# Euro-dollar polarization and heterogeneity in exchange rate pass-throughs within the euro zone

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# EURO-DOLLAR POLARIZATION AND HETEROGENEITY IN EXCHANGE RATE PASS-THROUGHS WITHIN THE EURO ZONE

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## Abstract

This paper provides an empirical study of the asymmetrical spillovers of the euro-US dollar exchange rate on inflation in the euro zone. We divide the euro zone members in two groups of countries: "core" (closely related to Germany) and "periphery", testing if the euro-US dollar exchange rate is still able to give a different impact on the groups ' performance as in the past US dollar-deutschmark polarization phenomenon. Using a dynamic panel data framework based on an exchange rate pass-through model, we estimate the elasticities of the two groups by system IV-GMM and the common correlated effects mean group estimator, testing for the asymmetry.

Estimating the model with the first type of method, the exchange rate pass-through coefficient is always significant but the asymmetry between the groups is rejected. Using the common correlated effects mean group estimator we find that the coefficient is significantly negative only for core countries and the hypothesis of asymmetry is confirmed. Note that the significance disappears if we control for the first three years of EMU, but the coefficients for core and periphery have opposite sign in any case. Instead, other unobservable factors, representing global events or spillovers effects, play a relevant role in all the specifications.

By using the nominal effective exchange rate instead, we found a significant coefficient in case of the whole EMU, while the elasticities for core and periphery are not statistically different from zero.

Based on these results, we can conclude that the euro-US dollar is an important factor, but not the only key factor, in determining the asymmetry in inflation between core and periphery. The nominal effective exchange rate instead is a very important driver for the inflation only considering the whole euro zone. Therefore, the EMU seems to not have insulate enough some member countries from shocks coming from outside, as in the case of nominal exchange rate shocks.

*Keywords*: Exchange Rate Pass-Through, Dynamic Panel Data, Inflation, Exchange Rates, European Monetary Union, Cross-sectional dependence.
*JEL Classification*: C33, E31, F31, F36, F41.

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## 1. INTRODUCTION

Brown (1979) and Giavazzi and Giovannini (1989) made the conjecture that an appreciation in US dollar (USD) vis-à-vis the deutschmark (DM) had important asymmetric effects on exchange rates within Europe, represented by different elasticity of European currencies *vis-à-vis* the USD with respect to movements in the USD-DM exchange rate[1]. After rising between the early 1970s and 1992, the tightness of this cycle declined into the mid-1990s and has since risen again until 1997.

The authors show that the European countries could be divided in 2 groups with respect to their elasticity *vis-à-vis* the USD and DM: one group follows the DM behavior (countries economically closer to Germany: Austria, Netherlands, Belgium, Denmark) having an elasticity closer to 1 and another follows the USD (Italy, Ireland, Spain) with different magnitudes in the response. Asymmetries and tensions in the European Monetary System (EMS) might be therefore also described through the concept of the polarization USD-DM, because of function of macroeconomic, financial and monetary factors.

The euro eliminated exchange rates within the European Monetary Union (EMU) and the asymmetries between the 2 groups, now core countries (highly rated, economically closer to Germany) and periphery countries (also called "giips"), can be displayed in different ways, through macroeconomic, financial, policy variables. The fiscal crisis in the euro area highlights the importance of underlying macroeconomic heterogeneity within a monetary union and in parallel, in the absence of currency movements; bond markets reveal important financial market heterogeneity in the euro area.

My aim consists in testing if the exchange rate *vis-à-vis* the USD still matters and if it affects core and periphery in a different way (in sign and/or magnitude) causing an asymmetrical reaction in inflation rates. We test the asymmetries in inflation rate by following Honohan and Lane (2003), which remark indeed that the degree of price dispersion in Europe appears to co-move with cycles in the euro-dollar (previous DM-dollar) exchange rate. Hence, we study the intra-euro area differences in exchange rate pass-through (ERPT), which is an important element of inflation dynamics.

In doing that, we use the standard specification used in the pass-through literature analyzing the model using IV-GMM techniques and, because of the presence of cross-sectional dependence in our data, factor analysis with the Common Correlated Effects Estimator (CCMG) developed by Pesaran and Tosetti (2011).

Estimating with IV-GMM, the empirical evidence does not support the hypothesis of asymmetrical effect of the dollar exchange rate on the 2 groups. The ERPT coefficient is always significant but the asymmetry between core and periphery is rejected.

Using the estimator by Pesaran and Tosetti (2011), we find that ERPT coefficient is significant only for core countries, confirming the asymmetrical effect of the exchange rate *vis-à-vis* the US dollar on inflation within euro zone, but the result is not robust. Indeed controlling for the first three years of EMU, in which

[1] An elasticity equal 1 means that the currency reacts in the same way as the DM.

probably the firms changed their price lists in order to adjust them to the new currency, the coefficients become not significant[2]. On the contrary, other unobservable factors related to HICP itself play a role in all the specifications. This is the result of common unobserved factors, for instance the presence of a crisis, or spillovers among countries, which are not directly expressed in the analysis (these factors loadings are treated as nuisance parameters). Instead by applying the nominal effective exchange rate (so a trade-weighted measure of nominal bilateral rates) as a regressor, this is a significant driver for the whole euro zone only, while is not significant if we divide the sample in core and periphery.

Based on these results, we can conclude that the euro-US dollar is an important factor, but not the only key factor, in determining the asymmetry in inflation between core and periphery and in any case the nominal effective exchange rate is a very important driver for the inflation in the whole euro zone. Therefore, the EMU seems to not have insulate enough some member countries from shocks coming from outside, as in the case of nominal exchange rate shocks.

The paper is organized as follows. Section 2 reviews the recent literature on the dollar-DM polarization, the ERPT and the asymmetries in inflation. Section 3 present the analytical framework on which our analysis is based and shows the empirical methodology used. Section 4 provides the results for the pass-through to consumer prices (with system IV-GMM and CCEMG) and Section 5 concludes and discusses policy implications.

## 2. OVERVIEW OF THE LITERATURE

There are three relevant literature's strands for our analysis: on the dollar-DM polarization, on asymmetries in inflation and on exchange rate pass-through (ERPT).

The "dollar-deutschmark polarization", represented by different elasticity of European currencies *vis-à-vis* the USD with respect to movements in the USD-DM exchange rate, emerged in the 1980s (Brown (1979), Giavazzi and Giovannini (1989)) and it was en vogue in the 1990s and early 2000s (Corsetti and Pesenti (1999), Galati (2001), Haldane and Hall (1991) and Taylor (2002)). Giavazzi and Giovannini (1989) show the phenomenon using the effective dollar exchange rate of 9 currencies. They underline that the conventional possible explanation of the polarization and the asymmetric but systematic movements of European exchange rates versus the US Dollar did not explain completely the data. They propose a dynamic CAPM model including capital controls and use it to capture their role in the EMS during the 80s.

Galati (2001) explains the phenomenon providing a test on the factors which could have affected the elasticity between the USD-DM rate and the other exchange rates of the EMS currencies (Table 1). The elasticity is function of macroeconomic, financial and monetary factors. He estimates the influence of these

[2] In this case the coefficients for core and periphery still have opposite sign, even if they are not significant anymore.

variables on the elasticity by using a SUR model and the Random Effect estimator, finding that the main factors affecting the relation USD-DM are the exchange rate policy, the trade links, and the portfolio bias.

