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In 2009 all ECB publications feature a motif taken from the €200 banknote.

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CONTENTS

Abstract

This paper analyses the determinants of inflation differentials and price levels across the euro area countries. Dynamic panel estimations for the period 1999-2006 show that inflation differentials are primarily determined by cyclical positions and inflation persistence. The persistence in inflation differentials appears to be partly explained by administered prices and to some extent by product market regulations. In a cointegrating framework we find that the price level of each euro area country is governed by the levels of GDP per capita.

Keywords: inflation differentials, inflation persistence, price level, convergence

JEL Classification: E32, E52, E43, F2

Non-technical summary

Some euro area countries experienced persistent inflation differentials vis-à-vis the euro area during almost the entire decade after the inception of the euro. These differences may reflect either a normal feature, a sign of overheating or structural rigidities. In this context, this paper closer investigates the determinants of inflation differentials.

We find that the main determinants of differentials in HICP inflation of EMU countries vis-à-vis the euro area are differences in business cycle positions and to some extent changes in product market regulations. External factors, such as differences in nominal effective exchange rate changes and differences in energy intensity as well as the fiscal stance play a minor role. In line with other studies, we also find that inflation differentials are persistent. Moreover, the persistence seems partly related to administered prices and to a limited extent to product market regulations.

The importance of price level adjustments as determinants of inflation differentials calls for a more thorough view on price levels. We explicitly model the long run determinants of price levels, such as levels of GDP per capita, or productivity and consumption, all relative to the euro area and quantify their importance separately in each euro area country. The analysis results in country-specific stationary cointegration relations which explain relative price level movements in each of the euro area countries. Importantly, the implications for the long run price level is only an equilibrium phenomenon if the developments in GDP per capita are sustainable.

1 Introduction

Although inflation dispersion has declined significantly across the euro area countries in the last two decades, some euro area countries continued to exhibit persistent inflation differentials vis-à-vis the euro area over large parts of the period since the inception of the euro.[1] In the absence of national monetary and exchange rate policies to adjust to shocks the question may arise whether the inflation differentials observed in some euro area countries vis-à-vis the euro area are a normal feature, or a sign of overheating or structural rigidities. Inflation differentials may reflect different business cycle positions or catching-up processes. Besides, they may also indicate structural phenomena such as price and wage rigidities reflecting, for instance, high degrees of product and labour market regulations. In general, it is important to know the nature and sources of these inflation differentials, as the appropriate policy responses may differ accordingly.

Against this background, in a first exercise, we quantify the determinants of inflation differentials within the euro area. The results show that inflation differentials vis-à-vis the euro area are primarily driven by different business cycle positions and to some extent by changes in product market regulations, while external factors such as differences in nominal effective exchange rates and energy intensity as well as the fiscal stance play a minor role. We add to findings in prior work in this field with respect to several aspects. First, we carry out a number of robustness checks which are not found in previous literature and extend the data set to 2006. For instance, we account for differences in administered prices between euro area countries. This factor, together with changes in product market regulations, seems to explain some limited part of the persistence in inflation differentials. Moreover, we examine the importance of non-linearities in the inflation output nexus and different measures of output gaps as well as wage, credit and house price developments to explain euro area inflation differentials.

The analysis of price dynamics also calls for a more thorough view on the evolution of national price levels. In a second exercise we therefore model long run determinants of price levels separately in each euro area country. Due to the non-stationarity of the underlying variables we apply a cointegrated VAR framework. We find that national price levels are governed by the evolution of relative GDP per capita or productivity levels in the long run.

The paper is structured in the following way. After a literature overview in this chapter, the theoretical framework is illustrated in the second chapter. Thereafter, we present some key

[1] Chart A1 in the Annex illustrates that the dispersion of inflation across the euro area countries is currently broadly similar to the inflation dispersion across 14 U.S. Metropolitan Statistical Areas. However, in several euro area countries inflation differentials are found to be more persistent than in the United States.

features of the data in Chapter 3 and the estimation results for the inflation differentials and the price level differentials in the euro area countries in Chapter 4. Conclusions are drawn in Chapter 5.

1.1 Some theoretical and empirical considerations: an overview of the literature

A vast amount of literature has investigated inflation differentials in the euro area. Many studies examine the potential for such differences, however, before the start of the EMU. More recently, the topic regained attention since euro area inflation differentials proved to be very persistent. Persistent inflation differentials may result from differences in equilibrium price developments across countries. For instance, different per capita income developments can be related to price differences between tradable and non-tradable sectors which may reflect Balassa-Samuelson effects, different capital-labour ratios, or different income elasticities between sectors. Country-specific price level adjustments may also arise due to structural reforms which make markets more efficient and which enhance relative price changes. Cyclical divergences (reflected in output gaps and fiscal stance) and external factors such as relative changes in the trade-weighted nominal exchange rate or different degrees of oil intensity may also potentially induce temporary asymmetric inflationary pressure across regions. Finally, inflation differentials may be related to non-market forces and originate from differences in wage flexibility, administered prices, indirect taxation and market power/competition. In this regard, Honohan and Lane (2003) emphasise the explanatory power of movements in the nominal effective exchange rate (NEER) in addition to the convergence of price levels and different business cycle positions. The authors do not, however, account for persistence in inflation differentials, which has been shown to be an important feature in the euro area (Rogers (2001), Berk and Swank (2002) and Ortega (2003)). Indeed, Angeloni and Ehrmann (2004) and Arnold and Verhoef (2004) reveal that external determinants of euro area inflation differentials, such as movements in the NEER, lose their explanatory power once one accounts for the persistence of inflation differentials. In accordance with the earlier studies, Stavrev (2007) finds that price level adjustment, business cycle positions and past inflation differentials are the main determinants of euro area inflation differentials.

As for the evolution of national price levels, Kravis and Lipsey (1982) demonstrate the robustness of the high positive correlation between price levels and real per capita GDP. Importantly, the implications for the long run price level is only an equilibrium phenomenon if the developments in GDP per capita are sustainable. Most studies focus on the Balassa Samuelson effect in order to explain this correlation. An alternative supply-side mechanism is

provided by Bhagwati (1984). He illustrates a positive link between price levels and real GDP per capita if one assumes that (i) non-tradable services are more labour-intensive in production, (ii) rich countries are capital-abundant and (iii) prices in tradable goods equilibrate due to commodity arbitrage. In this case, the national price level is lower in relatively poor countries resulting in a comparative advantage in producing services. In addition, Bergstrand (1991) highlights the relevance of a supplementary demand-side mechanism. In particular, a positive link between prices and demand is based on the assumption that non-traded services reflect mostly "luxuries" in consumption while traded commodities reflect mostly "necessities" and that income elasticity with respect to consumption of services is higher than for goods.

2 Inflation and price level differentials: the theoretical framework

In the following, we provide a simple analytical framework to derive the determinants of inflation differentials and the evolution of national price levels.

2.1 Inflation differentials

The following simple specifications of aggregate demand and supply allow a derivation of the determinants of inflation differentials *vis-à-vis* the euro area. Aggregate demand and supply in country *i* are given by

$$(1)\quad y_{it} = \bar{y}_{it} + d_1\left(y_{it-1} - \bar{y}_{it-1}\right) + d_2\Delta e_{it-1} + d_3 D_{it} + \varepsilon^d_{it}$$

$$(2)\quad \pi_{it} = \lambda_i \pi_{it-1} + b_1(y_{it} - \bar{y}_{it}) + b_2(p_{it-1} - \bar{p}_{it-1}) + \varepsilon^s{}_{it}$$

where y_{it} is real output, $\bar{y}_{it}$ potential output, Δe_{it-1} the lagged change in the nominal effective exchange rate[2], D_{it} reflects other demand factors such as the log of the fiscal position or house price inflation, π_{it} is the inflation rate, λ_i the degree of inflation persistence, p_{it} the log of the price level and $\bar{p}_{it}$ the log of the long run price level, ε^d_{it} a demand shock and ε^s_{it} a supply shock. The persistence of inflation can be derived from nominal rigidities, backward-looking price-setting behaviour or administered prices. We can derive a reduced form equation for inflation by combining (1) and (2)

[2] We suppose that changes in nominal exchange rate variability relative to the non-euro area trading partners explain most of the changes in real exchange rate variability in the short-run.

