DEPARTMENT OF ECONOMICS

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Eurozone Inflation Differentials and the ECB

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Abstract

This paper presents new evidence on inflation differentials in the Euro Area from different perspectives, and extending the sample including the recent financial crisis. First, we give an informal analysis of the evolution of inflation dispersion and inflation differentials since the start of EMU. Second, we perform formal statistical analyses of the stability properties of inflation differentials in the period 1999-2010. Univariate and multivariate tests reject the null of stability of inflation differentials when conducted over the entire sample period. However, when the financial crisis is excluded, the null of stability is not rejected for the large majority of countries. This finding implies the beginning of a new tendency since the global financial turmoil, and new challenges for the common monetary policy. Finally, we analyze the determinants of inflation differentials, empirically testing a number of theories including price level equalization, productivity differentials, differences in cyclical positions, labor and product market rigidities. We conclude that inflation differentials are not the result of equilibrating, transitory forces, but rather of persistent structural and country-specific factors. This calls for structural reforms in labor and product markets, and countercyclical fiscal policy measures at the individual country level. As inflation differentials pose a serious challenge for the monetary policy of the ECB, we further believe that the ECB should be equipped with additional policy instruments to cope with them in a more direct way.

JEL codes: E52, E58

Keywords: European Monetary Union, inflation differentials, ECB

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1. Introduction

Inflation differentials have existed since the start of the monetary union: while they were at their minimum when the common currency was introduced, they increased in the first years of EMU, and decreased somewhat in the middle of the decade, until the global financial crisis hit. The recent economic downturn, coupled with structural diversities among the Euro Area countries and heterogeneous domestic policy responses led inflation differentials to increase. This suggests that inflation differentials are not likely to disappear or decline in the near future: on the contrary, they could be increasing. Whether these recent developments are transitory or reflect deeper structural differences is still an open question. Nevertheless they constitute a matter of concern for the conduct of the common monetary policy.

The reduction of inflation differentials is not an immediate objective of the ECB. The first objective of the ECB is that of maintaining price stability (defined as lower but close to 2% over the medium term) in the Euro Area as a whole. In order to do so, the policy rate is set to match the needs of the whole currency area, considering the overall developments in inflation and output. Inflation differentials are of secondary importance, and only in as far as they hamper the realization of the primary objective. In that respect, according to the ECB, the definition of the inflation objective as "lower but close to 2%" is flexible enough to account for some degree of limited inflation dispersion. Moreover, the uniqueness of the monetary policy instrument does not allow for multiple targets.

Inflation differentials in currency areas are a subject of interest for policymakers and academics. In the words of the ECB, inflation differentials are not only unavoidable, but even desirable, when they are the result of equilibrating adjustment processes[3]. Nevertheless, they might pose serious challenges to monetary policymaking when they are driven by persistent factors, such as structural rigidities. For example, in the case of a country exhibiting, say, a persistently negative (positive) inflation differential with the Euro Area, a monetary policy concerned with stabilizing the average inflation of the whole currency area could potentially contribute to accentuate the difference and be deflationary (inflationary) in the low-inflation (high inflation) country. Therefore, identifying the factors driving inflation divergences across the Eurozone and distinguishing between equilibrating and non-equilibrating factors is of utmost importance in order to determine the most adequate ECB policy response.

Many theories have been put forward to explain inflation differentials, and they relate mainly to three factors: transitory factors, associated with the convergence process; permanent factors,

[3] ECB (2005), p.61

related to the specific underlying economic structures in national labor and product markets; and finally, heterogeneous national policies or different reactions to common policies. [4]

In this paper we focus on the dynamic properties of inflation differentials and on explaining their determinants. In particular, we first examine the evolution of inflation dispersion and inflation differentials since the start of the monetary union. Secondly, we investigate the stability properties of inflation differentials performing univariate and multivariate stability tests. While previous studies analyzed pairwise inflation differentials using regional disaggregated data (Beck and Weber (2005)) or country-level data (Busetti et al. (2007)), we focus on country inflation differentials with the Euro Area average, a quantity of interest for the common monetary policy. Moreover, extending the sample to 2011, we are able to investigate the effect of the recent financial crisis on the stability of inflation differentials. Finally, we explore the determinants if Eurozone inflation differentials, testing a number of theories put forward by the existing literature: catching-up effects, Balassa-Samuelson effects, differences in cyclical positions, structural causes (wage and price formation processes). Our model includes a more comprehensive set of variables, and adds to previous studies of inflation divergence in the EMU (Canzoneri et al. (2002), Honohan and Lane (2003), Stavrev (2008) and Marzinotto (s.d.). In the last section, we draw some policy conclusions based on the presented analysis.

2. Dynamic properties of Euro Area inflation differentials

2.1 Simple measures of inflation dispersion

This section presents an informal analysis of the evolution of inflation dispersion and inflation differentials since the start of the EMU. Figures 1 and 2 depict the evolution of inflation and inflation dispersion across the Euro area in the period 1990-2010[5]. Inflation is measured by the percentage change from the previous year of the harmonized consumer price index, the indicator of price stability used by the ECB. Twelve countries members of the Euro Area are considered.[6] We show the simple average, the median and the Euro area inflation rate (i.e. weighted average). As measures of cross-sectional dispersion, we consider the range, the un-weighted standard deviation and the un-weighted mean absolute deviation.

[4] Cfr. ECB (2003 and 2005) for a survey.

[5] Although in the rest of the paper we will use Eurostat data on HCPI (available since 1996), here we use OECD data in order to extend the sample to the pre-EMU period, and have a broader view of the evolution of inflation and inflation dispersion.

[6] Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain. The Euro Area average is a weighted average of the aforementioned countries.

It is readily seen that, judged by whatever measure, the run up to the monetary union was accompanied by a continuous drastic fall in inflation dispersion, which reached a minimum in 1999, coinciding with the start of the monetary union.

Figure 1 *– Inflation in the Euro Area*

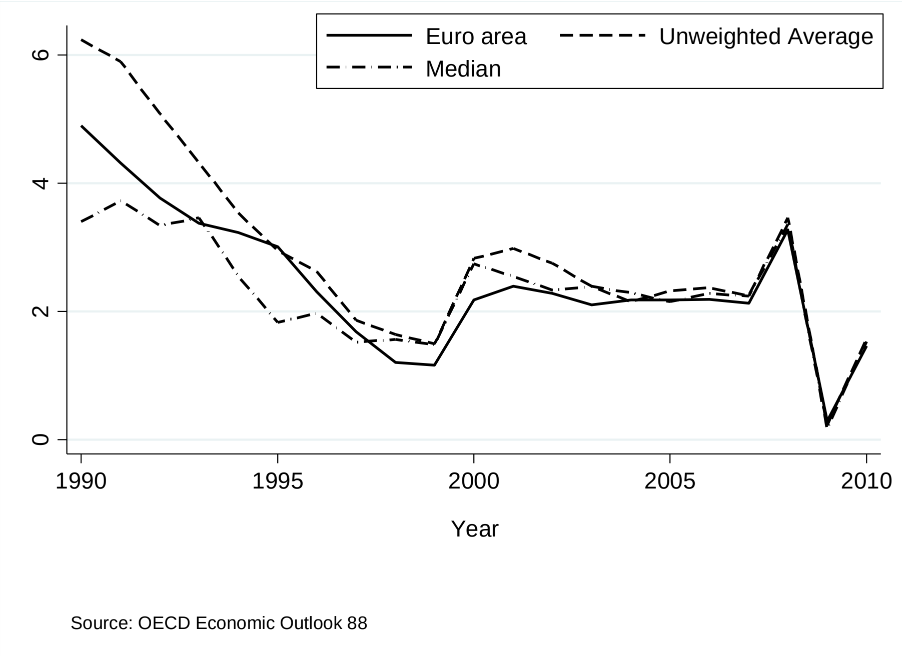
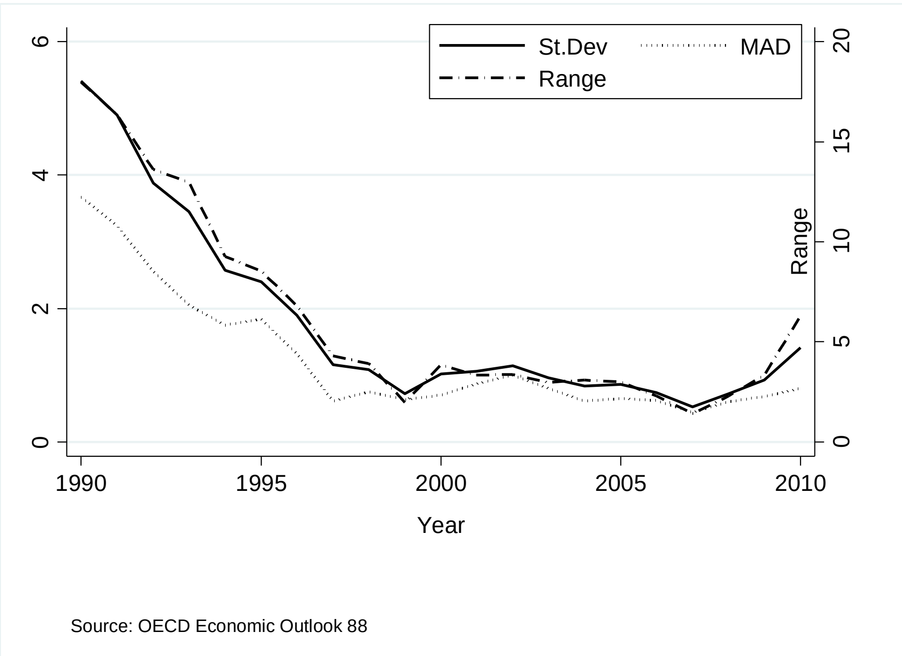