[TABLE 1 AROUND HERE]

Bénassy-Quéré et al. (1998) focus the analysis on the stabilization of the EU economy after joining EMU (represented by France and Germany only) and of volatility of the exchange rates towards the US dollar. Following their simulations, the EMU should have brought a decrease in volatility of the transatlantic exchange rate compared both to the ERM and to a floating regime.

However, because of structural and stochastic asymmetries[3], the benefits of EMU, in terms of the variability of inflation and of the real effective exchange rate, are smaller for France than for Germany.

The second relevant literature strand analyzed the relation between exchange rates and inflation differentials, which has been developed in the last decade by Angeloni and Ehrmann (2004), and Honohan and Lane (2003, 2004). In the first paper the authors build a stylized empirical model applying a variety of shocks which are able to generate the asymmetries in the EU, shocks on nominal and real effective exchange rates among them. Honohan and Lane (2003, 2004) stressed the impact of the weakness of euro on financial markets in the early periods of the EMU, whereas underlining at the end the situation of Ireland, which in their opinion has been influenced by the euro-US dollar exchange rate movements stronger than other members. They use quarterly data for 12 countries and 6 years applying IV methodology with as instruments 4 lags and assuming no covariance between inflation and output gap. The authors found a strong negative relation between change in prices and change in the nominal effective exchange rate (NEER). They used as explanatory variables lagged rate of inflation, the variation in the exchange rate, the output gap and impulse in the cyclically adjusted primary surplus. In addition, they remark that the degree of price dispersion in Europe appears to co-move with cycles in the euro-dollar (previous DM-dollar) exchange rate. Therefore, the cycle and shocks of the exchange rate towards US dollar might also have affected in a different way the euro area members.

The third literature strand which studies the impact of exchange rates on inflation is the exchange rate pass-through (ERPT), traditionally defined as the percentage change in (elasticity of) the local currency price of imports or in consumer price resulting from a 1 per cent change in the nominal exchange rate between the exporting partner and importing country.

On a theoretical point of view, the analysis of ERPT is based on Pricing To Market (PTM) studies, developed by Krugman (1987), Knetter (1989), Marston (1990) and Goldberg and Knetter (1997), in which the exchange rate induces price discrimination in international markets with a variation in the various mark-

[3] The authors apply stochastic simulations, which take different kinds of shocks simultaneously, in order to compare the variability of various macroeconomic variables, including the transatlantic exchange rate, in the three regimes namely ERM, EMU and floating, and to highlight the role of the intra-European exchange rate as a source of shocks or as an adjustment variable.

ups. The PTM depends on the export demand function; therefore an increasing in the demand elasticity caused by a variation of import or consumer prices gives a lower mark-up in this market. The marginal costs vary due to variations in output. We can have a complete ERPT (the elasticity is equal to 1) only if the mark-up and the marginal costs are constant. Incomplete ERPT is hence defined as an elasticity lower than 1. The New Open-Economy Macroeconomic (NOEM) literature approached the ERPT introducing it into a dynamic general-equilibrium (DGE), open-economy model with well-specified micro-foundations stressing how pass-through could be incomplete in an environment characterized by imperfect competition and pricing to market (PTM). Corsetti and Dedola (2005) explain that ERPT falls with firms' monopoly power and the size of mark-up and even if all the prices and wages are fully flexible (i.e. there are not nominal rigidities) the ERPT can be incomplete and in a OECD context is declining in the recent years.

Empirically, most of these studies are cross-sectional in nature and focus on explaining cross-country variations in pass-through elasticities (Campa and Goldberg (2005)), with the exception of Bailliu and Fujii (2004), which develop the analysis on a panel data framework. Campa and Goldberg (2005) show that the ERPT elasticity in the short run is normally higher than in the long run and the declining of ERPT elasticities for 23 OECD countries in the period 1975-2003 has been probably caused by improved macroeconomic conditions within import markets. In the analysis by Bailliu and Fujii (2004), the declining in ERPT has been the result from a transition to a low-inflation environment (the "great moderation" period), in the industrialized countries. A similar dynamic panel model analysis has been recently developed by Jimborean (2011) for new EU member states. The author has not found any statistically significant result for exchange rate pass-through estimated at the aggregate level for consumer prices (measured by the HICP).

In sum, as pointed out by Saiki (2011), the main macro and micro factors, which can have brought a decrease in ERPT in the last decades include: changes in trade structure (Campa and Goldberg (2002)), improvement in monetary policy (Taylor (2000)), substantial changes in basic macroeconomic conditions (as inflation, per capita incomes, tariffs, wages, long-term inflation, and long-term exchange rate variability), globalization and increasing in competition (Taylor (2000)), which can have reduced producer's ability to pass cost shocks onto the prices of final goods, and downward rigidities.

For the euro area, the literature confirms that a common shock that may affect countries in the euro area differently is exchange rate shocks and the strength of the ERPT can determine the impact of exchange rate shocks on HICP inflation (de Haan (2010)). ERPT is not homogeneous across the euro zone members and this issue can be influenced by the openness towards trading partners outside the euro zone itself (de Haan (2005)). This strand of literature allows me to use the difference in ERPT between core and periphery as a way to study the polarization, as an asymmetrical effect of US dollar rate within the euro zone.

## 3. EMPIRICAL METHODOLOGY AND DATA DESCRIPTION

**Description of the model**

Two approaches are generally used for estimating the exchange rate pass-through. These are the SVAR (Structural Vector Auto Regressive) models as in McCarthy (1999) and panel regressions (Bailliu and Fujii (2004)). The SVAR approach analyzes the impact of exchange rate shocks on prices by using the impulse response functions (IRF). It nevertheless presents a main limitation, since its effectiveness is lower during short period of analysis, as in our case. In addition, our aim is to build a framework which allows me to look for idiosyncratic and common factors influencing the inflation in the euro zone and to test for a significant difference in ERPT coefficients between two groups of countries in order to prove our polarization hypothesis. This is the reason why we decide to apply a single panel approach for our study. Therefore, following the model by Bailliu and Fujii (2004), we create a framework based on the pricing behavior of an exporting firm, which maximizes its profits. In our case the exporting firm is from the United States and the import partner is a country in the euro zone. This firm decides the price of the good taking into account this static maximization function:

$$max_p:\ \pi = \frac{1}{s}\,(p * q) - C(q) \tag{1}$$

where $\pi$ is the profit to be maximized expressed in US dollar, $1/s$ is the bilateral exchange rate (measured in units of dollars per one euro), $p$ stands for the price of good in euro, $q$ is the quantity of good demanded by the euro zone country and $C(q)$ are the costs faced by the US firm.

This maximization is solved by a first order condition:

$$FoC : \frac{\partial \pi}{\partial q} = 0 = \left(p * \frac{1}{s}\right) - \frac{\partial \pi}{\partial C(q)} * \frac{\partial C(q)}{\partial q} \tag{2}$$

that gives the optimum price for the good for the US exporting firm to the euro zone partner:

$$p^{opt} = MC * s * \mu \tag{3}$$

where $MC$ is the marginal cost (= $\partial C(q)/\partial q$) of the quantity of good $q$ and $\mu$ is the markup of price over the marginal cost (= $\partial \pi/\partial C(q)$).

Now log-linearizing the equation and taking $\eta = -\mu/(1 - \mu)$, as the price elasticity of demand for the good (where $\mu$ is the mark-up), we have a simple log-linear, reduced-form of the equation, expressed as follows:

$$p_t = \alpha + \beta s_t + \tau w_t + \eta y_t + \varepsilon_t \tag{4}$$

where $s$ is the nominal exchange rate (measured in units of euro per one dollar), $w$ is a variable for the foreign cost of labor (proxy for the marginal cost as also suggested in Bussiére, 2007) and $y$ is the domestic output gap. The coefficient $\beta$ thus measures ERPT.

