginal cost at time t. In this case, to the extent the nominal interest rate is exogenous to the inflation level at time t (this is the case in a currency union to the extent local economic condition are orthogonal to the centralized monetary policy process), equation **??** can be correctly identified. The identification of equation **??** then requires the identification of a shock to inflation that not affected by coincident marginal costs, considering the NKPC, I would need to identify a variable affecting ζ_t:

$$\pi_t = \lambda z_t + \beta E_t[\pi_{t+1}] + \zeta_t \tag{34}$$

I argue that a good candidate could be represented by discretionary net fiscal spending. The relevance of this instrumented is guaranteed by the substantial literature that has related fiscal policy to inflationary pressure (Sargent and Wallace, (1981), Alesina and Drazen, (1991), Cukierman et al. (1992), Calvo and Vegh, (1999)). The exogeneity to marginal cost is insured by its common use in the empirical literature on fiscal multipliers (this literature is particularly vast, however a notable contribution is Blanchard and Perotti (1999)): the idea is that discretionary fiscal action does not respond within a quarter to macroeconomic variables (such as output and inflation), as it takes policymakers more time to effectively learn about the status of the economy. The solidity of this exclusion restriction lies on its wide use in the fiscal policy literature.

I then estimate estimate the following panel for a sample of 12 Euro area countries[8] using quarterly series:

[8] These correspond to the original Euro block and Greece that joined in2001.

$$s_{it} = \alpha_i + \phi r^{IV}_{i,t-1} + \upsilon_{it} \tag{35}$$

Estimation is performed using two stage regressions. Lagged real interest rates are instrumented using discretionary fiscal balance at time t, as argue before this variable is assumed to be correlated with coincident inflation level but exogenous to the marginal cost within the same quarter. Discretionary fiscal balance is constructed by extrapolating the trend component via HP filtering, from quarterly series for fiscal surplus (deficit) on gap. Country fixed effects are considered. Estimation results are reported in Table **??**.

The first 3 models are estimated on the whole country sample. The first column reports the coefficient when no instrumental variable is used, in this case real interest rates are directly regressed on the labor share. The resulting coefficient is not significant at 10 percent significance level.

In the second equation I used discretionary fiscal balance as an instrument for the inflation rate, determining real interest rates. In this case the coefficient is negative and significant: in average across euro area members, a one percent change in the real interest rate correspond to a two percent change in the labor share with opposite sign. Recalling that the sign of this relationship depends directly from the elasticity of substitution, we can infer that this result is consistent with a less than unitary factor substitutability (factors are relative complements).

The third model is placebo regression that aims at testing weak instruments: the regression output is produced via bootstrapping and considering a random variable having equal moments to the instrument considering in the second equation. No evidence of spurious relationship exist in this case.

So far I considered the Eonia rate as fully exogenous to local economic conditions. This can be the case for a large currency union where the relative size of each of its regains is negligible with respect of the remaining part, but this assumption could be unrealistic when considering larger countries in the Eurozone. In the second set of regressions displayed in Table **??** I restrict the country sample to those countries for which the Eonia rate could be considered (almost) entirely exogenous. In determining which countries should be included in this restricted sample we could use simply the relative size of the country with respect of the entire euro area, however we have at our disposal a more sophisticated tool for this decision. This is what early in this paper I called MPAI, the index expressing relative monetary policy stance over the period 1999 to 2008 for euro area members. As a matter of fact there are two factor that determines the exogeneity of local economic conditions to the centralize monetary policy process: the relative size of a country and the correlation of its fundamental with respect to the rest of the currency union. In columns 4 to 6 (Table **??**) I then restrict my sample to those countries for which the MPAI indue was significantly different from zero (at 95 significance level), I am left with the following countries Ireland, Greece, Luxembourg, Spain, Portugal and Italy. When restricting the geographical sample no significant difference arise from the more general case.

The evidence reported in this table strongly suggests that the estimation of equation **??** produced unbiased coefficients that are consistent with the model predictions. Also it confirms that link existing between the real interest rate and the real unit labor cost within short term dynamics.

5 Cross-Section Evidence

In the previous paragraphs I established the theoretical link existing behind the relationship between fluctuations in real unit labor costs and real interest rates when deviating from the assumption of unitary elasticity of substitution. I also presented empirical evidence both in the long run and short run about the existence of such a relationship overtime, considering a panel of countries of the Eurozone.

To assess the role of such relationship in the process of accumulation of imbalances relating the real unit labor cost across euro area countries, it is now convenient to move to the cross sectional dimension of the data. In this paragraph I establish whether those countries experiencing lower interest rates also faced higher increases in the labor share. To answer this question I estimate the following panel:

$$\Delta s_{it} = a + \psi r_{it} + u_{it} \tag{36}$$

In this case however I will use the cross sectional dimension of the data, meaning I will use the between estimator[9]. In this case the estimated coefficient will express the relationship between the average (overtime) change in the labor share for each country i and the average real interest rate. A negative and significant coefficient signal that those countries experiencing lower real interest rates also presented higher increases in real unit labor cost. Regression results are reported in Table **??**. Different specifications are attempted but all produce consistent results. In the first three regressions the dependent variable is the real interest rate, in the following three I used Taylor residuals. Results suggest the existence of a negative relationship between the average overtime change in the labor share and the average level in real interest rates: In the euro area countries experiencing in average the lower real interest rates during the time sample considered also witnessed higher increases in the real unit labor cost.

The implications of this finding are significant as this implies that persistent differentials in relative monetary policy stance contribute to the accumulation of imbalances in real labor cost. Persistency real interest rates differentials is key as relative monetary policy stance is considered overtime.

[9]Considering first differences of the dependent variable eliminates country fixed effects, this also includes the steady state level of marginal cost which correspond to the inverse of the price markup. The between estimator in fact construct an overtime average of dependent and independent variable before estimating the cross-sectional coefficient. We can consider the overtime value of the marginal cost (computed on a sufficiently long time sample) as the actual price markup.

6 A Comparison With The US

Evidence presented in this paper supports the existence of a link between monetary policy stance and the accumulation of real labor cost imbalances in currency unions. If fluctuations in the labor share are determined by real interest rates, relative monetary policy stance becomes a determinant of real labor competitiveness differentials across regions of a monetary area.

A certain local variation in real interest rates is implicit in every currency area, then a policy relevant question is whether the existing cross-country variation in real interest rates in the Eurozone is comparable to the one of other currency unions. A natural comparison is represented be the US States, where a unique nominal interest rate is set at Federal level, despite possible regional variation in fundamentals. In Figures **??** and **??** I compare the standard deviation of both real interest rates and of (changes) in the labor share for the US[10] and the Eurozone. In the first panel of Figure **??** I plot overtime the cross-regional standard deviation of inflation for the two economies; in the second the overtime dispersion of RULC changes. In the two tables displayed in Figure **??** I show mean tests for both dispersion measures.

Few significant facts stand out from this comparison: effectively both cross-State variation in the inflation rate and in RULC changes are higher in the Eurozone than across US States. This difference is significant at 10 percent significance level for the time sample considered (Figure **??**). This evidence is consistent with the existence of a link between real interest rates and developments in the labor share as presented in this paper.