Figure 2 *– Inflation dispersion in the Euro Area*

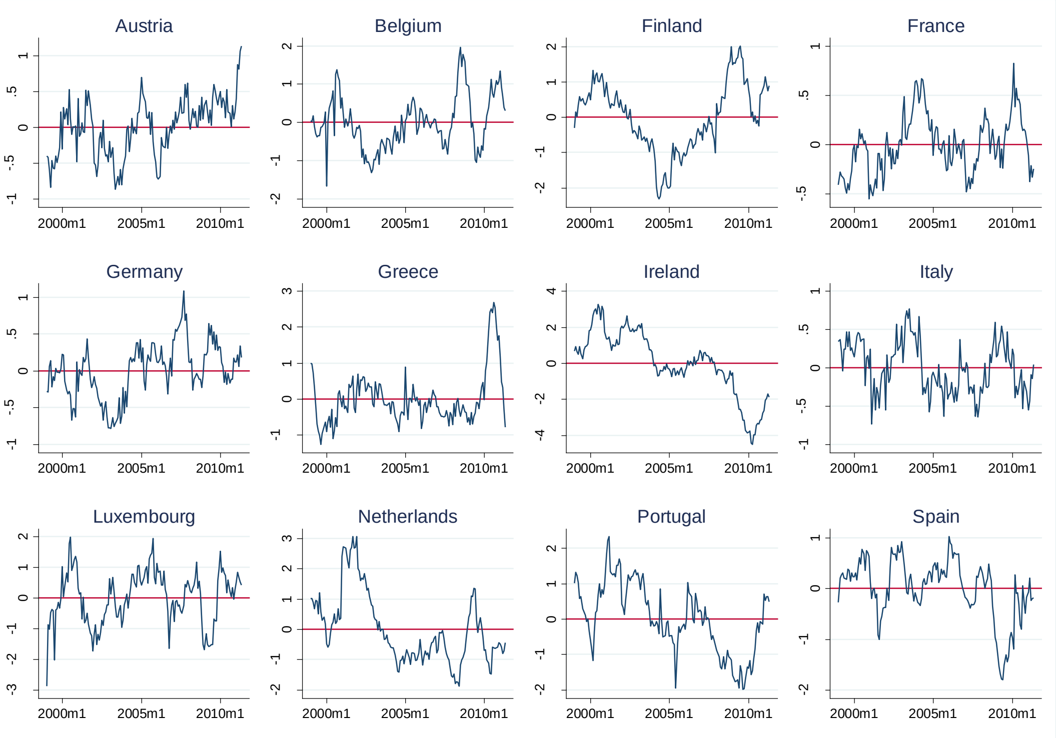


After the start of the monetary union, inflation dispersion across the Euro area, however, increased for a number of successive years. From 2003 onwards inflation dispersion went down again, reaching an absolute minimum in 2007. The years 2008 (with high average inflation), 2009 (with average inflation very close to zero) and 2010 were again characterized by increasing dispersion, which, judged by range and standard deviation, reached its peak since the start of the monetary union. Overall, the figure reveals that although inflation dispersion has declined appreciably since the beginning of the 1990s and under EMU, with a temporary upsurge shortly after the common currency was adopted, it increased markedly in the last three years. Whether the recent financial crisis marked the beginning of a new trend is unclear.

In the rest of the paper, we focus our attention on differentials in the EMU period only. In particular, we analyze the stability properties of inflation differentials vis-à-vis the Euro Area average. Each country's inflation differential is defined as:

$$\Delta\pi_{i,t} = \pi_{i,t} - \pi_{EA,t} \tag{1}$$

***Figure 3**: Inflation differentials in the Euro Area*



Source: Eurostat

Figure 3 shows the evolution of inflation differentials in the Euro-12 countries, at a monthly frequency. Inflation is measured as the yearly percentage change of the all-categories HCPI index. Two main characteristics of inflation differentials emerge from figure 3. First, inflation differentials exhibit very heterogeneous patterns across countries. While some countries (Finland, Ireland, Portugal and the Netherlands) present long periods of positive or negative inflation differentials, in others (Austria and Greece) inflation differentials are shorter-lived. In particular, in the context of the conduct of the common monetary policy, a persistently positive (negative) inflation differential with the Euro Area average suggests that the monetary policy stance is too loose (strict) for that country. Secondly, it is difficult to detect patterns of co-movements of inflation differentials across countries.

2.2 Testing the stability of inflation differentials

The formal assessment of convergence in Euro Area inflation rates has been the subject of a large amount of empirical studies, relying on time series and panel data techniques. The concept of dynamic convergence is mainly used in the context of economic growth, applied to GDP series (Baumol (1986), Barro and Sala-i-Martin (1991, 1992)). In the empirical growth literature, convergence is said to be present if time series of different countries exhibit mean reverting behavior. Specifically, absolute convergence implies that the different cross-sections are converging towards the same, long-term value, while conditional convergence implies that each country is converging towards its own steady state, which is not necessarily the same for all countries in the panel. In statistical terms, convergence between two or more series is said to be present whenever differences between countries tend to disappear over time, i.e. whenever long term forecasts of the difference between two countries tend to zero. This definition has being naturally associated with the familiar time series analysis concept of stationarity: in this context, univariate and multivariate unit root tests have been performed in order to assess the stability of inflation differentials. Rejection of the null hypothesis of non-stationarity has been gauged as evidence of convergence, while its non-rejection implies that differences across countries tend to accentuate over time.

As noted by Busetti et al (2007), the time series literature on convergence often does not clearly distinguish between the role of tests for unit roots and tests for stationarity in order to assess convergence. The main difference between the two lies in the specification of the null hypothesis: while unit-root tests test the null hypothesis of non-stationarity (implying that a series is stationary upon rejection of the null), in stationarity tests the null hypothesis is that of stationarity, and a rejection implies non-stationarity of the concerned series. The authors clarify that the two tests serve two different purposes: while unit root tests are helpful in assessing whether a set of variables is *in the process of converging*, stationarity tests are the appropriate tool for detecting whether two or more series *have already converged*, i.e. the difference between them is stable.