In Bailliu and Fujii (2004) this equation is estimated with a GMM methodology[4] and applied to three different dependent variables: import prices, producer prices and consumer prices. Prices are therefore regressed on their lags, on country and time dummy variables, on the nominal effective exchange rate, on the exchange rate interacted with two policy dummy variables indicating shifts in the inflation environment in the 1980s and 1990s, respectively, on the foreign unit labor cost[5] and on the output gap.

we elaborate a similar model to this standard pass-through specification described at equation (4)[6], extended to many destination countries and adding in an extended version of the model the Openness Index as in Roger (2002) in order to study the influence of openness towards trading partners outside the euro area (de Haan et al., 2005). we do that because the trade composition is not included in the model with the EURUSD exchange rate, while it is of course in the model using the NEER[7].

This framework follows the structure of a typical dynamic panel data model with lagged dependent variables (ARDL: Autoregressive Distributed Lag Model). The introduction of the lags becomes crucial to control for the dynamics of the process, allowing for price inertia (Bailliu and Fujii, 2004), because it is unlikely that prices completely adjust within one period especially at quarterly frequency (Bussiére, 2007). We also introduce a lagged effect of exchange rates on current inflation as in Campa and Goldberg (2005). We decide to use 2 lags for the dependent variable because from the third lag the coefficient is never significant, and one lag for the exchange rate, supposing that the reaction of prices to change in the euro-dollar exchange rate may take only one period, i.e. three months.

The equation is therefore as following:

$$p_{i,t} = \alpha_i + \theta_t + \gamma_1 p_{i,t-1} + \gamma_2 p_{i,t-2} + \beta s_{i,t-1} + \tau\, fulc_{i,t} + \eta\, gdpgap_{i,t} + \psi\, X_{i,t} + \varepsilon_{i,t} \tag{5}$$

[4] The authors stress that the standard estimators for a dynamic panel-data model with fixed effects generates estimates that are biased when the time dimension of the panel is small. Following Judson and Owen (1999) this bias can be sizable even when the number of observations per cross-sectional unit (T) reaches 20 and 30. Therefore, given that the panel-data set in Bailliu and Fujii (2004) has T = 25, the standard fixed-effects model would yield biased estimates. In order to deal with this issue, the authors use Arellano and Bond's dynamic panel-data GMM estimator, which is also useful because it can give unbiased estimations when one or more of the explanatory variables are assumed to be endogenous rather than exogenous.

[5] It is constructed from the real effective exchange rate deflated by unit labour costs subtracting the nominal effective exchange rate and adding the domestic unit labour costs.

[6] All the variables are taken in logs, as in Goldberg and Knetter (1997).

[7] The NEER (or, equivalently, the "Trade-weighted currency index") is indeed calculated by Eurostat as a trade weighted geometric average of the bilateral exchange rates against the currencies of competing countries. For comparison purposes, I also analyse the model using NEER as exchange rate.

where $s$ is the bilateral nominal exchange rate (which is in our case measured instead in units of dollars per one euro[8]), *fulc* is the foreign unit labor cost built as in Bailliu and Fujii (2004), *gdpgap* is the output gap relative to the potential value. At the end we added as control variable the Openness Index ($X$) or/and a dummy for each of the first three years of EMU. We introduce this dummy variable to control for first three years of EMU, in which probably the firms changed their price lists to euro-nominated ones.

In order to analyze the asymmetries between our two study groups and testing for the polarization, we used three dummies: one named EMU which takes value 1 if the country in period t has an irrevocable fixed exchange rate with euro and zero otherwise (6) and other two which divide the sample in core and periphery countries, whose dummy is named GIIPS in equation (7).

$$p_{i,t} = \alpha_i + \theta_t + \gamma_1 p_{i,t-1} + \gamma_2 p_{i,t-2} + \beta s_{i,t-1} + \xi \left(s_{i,t-1} * EMU\right) + \tau\, fulc_{i,t} + \eta\, gdpgap_{i,t} + \psi\, X_{i,t} + \varepsilon_{i,t} \tag{6}$$

$$p_{i,t} = \alpha_i + \theta_t + \gamma_1 p_{i,t-1} + \gamma_2 p_{i,t-2} + \beta s_{i,t-1} + \lambda \left(s_{i,t-1} * CORE\right) + \kappa \left(s_{i,t-1} * GIIPS\right) + \tau\, fulc_{i,t} + \eta\, gdpgap_{i,t} + \psi\, X_{i,t} + \varepsilon_{i,t} \tag{7}$$

we estimate this equation for whole EMU members (with composition changing over time) and then allowing for diversification in core and periphery groups. I test for homogeneity across core and periphery in ERPT by the comparison of coefficient λ and κ. If the sum of the coefficients is significantly different from zero (using a T-test), we will conclude that the ERPT is asymmetrical between core and periphery and the euro-dollar exchange rate influence in a different manner the two groups. If only one of the coefficient of the two groups is significant or they have opposite sign respect the other one, we will claim that there is still a polarization within the euro zone coming from the cycle of euro-US dollar exchange rate.
In the empirical analysis, the data covers the period from 2001 to 2011 (11 years) with quarterly frequency from 17 euro area countries, namely Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia and Spain. We define as core countries: Austria, Finland, France, Germany, Luxembourg and the Netherlands. Concerning the periphery, we include 5 countries: Greece, Ireland, Italy, Portugal and Spain.

[8] In Bailliu and Fujii (2004) the exchange rate is defined in terms of local currency units per unit of the (composite) foreign currency. I decide to specify the rate as units of dollars per one euro, because of the data I used. Therefore, this variable will take on a negative (positive) value in the case of depreciation (appreciation).

**Diagnostics and estimation strategy**

In a panel regression model with lagged endogenous variables, the fixed effects estimator (FE) has been proved to be inconsistent for finite T (Nickell (1981)) but the bias in dynamic FE estimator with T large enough is almost negligible (Roodman (2006)). Standing to this formulation however, we may have a problem of endogeneity between dependent variable and its lag and also among explanatory variables such as between exchange rate and output gap[9] (equation (6) and (7)).

Therefore, we will estimate the model with IV-GMM methodologies, as for instance in Jimborean (2011)[10]. The most used IV-GMM estimators are: the one built by Arellano and Bond (1991) which transforms all regressors by differencing them and the system IV-GMM designed by Arellano and Bover (1995) and fully developed by Blundell and Bond (1998). The latest one making use of instrument with respect to the equations in levels as well as those in differences, giving rise to a system GMM estimator.

We report only the Arellano-Bover/Blundell-Bond estimator, being aware that the system GMM usually increases efficiency. Following Jimborean (2011) and Baum (2006), I also apply here the so called Windmeijer (2005) finite-sample correction, which the standard errors in two-step estimation tend to be significantly downward biased without because of the large number of instruments involved. In order to avoid the bias that arises when the number of instruments is relatively too high in small samples, we collapse the instruments as suggested by Roodman (2009). Hence, in our model we apply instruments to the dependent variable, the exchange rate and output gap. The foreign unit labor cost is considered to be exogenous.