Evidence reported in Figures **??** and **??** clearly show that cross-State variation in both inflation and real labor costs is significantly higher in the Eurozone than in the US. There might be a number of different reasons why in the Eurozone regional inflation and RULC differentials are more significant than across US States: we can imagine that the Eurozone is subject to cost push shocks that are more disperse in nature, or that similar shocks might have a more heterogeneous effect across individual States that in the US, in this paper however I implicitly considered a different source of persistent inflation differentials: fiscal policy. To the extent fiscal balance can generate inflationary pressures, heterogeneous State level fiscal policy can be a significant determinant of European cross-regional inflation differentials. Clearly even individual US States have a fiscal budget and thus their spending might contribute to local price dynamics, however in general fiscal policy in the US is mainly implemented at centralized (Federal) level while in the Eurozone it is mainly local (National). In Figure **??** I show the share of public expenditure implemented at local (National-State) and Federal Communitarian level.

This structural difference between the two currency unions considered, which refer to

[10]Regnal data for individual US states are from the National Bureau of Economic Analysis (BEA), the labor share is computed as nominal compensation on nominal income, for the inflation rate (and thus for computing real interest rates) I consider for both economies the producer price index (PPI) as this is the only one viable for individual US States.

the level of government responsible for the largest share of the fiscal budget, might explain the different cross-State price dynamics in the Eurozone and the US.

A final consideration concerns the magnitude of cross-regional differentials in real unit labor cost developments in the US and the Eurozone and how such differentials are perceived in policy circles of the two economies. In Figure **??** I showed that in average the standard deviation of RULC changes in (roughly) 25 percent higher in the euro area than across US States. There are hardly technical tools to say wether this is enough for justifying the (far) more significant attention that the issue of imbalances has gained in Europe than in the US. However despite the damaging consequence that at local level a loss of real labor competitiveness can generate, it is hardly explainable how a simple polarization in real cost dynamics could affect a currency union as a whole. Probably, the reason why macroeconomic imbalances, including cost imbalances, are perceived as an issue in Europe and not in the US is more attributable to the significant difference in the structure of the two currency unions than to the magnitude of imbalances themselves. Local cost dynamics and thus competitiveness are more important across European States because of the role that National Governments have in the European context with respect to the US. To the extent European Sovereigns are responsible for essentially the entire provision of public services, investments and guarantees (i.e. on the banking sector) and in the absence of relevant cross-European transfers, national competitiveness dynamics that can affect the ability of euro area members to fulfill their obligations become relevant, even when they are merely the expression of a zero sum redistribution.

7 Conclusions

In the euro area relative monetary policy stance was significantly diverse across individual countries and especially so from 2003 to the beginning of the economic crisis. This paper provides evidence of the empirical link between the relative tightness of monetary policy and real cost imbalances in the Eurozone. After having presented the theoretical foundation for this relationship, I estimate a model relating the real unit labor cost to interest rates. Estimation results support the existence of such a link empirically for a panel of countries of the Eurozone.

To a certain extent cross-regional variation in real interest rates is common to all currency areas, however evidence shows that monetary policy stance and developments in the labor share are significantly more diverse across euro area members than US States. Explaining this difference is a crucial question for policy making: within the logic of the analysis presented in this paper, I consider an important factor that can potentially explain higher cross-regional differences in inflation rates in the Eurozone: fiscal policy.

Fiscal policy is implemented mainly at State level in Europe and mainly at Federal level in the US. Since 1999 and up to the beginning of the crisis in 2008, the absence of particular coordination in fiscal action across euro area members created persistent inflation differentials that are at the origin of divergent labor cost dynamics across members of the Eurozone.

The bottom line of the analysis presented in this paper is that heterogeneous labor cost developments are, to a certain extent, common to all currency areas. Even if it is true that such heterogeneity is prevailing in the Eurozone than across US States, the reason why the issue of cost imbalances is perceived as such in Europe and not in the US has probably more to do with the different structure of the two currency unions: the former having its focal point on the regional (State level) dimension and the latter on the Federal level. In a currency union cross-regional divergence in real labor costs could cause unpleasant consequences at local level (individual States), but it is not clear how it should affect the monetary area as a whole. In the specific case of the euro area, however, significant loss of competitiveness at State level could have more severe macroeconomic consequences, such as the economic undermining of national fiscal authorities, responsible of the vast majority of public spending. In the absence of a system of fiscal transfers, the Eurozone adds an additional constraint to the, per se already challenging, target of collective (Communitarian) economic growth and this involves the homogeneity of economic perspectives for all its members. Such constraint becomes relevant to the extent the economic risk affecting the National (local) dimension can easily put in jeopardy the stability of the entire communitarian system. It is clear then that it is within the structure of the Eurozone, in which the National dimension prevails on the Communitarian, that cross-States imbalances become relevant and perilous.

Referring to the empirical analysis developed, this paper has two main massages: the first is that real cost imbalances might accumulate across regions of a currency union without the need of cross-regional differentials in products or factor markets frictions, but simply as a consequence of differences in relative monetary policy stance. Within this logic, policy efforts to reduce frictions across members of the euro area are important but not sufficient to eliminate intra euro labor cost imbalances. The second is that, if the Eurozone wants to increase the homogeneity of its real cost developments it should work on one crucial aspect: higher fiscal coordination.

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A Interest Rates and Real Unit Labor Cost in a New Keynesian Model

The real unit labor cost has a key role in determining inflation models with sick prices, to the extent it is linked to marginal costs. In this section I present a New Keynesian Model with capital accumulation that I use for deriving a general equilibrium condition relating the real unit labor cost to the real interest rate. In this section the model is presented briefly, for a deeper discussion I invite the interested reader to maker reference to the mentioned papers. The main modification of this model concern the use of a CES production function (in line with the analysis developed previously) and the small open economy framework (international borrowing at an exogenous interest rate).

Consider an infinite number of household seeking to maximize:

$$\sum_{t=0}^{\infty} \beta^t U(C_t, L_t) \tag{37}$$

Households in each period can purchase a one period bond B_t at a price Q_t. They can consume C_t at prices P_t and they can buy next period capital K_{t+1}. They earn a real wage $W_t L_t$ and a capital market rent $(R_t)K_t$. Household budget constraint is:

$$B_{t-1} + P_t[W_t L_t + R_t K_t] = Q_t B_t + P_t C_t + P_t K_{t+1} \tag{38}$$

and the non-Ponzi condition:

$$\lim_{T\to\infty} = E_t[B_T] \geq 0 \tag{39}$$

First order condition for the household maximization problem are equations **??**, **??** and:

$$U_c(C_t, L_t) = \lambda_t P_t \tag{40}$$

$$U_l(C_t, L_t) = -\lambda_t P_t W_t \tag{41}$$

$$\lambda_t P_t = \beta \lambda_{t+1} R_{t+1} P_{t+1} \tag{42}$$

$$Q_t \lambda_t = \beta \lambda_{t+1} \tag{43}$$

Combining equations **??** and equation **??**, log-linearizing and calling $i_t = -log(Q_t)$, we obtain the intertemporal condition relating the nominal interest rate to expected real interest rate:

$$i_t - E_t[\pi_{t+1}] = E_t[R_{t+1}] \tag{44}$$

A.1 Firms

Firms are monopolistic competitors in the intermediate market, final output is produced from intermediate goods with Dixit-Stiglitz technology:

$$Y_t = \left[\int_0^1 y(i)_t^{\frac{\eta-1}{\eta}} di \right]^{\frac{\eta}{\eta-1}} \tag{45}$$