(3) $\pi_{it} = \alpha_1 \pi_{it-1} + \alpha_2 \left(y_{it-1} - \overline{y}_{it-1} \right) + \alpha_3 D_{it} + \alpha_4 \Delta e_{it-1} + \alpha_5 \left(p_{it-1} - \overline{p}_{it-1} \right) + \varepsilon_{it}$

where α_1 is a function of the parameter vectors *d* and *b* as well as λ_i, $\alpha_2 - \alpha_5$ are functions of *d* and *b*, and ε is a combination of supply and demand shocks. If one further assumes that the long run price levels are the same across the euro area countries ($\overline{p}_{it} = \overline{p}$), one can derive a reduced form equation for country *i*'s inflation differential relative to the euro area that is similar to the one imposed in Honohan and Lane (2003) and Arnhold and Verhoef (2004)

(4) $\pi_{it} = \alpha_0 + \alpha_t + \alpha_1 \pi_{it-1} + \alpha_2 \left(y_{it-1} - \overline{y}_{it-1} \right) + \alpha_3 D_{it} + \alpha_4 \Delta e_{it-1} + \alpha_5 p_{it-1} + \varepsilon_{it}$

where α_t are time-dummies that capture common movements in inflation and the explanatory variables across all euro area countries in each year. The model is hence purely backward-looking.[3] The estimation results are displayed in Chapter 4 below.

2.2 National long run price levels

As mentioned above, several studies detect a high positive correlation between price levels and real GDP per capita. We allow for country-specific long run price levels that are determined by variables such as per capita income, productivity levels and consumption shares.[4] Hence, we estimate the following long run relations for each euro area country

(5) $p_i = \beta_y y_i$,

where p_i is the comparative price level index and y_i is GDP per capita in purchasing power standards.

The positive relation between price levels and real per capita GDP can be explained by different mechanisms, such as the one described by Bhagwati (1984) (see above). Another explanation is the Balassa-Samuelson effect, which reflects relative price changes to

[3] Inflation dynamics may, however, alternatively be defined in terms of a hybrid Phillips curve in that they are governed by a combination of forward-looking inflation expectations and lagged realisations of inflation that represent a backward-looking price-setting behaviour, see Gali and Gertler (1999). In the medium to long run, inflation expectations in each country could, however, be expected to coincide with the overall inflation objective in the monetary union. Since the euro changeover we have already observed significant convergence of inflation expectations, according to survey data for instance from Consensus forecasts. A relaxation of this assumption by estimating a New-Keynesian Phillips curve containing forward-looking elements is left for future research, partly due to the lack of available consistent measures of inflation expectations across all euro area countries.

[4] We hence relax the assumption of equal long run price levels ($\overline{p}_{it} = \overline{p}$) across the euro area countries in the following. It should be stressed that this long run price level is only a long-run equilibrium if the developments in GDP per capita are sustainable.

differences in sectoral productivity.[5] Due to a limited availability of sector-specific time-series we use the overall productivity level (*a*). Hence, we estimate the following model for the price level in each euro area country:[6]

(6) $p_i = \beta_a a_i + \beta_{cs} cs_i$

where *a* is the productivity level and *cs* is the level of consumption. The estimation results are accounted for in Chapter 4 below.

3 Some key features of the data

The panel estimations on annual inflation differentials were conducted on a data sample covering the period 1999-2006 and twelve euro area countries (excluding Slovenia, Cyprus, Malta and Slovakia). Estimations were done on differentials in HICP inflation (infl), retrieved from Eurostat. The output gap (ygap) in the baseline estimation is taken from the European Commission's Ameco database and is calculated using a production function method. Data on the fiscal positions (fisu) are also collected from the European Commission. The nominal effective exchange rates (dneer) stem from the IMF's Financial Statistics. Increases in the index indicate an appreciation. The comparative price level indices (lnpcea) are published by Eurostat and are expressed relative to the euro area (excluding Slovenia, Cyprus, Malta and Slovakia). The log and growth rate of labour productivity are obtained from Eurostat. The index for product market regulations (pmr) from OECD[7] is used for the manufacturing sector using value-added manufacturing data from the EU KLEMS database of the European Commission as weights to aggregate sub-series.

In the robustness tests (see Annex) we use HICP inflation excluding administered prices (inflxa) vis-à-vis the euro area as a dependent variable.[8] We also measure an alternative output gap as the difference of output from potential output, where the latter is estimated employing a Hodrick-Prescott and a Baxter-King filter, respectively. Energy intensity (lnenin) is defined as the ratio of energy imports to overall GDP and is based on data from Eurostat.

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[5] Such mechanisms could be summarised in the following Balassa-Samuelson equation: $p = p_T + \delta[\phi_0 + \phi_1(a_T - a_N) + \phi_2(w_T - w_N) + \phi_3 cs]$, where p_T is the price of tradable goods, a_T, a_N and w_T w_N the productivity and wage of tradable and non-tradable good, respectively, and *cs* the consumption share.

[6] Equation (6) can be regarded as an alternative of the equation in the footnote above if PPP holds in the tradable sector and wage differentials are governed by productivity and consumption.

[7] These indicators measure the potential costs of anti-competitive regulation on manufacturing sectors of the economy, see http://www.oecd.org/dataoecd/18/52/38059809.xls. The respective costs measured for manufacturing industries have been weighted together using value-added manufacturing data from the EU KLEMS database.

[8] See Table A1 in the Annex for more information on the components considered as administered prices, see also http://www.ecb.int/stats/pdf/hicp_ap.pdf.

Information on wage growth (gwage) stem from Eurostat. The descriptive statistics for each country for the period from 1999 until 2006 are outlined in Table A2 in the Annex.

The price level estimations (see Section 4.2 below) are based on relative price level data for twelve euro area countries (excluding Slovenia, Cyprus, Malta and Slovakia). Data on comparative price level indices, GDP per capita, labour productivity, and consumption share stem from Penn World Table Version 6.2[9] (see Chart A2 in Annex), as other sources (including Eurostat) provide insufficiently long time series.[10] The Penn World Table Version 6.2 measures national price levels relative to the U.S. in order to allow for a comparison of price levels across countries.[11] In the price level estimations, we recalculate all variables relative to the corresponding realisations in the euro area. The sample period covers the period 1960-2003.

4 Empirical results

This chapter displays the empirical results from the estimations of inflation differentials and relative price levels, respectively.

4.1 Inflation differentials across the euro area

In this section, we apply a dynamic panel analysis to estimate variations of equation (4) in order to identify the determinants of inflation gaps vis-à-vis the euro area. The results are reported in Table 1. Note that we included time dummies in all specifications. The dummies capture EMU-wide common changes in inflation and the explanatory variables. It follows that the regressions are explaining inflation differentials in terms of idiosyncratic national changes in the determinants.[12]

[9] By Penn World Table Version 6.2 we intend Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 6.2, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, September 2006, throughout the paper.
See http://pwt.econ.upenn.edu/php_site/pwt62/pwt62_form.php

[10] Data in the 1960s may have some quality problems, which is why we have re-estimated the cointegration analysis starting in 1975. In this case the model does not well fit the data in five cases out of twelve, possibly due to an insufficient sample period for the cointegration estimations. The long run coefficients are largely robust. We hence use the longer sample. Data for Germany start in 1972 in the Penn World Table Version 6.2.

[11] We use the log of the variables in the cointegration analysis.

[12] In Table 1, we display, in addition to the conventional R^2, the percentage of variation explained by other factors than the time dummies. Hence, it reports the percentage explained by idiosyncratic national variables.