Note that the moment conditions of the GMM estimators are only valid if there is no serial correlation in the idiosyncratic errors. In addition, GMM methodologies work only if slope coefficients are invariant across the individuals. Instead, in case of cross-sectional dependence, there are variable and/or residual correlations across panel entities, normally due to common shocks (e.g. recession, crisis. . .) or spillover effects. Cross-sectional dependence (CSD) and heterogeneity in the slopes can lead to bias in tests results (contemporaneous correlation), not precise estimates and identification problems.

In the literature a dynamic model with lagged dependent variable and heterogeneity in the slopes can be estimated with a Swamy method, by using random coefficients, or Mean Group-type estimators.

Using the test developed by Pesaran (2004) we found that the hypothesis of cross-sectional independence in our dynamic panel is strongly rejected. This does not allow me to use IV-GMM methods.

Following Sarafidis and Wansbeek (2010), there are two methods to deal with cross-sectional dependent panel data: spatial models and factor structure models. In spatial econometrics you know in which way the entities are correlated and you model that. A simple case is to model the neighborhood. In the dynamic factor models (called also interactive models or common factor models) exist an unobserved common

[9] See Honohan and Lane (2004), page 4.

[10] As reported by Jimborean (2011), the Kiviet estimator is suggested for estimating panel data models with small N and large T. It is in an efficient approximation of the bias of the Least Square Dummy Variable (LSDV) estimator for dynamic panel data models but, its main drawback is the fact the endogeneity of the explanatory variables is not resolved.

component in the disturbance, for instance risk factors, which affect in a different way the entities and vary over time.

In order to go beyond to the limitations of the previous models, in Pesaran and Tosetti (2011) the authors proposed 3 different estimators for the model: the CCE (Common Correlated Effects) estimator[11], the CCEP, which is its pooled version and the CCEMG that stands for CCE Mean Group. The first one does not concern itself with cross-sectional dependence and it models these unobservable factors with a simple linear trend. The second estimator is the pooled version of CCE one and it is recommended in case of homogeneity in the technology parameters or in the observed individual effects (Teal and Eberhardt (2010)). The last one seems to be more effective to deal with cross-sectional dependences, both if the source is spatial spillovers or unobserved common factors, and in case of heterogeneity in slopes. The CCEMG estimator[12] allows for the empirical setup with cross sectional dependence, time-variant unobservable factors with heterogeneous impact across panel members and fixes problems of identification. These various estimators are designed for micro panel models with "large-T, small-N" (Roodman, 2009). In our case we had 17 countries and 11 years with quarterly frequency (T=44), therefore we considered that this command was able to fix the problems of our panel setting.

Following Pesaran and Tosetti (2011), a general specification of the factor model can be written as follows[13]:

$$y_{i,t} = \alpha_i' \boldsymbol{d}_t + \beta_i' \boldsymbol{x}_{i,t} + \gamma_i' \boldsymbol{f}_t + e_{i,t} \tag{8}$$

Where $\boldsymbol{d}_t = (d_{1t}, \dots, d_{nt})$ is the vector of observed common effects, $\boldsymbol{x}_{i,t}$ is the vector of observed individual effects and $\boldsymbol{f}_t$ is a vector of m unobserved common factors, which affect all the individuals at different times and at different degrees allowing for heterogeneity in the slope represented by the vector $\gamma_i = (\gamma_{i1}, \dots, \gamma_{im})'$.

Following the approach by Eberhardt et al. (2011), the cross-sectional average is $\bar{y}_{.t} = \bar{\beta}_i' \bar{\boldsymbol{x}}_{.t} + \bar{\gamma}_i' \boldsymbol{f}_t + \bar{\alpha}' \boldsymbol{d}_t$ given $\bar{e}_t \rightarrow 0$ as N $\rightarrow \infty$. Therefore, our unobservable factors are as below:

$$\leftrightarrow \boldsymbol{f}_t = \bar{\gamma}_i'^{-1} (\bar{y}_{.t} - \bar{\alpha}' \boldsymbol{d}_t - \bar{\beta}_i' \bar{\boldsymbol{x}}_{.t}) \tag{9}$$

Now, we substitute $\boldsymbol{f}_t$ into equation (8), which yields:

$$y_{i,t} = \alpha_i' \boldsymbol{d}_t + \beta_i' \boldsymbol{x}_{i,t} + \gamma_i' \bar{\gamma}_i'^{-1} (\bar{y}_{.t} - \bar{\alpha}' \boldsymbol{d}_t - \bar{\beta}_i' \bar{\boldsymbol{x}}_{.t}) + e_{i,t} \tag{10}$$

[11] A deep description of the CCE estimator is in Pesaran (2006).
[12] This approach has been recently used to estimate panel in the literature on private returns of research and development investment by Eberhardt et al. (2011) and in the house pricing debate by Holly et al.(2010).
[13] The main hypothesis of the model is that the number of factors cannot be more than the number of individuals.

$$\leftrightarrow \quad y_{i,t} = \alpha_i' \boldsymbol{d}_t + \beta_i' \boldsymbol{x}_{i,t} + \psi_{1i} \bar{y}_{.t} + \psi_{2i} \bar{\boldsymbol{x}}_{.t} + \psi_{3i} \boldsymbol{d}_t + e_{i,t} \tag{11}$$

According to the specification in equation (8), we re-build our equations (6) and (7) in order to replicate this factor model. The observed common effects across the units are the EURUSD exchange rates (when into the EMU). The idiosyncratic effects are the foreign ULC, the output gap and the Openness Index with respect to extra-EMU trade.

In the results the unobserved common factors are proxied by the cross-section averages of the dependent variable $\bar{y}_{.t}$ and of the regressors $\bar{\boldsymbol{x}}_{.t}$ (equation (11)).

In Pesaran and Tosetti (2011) the CCEMG is built starting from the MG estimator explained in Pesaran and Smith (1995):

$$\hat{\beta}_{MG} = N^{-1} \sum_{i=1}^{N} \hat{\beta}_i' \tag{12}$$

where $\hat{\beta}_i' = (\boldsymbol{X}_{i.}' \boldsymbol{M}_D \boldsymbol{X}_{i.})^{-1} \boldsymbol{X}_{i.}' \boldsymbol{M}_D \boldsymbol{y}_{i.}$ with $\boldsymbol{y}_{i.} = (y_{i1}, \dots, y_{iT})'$ ; $\boldsymbol{X}_{i.}' = (\boldsymbol{x}_{i1}, \dots, \boldsymbol{x}_{iT})$ ; $\boldsymbol{M}_D = \boldsymbol{I}_T - \boldsymbol{D}\,(\boldsymbol{D}'\boldsymbol{D})^{-1}\,\boldsymbol{D}'$ and $\boldsymbol{D}' = (\boldsymbol{d}_1, \dots, \boldsymbol{d}_T)$ .

Afterwards the observed regressors are augmented with the cross-section averages of the dependent variable $\bar{y}_{.t} = N^{-1} \sum_{i=1}^{N} y_{i,t}$ and of the regressors $\bar{x}_{.t} = N^{-1} \sum_{i=1}^{N} x_{i,t}$.