The demand function for intermediate goods is:

$$y_t(i) = Y_t \left[\frac{P_t(i)}{P_t} \right]^{\eta} \tag{46}$$

Intermediate goods are produced via CES production function:

$$f(K_t, L_t) = A \left[(\alpha) K_t^{\frac{\sigma-1}{\sigma}} + (1-\alpha) L_t^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{47}$$

Where K_t, L_t and A are respectively capital, labor and an exogenous technological parameter, $\alpha \in (0, 1)$ is the factor share and σ represents factors' elasticity of substitution.

First order conditions for cost minimization yield:

$$R_t = z_t f_k(K_t, L_t) \tag{48}$$

$$W_t = z_t f_l(K_t, L_t) \tag{49}$$

Combining this last equation with equation **??** we obtain the inter temporal condition relating the interest rate with the expected marginal product of capital:

$$i_t - E_t[\pi_{t+1}] = E_t[z_{t+1} f_k(K_{t+1}, L_{t+1})] \tag{50}$$

where i_t is the net interest rate.

Assume the existence of a number of identical firms, producing different products and facing constant price elasticity of demand given by **??**. As in Calvo (1983) assume further that in each period each firm has a fixed probability θ of adjusting its price and a probability $1-\theta$ of keeping its price unchanged. It can be shown that the aggregate price level p_t can be expressed as a linear combination of the price at time $t-1$ and the optimal price at time t:

$$p_t = \theta p_{t-1} + (1-\theta) p_t^* \tag{51}$$

Where the optimal price level p_t^* is defined as the price that maximizes the all future discounted profits subject to Calvo staggered pricing:

$$p_t^* = (1-\beta\theta) \sum_{j=0}^{\infty} (\beta\theta)^j E_t[z_{t+j} + p_{t+j}] \tag{52}$$

Where z_t is the marginal cost. Combining equations **??** and **??** and calling $\pi_t = p_t - p_{t-1}$ we obtain the standard New Keynesian Pricing Equation:

$$\pi_t = \lambda z_t + \beta E_t[\pi_{t+1}] \tag{53}$$

where $\lambda = \frac{(1-\theta)(1-\theta\beta)}{\theta}$ and the marginal cost z_t is measured as deviation from the steady state.

In this case the real unit labor cost is:

$$RULC_t = Z_t \left[1 - \alpha \left(\frac{K_t}{Y_t} \right)^{\frac{\sigma-1}{\sigma}} \right] \tag{54}$$

Again for $\sigma = 1$ and perfect competition $z_t = 1$, this equation collapses to $1-\alpha$, the constant labor share in case of a Cobb-Douglas.

The inter-temporal Euler equation (equation **??**) can be re-written as:

Calling the real interest rate at time t $R_t = i_t - E_t[\pi_{t+1}]$, then the inter-temporal Euler equation (equation **??**) becomes:

$$i_t = E_t[z_{t+1} f_k(K_{t+1}, L_{t+1}) + \pi_{t+1}] \tag{55}$$

Stating that the nominal rate should be equal to the expected marginal turn of capital in the next period in nominal terms.

Or equivalently:

$$i_{t-1} - \pi_t = z_t \alpha \left(\frac{Y_t}{K_t} \right)^{\frac{1}{\sigma}} - \upsilon_t \tag{56}$$

where υ_t is the forecasting error at time t of $z_t f_k(K_t, L_t) + \pi_t$.

$$R_{t-1} = z_t \alpha \left(\frac{Y_t}{K_t} \right)^{\frac{1}{\sigma}} - \upsilon_t \tag{57}$$

where υ_t is the forecasting error at time t of $z_t f_k(K_t, L_t)]$. Then solving for the capital output ratio, calling $R_{t-1} = i_{t-1} - \pi_t$ and substituting into **??** we have:

$$RULC_t = Z_t \left[1 - \alpha \left(\frac{R_{t-1} + \upsilon_t}{\alpha Z_t} \right)^{1-\sigma} \right] \tag{58}$$

Which is equation **??** in the text.

Taking Taylor approximation around the steady state we obtain:

$$s_t = \gamma z_t + \phi r_t + \eta_t \tag{59}$$

Where lower cases indicate deviations from the steady state, s_t is the real unit labor cost and $\gamma = \frac{\mu}{s}[1 - \alpha\sigma(\frac{1}{\beta\mu\alpha})^{1-\mu} + \mu(\sigma-1)(\frac{1}{\beta\mu\alpha})^{1-\sigma}\frac{1}{\mu}]$, $\phi = (\sigma - 1)\frac{1}{\beta s}(\frac{1}{\beta\alpha\mu})^{-\sigma}$ and $\eta_t = \upsilon_t \frac{1}{\mu}(\sigma - 1)(\frac{1}{\beta\alpha\mu})^{-\sigma}$.

This is a linear equation relating the labor share to the real interest rate and it represents the theoretical base for the estimation performed in this paper.