Convergence of European inflation rates *before* the introduction of the common currency has been established by numerous empirical studies, relying on time series and panel data techniques. In an early contribution, Kocenda and Papell (1997) assess the presence of inflation convergence by means of panel unit-root tests. Evidence of inflation convergence is found to be particularly strong in countries participating in the Exchange Rate Mechanism from the beginning. Siklos and Wohar (1997), Holmes (1998) and Amián and Zumaquero (2002) explore the issue of inflation convergence by means of cointegration techniques. In particular, they test for the presence of common trends in European inflation rates, which are regarded as evidence of convergence. Beck and Weber (2005) examine beta and sigma convergence using data on European regional inflation rates from 1991 to 2004. In particular, they complement their univariate results on beta convergence with the Levin and Li (1992) panel unit-root test. While they are able to reject the null hypothesis of non-stationarity, they find that convergence happens at a very limited speed. More recently, Busetti et al. (2007) analyze convergence and stability of European inflation rates in both the pre-EMU and the EMU period. They find that while convergence in European inflation rates had taken place by the start of the EMU, there is evidence of divergence after the introduction of the common currency. In particular, between 1998 and 2004, European countries can be classified into two "stability clubs": the first, comprising Germany, France, Belgium, Austria, and Finland, is characterized by low inflation; the second, composed of the Netherlands, Spain, Greece, Portugal, and Ireland constitutes the high-inflation group.

2.3 Univariate stability tests

In what follows we investigate the stability of inflation differentials in the Euro Area in the period 2000-2011. In other words, we test whether European inflation differentials have converged in the EMU period. We use Eurostat data on the Harmonized Consumer Price Index (HCPI) at a monthly frequency to construct monthly inflation differentials, which we adjust for seasonality.[7]

First, we perform a univariate stability test as developed by Kwiatkowski et al. (1992), commonly known as KPSS test. The null hypothesis of the KPSS test is of stability (stationarity) of inflation differentials: a rejection of the null hypothesis implies that there is evidence of non-stationarity of the tested series. As our interest lies in testing whether inflation differentials have converged around a zero mean, we perform the test on inflation differentials without demeaning or detrending the series (cfr. Busetti et al. (2007)). The test is based on the following test statistic:

$$\varepsilon = \frac{\sum_{t=1}^{T}\left(\sum_{j=1}^{t} \Delta_j\right)^2}{T^2 \hat{\sigma}_{LR}^2} \tag{2}$$

[7] Seasonality has been removed by subtracting from each series the seasonal component. The latter is estimated regressing each country's inflation differential on 12 (monthly) dummy variables.

Where Δ_j is the relevant inflation differential vis-à-vis the Euro Area, T is the sample size and $\hat{\sigma}_{LR}^2$ is a non-parametric estimator of the long-run variance of Δ_t. If the test statistic is greater than the critical values at the chosen confidence level[8], the null hypothesis is rejected, thereby leading to the conclusion that convergence has not taken place. The results of the test on the single inflation differentials over the entire sample period are reported in Table 1.

Table 1: KPSS stationarity test of inflation differentials, 2000m1 to 2011m2

Series	*Lags*								
	0	1	2	3	4	5	6	7	8
Austria	0.323	0.384*	0.414*	0.453*	0.482**	0.510**	0.510**	0.512**	0.511**
Belgium	0.184	0.245	0.293	0.311	0.324	0.383	0.313	0.308	0.313
France	0.068	0.066	0.078	0.095	0.116	0.125	0.113	0.109	0.112
Finland	0.616**	0.559**	0.527**	0.528**	0.527**	0.513**	0.484**	0.455*	0.438*
Germany	0.467*	0.639**	0.696**	0.719**	0.773**	0.761*	0.736**	0.694**	0.683**
Greece	0.028	0.042	0.051	0.057	0.062	0.083	0.071	0.076	0.081
Ireland	2.2**	2.02**	1.76**	1.55**	1.42**	1.29**	1.16**	1.05**	0.964**
Italy	0.020	0.028	0.035	0.042	0.055	0.069	0.059	0.058	0.059
Luxembourg	0.080	0.083	0.089	0.094	0.106	0.111	0.105	0.109	0.115
Netherlands	0.567**	0.523**	0.526**	0.510**	0.511**	0.494**	0.458**	0.434**	0.412**
Portugal	0.365*	0.358*	0.416*	0.459*	0.524**	0.578**	0.527**	0.490**	0.473**
Spain	0.23	0.232	0.257	0.304	0.366*	0.409*	0.367*	0.347*	0.338*

Null Hypothesis: Stationarity of inflation differential
Critical Values of KPSS statistic: 10%: 0.347 5%: 0.463 1%: 0.739
* Reject the null at 10% ** Reject the null at 5%

Table 1 reports the test statistic for values of the lag truncation parameter from 0 to 8[9]. While lags do not appear explicitly in the test statistic, they enter the computation of the estimated long run variance. As Kwiatkowski et al. (1992) point out[10] the choice of 8 lags is a good compromise between the size distortions that would prevail under the null for 4 lags and the power loss that would occur for a number of lags, say, equal to 12.

Table 1 does not provide clear-cut evidence of convergence in Euro Area inflation differentials. In particular, the null hypothesis of stationarity is rejected in 6 countries out of 12. For Austria, Finland, Germany, Ireland, the Netherlands and Portugal we do not find evidence that convergence has occurred. Given the stylized facts described in section 2.1, which detected an increase in inflation dispersion in the most recent years, we split the sample and conduct the stationarity test excluding the recent financial crisis. The results from this exercise are reported in Table 2.

[8] Details on the distribution of the test statistic under the null hypothesis can be found in Busetti et al. (2006). Critical values at different confidence levels have been tabulated by Nyblom (1989).
[9] The lag truncation parameter is used in the estimation of the long-run variance. In particular, it amounts to the number of autocovariances used in the estimation of the variance.
[10] Kwiatkowski et al. (1992) pp. 174-175

When the financial crisis is excluded, the null hypothesis of stationarity is rejected only in 3 countries out of 12 (Finland, Ireland and the Netherlands), thereby implying that, before the global financial turmoil, convergence had taken place. Given that the sample of data from the beginning of the crisis to the present day is rather short, we cannot detect whether the financial crisis constituted a structural break for inflation convergence, or whether the instability of inflation differentials is a temporary phenomenon.

Table 2: KPSS stationarity test of inflation differentials, 2000m1 to 2006m12

Series	*Lags*								
	0	1	2	3	4	5	6	7	8
Austria	0.031	0.038	0.042	0.045	0.049	0.057	0.061	0.062	0.061
Belgium	0.040	0.047	0.062	0.071	0.096	0.128	0.097	0.092	0.102
France	0.110	0.110	0.132	0.164	0.191	0.201	0.186	0.186	0.193
Finland	0.453*	0.406*	0.397*	0.401*	0.409*	0.412*	0.407*	0.402*	0.396*
Germany	0.159	0.239	0.289	0.288	0.318	0.314	0.323	0.32	0.321
Greece	0.010	0.017	0.025	0.028	0.035	0.059	0.049	0.058	0.069
Ireland	0.701**	0.715**	0.693**	0.663**	0.666**	0.623*	0.589**	0.555**	0.533**
Italy	0.024	0.036	0.049	0.054	0.070	0.077	0.070	0.075	0.077
Luxembourg	0.052	0.061	0.073	0.080	0.098	0.104	0.090	0.912	0.093
Netherlands	0.591**	0.561**	0.576**	0.574**	0.592**	0.572**	0.521**	0.480**	0.445*
Portugal	0.168	0.167	0.196	0.228	0.269	0.310	0.311	0.308	0.032
Spain	0.043	0.040	0.041	0.052	0.068	0.080	0.071	0.065	0.063

Null Hypothesis: Stationarity of inflation differential
Critical Values of KPSS statistic: 10%: 0.347 5%: 0.463 1%: 0.739
* Reject the null at 10% ** Reject the null at 5%