Table 1: Determinants of inflation differentials - (dynamic) panel estimation

Inflation based on HICP

	OLS	GMM	OLS	GMM[1]	GMM-sys	GMM	GMM[2]	GMM
	Replication of Honohan and Lane							
L.infl			.477**	.529**	.610**	.522**	.535**	.559**
			(5.11)	(7.80)	(20.44)	(7.71)	(7.64)	(7.13)
ygap	.361**	.536**		.221**	.206**	.228**	.367**	.290**
	(3.57)	(5.11)		(2.82)	(3.03)	(2.92)	(3.43)	(3.08)
L.ygap			.191**					
			(2.42)					
lnfisu	.047	.041						
	(.99)	(.42)						
L.dneer	-.093	-.015	-.043	-.016	.071**	-.009	.076	.058
	(-1.08)	(-.17)	(-.59)	(-.27)	(2.11)	(-.14)	(1.33)	(.85)
L.lnpcea	-3.30**	-3.77**	-1.61**	-1.38**	-1.36**	-1.86**	-2.16**	-1.64**
	(-4.58)	(-5.11)	(-2.71)	(-2.71)	(-4.42)	(-1.97)	(-4.00)	(-2.97)
L.lnprod						.209		
						(.54)		
gprod						2.17		
						(.56)		
gpmr							.116**	
							(2.15)	
time dummies	yes	yes	yes	yes	yes	yes	yes	yes
country FE	no	no	no	no	yes	no	no	no
period	99-06	99-06	99-06	99-06	99-06	99-03	99-03	99-03
countr./obs.	12/71	12/64	12/96	12/96	12/96	12/96	11/55	11/55
R-squared	.571	.577	.697	.719		.720	.823	.789
% explained	.345	.443	.463	.661		.529	.732	.680
1. auto-corr.	.002	.004	.747	.441	.040	.438	.198	.177
2. auto-corr.					.831			
Hansen-test		.392		.942	.998	.751	.731	.766

Infl *correspond to HICP inflation,* ***ygap*** *to output gap,* ***lnfisu*** *to the log of the primary fiscal position,* ***dneer*** *to the change in the nominal effective exchange rate,* ***lnpcea*** *to the comparative price level indices,* ***lnprod*** *the log of relative labour productivity,* ***gprod*** *the growth rate of relative labour productivity,* ***gpmr*** *to the changes in product market regulation and* ***L*** *to the first lag of a corresponding variable. 1) A Hausman-test indicates that country fixed effects are not correlated with the explanatory variables (p-value = .376). 2) In the last two columns we exclude Luxembourg since gpmr for this country is not available.* ***Percentage explained*** *is the percentage of the variation in the dependent variable explained by factors other than the time dummies, and it is measured as one minus the mean squared residual standard error divided by the mean squared residual standard error of a regression on the time dummies alone. We consider ygap as potentially endogenous and employ the first two lags of this variable as exogenous instruments. We always include heteroscedasticity robust standard errors and time-fixed effects. ** denote significance at the 5% level. Data are expressed in annual frequency.*

The first two columns replicate the analysis of Honohan and Lane (2003) for the extended sample period 1999-2006. Our findings are consistent with those of Honohan and Lane (2003) in the sense that we identify different positions in business cycles (output gap) and price level convergence across euro area countries as determinants of euro area inflation differentials. However, in contrast to their study, we find that external shocks (relative changes in nominal effective exchange rates) have a mostly insignificant influence on differences in inflation

rates.[13] To this extent, our results support the findings by Arnold and Verhoef (2004) which also reject a significant impact of external factors on EMU inflation differentials. Moreover, a test for serial correlation reveals that the model specifications in the first two columns suffer from serial correlation in the error term. Indeed, column 3 and 4 show that the first lag of inflation is significant. The overall findings remain broadly similar to those of Honohan and Lane (2003), when including lagged inflation. In the following estimations, we exclude the fiscal position since it is not significant.

Column 3 and 4 of Table 1 show that the inflation differential in the previous period, national output gaps and lagged price levels relative to the euro area explain contemporaneous inflation differentials. We are not able to detect evidence of serial correlation in the error term after the inclusion of a lagged dependent variable. Since the output gap might be affected by contemporaneous changes in inflation, we apply a GMM estimator in column 4, whereby we use the first two lags of output gap as instruments for the contemporaneous levels. The Hansen test of over-identifying restrictions supports the validity of these instruments. In fact, the results hardly change relative to the pooled OLS estimation. A Hausman test suggests that country-specific fixed factors are not correlated with the explanatory variable (p-value = .561).[14] Nevertheless, we report the results for the Blundell and Bond (1999) estimator in column 5. Their methodology yields consistent estimates in the presence of a lagged dependent variable and country fixed effects.[15] The qualitative results are similar to the previous estimation which confirms the findings of the Hausman test. In column 6, we additionally include the log and growth rate of labour productivity in order to check if a link between price and productivity levels helps to explain the effect of lagged price levels on euro area inflation differentials. However, neither of the variables is significant at conventional levels. Nevertheless, we explicitly model the long run effect of productivity levels on national price levels relative to the euro area in the next section (see Section 4.2) and find that productivity level movements explain (cointegrated) price level movements in each euro area country. Thus, long-run relative productivity convergence is an important underlying factor explaining relative price level convergence in the euro area. Finally, we account for differences in changes in product market regulations across the EMU countries in column 7.[16]

[13] The only significant case shows that different exchange rate dynamics across the euro area countries have contributed slightly to increasing inflation differentials in the first years on EMU.

[14] OLS estimations may be biased if country-specific fixed effects are introduced. The Hausmann test shows nevertheless that such effects are not needed in this specification. Therefore the OLS estimations are not biased.

[15] We note, however, that the results of the Blundell and Bond (1999) estimator have to be regarded with caution due to the limited number of cross-section observations (countries). That is, the asymptotic properties of the estimator are only valid for a large number of cross-section observations which is not satisfied in our sample.

[16] A panel unit root test à la Im, Pesaran and Shin (1997) indicates a unit root in the corresponding levels in each country.

We find that national differences in changes of product market regulations help explain inflation differentials in the euro area. In particular, an increase in product market regulations in a country relative to the euro area, *ceteris paribus*, leads to higher inflation relative to the euro area average. Note that the inclusion of product market regulations restricts the sample to 1999-2003 and excludes Luxembourg. A comparison between columns 7 and 8 -- which are identical with respect to time and country dimensions -- shows that the inclusion of changes in product market regulations is associated with a slight drop of inflation persistence and a higher effect on inflation differentials from different cyclical positions.[17]

A number of robustness test are displayed in the annex (see Tables A3 and A4 in the Annex).

The interpretation of the impact of lagged dispersion in relative price levels on inflation differentials is questionable as these series are non-stationary. In fact, a panel unit root test following Im, Pesaran and Shin (1997) shows that price levels relative to the euro area are non-stationary in each country. This suggests that the above results as well as the corresponding ones in the literature might suffer from spurious relations. Nonetheless, as discussed in section 1.1, there may be price level catching-up effects at play which could be captured by different productivity trends and possibly deviations from equilibrium price levels, explained by (i) a Balassa Samuelson effect, (ii) by an alternative supply-side mechanism provided by Bhagwati (1984), or (iii) by a supplementary demand-side mechanism a la Bergstrand (1991). Such phenomena would probably be better captured over longer periods. Therefore, we separately analyse the determinants of national price levels by means of country-specific cointegration estimations using data since the 1960s in Section 4.2.

4.2 Price level differentials

In this section, we apply a cointegrated VAR framework to estimate the long run determinants of national price levels based on equations (5) and (6) (see Tables A4 and A5 in the Annex).

An augmented Dickey-Fuller test reveals a unit root in all variables for all countries.[18] Starting with specification (5), we determine the appropriate lag length of the VAR models in each country by computing an F-test. In addition, we look at the Hannan-Quinn and Akaike information criteria. Thereafter, we run misspecification tests on the residual in (5) to check for the validity of the asymptotic distributions. In particular, we test for autocorrelation (Lagrange-Multiplier test), for normality (Jacques-Bera test), and for heteroscedasticity (Arch-test). The data allow for well-specified models in all countries. In some country-

[17] This finding is consistent with the presumption that product market regulations affect nominal rigidities on the supply side (λ_i) in equation (2) which, in turn, influence the degree of inflation persistence.