Therefore the CCEMG is:

$$\hat{\beta}_{CCEMG} = N^{-1} \sum_{i=1}^{N} \hat{\beta}_{CCE} \tag{13}$$

where $\hat{\beta}_{CCE} = (\boldsymbol{X}_{i.}' \,\bar{\boldsymbol{M}}\, \boldsymbol{X}_{i.})^{-1} \boldsymbol{X}_{i.}' \,\bar{\boldsymbol{M}}\, \boldsymbol{y}_{i.}$

## 4. RESULTS

The results for a sample of 17 euro area reporting countries during 2001-2011 estimated by Blundell- Bond system IV-GMM estimator are reported in Table 2. Column 2 reports the regression when we control for the EMU membership, without dividing the sample. The ERPT coefficient for the EMU and for both groups is positive and significant, which means that in case of an appreciation of the euro towards the dollar the inflation should increase in euro zone as a whole. In Column 3, we report the estimates of the standard model as in Bailliu and Fujii (2004) dividing the analysis in core and periphery. In Column 4 to 6 we add the controls for the first 3 years of EMU and the Openness Index. Table 3 reports the results using the NEER towards 41 trading partners[14] instead of the exchange rate *vis-à-vis* the US dollar. In this case the coefficients are never significant.

[TABLE 2 AROUND HERE]

These results suggest that the exchange rate *vis-à-vis* the US dollar is still important for EMU countries and an appreciation of the euro could give normally an increase in inflation. The asymmetry between the 2 groups of study, core and periphery, is however not significant. Instead using NEER as exchange rate, the ERPT to inflation is never significant and therefore NEER does not influence the inflation performance. At the end for the specification with EURUSD, the coefficient for foreign unit labor costs is always significant and positive across all the specifications and the dummy variables for the first three years of the EMU are negative and significant.

[TABLE 3 AROUND HERE]

After the IV-GMM estimations, we also test the hypothesis of cross-sectional independence in panel data by implementing the parametric testing procedure proposed by Pesaran (2004)[15]. In our panel data we reject the null of cross-sectional independence and therefore we decide to use the factor model reported in the previous section, dealing for heterogeneity in the slopes and cross-sectional dependence. The results are shown in Table 4 for EURUSD and Table 5 for NEER.

[TABLE 4 AROUND HERE]
[TABLE 5 AROUND HERE]

[14] The 41 partners are: EU27, 9 industrialized countries (Australia, Canada, US, Japan, Norway, New Zealand, Mexico, Switzerland and Turkey) and 5 emerging countries (Russia, China, Brazil, South Korea and Hong Kong).
[15] The test is robust to single or multiple breaks in the slope coefficients and/or error variances, it has the correct size in very small samples and quite robust to the presence of unit roots and structural breaks.

Estimating with CCEMG the ERPT coefficient is significant (if we do not control for the first three years of EMU) and negative only for the core group, while for the periphery is not significant and positive. The difference between the ERPT coefficients of core and periphery is always significantly different from zero. An appreciation of the euro towards the dollars brings a decreasing in inflation for the core, helping these countries in gaining competitiveness, and has not influence on the periphery. Among the common observed factors, only the output gap is significant when we control for Openness Index and the first three year of EMU.

The key role in CCEMG estimation is played by unobservable factors, which are common across the individuals and can be represent global issues or spillovers effects. Chudik et al. (2011) demonstrate indeed by simulation that the CCE approaches are robust to the presence of both a limited number of strong factors, such as a global crisis, global changes in technology and in general global or multi-countries events, and an infinite number of weak factors, which can represent spillovers effects among individuals[16]. In our analysis we find that other unobservable factors (here as the cross-section average of the dependent variable and its lags) play indeed a relevant role in explaining inflation performances and they get the better of other observed common or idiosyncratic factors. This result may show the impact on EMU countries of the global crisis started in 2008 together with the spillover effect of the EU integration process and of the European crisis after 2010 as well. This relevant role of spillovers can be viewed also as the process behind the convergence path of inflation and exchange rate pass-through for the euro area economies[17].

My results imply that the effect of EURUSD in influencing inflation in the euro area is still present only as an asymmetrical driver if we compare core and periphery. The reaction of HICP inflation in changing in NEER is not significantly different from zero if we split the sample while the NEER is an important driver in case of the euro zone as a whole. This conclusion is in line with the recent literature on ERPT (Jimborean, 2011) and it is robust using different econometric methodologies. Therefore, concerning our hypothesis of a new polarization induced by change in EURUSD rate, if we estimate our model with IV-GMM, the reaction in the inflation HICP rate is not asymmetric between core and periphery. Instead, by applying the framework by Pesaran and Tosetti (2011), which suits our model better allowing for cross-sectional dependence, the asymmetry between the groups is relevant because the change in EURUSD rate only influences core countries in a relevant way. Note that this significance disappears only if we control for the first three years of EMU, in which we can suppose that all the firms and institutions changed their price lists in order to adjust them to the new currency. The results are instead robust controlling for openness towards the rest of the world.

[16] This has been stressed also by Eberhardt et al.(2011) and Holly et al. (2010).

[17] For an analysis of ERPT convergence in the euro zone, see Saiki (2011).

## 5. CONCLUSION

The degree of exchange rate pass-through is of key importance for the conduct of monetary policy and a central element in the measurement of price competitiveness and therefore in understanding current account imbalances. As reported by Bussière (2007) quoting Mann (1986), for instance the lack of response of the US trade balance deficit to the depreciation of the dollar that took place in the mid-1980s has been partly due to low pass-through.

Having a high degree of heterogeneity in pass-through within the euro area, and above all between core and periphery, may bring other issues in defining a common monetary policy but also in deciding structural reforms to deal with current and trade imbalances.

My aim was checking if, among the different sources of heterogeneous macro performance, the exchange rate *vis-à-vis* the US dollar still matters and if it affects a group of countries more than another within the euro zone, creating a sort of "new polarization" among the euro zone members comparable to the one before the introduction of the euro.

Using a dynamic panel data framework based on an Exchange Rate Pass-Through (ERPT) model, we estimate the ERPT elasticities of the 2 groups by system IV-GMM and the Common Correlated Effects Mean Group (CCEMG) estimator, testing for the asymmetry between core and periphery. Using the CCEMG estimator, which is in our opinion the most correct type for our framework, we find such an asymmetry. Only in these cases, we conclude that the coefficients for core and periphery are different to each other and there is an asymmetrical effect of euro-US dollar rate on inflation in the two groups of study. Here the coefficient for core is significant and negative, while periphery's coefficient is both not significant and positive. Hence, we can claim that there is still a polarization within the euro zone coming from the cycle of euro-US dollar exchange rate. An appreciation of the euro towards the dollars brings a relevant decreasing in inflation for the core, helping these countries in gaining competitiveness. Instead by applying the nominal effective exchange rate (so a trade-weighted measure of nominal bilateral rates) as a regressor, this is a significant driver for the whole euro zone only, while is not significant if we divide the sample in core and periphery.

Based on these results, we can conclude that the euro-US dollar is an important factor, but is not the only key factor, in determining the asymmetry in inflation between core and periphery. The nominal effective exchange rate is a very important driver for the inflation in the whole euro zone. Therefore, the EMU seems to not have insulate enough some member countries from shocks coming from outside, as in the case of nominal exchange rate shocks and the NEER seems to be an important factor to drive the HICP inflation index down.

## 6. REFERENCES


Angeloni I. and Ehrmann M. (2004), “Euro Area inflation differentials”, Working Paper Series, No. 388, September 2004, ECB.

Arellano M., Bond S. (1991), “Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations”, *The Review of Economic Studies*, 58 pp.277-297.

Bailliu J. and Fujii E. (2004), "Exchange Rate Pass-Through and the Inflation Environment in Industrialized Countries:An Empirical Investigation", Bank of Canada Working Paper 2004-21, June 2004.

Baum K. (2006), "An introduction to modern econometrics using Stata ", Stata Press.