Figure 1: Evolution of key macroeconomic variables for major euro area countries

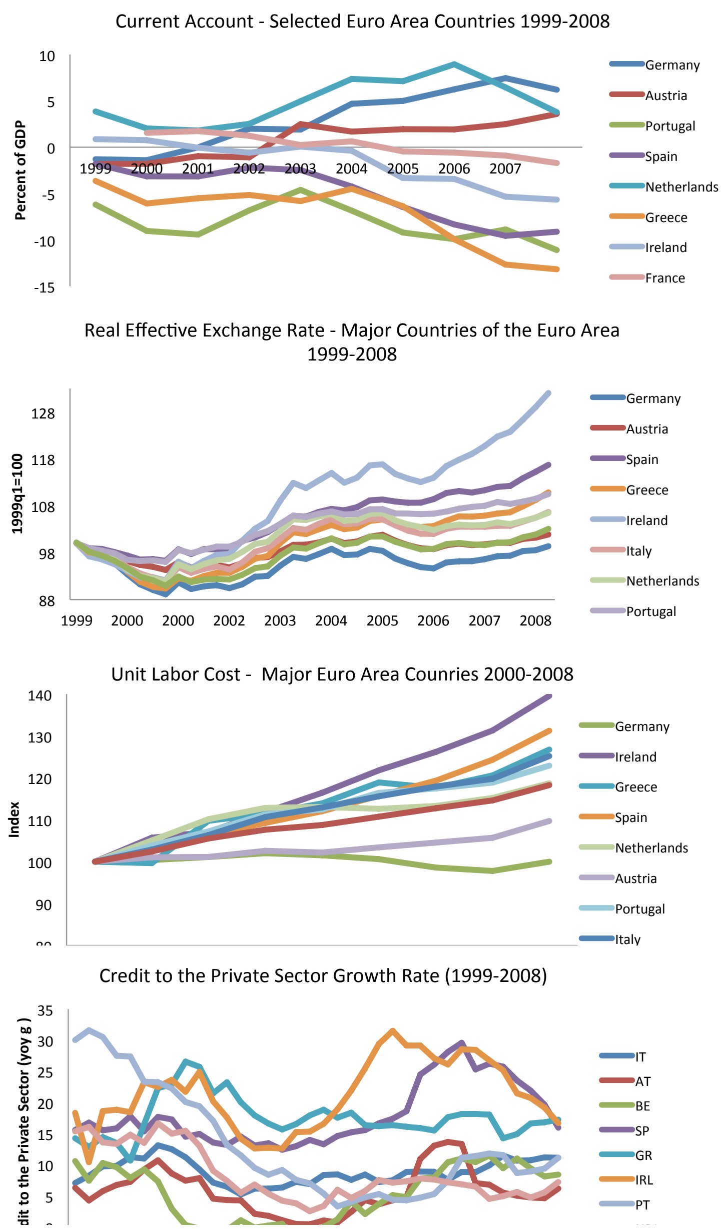
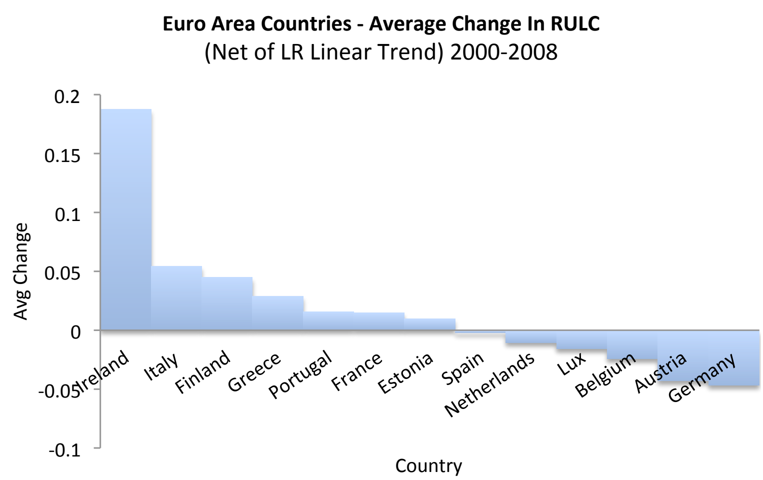


Figure 2: Real Unit Labor Cost Imbalances in the Euro Area



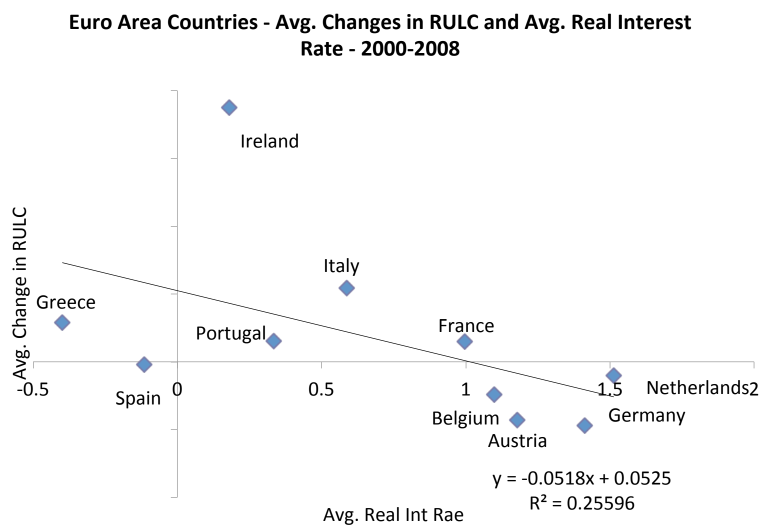
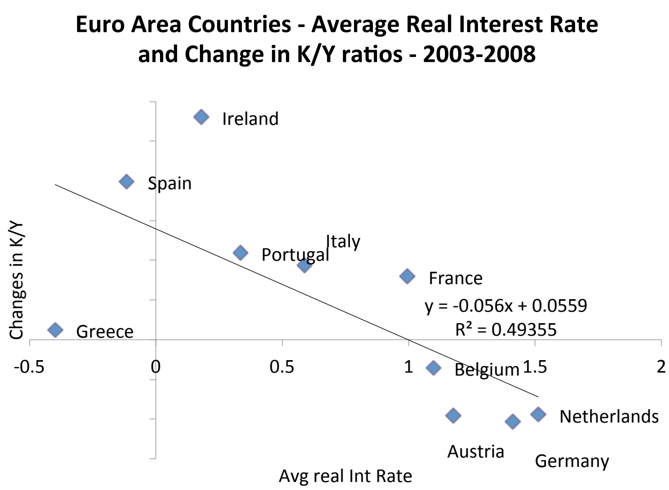


Figure 3: Real Interest Rates, Capital Accumulation and the Labor Share in the Eurozone



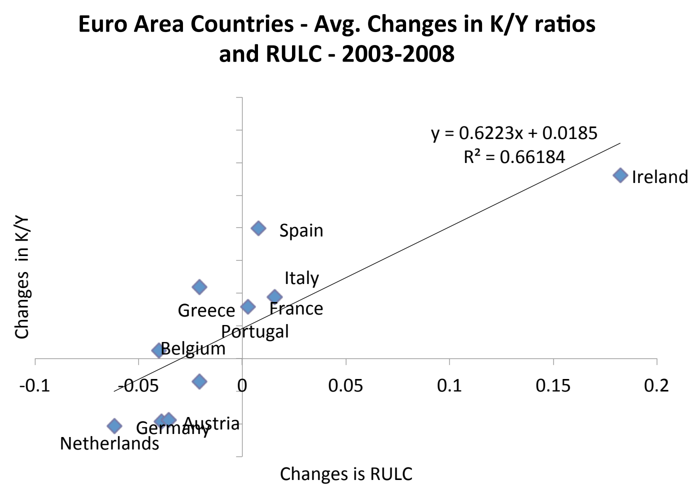


Table 1: Estimation Results for Basic Coincident and Forward Looking Interest Rate Rule, Euro Area

	(1)	(2)	(3)	(4)	(5)	(6)
	Eonia	Eonia	Eonia	Eonia	Eonia	Eonia
Output Gap	0.562***			0.589***		
	(0.0650)			(0.0415)		
Inflation	-0.0131			0.401***		
	(0.157)			(0.124)		
Output Gap t+1		0.467***			0.522***	
		(0.0671)			(0.0460)	
Inflation Gap t+1		0.318*			0.430***	
		(0.172)			(0.145)	
Output Gap t+2			0.352***			0.421***
			(0.0709)			(0.0503)
Inflation Gap t+2			0.676***			0.722***
			(0.194)			(0.155)
Trichet (from 09/2003)				-0.811***	-0.931***	-0.908***
				(0.112)	(0.143)	(0.177)
Constant	2.938***	2.892***	2.869***	3.322***	3.320***	3.286***
	(0.0822)	(0.0989)	(0.110)	(0.106)	(0.126)	(0.131)
Adjusted R^2	0.638	0.512	0.414	0.845	0.782	0.667
Observations	38	38	38	38	38	38