[18] A panel unit root test following Im, Pesaran and Shin (1997) result in the same conclusion.

estimations we had to increase the lag-length in order to reject autocorrelation in the residuals.[19] The well-specified VAR models provide the basis for a sound cointegration analysis. Moreover, if the residual, ε_t, in (5) is stationary, the series are said to be cointegrated with a vector $\lfloor 1 - \beta_y \rfloor$ (see Chart A3 in the Annex).[20] We implement a trace test to test for the cointegration rank following Johansen (1995). The corresponding statistics are listed in the first two rows of Table A5. The trace statistic does not yield clear-cut results in some countries. In these cases, we additionally consider the information from the roots of the companion matrices and the equilibrium error correction characteristics of the implied cointegration vectors to determine the appropriate cointegration rank. After imposing the corresponding cointegration rank, we estimated the long run cointegration vectors (β) and the corresponding error correction coefficients (α) which capture the equilibrium correction of the long run relations.

Table A5 shows that the price level and the level of real GDP per capita – both relative to the euro area -- are cointegrated in most countries. The implied vector β_y is positive and significant in all countries, except in Greece.[21] In all countries apart from Austria, we remove the constant in the cointegration relation between logged price and output series since it is not significant at conventional levels. As to the short-term equilibrium corrections, we suppose that causality is running from changes in relative real GDP per capita to the relative price level. The direction of causality, as implied by the short run equilibrium correction coefficients α_p and α_y, shows indeed that α_p is significantly different from zero and negative in all countries except Austria and to some extent Greece.[22] This implies that a rise in real GDP per capita seems to cause an increase in the price level since the latter error corrects to the cointegration relation. In other words, the relative price level would decline (rise) if it is above (below) the long run level implied by the relative level of real GDP per capita.

[19] The tables with the test statistics for each country and the unit root test are available from the authors upon request.

[20] Ireland is a particular case with very strong GDP per capita growth in recent years, which seems to suggest that the relative price level is "too low" from an equilibrium point of view, see chart A3 in the Annex. To some extent, this very strong GDP per capita in generated by firms and persons with foreign origins and thus some of the income generated in Ireland is transferred abroad. PPP-adjusted gross domestic product in Ireland grew by 8.3% per annum on average in the period 1998-2006, while PPP-adjusted gross national income grew by 7.9%. Using relative GNP per capita, however, changes the results only marginally.

[21] There is a broadly agreed shift in Greek economic performance in the period up to the mid 1970's and thereafter, which most likely explains why we cannot find a long run cointegration relation between the relative price level and relative GDP per capita in Greece. Alogoskoufis (1995) points to a major regime change in Greek economic policy after the mid 1970's. Christodoulakis, Dimeli and Kollintzas (1996) finds that the more pronounced break in the growth rate of GDP per capita occurred around 1980, partly due to the reduction in industry protection accompanying Greece's entry in the EU and the impact on investment of uncertainties about the future political situation.

[22] The error correction behaviour is very slow in these countries.

Moreover, a likelihood ratio test highlights that the error correction coefficient of output α_y is not statistically different from zero in any country, except in Austria and Greece.[23] The corresponding p-values are reported in the second last row of Table A5. Hence, in most countries there appears to be a one way causality running from output to prices, i.e. relative real GDP per capita is weakly exogenous. These findings show that the long run price level may not be equal for all euro area countries, but rather depend on developments in real per capita income levels. Importantly, the implications for the long run price level is only an equilibrium phenomenon if the developments in GDP per capita are sustainable.

We stated above that the positive long-run relation between relative levels of prices and real GDP per capita may be explained by changes in the relative productivity level and the consumption share over time. Therefore, we extend the previous analysis by estimating a long-run relation between price levels, aggregate total labour productivity and the aggregate consumption level in relative terms as expressed in equation (6). This extended model may be regarded as a deeper analysis of the underlying supply and demand factors, i.e. changes in relative productivity and consumption, that cause price and real GDP levels to be positively cointegrated in the long run. Since sufficiently long time series for productivity or the consumption share at the sectoral level are not available we employ aggregate measures of productivity and consumption.[24]

In Table A6 we report the results for the corresponding cointegration relations. We adopt an identical procedure in order to determine lag length and rank, as well as to detect auto-correlation, non-normality and heteroscedasticity as outlined above. We believe that the sample periods from 1960-2003 are long enough in order to detect representative long run price dynamics in each country. Moreover, Chart A2 in the Appendix does not reveal any evidence for structural breaks in the long run behaviour of price levels in any of the countries. Note that (transitional) divergences of prices from their long run levels in a given country can nevertheless induce country-specific price changes since the euro changeover.

We check for a bivariate cointegration relation between national price levels and relative productivity or consumption levels in all countries. If prices are cointegrated with both

[23] The likelihood ratio test also indicates that the constant in the cointegration relations is not statistically different from zero in any country, except in Greece and Austria. Hence, the evolution of the relative price and real GDP per capita levels are characterised by the same deterministic trend in our sample.

[24] Recall that most of the changes in productivity are generally attributed to changes in the traded sectors due to international competition and technology diffusion in these sectors. Furthermore, the consumption share of non-tradables is found to be strictly increasing in the overall level of consumption in most countries (Égert, 2007 and Chart A4 in Annex).
The yearly data frequency allows us to account for price movements stemming from changes in the capital-labour ratio (*k/l*) over time, whereby capital is derived from investment series by the perpetual inventory method, as has been emphasised Bhagwati (1984). However, we are not able to find a positive cointegration relation between these variables in any country. Therefore, we drop *k/l* from the analysis.

measures we choose the model with the better fit according to the log likelihood. We find a long-run relation with the expected positive sign between relative price levels and the aggregate relative productivity levels in all countries except in Greece, where prices appear to be governed by relative consumption levels.[25] We reveal a significant error correction behaviour of prices to the corresponding long-run cointegration relations ($\alpha_p < 0$) in all countries so that causality appears to be running from the real variables to the national relative price levels. Moreover, there seems to be a bivariate causality in Austria, Ireland and Luxemburg. It follows that productivity or consumption levels are weakly exogenous ($\alpha_{a,cs} = 0$) in all other countries.

A comparison of the long-run coefficients (β) between countries in Table A6 illustrates that the response of relative prices to changes in relative productivity levels are remarkably similar across countries, with the exception of Luxembourg and Greece. In particular, a 1% increase in the productivity level relative to the euro area is associated with an increase in national price levels relative to the euro area of approximately 1%. The corresponding coefficients vary between 0.97% (Italy) and 1.09% (Finland) (see Table A6). However, the pace of the error correction behaviour of prices (α) differs quite substantially across countries. If price levels deviate from their long-run equilibrium implied by the realisations of relative productivity levels, they adjust relatively fast back to their long run in Finland and Luxembourg while the speed of price level adjustments is found to be relatively slow in the Netherlands, Greece, France, Belgium and Ireland. The corresponding half lives of a shock to national long-run price levels vary from 1.1 to 11 years.

Comparing the long-run coefficient on relative productivity (or GDP per capita) with results from existing academic literature, Fischer (2007) finds an elasticity of 0.5-0.6 for a one percent shock to relative productivity on relative price levels in panel estimations for the euro area countries. Other studies are cross sectional (Kravis et al, 1988) and coefficients are in the range of 0.80 (for industrialised countries) and 0.20 (for non-industrialised countries). Given that the long run coefficient of relative productivity is around one for most countries in our sample, we complement the above results by carrying out a panel cointegration analysis, where the same coefficient is imposed for all countries. A Pedroni panel cointegration test shows that it cannot be rejected that (i) the series of relative prices and relative productivity

[25] We also check for a possible cointegration relation between all three variables. In some countries, we find an additional cointegration relation between relative productivity and consumption levels (not reported in Table A4). Yet, changes in relative productivity levels are weakly exogenous in these cases so that price as well as consumption levels are exogenously driven by productivity in these countries.

are cointegrated, and (ii) that the long run CI coefficients are the same across all countries.[26] In view of the results that prices and productivity are cointegrated, we estimate the long run CI vector and the error correction coefficients in the panel using the pooled mean group estimator following Pesaran et al (1999) see Table A7 in the Annex. This is an alternative to the Pedroni dynamic OLS panel CI estimator. The results suggest a long-run coefficient of 0.93 for the full sample. Moreover, we find that it varies between 1.08 and 1.28 for shorter sample periods.[27] The Hausman test suggests that we cannot reject that the long-run CI coefficients are the same across all countries for the basic specification. In the last three columns of Table A7, we used data from Eurostat instead of the Penn World Tables. The data are considered to have smaller measurement errors but are only available from 1996-2006.[28] Still, we find a long-run coefficient which is around one for this different data set.