2.4- Multivariate stability tests

In order to exploit at best the information contained in our dataset, we complement the univariate stability tests with a panel counterpart, proposed by Hadri (2000). Testing for stationarity in a panel framework increases the power of the test[11] as the number of cross-sections grows, leading the distributions of the test statistics to (asymptotically) approach normality. The logic of Hadri's test is as follows. Consider the following representation of a variable y_{it}:

$$y_{it} = r_{it} + \varepsilon_{it} \tag{3}$$

Where ε_{it} is a stationary process ($iid\ N(0, \sigma_\varepsilon^2)$) and $r_{it} = r_{it-1} + u_{it}$ is a random walk, with $u_{it} \sim iid\ N(0, \sigma_u^2)$. As the null hypothesis is stationarity of y_{it}, it amounts to test whether the variance of u_{it} is equal to zero. If this is the case, given an initial value r_{i0}, we can substitute backwards and obtain (denoting $e_{it} = \sum_{j=0}^{t} u_{ij} + \varepsilon_{it}$):

[11] The power of a statistical test is the probability that the test rejects the null hypothesis when it is actually false. As power increases, the probability of type II errors (i.e. not rejecting the null when it is false) decreases.

$$y_{it} = r_{i0} + \sum_{j=0}^{t} u_{ij} + \varepsilon_{it} \quad (4)$$

$$y_{it} = r_{i0} + e_{it} \quad (5)$$

Since the ε_{it} are assumed independently and identically distributed, under the null hypothesis y_{it} is stationary around a mean, because if $\sigma_u^2 = 0$, r_{it} reduces to a constant.[12] The test is then a Lagrange Multiplier test on the restriction imposed under the null hypothesis, and it is based on the partial sum of the residuals $\hat{e}_{it}$ of the regression of y_{it} on an intercept. The LM test statistic is the following:

$$LM = \frac{\frac{1}{N}\sum_{i}^{N}\frac{1}{T^2}\sum_{t=1}^{T} S_{it}^2}{\hat{\sigma}_e^2} \quad (6)$$

Where $S_{it} = \sum_{j=1}^{t} \hat{e}_{it}$.

We apply Hadri's test on our panel of 12 inflation differentials from 1999 to 2001. The results of the tests are reported in Table 3, in the left column.

Table 3: Hadri (2001) Panel Stationarity Test

	1999m1 – 2011m2		*1999m1-2006m12*	
Specification	*Test statistic*	*P-value*	*Test statistic*	*P-value*
Homoskedasticity	4.655	0.0000	-0.394	0.6532
Heteroskedasticity	5.116	0.0000	0.279	0.3902
Observations:	N=12 T=146		N=12 T=96	

The table reports two test specifications. The first assumes homoskedastic error terms, while the second one allows for heteroskedasticity. The results of the Hadri test largely mirror the univariate ones. When the test is performed over the full sample, stationarity is rejected. It is important to notice, though, that the null hypothesis is that of stationarity of all the series in the panel. Therefore, the null is rejected if at least one of the series in the panel is non-stationary. When the financial crisis is removed from the sample, the null hypothesis of stationarity is not rejected at all conventional significance levels. Hence, the conclusions drawn for the univariate analysis apply here. While the analysis inflation differentials considering the entire post-EMU sample rejects the null hypothesis of stationarity, the results for the sample excluding the financial crisis point towards an overall stability of inflation differentials.

Our results complement the findings of Busetti et al. (2007). These authors study, using a similar methodology, the stability of pairwise inflation differentials in the Euro 12 countries from 1998 to 2004. While they find that inflation differentials are stable across groups of countries (in particular, stability is found within Austria, Germany, Finland and France and within Spain, Portugal, Greece and Ireland) their conclusion is the absence of overall convergence of inflation differentials since the

[12] r_{i0} can be considered a fixed effect, i.e. a heterogeneous intercept.

adoption of the Euro. Our results show that when inflation differentials are computed vis-à-vis the Euro Area average (much more relevant for the ECB's policy) there is evidence of convergence in the period 2000-2006. Nevertheless, when the financial crisis is added to the sample, such stability breaks down. Assessing whether the financial crisis constituted a structural break for inflation convergence, or whether the instability of inflation differentials is a temporary phenomenon is an interesting subject for future research.

3. Theories of inflation differentials

What explains the evolution of inflation dispersion? The drastic fall of inflation dispersion in the 1990s has been explained by the EU member countries aiming to fulfill the inflation convergence criterion laid down by the Maastricht Treaty. It is the increased dispersion shortly after the introduction of EMU that attracted the attention of many researchers. Several explanations co-exist.

A first possible explanation is price *level* convergence. Countries with different price levels that start a monetary union may experience high inflation divergence as a result of a process of price equalization across the union. All by all, the law of one price states that prices of similar tradable goods, when expressed in a common currency, will be equalized internationally. In a monetary union, prices are expressed in the same currency, which makes price comparison across borders even easier. If price level equalization operates, countries with lower initial price levels will exhibit higher inflation rates, and hence higher inflation differentials, than countries with higher initial price levels. Price level equalization has been emphasized by the ECB as an explanation for inflation dispersion in a monetary union (ECB, 1999), and has been shown to be part of the explanation for increased inflation divergence after the start of the monetary union (see Rogers, 2002; Duarte, 2002; ECB, 2003; Honohan and Lane, 2003). The role of price level convergence has since then however declined (Stavrev, 2008).

A second possible explanation relates to differences in productivity levels and related catching-up processes of productivity growth. This argument refers to the Balassa-Samuelson mechanism. Countries starting with relatively low productivity levels and experiencing high productivity growth due to a catching-up process will in general also experience higher inflation. The reason for this lies in the wage formation mechanism. Productivity growth differences between countries can often be traced back to differences in labor productivity in the tradable goods sector (industry). In the non-tradable goods sector (mostly services), where productivity increases are much smaller, the difference between countries are only minor. If the shares of labor and capital in value added remain constant over time, wage increases in the tradable goods sector will equal the sum of productivity growth in this sector and the rate of change of output prices (the latter being the same in all countries in the union). If also in the non-tradable goods sector labor and capital manage to keep their shares in value added unchanged, price increases in the non-tradable goods sector will equal the rate of change of wages in this sector minus the rate of growth of productivity. Finally, wage increases in the high-productivity tradable goods sector often serve as a benchmark for wage increases in the low-productivity non-tradable goods sector. The upshot of all this is that countries with the highest productivity growth will also experience the highest inflation (due to higher inflation in the non-tradable goods sector). Evidence concerning the relevance of the Balassa-Samuelson mechanism as an explanation for inflation dispersion in the monetary union is mixed: while Canzoneri et al. (2002) assert its significance, Honohan and Lane (2003) do not.

Different cyclical positions constitute the third explanation for inflation divergence. According to Marzinotto (s.d.) this is the main reason, catching-up processes explaining only 40% of inflation dispersion in the few years after the start of EMU. Statistically significant correlations between inflation and output gaps have been found by European Central Bank (2003), Hohonan and Lane (2003) and Balazs (2007).

Honohan and Lane (2003) offer a fourth explanation for inflation differentials, focusing on the increased inflation dispersion in the EMU in the period 1999-2003. This period was for the largest part characterized by a weakening euro. They argue that different exposures of member countries to international trade with non-euro nations gave them a different sensitivity to the weakness of the euro on international currency markets. Countries that import much from non-euro nations were more affected by the euro weakness, since they suffered more from increasing import prices. This argument should work symmetrically and implies euro appreciation to be accompanied by convergence of inflation, a prediction that is consistent with the increased inflation convergence after 2003, when the euro appreciated considerably against the dollar. In our view Honohan and Lane's (2003) argument can be extended to include the different exposure of the EMU members to imported energy, basic food prices or raw materials.

Finally, structural factor, such as labor and product market rigidities may contribute to enhance inflation differentials (ECB, 2011). As Euro Area countries are subject to different degrees of rigidities, such differences can translate into different cost pressures and inflation rates.

Summing up, various explanations can be offered for the existence of inflation differential among the EMU members. These explanations relate to price level equalization and productivity, catching-up processes, differences in cyclical positions, different sensitivity to euro appreciation/depreciation or to international price increases and, finally, to differences in labor and product market rigidities. Price level equalization and catching-up processes are by nature temporary, but the other explanations refer to long-lasting mechanisms. If the latter dominate, inflation differentials will hardly be fully eliminated.