Inflation is the annual percentage increase in prices for non energy and non unprocessed food.
Output gap is defined as percentage deviation
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 4: Actual and Predicted Values for EONIA Rates, Euro Area (Coincident Policy Rule - Model 7)

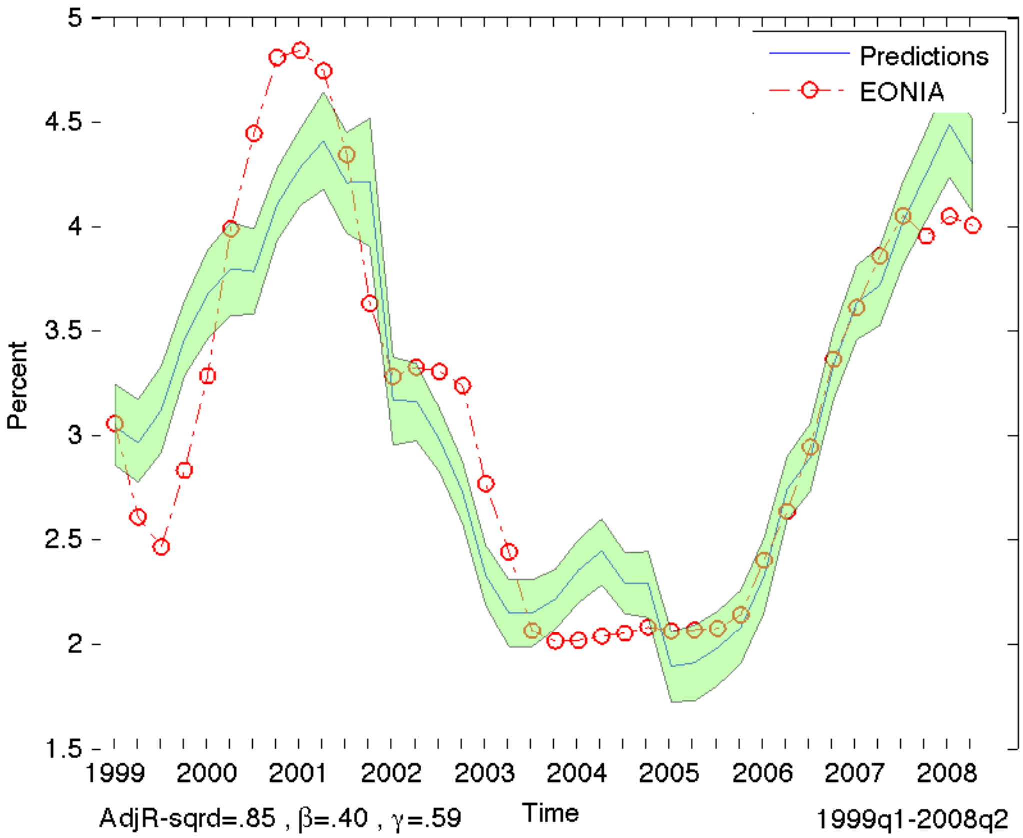


Figure 5: Actual and Predicted Values for EONIA Rates, Core (Coincident Policy Rule - Model 7)

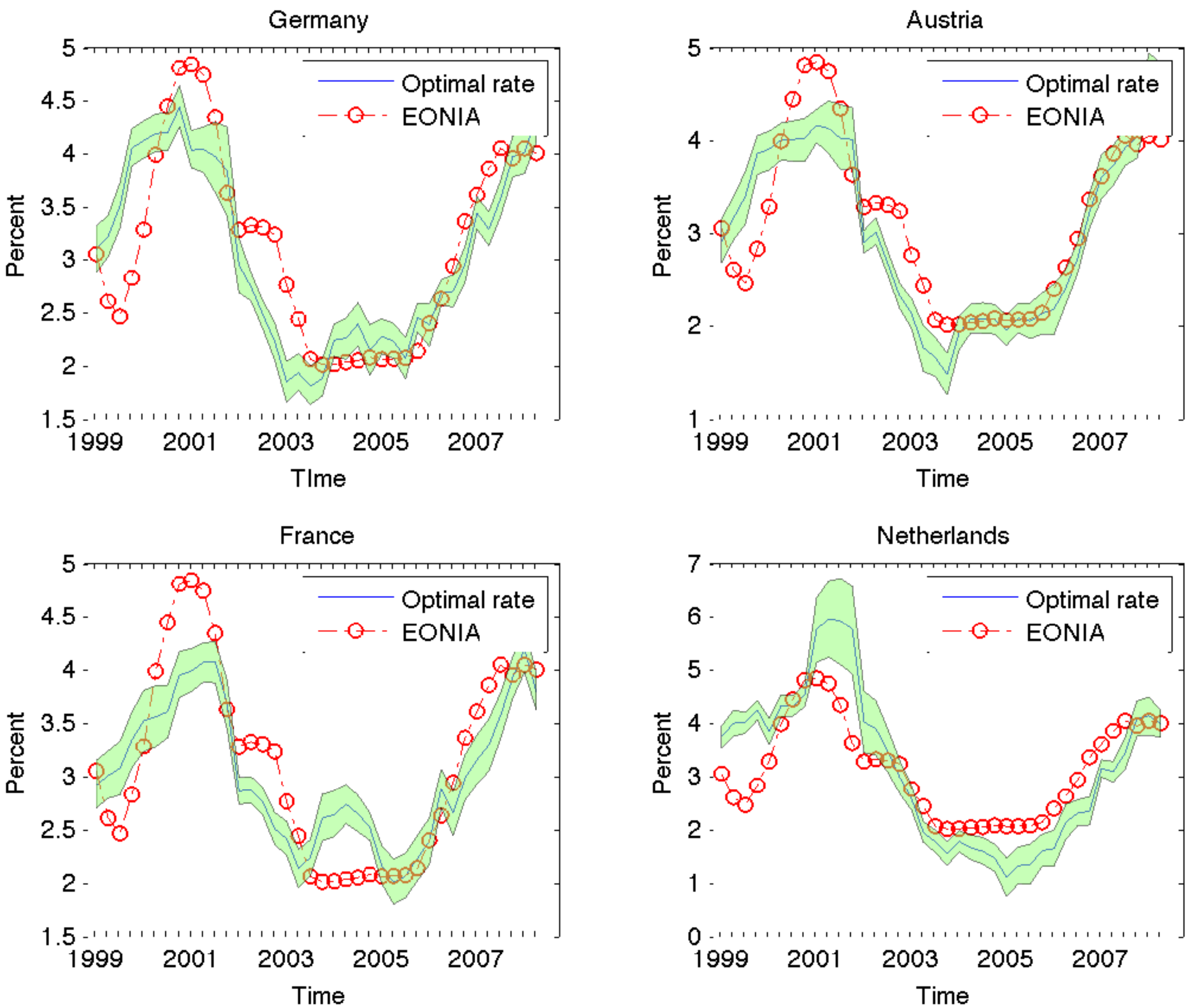


Figure 6: Actual and Predicted Values for EONIA Rates, Periphery (Coincident Policy Rule - Model 7)