In sum, we can confirm a traditional cointegration relationship between the price level and real GDP per capita in relative terms, as found in Kravis and Lipsey (1982). The more detailed analysis reveals that the relation is (mainly) governed by the evolution of relative aggregate productivity levels. Moreover, we find that differences in national price levels in the euro area stem from (i) cross-country differences in the evolutions of productivity (and consumption) levels as well as (ii) heterogeneity in the speed of adjustment of national price levels to productivity shocks. The latter finding implies that productivity shocks of similar magnitude in the EMU member states may still cause temporary disparities in national inflation rates due to national differences in the speed of price level adjustment. Different transmissions of common productivity shocks to inflation across euro area countries may be due to national differences in price-setting behaviour of firms or in the process of wage-bargaining.

5 Conclusions

This paper analyses the determinants of inflation differentials and price levels across the euro area countries. Dynamic panel estimations for the period 1999-2006 show that inflation differentials are primarily determined by different developments in per capita GDP or productivity levels, cyclical positions, and to some extent wage growth and changes in

[26] We do reject the null hypothesis of no cointegration relation between prices in PPP and real GDP per worker in PPP, both relative to the euro area, on a 5% significance level according to the Panel rho-Statistic (2.08, p-value of 0.05) and the Group rho-Statistic (2.49, p-value of 0.02) of the Pedroni test in a sample of 540 observations for 12 countries.
[27] The 95% confidence interval for the 1.08 coefficient is [0.73,1.44] and for the 1.28 coefficient it is [1.00,1.56].
[28] In addition, real GDP per capita is not adjusted for purchasing power parities. However, apart from Greece all countries fixed their exchange rates in the European Monetary Union. The constant differences between the fixed conversion rates are captured by the country fixed effects.

product market regulations. We also find significant persistence in inflation differentials, which appears to be partly associated with administered prices and product market regulations. In a cointegrating framework, we find that the price level of each euro area country is governed by the levels GDP per capita, in turn determined by the levels of productivity and consumption.

The results from this paper broadly confirm previous findings by Honohan and Lane (2003) in the sense that cyclical positions seem to be important determinants of inflation differentials, and Arnold and Verhoef (2004) in that external factors, such as for instance the exchange rate, play a minor role. The findings of persistence in inflation differentials are in line with earlier work by Rogers (2001), Berk and Swank (2002) and Ortega (2003). The results from the cointegrating framework of price level estimations are also broadly in line with findings by Kravis and Lipsey (1982) and Bergstrand (1991). Importantly, however, the long-run price level is only a long-run equilibrium if the developments in GDP per capita are sustainable.

We add to the findings of previous literature by extending the data set to 2006 and carrying out a number of robustness checks which are not found in previous literature. For instance, we account for differences between euro area countries in administered prices and product market regulations. These factors, together with wage growth, appear partly associated with the persistence in inflation differentials. Moreover, we examine the importance of non-linearities in the inflation output nexus and different measures of output gaps as well as wage and house price developments in explaining euro area inflation differentials.

Finally, further analysis using additional specifications of inflation expectations as well as a more robust check of the implications of different indirect tax rates as well as country-specific exchange conversion rates at the time of the euro changeover would be interesting areas for further research on the determinants of inflation differentials. It would also be appealing to conduct a more appropriate test to what extent the degree of regulations affect price levels and persistence in inflation differentials, if longer time series were available on employment protection legislation and product market regulations.

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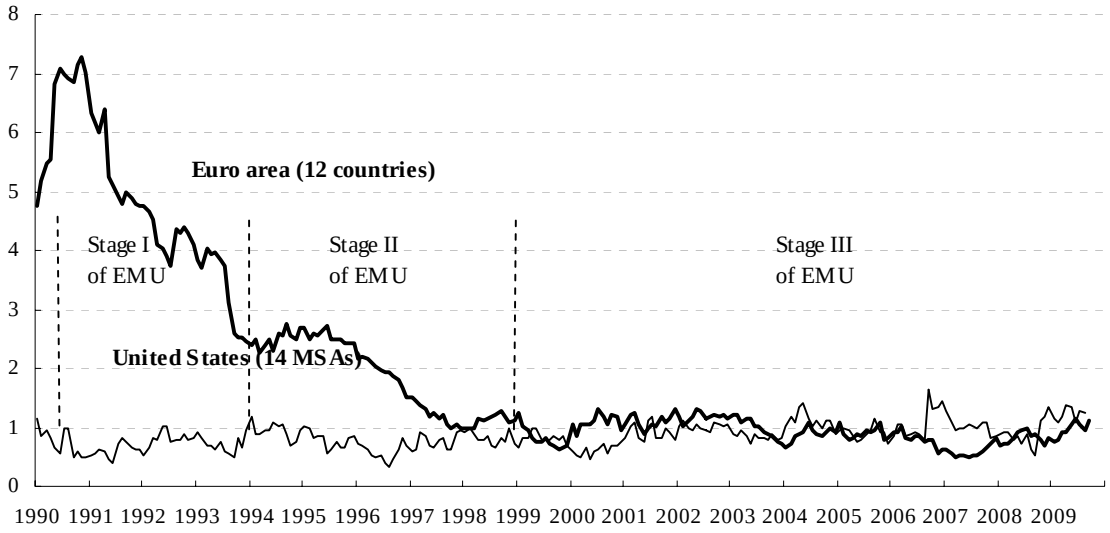
Annex

Chart A1: Dispersion of annual inflation across euro area countries and the 14 US Metropolitan Statistical Areas (MSAs)



Sources: Eurostat and US Bureau of Labor Statistics.

Remark: Euro area data up to September 2009 and US data up to August 2009.

Table A1: Components considered as administered prices

COICOP code	Description	euro area weights (see footnote)	Number of countries included
	Non-energy industrial goods		
044100	Water supply	0.75	13
061100	Pharmaceutical products	1.11	8
0612_3	Other medical products, therapeutic appliances and equipment	0.14	3
095100	Books	0.01	1
	Energy		
045100	Electricity	1.87	10
045200	Gas	0.92	5
045300	Liquid fuels	0.01	1
045500	Heat energy	0.49	3
072200	Fuels and lubricants for personal transport equipment	0.02	1
	Housing		
0411_2	Actual rentals paid by tenants including other actual rentals	0.45	2
044200	Refuse collection	0.52	12
044300	Sewerage collection	0.45	13
044400	Other services relating to the dwelling n.e.c.	0.18	1
	Transport		
072400	Other services in respect of personal transport equipment	0.06	5
073100	Passenger transport by railway	0.40	11
073200	Passenger transport by road	0.34	12
073300	Passenger transport by air	0.01	1
073400	Passenger transport by sea and inland waterway	0.04	3
073500	Combined passenger transport	0.49	10
073600	Other purchased transport services	0.00	1
125400	Insurance connected with transport	0.01	2
	Communication services		
081000	Postal services	0.19	12
083000	Telephone and telefax services	1.27	7
	Recreation and personal		
094100	Recreational and sporting services	0.05	2
094200	Cultural services	0.70	6
111200	Canteens	0.00	1
	Miscellaneous		
0621_3	Medical and paramedical services	0.63	6
062200	Dental services	0.35	5
063000	Hospital services	0.45	7
100000	Pre-primary, primary, second., etc, & educ. not def. by level	0.50	7
124000	Social protection	0.80	7
125300	Insurance connected with health	0.33	3
127000	Other services n.e.c.	0.18	3
	Total administered prices weight in the overall HICP	13.8	-

Note: estimates of euro area administered prices are weighted aggregates of national administered price indices. The euro area weights are calculated by multiplying the weight of the sub-index in each country in which the item is considered to be administered by the corresponding country weight. Since, for any one sub-index, prices may be administered in only a subset of euro area countries, the weights in this table will generally be smaller than the euro area sub-index weights published by Eurostat.