4. Econometric analysis of the determinants of inflation differentials

4.1 Model and variables

In this section we test empirically the previously described theories of inflation differentials. Our panel dataset includes yearly observations for the 12 Euro Area countries subject to our investigation, from 1999 to 2010. To this end, we estimate a dynamic panel data model, using the Arellano-Bond (1991) GMM panel estimator. The econometric model is specified as follows:

$$\Delta\pi_{it} = \gamma_1 \Delta\pi_{it-1} + \mathbf{x'}_{it}\boldsymbol{\beta} + u_{it} \tag{7}$$

Where the dependent variable $\Delta\pi_{it}$ is the inflation differential of country *i* with the Euro Area average, $\Delta\pi_{it-1}$ is the lagged dependent variable and $\mathbf{x}_{it}$ is the vector of independent variables. $u_i = \alpha_i + \varepsilon_{it}$ is a composite error term, composed of a country fixed effect, α_i, and an idiosyncratic shock ε_{it}. The vector $\mathbf{x}_{it}$ comprises the explanatory variables corresponding to the main theories of inflation dispersion, and additional control variables. Table 4 presents a detailed description of the variables included in the model and the data sources.

The price level equalization explanation put forward by the ECB (1999) is captured by the $\log\left(\frac{P_{i,t0}}{P_{EA,t0}}\right)$ term, which represents the log-difference between the price level in country *i* at the beginning of the sample to the average price level in the Euro Area at the beginning of the sample (1999). In this context, we expect countries with lower initial price levels to exhibit higher inflation differentials with the Euro Area, implying a negative coefficient.

The variable $(n_{MAN,t} - n_{SERV,t})$ represents the labor productivity growth differential between the tradable and the non-tradable sectors (proxied by the manufacturing and services sector respectively), and reflects the theory relating inflation to productivity differentials between sectors (Balassa-Samuelson effect). In particular, we expect this variable to have a positive coefficient.

Differences in cyclical positions are accounted for by the term $(\tilde{y}_{i,t} - \tilde{y}_{EA,t})$, representing the difference between a country's output gap[13] and the Euro Area output gap. A positive output gap corresponds to a situation of economic overheating, thereby implying a higher inflation rate (Phillips curve). If a country in the monetary union is in an over-expansionary phase while the Euro Area as a whole is in a negative phase of the business cycle, the inflation differential for the considered country will be positive.

[13] The output gap is defined as the deviation of realized output from potential output. A positive (negative) output gap implies a country is in the booming (bust) phase of the business cycle.

In order to explore the effects of currency movements and trade patterns on inflation differentials, we include the variable $TRADE_{i,t}$ obtained multiplying the share of a country's trade with non-eurozone countries by the euro/dollar nominal exchange rate (defined as the number of euro for 1 US dollar, so that an increase in the exchange rate implies a depreciation of the euro). Intuitively, when a country has strong trade ties with, say, the United States, a depreciation of the euro vis-à-vis the US dollar tends to increase domestic inflation, as the price of imports increase. Hence, we expect the estimated coefficient of this variable to be positive.

Structural factors in the form of labor and product market rigidities are accounted for by, respectively, variables $EPL_{i,t}$ and $PMR_{i,t}$. The Employment Protection Legislation (EPL) index compiled by the OECD measures rigidities in the labor market stemming from restrictions to employers to dismiss workers, and from the required compensation to employees in case of dismissal. It is available for a wide range of countries from 1985 to 2008. The index of Product Market Regulation (PMR, also compiled by the OECD), summarizes a comprehensive and internationally comparable set of indicators that measure the degree to which policies promote or inhibit competition in areas of the product market where competition is viable. The indicators cover formal regulations in the following areas: state control of business enterprises; legal and administrative barriers to entrepreneurship; barriers to international trade and investment. The PMR indicator is available in the OECD database for three distinct years: 1998, 2003 and 2008. In order to adapt the variable to the yearly frequency of our dataset and check for robustness of the transformation, we expanded the data points in two ways. First, we assumed that the PMR index is constant and equal to the last available entry in all years in which information is missing: that is, we assume that the index is constant and equal to its 1998 value from 1998 to 2002 and that it is constant and equal to its 2003 value from 2004 to 2007 (variable $PMR_{i,t}$). Secondly, we generate a yearly PMR index variable by means of linear interpolation ($PMR\_i_{i,t}$). In general, as noted by the ECB (2011), countries with more regulated labor and product markets experience higher inflation rates. Hence, the coefficient on these variables is expected to be positive.

In addition, we include two variables which we deem important in explaining inflation differentials. First, we account for differences in fiscal policy stance. While countries belonging to the Eurozone are subject to a common monetary authority, fiscal policy is in the hands of national governments, although criteria are established in terms of annual government deficit and debt. We expect that countries pursuing a more restrictive fiscal policy (e.g. higher taxes and/or lower government expenditure) exhibit a lower-than-average inflation rate, implying a negative estimated coefficient.

Table 4: *Explanatory variables*

Variable	*Expected Sign*	*Theory*	*Description*	*Source*
$\Delta\pi_{i,t}$	/	-	Dependent variable. Inflation differential of country *i* vs the Euro Area. Obtained by subtracting the Euro Area average inflation rate from country *i*'s inflation rate	Eurostat data on HCPI inflation
$\Delta\pi_{i,t-1}$	?	Persistence	Lagged inflation differential, measuring persistence and inflation inertia	Eurostat
$IMP\_PRICE_{i,t}$	+	Imported inflation	Yearly percentage change in the Import price index (goods and services, all trading partners). It measures imported inflation.	Eurostat
$\log\left(\frac{P_{i,t0}}{P_{EA,t0}}\right)$	-	Price level convergence	Logarithm of the price level ratio of country *I* and the Euro Area at the beginning of the sample (1999). It measures price level convergence.	Eurostat data on price levels
$GOVBAL_{i,t}$	-	Fiscal stance	Government balance as a percentage of GDP: negative if deficit, positive if surplus.	Eurostat
$GOV\_EXP_{i,t}$	+	Fiscal stance	Government expenditure as a percentage of GDP.	Eurostat
$GOV\_REV_{i,t}$	-	Fiscal stance	Government revenue as a percentage of GDP.	Eurostat
$PRIMBAL\_DIFF_{i,t}$	-	Fiscal stance	Difference between country *i*'s primary balance and the Euro Area average.	Eurostat data on primary balance
$(n_{MAN,t} - n_{SERV,t})$	+	Balassa-Samuelson	Difference in labor productivity growth in the manufacturing and services sector. Labor productivity growth has been constructed dividing the contribution to GDP of the manufacturing and services sector by the number of hours worked in each sector. The services sector includes real estate, financial intermediation, hotels, restaurants, wholesale and retail. It proxies the Balassa-Samuelson effect.	Eurostat data on contributions to GDP of manufacturing and services sector and hours worked.