Bénassy-Quéré A., Mojon B. (1998), "EMU and Transatlantic Exchange Rate Stability", CEPII Working Paper, No 1998 — 02, March.

Bergsten C.F. (1998), “Weak Dollar, strong Euro? The international impact of EMU”, Centre for European Reform (CER), London.

Blundell R., Bond S. (1998), “Initial conditions and moment restrictions in dynamic panel-data models”. *Journal of Econometrics* 87: 115—143.

Brender A., Gagna E., Pisani F. (2009), “Can we understand the recent moves of euro-dollar exchange rate?”, Voxeu.org

Brown B. (1979), “The Dollar/Mark Axis”, London, MacMillan.

Buiter W.H., Corsetti G. and Pesenti P.A. (1998), “Financial markets and European monetary cooperation. The lessons of the 1992-93 Exchange Rate Mechanism Crisis”, Cambridge University Press, 1998

Bussière M. (2007), “Exchange Rate Pass-Through to Trade Prices: The Role of Nonlinearities and Asymmetries”. Working paper no. 822., European Central Bank.

Chen R., Milesi-Ferretti G.M., Tressel T. (2012), “External Imbalances in the Euro Area”, *Economic Policy*, forthcoming.

Chudik, A., Pesaran, H. and & Tosetti, E. (2011), ‘Weak and strong cross-section dependence and estimation of large panels’, *Econometrics Journal*, 14, 45-90.

Corsetti G., Pesenti P.A. (1999), “Stability, Asymmetry, and Discontinuity: The Launch of European Monetary Union”, *Brookings Papers on Economic Activity*, Vol. 1999, No. 2 (1999), pp. 295-372.

Darvas Z. (2001), “Exchange rate pass-through and real exchange rate in EU candidate countries”, Discussion paper 10/01, Economic Research Centre of the Deutsche Bundesbank, May 2001.

De Grauwe P.(2009), "Crisis in the Eurozone and how to Deal with It", CEPS Policy Brief No. 204.

De Haan, J., Eijffinger, S. C. W., Waller, S. (2005), “The European Central Bank Credibility, transparency, and centralization”, Cambridge: MIT Press 2005.

De Haan J. (2010), “Chapter 2. Inflation Differentials in the Euro Area: A Survey” in J. de Haan and H. Berger (eds.), The European Central Bank at Ten, Springer-Verlag Berlin Heidelberg 2010.

Delatte A-L., López-Villavicencio A. (2010), “Asymmetric responses of prices to exchange rate variations. Evidence from the G7 countries”. Working paper.

Devereux, M. and C. Engel (2002), “Exchange Rate Pass-through, Exchange Rate Volatility and Exchange Rate Disconnect”, *Journal of Monetary Economics*, 49, 2002, pp. 913-940.

Eberhardt, M., Helmers, C., and Strauss, H. (2010), "Do spillovers matter when estimating private returns to R&D?". *The Review of Economics and Statistics*, (0).

Eichengreen B. J. (2011), “Exorbitant Privilege. The rise and fall of the Dollar”, Oxford University Press.

Eichengreen B. J. andWyplosz C. (1993), “The Unstable EMS”, *Brookings Papers on Economic Activity*, Vol. 1993, No. 1 (1993), pp. 51-143.

Galati G. (2001), “The Dollar-Mark Axis”, *Weltwirtschaftliches Archiv*, Bd. 137, H. 1 (2001), pp. 36-57.

Giavazzi F. and Giovannini A. (1986), “The EMS and the Dollar”, *Economic Policy*, Vol.1, No.2 (Apr.,1986), pp.455-485.

Giavazzi, F., and Giovannini A. (1989), “Limiting Exchange Rate Flexibility”, Cambridge: MIT Press.

Giavazzi F. and Giovannini A. (1989),“Limiting exchange rate flexibility. The European Monetary System”, Cambridge: MIT Press, chapter 6 “The Dollar- Deutsche Mark Polarization”, pp. 131-159.

Goldberg, P.K. and Knetter M. (1997), “Goods Prices and Exchange Rates: What Have We Learned?” *Journal of Economic Literature* 35: 1243—72.

Haldane A.G. and Hall S.G. (1991), “Sterling’s relationship with the Dollar and the Deutschemark: 1976-89”, *The Economic Journal*, 101, may 1991, 436-443.

Holly S., Pesaran, M. H., Yamagata T. (2010), "A spatio-temporal model of house prices in the USA," *Journal of Econometrics*, Elsevier, vol. 158(1), pages 160-173, September.

Honohan P. and Lane P.H. (2003), “Divergent Inflation Rates in EMU”, *Economic Policy* October 2003.

Honohan P. and Lane P.H. (2004), “Exchange Rates and Inflation under EMU: An Update”, IIIS Discussion Paper, No.31/July 2004.

Im, K., Pesaran, H., Shin, Y., (2003), "Testing for unit roots in heterogenous panels ", *Journal of Econometrics*, vol. 115.

Jimborean R. (2011), "The Exchange Rate Pass-Through in the New EU Member States ", Banque de France, Working Paper n◦341

Knetter M., (1989), "Price Discrimination by U.S. and German Exporters", *American Economic Review*, American Economic Association, vol. 79(1), pages 198-210, March.

Krugman P., (1987), "Pricing to market when the exchange rate changes", NBER Working Paper No. 1926.

Mann C., (1986), “Prices, Profit Margins and Exchange Rates”, Federal Reserve Bulletin, 72, June, pp.366-379.

Marston, R., (1990), “Pricing to Market in Japanese Manufacturing”, *Journal of International Economics*, 29, pp. 217-236.

McCarthy, J. (1999). "Pass-through of Exchange Rates and Import Prices to Domestic Inflation in Some Industrialised Economies." BIS Working Paper no. 79

McCauley R.N. (1997), “The Euro and the Dollar”, *Essays in international finance*, No.205, November 1997. Department of Economics, Princeton University, New Jersey.

Mundell R. A. (1961). "A Theory of Optimum Currency Areas", *American Economic Review* 51 (4): 657—665.

Neri S. and Nobili A. (2010), “The Transmission of US Monetary Policy to the Euro Area”, *International Finance* 13:1, 2010: pp. 55—78.

Nickell S., (1981), "Biases in Dynamic Models with Fixed Effects," *Econometrica*, 49, 1981, 1417-1426.

Organization for Economic Cooperation and Development (1999), “EMU: Facts, Challenges and Policies”, OECD Paris.

Pesaran M.H., Smith R.P. (1995), “Estimating long-run relationships from dynamic heterogeneous panels”, *Journal of Econometrics* 68(1): 79—113.

Pesaran M.H. (2004), “General diagnostic test for cross-sectional dependence in Panel”, Cambridge Working Papers in Economics 0435, Faculty of Economics, University of Cambridge.

Pesaran M. H. (2006), “Estimation and inference in large heterogeneous panels with a multifactor error structure”, *Econometrica* 74(4): 967—1012.

Pesaran, M. H. (2007), "A simple panel unit root test in the presence of cross-section dependence", *J. Appl. Econ.*, 22: 265—312. doi: 10.1002/jae.951

Pesaran M. H., Yamagata T. (2008), “Testing Slope Homogeneity in Large Panels”, *Journal of Econometrics* , vol. 142(1), pages 50-93, January.

Pesaran M.H., Tosetti E. (2011), “Large panels with common factors and spatial correlation”, *Journal of Econometrics* 161 (2011) 182—202.