Source: The National Central Banks of the ESCB and ECB.

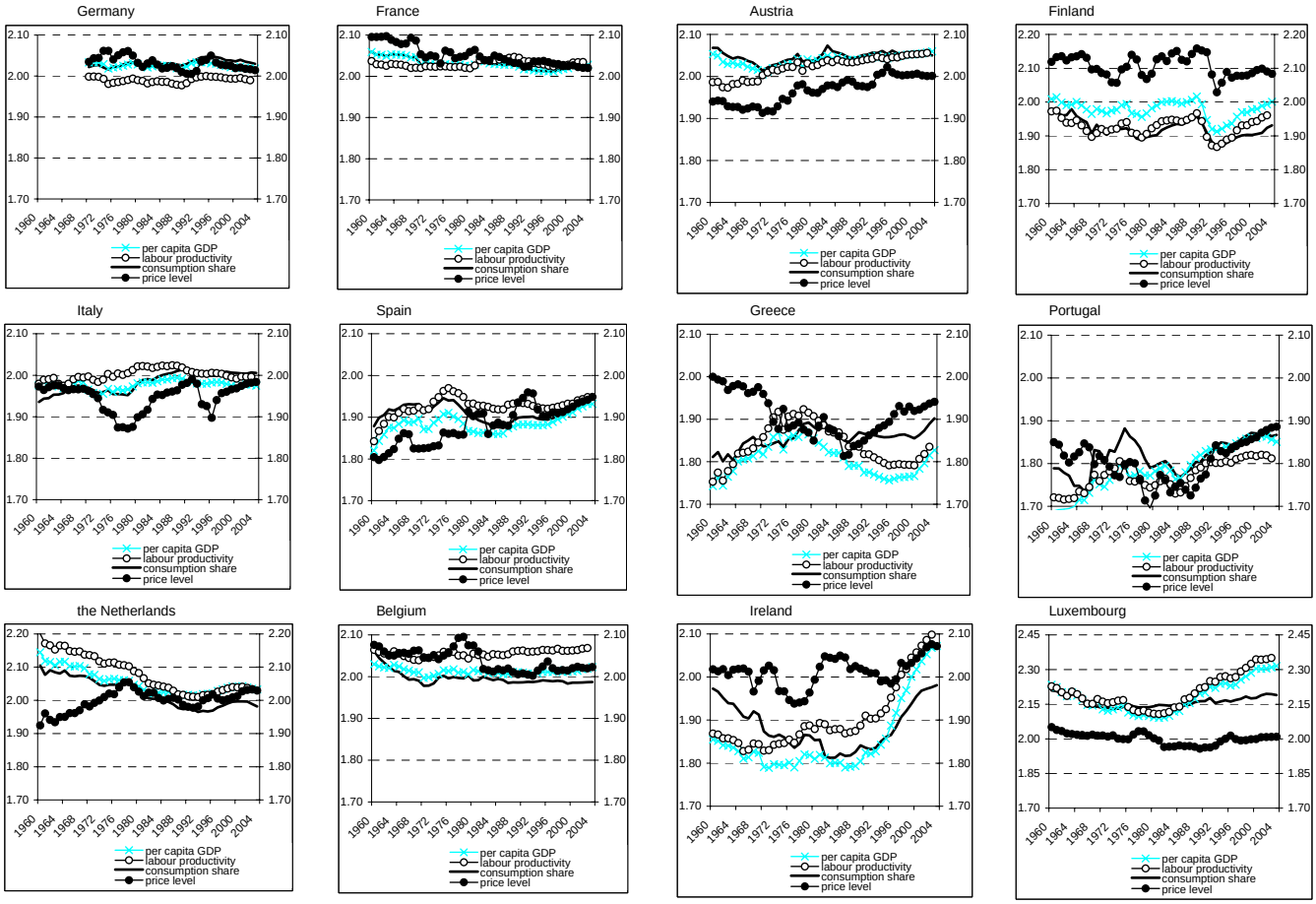
Table A2: Descriptive statistics of variables in panel estimations based on the period 1999-2006

		infl	ygap	dneer	pcea	gpmr	pceu	fisu	inflhp	enin	ygapbky	ygaphpy
AT	mean	1.823	-0.047	0.132	-0.148	-2.369	102	4296	0.822	142	-0.005	-0.004
AT	stdev	0.653	1.327	1.981	0.120	1.344	2	1796	2.702	5	1.329	1.270
BE	mean	2.009	0.138	0.382	-0.346	-2.706	102	14168	6.401	225	0.072	0.149
BE	stdev	0.567	0.955	2.892	0.095	0.970	2	3627	1.421	14	1.639	0.957
DE	mean	1.584	-0.396	0.550	-0.046	-1.796	108	11231	-0.520	161	-1.093	-0.193
DE	stdev	0.586	1.207	3.522	0.124	0.903	4	39145	0.979	2	14.613	1.358
ES	mean	3.226	0.430	0.126	-0.283	-4.997	85	19492	15.363	225	-0.119	0.237
ES	stdev	0.426	1.336	2.222	0.133	2.204	2	6921	2.620	3	2.568	0.646
FI	mean	1.521	0.303	0.891	-0.690	-2.813	112	8209	6.022	271	-0.015	0.607
FI	stdev	1.017	1.806	3.422	0.092	0.651	2	2592	2.352	7	1.141	1.555
FR	mean	1.706	0.527	0.212	-0.205	-2.645	104	1571	10.799	188	0.959	0.400
FR	stdev	0.492	1.229	3.051	0.119	0.863	2	16319	3.264	2	8.306	0.992
GR	mean	3.239	0.239	0.397	0.081	-1.404	79	1511	9.475	255	-0.203	-0.063
GR	stdev	0.346	1.284	3.570	0.109	2.723	1	3426	4.378	9	0.479	0.913
IE	mean	3.601	2.241	0.281	-0.393	-3.256	112	3892	13.233	169	0.240	1.629
IE	stdev	1.397	2.294	5.024	0.105	1.459	5	2050	4.001	12	0.915	1.898
IT	mean	2.318	0.142	0.867	-0.176	-4.319	95	30152		187	0.117	0.193
IT	stdev	0.397	1.379	3.088	0.133	1.833	4	22839		3	8.215	1.182
LU	mean	2.294	0.237	0.192	-0.515		109	10623	11.382	190	0.012	0.398
LU	stdev	0.621	2.489	1.849	0.103		3	8643	2.883	5	0.277	2.211
NL	mean	2.371	0.199	0.234	-0.193	-3.731	104	-116	8.572	201	0.455	0.597
NL	stdev	1.152	2.047	3.280	0.137	4.023	1	133	6.176	2	3.470	2.055
PT	mean	3.020	0.302	0.115	-0.086	-4.596	77	-1142	-4.002	244	0.252	0.950
PT	stdev	0.721	2.198	1.898	0.140	1.741	4	1756	20.097	7	0.896	2.001

Source: own computations.

Note: Only data for which we report the results are included.

Chart A2: Comparative price level indices, relative GDP per capita in purchasing power standards, relative labour productivity per person employed and relative ratio of consumption to GDP, logarithms euro area=log(100)



Source: own computations on Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 6.2, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, September 2006.

Robustness tests

To analyse the robustness[29] of the results in Section 4.1, we have complemented of our results with respect to (i) HICP adjusted for administered prices as a dependent variable, (ii) the functional form of the output-inflation trade-off, (iii) additional explanatory variables that may capture cross-country differences in boom-bust cycles or the impact of external factors (such as relative energy intensity and residential property prices), and (iv) alternative measures of the output gap (applying a Hodrick-Prescott and Baxter-King filter to obtain potential output, respectively).[30]

- In Table A3, we employ a dependent variable based on HICP excluding administered prices. The results are broadly consistent with the ones above.[31] The main difference is that inflation differentials are somewhat less persistent and that the output gap explains relatively more of the differentials in inflation excluding administered prices.
- The results from robustness tests (ii) to (iv) are given in Table A4.[32] The first three columns reveal some limited evidence in favour of robustness test (ii), i.e. asymmetries in the underlying output inflation trade-off (non-linear Phillips Curve).[33] In particular, we identify a significant convex functional form of the "Phillips Curve" if we apply the pooled OLS estimator. Hence, there is some evidence that the inflationary pressure of an increase in output increases disproportionaly with the size of the output gap. It follows that periods of *exceptional booms* in some member countries (relatively large output gaps) may account for a relatively large part of the euro area inflation differentials.