Table 4 (continued): *Explanatory variables*

Variable	*Expected sign*	*Theory*	*Description*	*Source*
$(\tilde{y}_{i,t} - \tilde{y}_{EA,t})$	+	Differences in cyclical position	Difference in output gap between country *i* and the Euro Area. It measures differences in cyclical positions.	OECD Economic Outlook 88
$UNEMP_{i,t}$	-	Differences in cyclical position/demand effect	Unemployment rate. It is a further indicator of business cycle position.	Eurostat
$TRADE_{i,t}$	+	Trade exposure & currency movements	Interaction term obtained by multiplying the €/$ exchange rate by the share of extra-UE imports in total imports. It measures the effect of currency movement and trade patterns.	Eurostat data on bilateral exchange rate and share of extra-UE imports
$EPL_{i,t}$	+	Structural factors	Employment protection legislation index. It considers restrictions to employers to dismiss workers and the required compensation in case of dismissal. The index ranges on a scale from 0 (least stringent) to 6 (most restrictive). It measures labor market rigidities.	OECD Statistical Database
$PMR_{i,t}$	+	Structural factors	Index of Product Market Regulation. This index summarizes a comprehensive and internationally comparable set of indicators that measure the degree to which policies promote or inhibit competition in areas of the product market where competition is viable. This variable considers the PMR index to be constant and equal to the last available entry in all years in which information is missing	OECD Statistical Database
$PMR\_i_{i,t}$	+	Structural factors	Index of Product Market Regulation, constructed by linearly interpolating the data points.	OECD Statistical Database

In order to test for the effect of fiscal policy on inflation differentials, we include three variables: government balance as a percentage of GDP ($GOVBAL_{i,t}$), government revenue as a percentage of GDP ($GOV\_REV_{i,t}$) and government expenditure as a percentage of GDP ($GOV\_EXP_{i,t}$). Furthermore, we include the variable $PRIMBAL\_DIFF_{i,t}$ (defined as the difference between country i's primary balance and the Euro Area average) to measure the relative fiscal stance of country *i*. We expect a country exhibiting a positive government balance, a high government revenue (a proxy for high tax burden) or low expenditure to be characterized by a lower inflation differential with the Euro Area. In order to avoid multicollinearity issues, inclusion of these variables is mutually exclusive.

Second, we account for aggregate demand developments driving inflation differentials by means of the variable $UNEMPL_{i,t}$, i.e., the unemployment rate in country *i.* We expect countries characterized by higher unemployment to experience lower-than-average inflation rates as a result of lower demand.

We test the proposed theories of inflation differentials controlling for two additional factors. First, we control for persistence in inflation differentials, by means of the lagged inflation differential $\Delta\pi_{i,t-1}$. Secondly, we control for imported inflation by including the percentage change in the import price index as an explanatory variable ($IMP\_PRICE_{i,t}$).

5.2 Estimation methodology

As it is well known, estimating equation (7) with OLS, standard fixed and random effect estimators leads to inconsistent estimates as, by construction, π_{it-1} is correlated with the fixed effect, comprised in the error term. Dynamic panel data models are usually estimated using instrumental variable estimators on the first differenced model[14]:

$$\Delta(\Delta\pi_{it}) = \gamma_1\Delta(\Delta\pi_{it-1}) + \Delta\mathbf{x}'_{it}\boldsymbol{\beta} + \Delta\varepsilon_{it} \quad (8)$$

The instrumental variable approach is necessary because of the inconsistency of OLS estimators of the difference equation, caused by the correlation between $\Delta\pi_{it-1}$ and $\Delta\varepsilon_{it}$. Moreover, in contrast with the fixed effect and random effect transformations, the first difference transformation allows to find instruments not correlated with the error term. Arellano and Bond (1991) propose an instrumental variable (GMM) estimator, which uses past lags of the dependent variable as instruments for $\Delta\pi_{it-1}$.

The specified model includes simultaneously a lagged dependent variable and country fixed effects. This reduces the bias in the estimated coefficients resulting from omitted variables. Moreover, it amounts to adopting a rather conservative estimation approach, as it results in an increase in the

[14] For technical details on the estimation of dynamic panel models, see Baltagi (2005).

probability to incorrectly reject the null hypothesis that a variable is significant in explaining inflation differentials. In other words, we run the risk that fewer variables will turn out to be significant, rather than too many. Finally, including a lagged dependent variable considerably reduces residual autocorrelation. We estimate the econometric model using the Arellano-Bond estimator with robust standard errors. In this context, it is important define the nature of the explanatory variables. Specifically, it is important to distinguish between strictly exogenous and predetermined variables, as this will affect the estimation procedure through the available lags of the independent variables that can be used as instruments. A variable is strictly exogenous if an idiosyncratic shock ($\varepsilon_{i,t}$) at time t cannot have an effect on the regressor at time $s > t$. Otherwise stated, strictly exogenous variables are not correlated with past, contemporaneous or future error terms. In this case, we can include the whole vector of differences of observed regressors into the instrument matrix. On the other hand, a regressor is predetermined if feedback from an idiosyncratic shock at time t on the regressor at time $s > t$ is allowed. In our case, a regressor is predetermined if an unobserved shock in a country's inflation differential can affect the regressor at future points in time. In our model, we specify the variables related to fiscal policy ($GOVBAL_{i,t}$, $GOV\_EXP_{i,t}$, $GOV\_REV_{i,t}$) , unemployment ($UNEMPL_{i,t}$) and imported inflation ($IMP\_PRICE_{i,t}$) to be predetermined rather than strictly exogenous. In fact, it is reasonable to assume that, say, a positive shock in a country's inflation differential triggers a countercyclical fiscal policy (i.e. an increase in the government balance due to higher tax burden or lower expenditure) and a decrease in unemployment (as firms' revenue increases and real wages decrease). Furthermore, inflation differentials, i.e. our dependent variable, are defined as deviations from each country's inflation from the Euro Area average. As the data on import prices used to construct the variable $IMP\_PRICE_{i,t}$ comprise all trading partners, and given the importance of internal trade relationships, it is reasonabe to assume a degree of feedback between these two variables. Therefore, the second lag of these variables is used as an instrument in the estimation. Finally, in order to account for possible endogeneity of the contemporaneous value of the difference in output gap in the regression, we specify it as endogenous. In order to formally put our modeling choices to a test, we report the Sargan test for overidentifying restrictions (cfr. Table 6). This test provides indication as to whether the chosen instruments are valid, i.e. are uncorrelated with the error term. The null hypothesis is that the overidentifying restrictions are valid: hence, a non-rejection implies that the model is correctly specified.[15]

We proceed in our estimation as follows. First, we run separate regressions including one variable at a time, controlling for inflation persistence and imported inflation. In a second stage we derive a parsimonious model following a general-to-specific approach. We estimate each model specification

[15] The Sargan test rejects the null hypothesis when the variables $GOVBAL_{i,t}$, $UNEMPL_{i,t}$ and $IMP\_PRICE_{i,t}$ are considered strictly exogenous.

with the explanatory variable of interest introduced first contemporaneously and then lagged one period. For the sake of brevity, we only report the specification in which the estimated coefficient is statistically significant. In case neither the contemporaneous nor the lagged variable's coefficient is statistically significant, we report the coefficient of the contemporaneous variable.

The estimation of the model is performed using the command *xtdpd* in Stata10. This is motivated by the following. First, because it allows the error term to follow a moving average process of low order. The Arellano-Bond test for residual autocorrelation detects the presence of second order correlation in two model specifications (cfr. column 4 in Table 5 and column 9a in Table 5a) therefore we allow for it in the estimation procedure. Second, because it allows more flexibility in estimating the coefficients of time-invariant regressors[16] which are normally wiped away in the first difference model. Hence, we are able to obtain estimates of the coefficient of the variable $\log\left(\frac{P_{i,t0}}{P_{EA,t0}}\right)$.

Table 5 presents the results of our estimation. Each column in the table corresponds to a different estimated model; p-values obtained from robust standard errors are reported in parentheses. The bottom rows report the Sargan test of overidentifying restrictions and the Arellano-Bond test for residual autocorrelation. First of all, we can see that the lagged dependent variable is positive and statistically significant at the 1% level in all specifications, implying that inflation differentials in the Eurozone are persistent. In particular, the average estimated persistence across all estimated models is equal to 0.477, meaning that each year, a positive inflation differential of roughly 0.5 transmits to the next period. While our second control variable, import price change, measuring imported inflation is not significant in any specification, its coefficient is positive, consistently with prior expectations. Among the explanatory variables representing theories of inflation differentials, only two estimated coefficients carry an unexpected sign: the variable related to government balance and the variable related to the Balassa-Samuelson effect (i.e. differences in labor productivity growth in the tradables and non-tradables sectors). While the latter is not statistically significant at any conventional level, we find that an increasingly positive government balance (which is a proxy for restrictive fiscal policy) significantly increases inflation differentials, despite by a very small amount. When alternative variables are used to proxy fiscal policy, we obtain similar, counterintuitive results. Columns 2a, 2b and 2c of Table 5a present the regressions using alternative explanatory variables to proxy for fiscal policy. In particular, government expenditure as a percentage of GDP ($GOV\_EXP_{i,t}$), government revenue as a percentage of GDP ($GOV\_REV_{i,t}$) and the deviation of country *i*'s primary balance to the Euro Area average ($PRIMBAL\_DIFF_{i,t}$) are used respectively. In all specifications, the estimated coefficient's sign contradicts expectations.