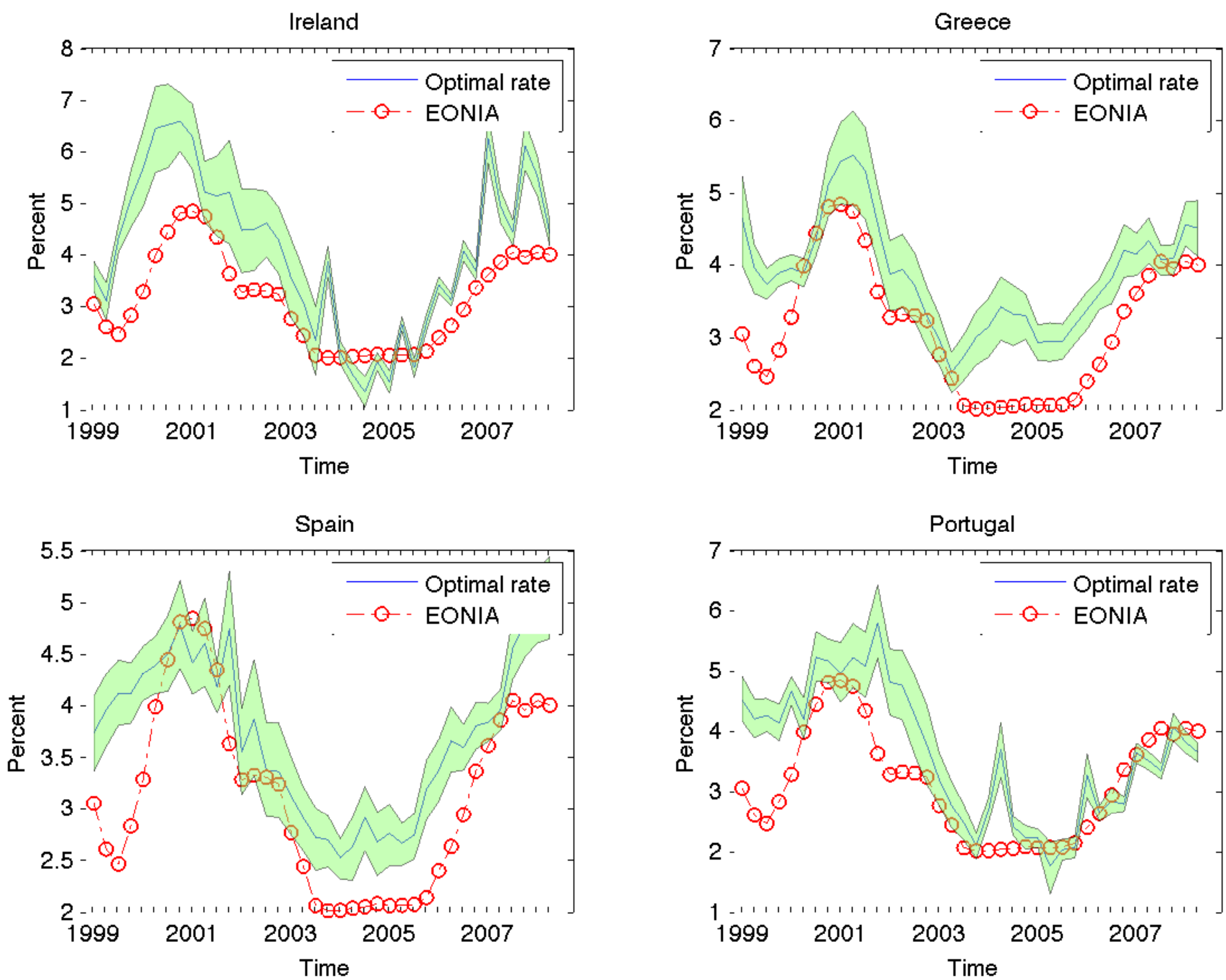


Figure 7: Index of Monetary Policy Adequacy, different specification

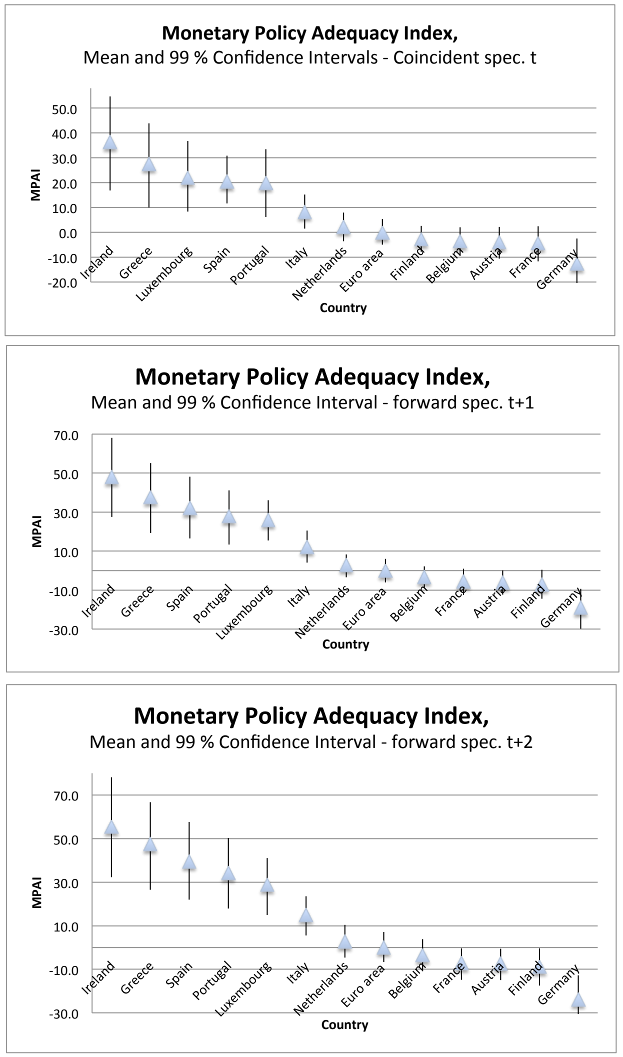
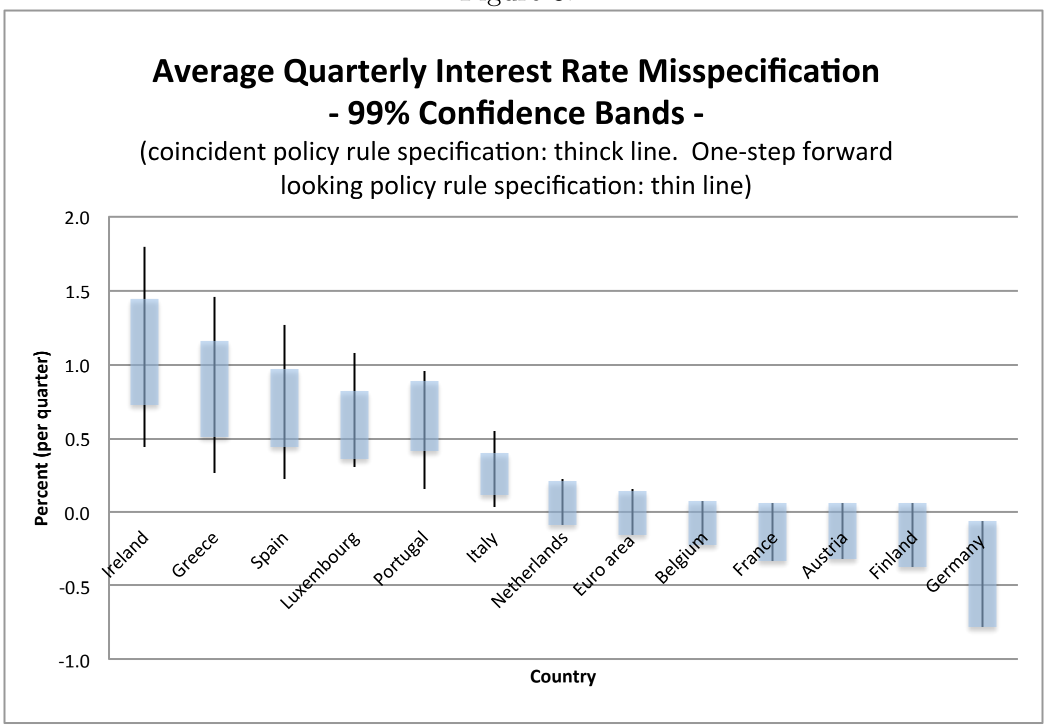
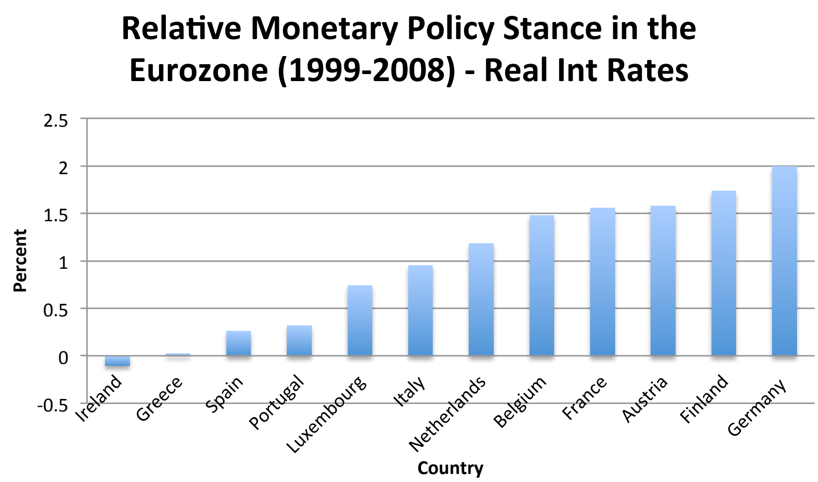


Figure 8:



Average Quarterly Interest Rate Misspecification
- 99% Confidence Bands -
(coincident policy rule specification: thinck line. One-step forward looking policy rule specification: thin line)
Percent (per quarter)
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
Ireland
Greece
Spain
Luxembourg
Portugal
Italy
Netherlands
Euro area
Belgium
France
Austria
Finland
Germany
Country

Figure 9:


Relative Monetary Policy Stance in the Eurozone (1999-2008) - Real Int Rates
Percent
2.5
2
1.5
1
0.5
0
-0.5
Ireland
Greece
Spain
Portugal
Luxembourg
Italy
Netherlands
Belgium
France
Austria
Finland
Germany
Country

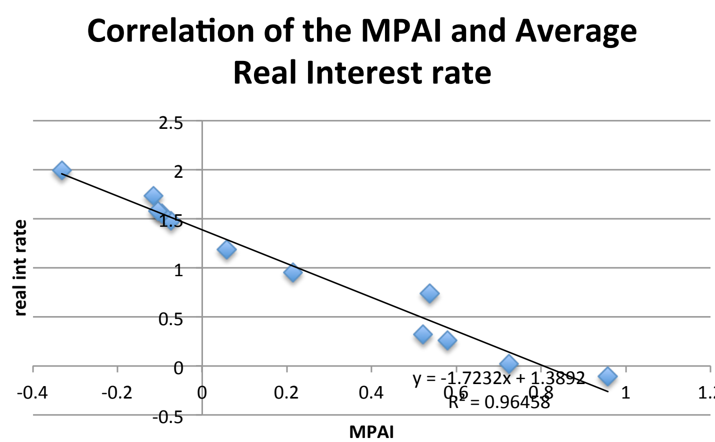

Correlation of the MPAI and Average Real Interest rate
real int rate
2.5
2
1.5
1
0.5
0
-0.5
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