Rogers J.H. (2002), “Monetary union, price level convergence, and inflation: How close is Europe to the United States?”, Board of Governors of the Federal Reserve System. International Finance Discussion Papers Number 740, October 2002

Roodman D. (2006), “How to do xtabond2: an introduction to “Difference” and “System” GMM in Stata. Center for Global Development Working Paper N.103.

Roodman D., (2009), "A Note on the Theme of Too Many Instruments ", *Oxford Bulletin of Economics and Statistics*, Department of Economics, Vol. 71(1), pp.135-158.

Saiki A. (2011), "Exchange Rate Pass-Through and Monetary Integration in the Euro Area", De Nederlandsche Bank Working Paper No. 308, August 2011

Sarafidis V.,Wansbeek T. (2010), "Cross-sectional Dependence in Panel Data Analysis," MPRA Paper 20367, University Library of Munich, Germany.

Taylor C. (2002), "Sterling Volatility and European Monetary Union, NIESR Discussion Papers 197, National Institute of Economic and Social Research.

Taylor J. B. (2000), “Low Inflation, Pass-through and the Pricing Power of Firms”, *European Economic Review*, 44, pp. 1389-1408.

Teal F. and Eberhardt M. (2010), "Aggregation versus Heterogeneity in Cross-Country Growth Empirics", Economics Series Working Papers CSAE WPS/2010-32, University of Oxford, Department of Economics.

Welfens P.J.J. (2001), "European Monetary Union and Exchange Rate Dynamics. New approaches and Application to the Euro", Springer, 2001.

Williamson J. (2004), "The Dollar/Euro exchange rate", *Économie international*, 100 (2004), p. 51-60.

Windmeijer F. (2005), "A finite sample correction for the variance of linear efficient two-step GMM estimators ", *Journal of Econometrics* 126: 25-51.

## 7. APPENDIX

### Data descriptions

In Equation (5), the dependent variable is the Harmonized Index of Consumer Price (HICP), which we have obtained from IMF International Financial Statistics (IFS). Regarding the explanatory variables, the exchange rates are obtained from IMF IFS (national currencies versus USD) and Eurostat (for euro versus USD). They correspond to the nominal bilateral exchange rate of the euro/EMU/national currency, *vis-à-vis* the US dollar, with an increase (decrease) indicating a appreciation (depreciation) towards the US dollar. The Nominal Effective Exchange Rate is trade weighted for 41 partners and taken from Eurostat. The output gap is calculated by Hodrick-Prescott (HP) filtering real GDP data from IMF IFS. We also create an Openness Index as in Rogers (2002), using data from IMF Direction of Trade Statistics (DOTS). The foreign unit labor cost is built following Bailliu and Fujii (2004) as the Real Effective Exchange Rate (REER) deflated by Unit Labor Costs (ULC) subtracting the NEER and adding the domestic unit labor costs. The data for REER with ULC as deflator and NEER are obtained from Eurostat and at the end, the domestic ULC data are from OECD.

| Variable | Description | Source |
|---|---|---|
| HICP | Harmonized Index of Consumer Prices (2005=100) - all items | IMF, IFS |
| EURUSD | Bilateral exchange rate<br>- units of United States dollars per 1 national currency | IMF, IFS - Eurostat |
| FULC | Unit Labor Cost (2005=100) for the rest of the world<br>fulc = (reer - neer + domestic ulc) | Eurostat - OECD |
| GDPGAP | HP detrended real GDP | IMF, IFS |
| NEER | Nominal Effective Exchange Rate weighted for 41 competitors | Eurostat |
| Openness Index | Openness Index with extra-EMU countries (Rogers, 2002)<br>OI = [Trade with World - Intra EMU trade] / GDP | IMF, DOTS |
| Dummies | | |
| EMU | Dummy = 1 if the country is a EMU member | ECB website |
| CORE | Dummy = 1 if AAA/AA+ rating by Fitch or Moody's:<br>Germany, France, Netherlands, Austria, Finland, Luxembourg | The Guardian,<br>July 2012 |
| GIIPS | Dummy =1 if periphery: Greece, Italy, Ireland, Portugal, Spain | Consensus |

Countries: Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Spain (17)
Time: 2001Q1 - 2011Q4

**Table 1: Currency links with the Mark and the Dollar, 1994-1997**

| Currency | Elasticity | R2 |
|---|---|---|
| Swiss franc | 1.10 | 0.88 |
| Austrian schilling | 1.00 | 1.00 |
| Dutch guilder | 0.99 | 1.00 |
| Belgian franc | 0.98 | 0.99 |
| Danish krone | 0.91 | 0.97 |
| French franc | 0.88 | 0.92 |
| Escudo | 0.86 | 0.92 |
| Markka | 0.80 | 0.74 |
| Peseta | 0.79 | 0.80 |
| Irish pound | 0.58 | 0.57 |
| Swedish krona | 0.57 | 0.39 |
| Lira | 0.53 | 0.37 |
| Pound sterling | 0.43 | 0.37 |
| Canadian dollar | -0.11 | 0.05 |
| Australian dollar | -0.11 | 0.02 |

Note: the first column reports elasticities obtained from regressions of (the difference of the logarithm of) the dollar exchange rate of a currency on a constant and (the difference of the logarithm of) the dollar/mark exchange rate. They are estimated with daily data (taken at 2:15PM) over the period January 1994-December 1997. Adjusted R2s for the regressions are reported in the second column. Over the same sample period, the yen had elasticity with respect to dollar/mark rate changes of 0.69 and an R2 of 0.38. Source: Galati (2001).

**Table 2: system IV-GMM estimations using EURUSD as exchange rate**

| VARIABLES | (1)<br>HICP | (2)<br>HICP | (3)<br>HICP | (4)<br>HICP | (5)<br>HICP | (6)<br>HICP |
|---|---|---|---|---|---|---|
| HICP (t-1) | 0.703** | 0.673 | 0.444 | 0.510 | 0.763 | 0.359 |
| | (0.337) | (0.651) | (0.602) | (0.596) | (0.643) | (0.779) |
| HICP (t-2) | 0.272 | -0.753 | -0.187 | -0.253 | -0.848 | -0.185 |
| | (0.476) | (0.849) | (0.668) | (0.700) | (0.959) | (0.960) |
| **EURUSD (t-1)** | **0.0916** | | | | | |
| | **(0.00374)** | | | | | |
| **EURUSD (t-1) * EMU** | | **0.146*** ** | | | | |
| | | **(0.0403)** | | | | |
| **EURUSD (t-1) * CORE** | | | **0.108** ** | **0.117*** ** | **0.153* ** | **0.129** ** |
| | | | **(0.0485)** | **(0.0451)** | **(0.0895)** | **(0.0511)** |
| **EURUSD (t-1) * GIIPS** | | | **0.109* ** | **0.109** ** | **0.106* ** | **0.123* ** |
| | | | **(0.0565)** | **(0.0491)** | **(0.0619)** | **(0.0717)** |
| ULC | 0.0162 | 0.340*** | 0.236** | 0.216** | 0.325** | 0.225** |
| | (0.0735) | (0.116) | (0.108) | (0.0855) | (0.138) | (0.0997) |
| GDPGAP | -0.00972 | 0.00269 | -0.0103 | -0.00303 | -0.00276 | -0.00511 |
| | (0.00817) | (0.00920) | (0.0164) | (0.0155) | (0.0222) | (0.0211) |
| Openness Index | | | | | 0.0689 | 0.0203 |
| | | | | | (0.0493) | (0.0874) |
| year = 2002 | | | | -0.0361** | | -0.0360** |
| | | | | (0.0172) | | (0.0180) |
| year = 2003 | | | | -0.0403** | | -0.0444** |
| | | | | (0.0162) | | (0.0198) |
| year = 2004 | | | | -0.0281** | | -0.0330 |
| | | | | (0.0123) | | (0.0246) |
| Constant | 0.00807 | 3.406*** | 2.292** | 2.418** | 3.443** | 2.739** |
| | (0.816) | (1.134) | (1.026) | (1.103) | (1.558) | (1.196) |
| Methodology | sy IV-GMM | sy IV-GMM | sy IV-GMM | sy IV-GMM | sy IV-GMM | sy IV-GMM |
| AR (1) | 0.200 | 0.119 | 0.132 | 0.010 | 0.050 | 0.164 |
| AR (2) | 0.323 | 0.812 | 0.749 | 0.546 | 0.401 | 0.614 |
| Hansen test | 0.381 | 0.657 | 0.94 | 0.743 | 0.870 | 0.600 |
| Sargan test | 0.000 | 0.092 | 0.196 | 0.005 | 0.276 | 0.004 |