[16] It corresponds to the Arellano and Bover (1995) System GMM estimator.

Table 5: *Estimation results: Arellano-Bond estimator with robust standard errors (p-values in parentheses)*

Dependent variable: $\Delta\pi_{i,t}$									
	Specification								
Independent Variable	1	2	3	4	5	6	7	8	9
Constant	0.0539 (0.558)	0.2367** (0.041)	0.0238 (0.789)	0.0823 (0.468)	0.1270 (0.189)	1.008** (0.025)	-.5537 (0.522)	-4.697** (0.021)	-.7213 (0.161)
$\Delta\pi_{i,t-1}$	0.5526*** (0.001)	0.4391*** (0.000)	0.4798*** (0.000)	0.4223*** (0.000)	0.548*** (0.000)	.4330*** (0.000)	.5037*** (0.001)	0.4077*** (0.000)	.5112*** (0.000)
$IMP\_PRICE_{i,t}$	2.270 (0.400)	1.286 (0.601)	2.682 (0.305)	1.795 (0.435)	2.285 (0.104)	2.597 (0.214)	1.849 (0.437)	0.0860 (0.976)	2.090 (0.437)
$GOVBAL_{i,t}$		0.0591** (0.016)							
$(\tilde{y}_{i,t-1} - \tilde{y}_{EA,t-1})$			0.2165*** (0.002)						
$(n_{MAN,t} - n_{SERV,t})$				-1.168 (0.256)					
$\log\left(\frac{P_{i,t0}}{P_{EA,t0}}\right)$					-2.538 (0.244)				
$UNEMP_{i,t}$						-.1260* (0.079)			
$TRADE_{i,t}$							.0205 (0.496)		
$EPL_{i,t}$								1.927** (0.018)	
$PMR_{i,t}$									.4568 (0.127)
Sargan OR test	93.992 (0.1721)	107.73 (0.1753)	89.062 (0.2782)	63.911 (0.276)	94.855 (0.3427)	102.475 (0.2820)	85.586 (0.099)	52.68 (0.6724)	92.3832 (0.2031)
AR test: 1st order	-2.25 (0.0244)	-2.284 (0.0224)	-2.416 (0.0157)	-1.871 (0.061)	-2.229 (0.0258)	-2.559 (0.0105)	-2.609 (0.009)	-1.979 (0.0478)	-2.479 (0.013)
2nd order	-1.215 (0.224)	-1.2963 (0.1949)	-1.327 (0.1845)	-2.2363 (0.0253)	-1.2652 (0.2058)	-1.204 (0.2286)	-1.833 (0.066)	-1.577 (0.1147)	-.988 (0.3230)

Note: *** Statistically significant at 1% level; ** Statistically significant at 5% level; *Statistically significant at 10% level.

Our results point towards the dominance of structural and cyclical factors over equilibrating and catching-up effects in explaining inflation differentials in the Eurozone. In particular, we find that booming periods (i.e. periods characterized by output gaps greater than the Euro Area average output gap) are associated with significantly higher inflation differentials. This result is in line with the findings of by European Central Bank (2003), Hohonan and Lane (2003) and Balazs (2007). Moreover, inflation differentials are significantly influenced by demand factors: an increase in the unemployment rate (with associated lower demand), results in significantly lower inflation differentials. Finally, as postulated by the ECB (2011) labor market rigidities significantly increase inflation differentials. As for product market rigidities, slightly different results emerge based on the construction of the PMR series.

In specification 9, the PMR index is assumed to be constant and equal to its previous value during the missing periods. Such specification results in a positive and non statistically significant coefficient. This could be due to the limited time variability of the index. In column 9a of Table 5a, we run the regression using the linearly interpolated values. Here, the coefficient is positive and statistically significant at the 10% level at the expense of residual correlation. Despite the chosen estimation method allows for residual autocorrelation, we are cautious in interpreting our results.

Table 5a: *Alternative specifications: Arellano-Bond estimator with robust standard errors (p-values in parentheses)*

Dependent variable: $\Delta\pi_{i,t}$				
	Specification			
Independent Variable	2a	2b	2c	9a
Constant	3.1188 (0.007)	-.6604 (0.762)	.0726 (0.520)	-.8443* (0.070)
$\Delta\pi_{i,t-1}$	.4371*** (0.000)	.5773*** (0.001)	.4170*** (0.000)	.3797*** (0.000)
$IMP\_PRICE_{i,t}$	2.0248 (0.370)	3.063 (0.220)	2.481 (0.342)	.7277 (0.760)
$GOV\_EXP_{i,t}$	-.0652** (0.012)			
$GOV\_REV_{i,t}$		.0156 (0.747)	.0912*** (0.000)	
$PRIMBAL\_DIFF_{i,t}$				
$PMR\_i_{i,t}$				.6075* (0.060)
Sargan OR test	101.4436 (0.3066)	100.2303 (0.3369)	98.222 (0.3899)	63.035 (0.3029)
AR test: 1st order	-2.3559 (0.0185)	-2.2215 (0.0263)	-2.2825 (0.0225)	-2.3872 (0.0170)
2nd order	-1.3939 (0.1633)	-1.2049 (0.2282)	-1.3534 (0.1759)	-2.1239 (0.0337)

Note: *** Statistically significant at 1% level; ** Statistically significant at 5% level; *Statistically significant at 10% level.

Factors related to catching up processes in price levels and productivity growth emphasized by the literature are not found to be significant in the EMU. An explanation of the lack of significance of these factors can be found considering the sample period and the countries considered in our analysis. In fact, by the start of the EMU, the bulk of convergence in prices, interest rates and economic performances was already achieved. Factors related to catching up forces are found to be significant determinants of inflation differentials in the pre-EMU period. In particular, in Canzoneri et al. (2002), the Balassa-Samuelson effect is found to be an important determinant of inflation dispersion before the introduction of the common currency; moreover, evidence of increase in inflation dispersion due to price level convergence has been found by Rogers (2002), Duarte (2002) and Honohan and Lane (2003), albeit its importance has declined in more mature phases of the EMU (Stavrev (2008)).[17]

In a second stage, we try to obtain a parsimonious model of the determinants of Eurozone inflation differentials following a general-to-specific approach. In particular, we start from a model where all explanatory variables corresponding to the different theories are included contemporaneously. As expected, the full model performs very poorly in terms of significance. Secondly, we proceed with the elimination of the non-significant variables, starting with the least significant one. As before, variables are introduced contemporaneously and lagged by one period. Table 6 presents the final model resulting from this procedure.

Table 6: *Determinants of Eurozone inflation differentials*

Dependent variable: $\Delta\pi_{i,t}$	
Independent variables	
Constant	-1.982** (0.034)
$\Delta\pi_{i,t-1}$	.4608** (0.028)
$IMP\_PRICE_{i,t}$	1.822 (0.428)
$(\tilde{y}_{i,t} - \tilde{y}_{EA,t})$	.1253*** (0.002)
$UNEMP_{i,t}$	-.1183** (0.028)
$EPL_{i,t}$	1.163*** (0.003)
Sargan Test:	82.258 (0.3490)
AR test: 1st order	-2.1991 (0.0279)
2nd order	-1.7212 (0.0852)

Note: *** Statistically significant at 1% level; ** Statistically significant at 5% level; *Statistically significant at 10% level.

The estimation results in table 6 confirm the previous findings. Controlling for lagged inflation differential and the change in import prices, the significant variables relate to different cyclical positions, unemployment and labor market rigidities[18].