y = -1.7232x + 1.3892
R² = 0.96458
MPAI

Table 2: Imbalances and Monetary Policy: Panel ECM

	(1) Δ RULC	(2) Δ RULC
Long Run		
Output Per Worker (t)	0.440**	0.636**
	(0.165)	(0.276)
Constant	-0.358**	-0.388**
	(0.097)	(0.101)
ψ (Speed of Adjustment)	-0.572**	-0.053**
	(0.077)	(0.019)
Short Run		
Δ Output Per Worker (t)	-0.378**	-0.383**
	(0.031)	(0.032)
Δ Output Per Worker (t-1)		-0.02
		(0.037)
Δ RULC (t-1)		-0.177**
		(0.049)
Time FE	Yes	Yes
Implied LR Parameters		
σ	0.69	0.61
α	0.30	0.32
Sample	1999-2008	1999-2008
N	468	468

Standard errors in parentheses. Panel error correction models, dynamic fixed effect estimation. The long run relationship between the real unit labor cost and output per worker is presented in the first part of the table. Implied long run elasticity of substitution σ and factor shares α are in the last part of the table. Quarterly Frequency from 1999q1 to 2008q2. Time fixed effects.

* $p < 0.10$, ** $p < 0.05$

Table 3: Imbalances and Monetary Policy, Real Interest Rates and Changes in Unit Labor Cost.