[29] We have also carried out the estimations based on inflation corrected for rents and items related to housing. The definition of such a component is far from clear-cut and tends to affect the results. This robustness test is not reported here.

[30] In a monetary union it is possible that periods of potential over- or undershooting are emphasised and extended in time, due to the lack of quick adjustment via national monetary and exchange rate policies. Hence, standard measures of output gaps, estimated over a long time period, may not fully capture such potential changes in duration and magnitude after the euro-changeover. However, a rough comparison of output gap estimations using HP-filters over the periods 1980-2008 and 1997-2008, respectively, including forecasts for 2007 and 2008 from the European Commission, show a very marginal change in the sizes of output gaps, suggesting that no discernable change took place after 1999.

[31] Column two, three, five and six of Table A3 can be compared directly to the last four columns of Table 1.

[32] Given the many possible dimensions, we have restricted the number of estimations shown in Table A4 to two sets for each "robustness" variable, showing the results either with or without the presence of the variable for changes in product market regulations. For simplicity, we also do not account for any results of simultaneously using two or several "robustness" variables in the table.

[33] These asymmetries are justified on a theoretical basis in the presence of short-run capacity constraints in capital (Evans, 1985), downward nominal wage rigidities (Akerlof et al., 1996) or asymmetric price setting behaviour in firms (Ball and Mankiw, 1994).

Table A3: Robustness: determinants of inflation differentials

Inflation based on HICP excluding administered prices

	OLS	GMM[1]	GMM-sys	GMM	GMM[2]	GMM
L.inflxa	.436**	.466**	.551**	.461**	.384**	.450**
	(4.50)	(6.31)	(10.40)	(6.53)	(4.37)	(5.38)
ygap		.243**	.220**	.244**	.467**	.346**
		(2.88)	(2.74)	(3.05)	(4.25)	(3.70)
L.ygap	.199**					
	(2.29)					
L.dneer	-.116	-.089	.020	-.076	.005	-.013
	(-1.63)	(-1.52)	(.37)	(-1.21)	(.10)	(-.20)
L.lnpcea	-1.90**	-1.72**	-1.78**	-2.96**	-2.93**	-2.06**
	(-2.59)	(-2.66)	(-4.32)	(-2.25)	(-4.35)	(2.90)
L.lnprod				.548		
				(.92)		
gprod				2.21		
				(.42)		
gpmr					.167**	
					(2.50)	
time dummies	yes	yes	yes	yes	yes	yes
country FE	no	no	yes	no	no	no
period	99-06	99-06	99-06	99-06	99-03	99-03
countr./obs.	12/96	11/96	12/96	12/96	11/55	11/55
R-squared	.628	.650		.655	.738	.688
% explained	.267	.329		.334	.356	.304
1. auto-corr.	.783	.532	.012	.021	.675	.092
2. auto-corr.			.729			
Hansen-test		.861	.998	.884	.897	.870

Inflxa *correspond to inflation excluding administered prices,* ***ygap*** *to output gap,* ***dneer*** *to the change in the nominal effective exchange rate,* ***lnpcea*** *to the comparative price level indices,* ***lnprod*** *the log of relative labour productivity,* ***gprod*** *the growth rate of relative labour productivity,* ***gpmr*** *to the growth rate of product market regulation and* ***L*** *to the first lag of a corresponding variable. 1) A Hausman-test indicates that country fixed effects are correlated with the explanatory variables (p-value = .482). 2) In the last two columns we exclude Luxemburg since gpmr is not available. Percentage explained is percentage of the variation in the dependent variable explained by factors other than the time dummies, and is measured as one minus the mean squared residual standard error divided by the mean squared residual standard error of a regression on the time dummies alone. We consider ygap as potentially endogenous and employ the first two lags of this variable as exogenous instruments. We always include heteroscedasticity robust standard errors and time-fixed effects. ** denote significance at the 5% level.*

- We control (robustness test (iii)) for some additional variables that might be related to inflation differentials as a robustness check. However, the effect of the log of energy intensity (lnenin), which we consider as an alternative measure of external effects, is not significantly different from zero. Moreover, we include several variables that might capture the effect of overheating in some economies.[34] In particular, we include wage inflation which we instrument with its first two lags in the GMM estimation

[34] We find no impact on inflation differentials from euro area differences in GDP growth or the growth rate of credits, and a very weak impact from house prices (not reported in Table A4). Data on credit growth come from Eurostat and GDP growth from the European Commission's Ameco database, and house price inflation rates for the euro area countries stem from various national sources.

since contemporaneous realisations are likely to be endogenous. We find a positive impact on inflation differentials stemming from differentials in wage inflation if we additionally control for changes in product market regulations (see Table A4 column 5). Thus, idiosyncratic dynamics in the wage-setting processes in some EMU member states seem to help explaining inflation differentials in the euro area. Finally, as regards robustness test (iv), the qualitative results are very similar if we employ a Hodrick-Prescott filter to approximate the output gap, which can be seen in the last two columns of Table A4. Yet, the output gap loses its significance when based on a Baxter-King filter.

Table A4: Robustness: determinants of inflation differentials

	Inflation based on HICP								
	OLS	*GMM*	*GMM*[1]	*GMM*	*GMM*	*GMM*	*GMM*	*GMM*[2)]	*GMM*[2)]
L.infl	.510**	.527**	.520**	.481**	.453**	.483**	.536**	.549**	.622**
	(7.59)	(8.28)	(8.41)	(4.90)	(5.63)	(6.87)	(7.61)	(8.29)	(8.35)
ygap	.118**	.139*	.290**	.216*	.254**	.259**	.367**	.222**	-.012
	(2.56)	(1.80)	(2.89)	(1.83)	(3.05)	(2.91)	(3.40)	(2.29)	(-.57)
ygap^2	.059**	.054	.0484						
	(2.53)	(1.41)	(1.49)						
gwage				-.037	.107**				
				(-.50)	(2.36)				
lnenin						-.286	-.022		
						(-.99)	(-.09)		
L.dneer	.056	.040	.130**	-.063	.152**	-.022	.076	-.002	-.025
	(1.10)	(.64)	(2.31)	(-.62)	(3.14)	(-.35)	(1.34)	(-.03)	(-.35)
L.lnpcea	-1.69**	-1.46**	-2.18**	-2.42**	-1.90**	-1.83**	-2.17**	-1.40**	-.992*
	(-3.14)	(-2.72)	(-4.36)	(-3.30)	(-3.80)	(-3.36)	(-3.88)	(-2.69)	(-1.77)
gpmr			.130**		.120**		.116**		
			(2.87)		(2.84)		(2.15)		
time-dum.	yes	yes	yes	yes	yes	yes	yes	yes	yes
period	99-06	99-06	99-03	99-06	99-03	99-06	99-03	99-06	99-06
countr./obs.	12/96	12/96	11/55	12/93	11/55	12/72	11/55	12/96	12/96
R-squared	.750	.747	.842	.655	.854	.768	.823	.717	.660
% expl.	.519	.557	.622	.456	.640	.550	.592	.525	.469
1.auto-corr.	.860	.874	.703	.616	.136	.288	.144	.752	.984
Hansen-test		.438	.304	.443	.363	.826	.735	.264	.977

Infl *correspond to HICP inflation,* ***ygap*** *to output gap,* ***ygap^2*** *corresponds to the squared output gap,* ***gwage*** *to log changes in compensation per employee,* ***lnenin*** *to the log of energy intensity,* ***dneer*** *to the change in the nominal effective exchange rate,* ***lnpcea*** *to the comparative price level indices,* ***gpmr*** *to the growth rate of product market regulation and* ***L*** *to the first lag of a corresponding variable.. 1) We exclude Luxembourg whenever we include gmpr since this variable is not available for Luxembourg. 2) In the last two columns, the output gap is based on a Hodrick-Prescott and Baxter-King filter, respectively.*

Overall, we find that the main determinants of differentials in HICP inflation of EMU countries vis-à-vis the euro area are differences in business cycles, country-specific changes in product marker regulations, and persistence in inflation differentials. Interestingly, from the robustness tests it appears that wage growth is able to explain some of the inflation differentials, somewhat reducing the estimated degree of persistence and the impact of output gaps. External factors, such as differences in the nominal effective exchange rate or

differences in energy intensity, as well as convexities in the output-inflation nexus in euro area countries and house price inflation play a minor role. In line with other studies, we also find that inflation differentials are persistent. Moreover, the persistence seems due to differences in changes in product market regulations, administered prices and wage growth to a limited extent.