The analysis presented in this section reveals that inflation differentials in the Eurozone are not the result of equilibrating, transitory forces, but rather of persistent structural and country-specific

[17] In order to test for possible non-linear effects of price level convergence and differences in productivity, we run the regressions inclusing a squared term for these two variables. The estimated coefficients are, however, not statistically significant. The results are not reported but are available upon request.

[18] We check for possible multicollinearity in the model due to the simultaneous introduction of the three variables. The value of the Variance Inflation Factor, commonly used to detect multicollinearity, corresponding to this regression is 1.33, well below to the critical value of 10.

factors. This has important implications for policymaking, as it implies that inflation differentials will not tend to disappear autonomously, but need to be addressed by specific, Euro Area wide policies.

5. Conclusions and policy implications

Inflation rates have diverged more widely among the members of the Eurozone than expected and the recent surge in inflation dispersion illustrates that there is no tendency for inflation differentials to decline or to disappear.

The question whether inflation differentials constitute a matter of concern for the central bank of a monetary union and for the ECB in particular is subject to discussion. On the one side are those who claim that monetary policymakers should not care about regional differences in inflation rates. According to this view, what matters is the inflation rate of the Eurozone. This view is also implicitly translated in the ECB's first objective, viz. to maintain price stability in the euro area as a whole. On the other side are those who find that inflation differentials should play a role in the ECB's policy formulation.

The differences between both views can be downplayed to the belief whether inflation differentials are part of an equilibrating adjustment process and therefore desirable, or, on the contrary, the result of misaligned fiscal policies and structural rigidities in labor and product markets, and therefore contributing to large changes in real exchange rates and gains/losses of competitiveness among the members of the monetary union.

As we show in this paper, persistent inflation differentials have arisen in recent years. Therefore, they should be taken into account by the ECB when formulating the monetary policy decisions. Based on augmented monetary policy reaction functions, Fendel & Frenkel (2006) showed that in practice inflation differentials did influence the interest rate setting by the ECB. For a given average Eurozone inflation rate, an increase in inflation differentials has lead the ECB to set a *lower* policy rate. Actually, this may have reflected the fear of deflation in low inflation countries (like Germany).

Furthermore, we show that inflation differentials are not the result of equilibrating, transitory forces, but rather of persistent structural and country-specific factors. This has important implications for policymaking, as it implies that inflation differentials will not tend to disappear autonomously, but need to be addressed by specific policies. Structural reforms in product and labor markets, and countercyclical fiscal policy measures at the individual country level are therefore needed.

The issue as to which policies are better suited to deal with inflation differentials at the common monetary policy level is complicated by the uniqueness of the monetary policy instrument available to the ECB. The ECB can only set one policy rate (in principle based on the Eurozone average inflation rate). This policy rate will be too low for high inflation countries, adding to the inflationary boom, since the real interest rate for these countries will be too low (assuming inflation is demand driven). This will lead to a real appreciation and loss of competitiveness. Without the instrument of a nominal devaluation as member of the eurozone, the regaining of competitiveness will be a difficult and painful process. The policy rate will, on the other hand, be too high for low inflation countries, adding to the deflationary bust, because their real interest rate will be too high. This will result in a real depreciation and increased competitiveness.

The findings of Fendel & Frenkel imply that the inflationary boom effect described above has actually been more pronounced, since the ECB has set the policy rate below the rate based on the average inflation. This policy may actually have contributed to a further real appreciation and loss of competitiveness in some euro members.

Additional instruments, complementary to traditional monetary policy, should therefore be designed at the common level. Such policies, however, cannot be designed to match the needs of individual countries, as this would violate the basic principle constituting the Economic and Monetary Union. The policy should hold for the pool of EMU, but be effective only in those countries where it is most needed. One may think for example of temporarily quantitative credit restrictions that will only have an effect in those countries where excessive credit expansion threatens price stability.

References

Amian, C. G. and A. M. Zumaquero, 2002, “Complete or Partial Inflation Convergence in EU”, *mimeo*, Universidad de Malaga.

Balazs, E. (2007), Real convergence, price level convergence and inflation differentials in Europe, *CESifo Working Paper*, no. 2127, CESifo Group.

Baltagi, B.H., 2005, *Econometric Analysis of Panel Data*, Third edition, Chichester, Wiley.

Barro R.J. & Sala-i-Martin X., 1991, "Convergence across States and Regions," *Brookings Papers on Economic Activity*, vol. 22(1), pp. 107-182.

Barro R.J. & Sala-i-Martin X., 1992, "Convergence," *Journal of Political Economy*, vol. 100(2), pp. 223-51, April.

Baumol, W.J., 1986, “Productivity Growth, Convergence, and Welfare: What the Long-run Data Show”, *American Economic Review*, 76(5), pp.1072 - 85.

Beck G.W. & Weber, A.A., 2005, "Inflation Rate Dispersion and Convergence in Monetary and Economic Unions: Lessons for the ECB" CFS Working Paper Series 2005/31.

Busetti, F. , Forni, L., Harvey, A. and Venditti, F.(2007), Inflation convergence and divergence within the European Monetary Union, *International Journal of Central Banking*, Vol. 3, no. 2, pp.95-121.

Canzoneri, M., Cumby, R., Diba, B. and Eudey, G. (2002), Productivity trends in Europe: implications for real exchange rates, real interest rates, and inflation, *Review of International Economics,* Vol. 10, no. 3, pp. 497-516.

Duarte, M. (2003), The euro and inflation divergence in Europe, *Federal Reserve Bank of Richmond Economic Quarterly,* Vol. 89, no. 3 (Summer), pp. 53-70.

European Central Bank (1999), Inflation differentials in a monetary union, *ECB Monthly Bulletin*, October, pp. 35-44.

European Central Bank (2003), "Inflation differentials in the euro area: Potential causes and policy implications", September 2003.

European Central Bank (2005), "Monetary policy and inflation differentials in a heterogeneous currency area", *ECB Monthly Bulletin*, May 2005

European Commission (2006), Cyclical synchronization within the euro area: what do recent data tell us?, *Quarterly Report on the Euro Area*, 5(2), pp. 19-24.

ECB, 2011, Monthly Bulletin, January 2001, pp.40-41

Fendel, R. and Frenkel, M., 2009, "Inflation differentials in the Euro area: did the ECB care?", *Applied Economics*, 41, issue 10, p. 1293-1302

Hadri, K., 2000, "Testing for stationarity in heterogeneous panel data", *Econometrics Journal*, Vol.3, pp. 148–161
Holmes, M., 1998, "Inflation Convergence in the ERM. Evidence for Manufacturing and Services", *International Economic Journal* (12), pp. 1-16.

Honohan, P. and Lane, Ph. R. (2003), Divergent inflation rates in EMU, in: Baldwin, R., Bertola, G. and Seabright, P. (2003), EMU: Assessing the impact of the euro, Blackwell Publishing, pp. 65-102.

Kočenda, E., Papell, D. H., 1997, "Inflation Convergence Within the European Union: A Panel Data Analysis", *International Journal of Finance and Economics*, 2(3), 189-198.

Kwiatkowski, D., P. C. B. Phillips, P. Schmidt, and Y. Shin, 1992, " Testing the Null Hypothesis of Stationarity against the Alternative of a Unit Root", *Journal of Econometrics,* 54, 159–178

Marzinotto, B. (s.d.), *Are inflation differentials in the euro-area a challenge to EMU economic governance? Some preliminary evidence on the political sustainability of divergences in EMU.* European Economic Governance Monitor, EEGM papers P-2.

Nyblom, J. 1989. "Testing for the Constancy of Parameters over Time" *Journal of the American Statistical Association* 84 (405) pp. 223–30.

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, no. 740 (October).

Siklos, P. L. & Wohar, M. E., 1997 "Convergence in Interest Rates and Inflation Rates across Countries and over Time", *Review of International Economics*, vol. 5(1), pages 129-41.

Stavrev, E. (2008), What explains growth and inflation dispersion in EMU?, *Czech Journal of Economics and Finance,* Vol. 58, no. 1-2, pp. 57-67.