	OLS	IV	Placebo	OLS	IV	Placebo
	(1) RULC	(2) RULC	(3) RULC	(4) RULC	(5) RULC	(6) RULC
L.Real Rate+	0.353	-2.005*		0.591	-1.889*	
	(0.342)	(1.124)		(0.356)	(1.039)	
Placebo			0.00336			-0.0000917
			(0.00580)			(0.00642)
Constant	-0.606**	-0.586**	-0.611**	-0.648**	-0.625**	-0.642**
	(0.00291)	(0.00974)	(0.0153)	(0.00335)	(0.0101)	(0.0171)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Sample	All	All	All	Limited	Limited	Limited
Weak Identification Test						
K-P rk Wald F statistic		26.729			32.631	
S-Y critical values		16.38			16.38	
N	470	470	470	249	249	249
Adjusted R^2	0.0177	0.222	-0.00133	0.0510	0.043	-0.00395
Sample	1999-2008	1999-2008	1999-2008	1999-2008	1999-2008	1999-2008
Countries	12	12	12	6	6	6

Standard Errors in parenthesis. FE estimator. Quarterly Frequency from 1999q1 to 2008q2 for the Euro area members from 1999 plus Greece, Estonia is excluded for data limitation. + in the first and forth equation real interest rates are simply computed as difference between the Eonia rate and expected inflation, in the send and fifth real interest rates are instrumented via cyclically adjusted fiscal balance. Placebo regression consider a model where the regressor has same first and second moment of the instrument used in equation 2 and 5. Restricted sample includes countries for which monetary policy was relatively inadequate in the sense defined by the index of monetary policy presented in this paper. These countries can be considered more exogenous to the centralized monetary process and thus to nominal interest rates than others. This limited sample includes are: Ireland, Greece, Luxembourg, Spain, Portugal and Italy. K-P stands for Kleibergen-Paap, S-Y stands for Stock-Yogo, reported critical values for both tests are at 10 percent.

* $p < 0.10$, ** $p < 0.05$

Table 4: Robustness controls, The Real Interest Rate and Changes in Unit Labor Cost

	Baseline (1) RULC	NW SE (2) RULC	Dynamic (3) D.RULC	Relevance (3) RULC
L.Real Rate^{iv}	-2.005*	-2.056*	-5.824*	-0.176
		(1.233)	(3.119)	(0.183)
L.RULC			-0.267**	
			(0.0464)	
Constant	-0.586**	-0.507**	-0.00128**	-0.0417**
	(0.00974)	(0.0234)	(0.000570)	(0.0130)
L.Real Rate				-0.023
				(0.062)
Country FE	Yes	Yes	N/A	Yes
Sample	All	All	All	All
N	470	470	470	470
Sample	1999-2008	1999-2008	1999-2008	1999-2008
Countries	12	12	12	12

Standard Errors in parenthesis. Quarterly Frequency from 1999q1 to 2008q2 for the Euro area members from 1999 plus Greece, Estonia is excluded for data limitation. Real interest rates are instrumented via cyclically adjusted fiscal balance. First model is the baseline specification, second model uses Newey-West SE to account for possible serial correlation, third model is a dynamic panel estimated using Arellano-Bond linear dynamic panel-data estimator.

* $p < 0.10$, ** $p < 0.05$

Table 5: Imbalances and Monetary Policy: The Real Interest Rate and Changes in Unit Labor Cost, Cross-Country Evidence

	IV	OLS	IV	OLS
	(1)	(2)	(3)	(4)
	Δ RULC	Δ RULC	Δ RULC	Δ RULC
L.Real Rate^{iv}	-0.384**			
	(0.132)			
L Δ Real Rate ^{iv}			-0.0820**	
			(0.0238)	
L. Real Rate		-2.295		
		(2.638)		
L.Δ Real Rate				0.914
				(0.542)
Constant	0.0875	-0.292**	-0.00179**	0.0114
	(0.152)	(0.123)	(0.000624)	(0.0142)
N	433	458	391	432
Adjusted R^2	0.382	-0.0207	0.498	0.144
Sample	1999-2008	1999-2008	1999-2008	1999-2008
Countries	12	12	12	12

Standard errors in parenthesis. Between estimator. Quarterly Frequency from 1999q1 to 2008q2 for euro area members since 1999 and Greece. Real interest rates computed subtracting one step forward inflation from the Eonia rate. Inflation is instrumented via discretionary fiscal balance when instrument are used.

* $p < 0.10$, ** $p < 0.05$

Figure 10: Inflation and RULC Differentials: Comparing the US and the Eurozone

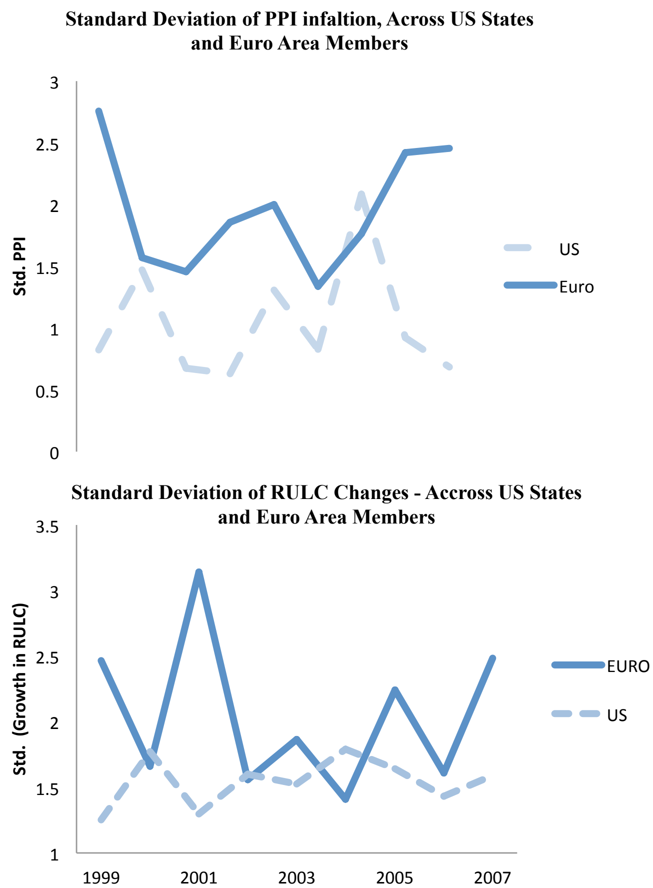


Figure 11: Inflation and RULC Differentials: Tests on the Average Standard Deviation of PPI and RULC Growth for The US and Eurozone e

Std. Of PPI Inflation 1999-2007: Paired t-test

STD PPI	Obs	Mean	Std.Err,	Std. Dev	95% conf int	
US	9	1.047	0.161	0.4851		
EURO	9	2.194	0.121	0.3615		
Diff.		-1.146	0.193	0.579	-1.592	-0.7014

Degrees of Freedom 8

t= -5.937

H1: mean(diff)<0 Pr(T<t)=0.0002

Std. Of Changes in RULC 1999-2007: Paired t-test

STD PPI	Obs	Mean	Std.Err,	Std. Dev	95% conf int	
US	9	1.544	0.0631	0.189		
EURO	9	2.048	0.1909	0.573		
Diff.		-0.504	0.2371	0.713	-1.052	0.043

Degrees of Freedom 8

t= -2.12

H1: mean(diff)<0 Pr(T<t)= 0.033

Figure 12: Centralization of Fiscal Policy: Comparing the US and the Eurozone.