Note: Two-step System GMM with Windmeijer (2005) finite-sample correction. Standard errors in parentheses. ***, **, and * denotes statistical significance at the 1,5, and 10 level, respectively.

**Table 3: system IV-GMM estimations using NEER as exchange rate**

| VARIABLES | (1)<br>HICP | (2)<br>HICP | (3)<br>HICP |
|---|---|---|---|
| HICP (t-1) | 0.812*** | 0.842*** | 0.989*** |
| | (0.160) | (0.142) | (0.142) |
| HICP (t-2) | -0.137 | 0.0835 | -0.0919 |
| | (0.300) | (0.389) | (0.163) |
| NEER (t-1) | **0.182** | | |
| | **(0.176)** | | |
| NEER (t-1) * EMU | | **-0.00615** | |
| | | **(0.0191)** | |
| NEER (t-1) * CORE | | | **0.00157** |
| | | | **(0.00303)** |
| NEER (t-1) * GIIPS | | | **0.00184** |
| | | | **(0.00261)** |
| ULC | 0.0877 | 0.0809 | 0.0436 |
| | (0.0761) | (0.0759) | (0.0595) |
| GDPGAP | -0.00654 | -0.000714 | -0.000255 |
| | (0.0111) | (0.0128) | (0.00654) |
| Constant | 0.236 | -0.00171 | 0.272 |
| | (0.457) | (0.989) | (0.433) |
| Methodology | sy IV-GMM | sy IV-GMM | sy IV-GMM |
| AR (1) | 0.136 | 0.000 | 0.027 |
| AR (2) | 0.369 | 0.999 | 0.288 |
| Hansen test | 0.557 | 0.308 | 0.353 |
| Sargan test | 0.027 | 0.000 | 0.000 |

Note: Two-step System GMM with Windmeijer (2005) finite-sample correction. Standard errors in parentheses. ***, **, and * denotes statistical significance at the 1,5, and 10 level, respectively.

**Table 4: CCEMG estimations using EURUSD as exchange rate**

| VARIABLES | (1) HICP | (2) HICP | (3) HICP | (4) HICP | (5) HICP | (6) HICP |
|---|---|---|---|---|---|---|
| HICP (t-1) | 0.518*** | 0.298* | 0.647*** | 0.746*** | 0.127 | 0.0662 |
| | (0.130) | (0.170) | (0.151) | (0.164) | (0.390) | (0.391) |
| HICP (t-2) | 0.503* | 0.724** | 0.239* | 0.140 | 0.343** | 0.378** |
| | (0.263) | (0.329) | (0.126) | (0.112) | (0.173) | (0.173) |
| **EURUSD (t-1)** | **0.00406** | | | | | |
| | **(0.0156)** | | | | | |
| **EURUSD (t-1) * EMU** | | **0.00749** | | | | |
| | | **(0.0229)** | | | | |
| **EURUSD (t-1) * CORE** | | | **-0.0145**** | **-0.0163** | **-0.0318**** | **-0.0104** |
| | | | **(0.00692)** | **(0.0108)** | **(0.0151)** | **(0.0237)** |
| **EURUSD (t-1) * GIIPS** | | | **0.00583** | **0.00334** | **0.00796** | **0.00913** |
| | | | **(0.0133)** | **(0.0107)** | **(0.0152)** | **(0.0161)** |
| ULC | 0.0230 | -0.0385 | 0.0451 | 0.0420 | 0.102 | 0.106 |
| | (0.0220) | (0.0585) | (0.0402) | (0.0420) | (0.117) | (0.119) |
| GDPGAP | -0.000635 | -0.000286 | -0.000864 | -0.000194 | -0.00219** | -0.00233* |
| | (0.000682) | (0.000624) | (0.000923) | (0.000993) | (0.00111) | (0.00136) |
| Openness Index | | | | | -0.0632 | -0.0607 |
| | | | | | (0.0547) | (0.0610) |
| year = 2002 | | | | 0.00181 | | -0.000430 |
| | | | | (0.00142) | | (0.00204) |
| year = 2003 | | | | -0.000228 | | -0.000583 |
| | | | | (0.000722) | | (0.00162) |
| year = 2004 | | | | -0.000809 | | -0.00131 |
| | | | | (0.00143) | | (0.00219) |
| Constant | 0.184 | -0.145 | 0.0204 | -0.0662 | 0.0606 | 0.0895 |
| | (0.164) | (0.257) | (0.136) | (0.140) | (0.443) | (0.500) |
| Methodology | CCEMG | CCEMG | CCEMG | CCEMG | CCEMG | CCEMG |

Note: Common Correlated Effects Mean Group (CCEMG) estimator. Standard errors in parentheses. ***, **, and * denotes statistical significance at the 1,5, and 10 level, respectively. We do not report the estimations for unobserved factors, among which only averages of HICP and its lags are strongly significant and positive.

**Table 5: CCEMG estimations using NEER as exchange rate**

| VARIABLES | (1)<br>HICP | (2)<br>HICP | (3)<br>HICP |
|---|---|---|---|
| HICP (t-1) | 0.642*** | 0.749*** | 0.825*** |
| | (0.131) | (0.126) | (0.173) |
| HICP (t-2) | 0.161 | -0.166 | -0.0766 |
| | (0.143) | (0.293) | (0.268) |
| **NEER (t-1)** | **0.0258** | | |
| | **(0.0710)** | | |
| **NEER (t-1) * EMU** | | **-0.0895*** | |
| | | **(0.0313)** | |
| **NEER (t-1) * CORE** | | | **-0.0426** |
| | | | **(0.0390)** |
| **NEER (t-1) * GIIPS** | | | **-0.0162** |
| | | | **(0.0149)** |
| ULC | -0.0397* | 0.0274 | 0.00883 |
| | (0.0230) | (0.0480) | (0.0243) |
| GDPGAP | -0.000376 | -0.000388 | -0.000183 |
| | (0.000696) | (0.00100) | (0.00143) |
| Constant | 0.136 | 0.277 | -0.0199 |
| | (0.125) | (0.209) | (0.211) |
| Methodology | CCEMG | CCEMG | CCEMG |

Note: Common Correlated Effects Mean Group (CCEMG) estimator. Standard errors in parentheses. ***, **, and * denotes statistical significance at the 1,5, and 10 level, respectively. We do not report the estimations for unobserved factors, among which only averages of HICP and its lags are strongly significant and positive.