Table A5: Long-run relation between price levels and real per capita income; $p = \beta_y y$

	DE	FR	IT	ES	NL	BE	AT	FI	GR	IE	PT	LU
Model	VAR(2)	VAR(2)	VAR(3)	VAR(2)	VAR(3)	VAR(3)	VAR(2)	VAR(2)	VAR(2)	VAR(2)	VAR(2)	VAR(3)
trace test (R, λ_{trace})	(0, 16.6) (1, 4.99)	(0, 15.4) (1, 5.26)	(0, 16.4) (1, 5.61)	(0, 7.71) (1, 3.67)	(0, 18.9*) (1, 5.57)	(0, 11.8) (1, 4.01)	(0, 18.7*) (1, 1.47)	(0, 24.6**) (1, 7.58)	(0, 27.6**) (1, 7.18)	(0, 12.1) (1, 2.12)	(0, 11.5) (1, 3.99)	(0, 26.3**) (1, 1.17)
cointegration rank	R=1	R=1	R=1	R=1	R=1	R=1	R=1	R=1	R=1	R=1	R=1	R=1
β_p, p	1.00	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
β_y, y	1.00 (131.2)	1.08 (141.6)	.984 (189.6)	1.01 (77.1)	.995 (99.5)	1.01 (170.9)	2.36 (7.29)	1.06 (148.2)	.164 (-.67)	1.10 (72.67)	1.01 (65.66)	.125 (2.70)
α_p, Δp	-.237 (-2.29)	-.285 (-2.87)	-.204 (-2.48)	-.112 (-2.00)	-.078 (-3.40)	-.133 (-1.98)	-.101 (-1.35)	-.569 (-3.83)	-.132 (-1.75)	-.097 (-2.14)	-.110 (-2.34)	-.258 (-2.99)
α_y, Δy	.00	.00	.00	.00	.00	.00	.173 (3.49)	.00	.204 (4.74)	.00	.00	-.419 (-3.06)
const	.00	.00	.00	.00	.00	.00	-2.84 (-4.31)	.00	1.60 (3.60)	.00	.00	1.73 (17.3)
"Half life" in years	2.6	2.1	3.0	5.8	8.5	4.9	6.5	0.8	4.9	6.8	5.9	2.3
restriction imposed	α_y =0 *const* =0	α_y =0 *const* =0	α_y =0 *const* =0	α_y =0 *const* =0	α_y =0 *const* =0	α_y =0 *const* =0		α_y =0 *const* =0		α_y =0 *const* =0	α_y =0 *const* =0	
LR-test (p-value)	.042	.332	.100	.999	.311	.164		.150		.064	.327	
Sample	72-04	62-04	63-04	62-04	63-04	63-04	62-04	62-04	62-04	62-04	62-04	63-04

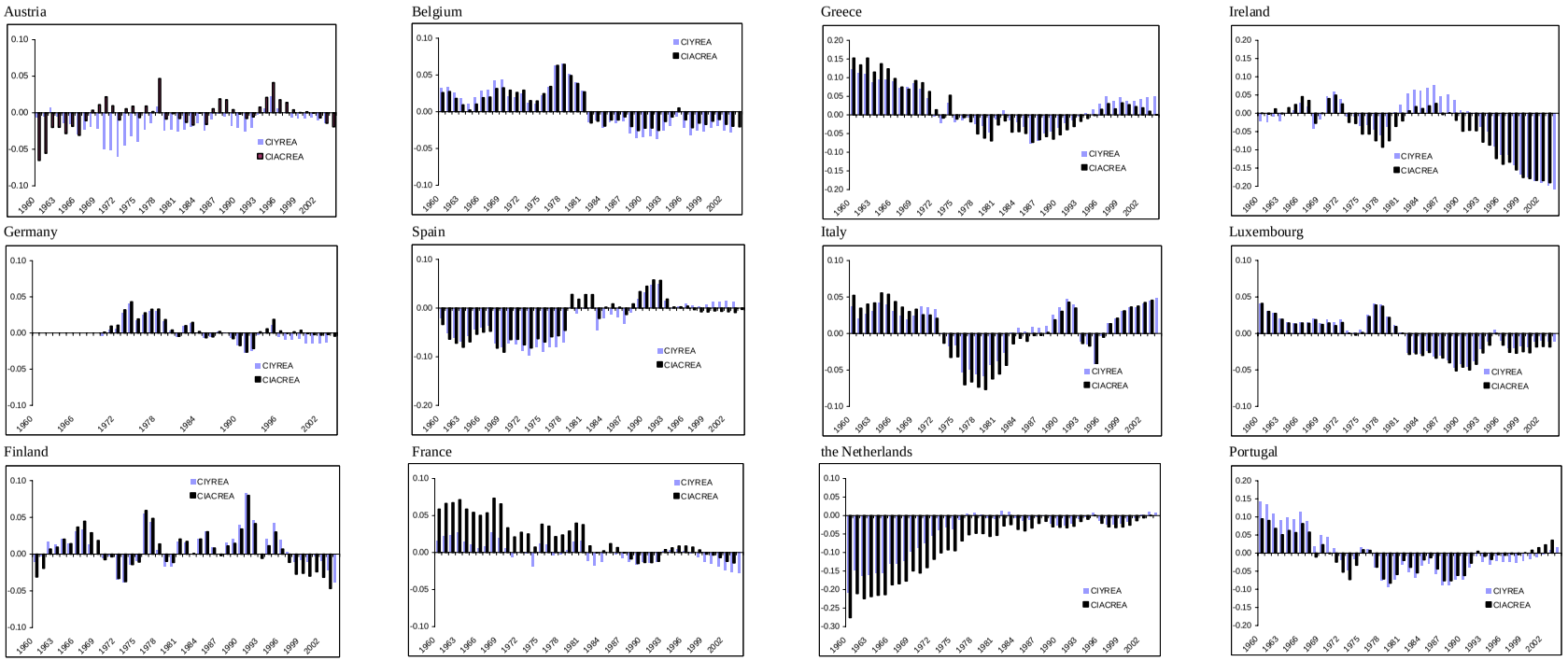
**, ** denote significance at the 10 and 5% level. P-values are presented in parentheses below the coefficients. "Half life" is defined as -log(2) / log(1+ α_p) and indicates the time in years for half of a shock to the relative price level to decay.*

Table A6: Estimation of country-specific price level determinants; $p = \beta_a a + \beta_{cs} cs$

Model	DE	FR	IT	ES	NL	BE	AT	FI	GR	IE	PT	LU
	VAR(2)	VAR(3)	VAR(3)	VAR(2)	VAR(3)	VAR(3)	VAR(2)	VAR(2)	VAR(2)	VAR(2)	VAR(3)	VAR(3)
trace test (R, λ_{trace})	(0, 12.9)	(0, 12.3)	(0, 11.6)	(0, 12.8)	(0, 22.5**)	(0, 10.8)	(0, 27.3**)	(0, 24.3**)	(0, 11.8)	(0, 22.7**)	(0, 11.8)	(0, 24.1**)
	(1, 4.11)	(1, 4.29)	(1, 3.04)	(1, 3.78)	(1, 6.96)	(1, 3.24)	(1, 5.19)	(1, 9.49*)	(1, 5.04)	(1, 2.73)	(1, 3.18)	(1, 1.41)
cointegration rank	R=1	R=1	R=1	R=1	R=1	R=1	R=1	R=1	R=1	R=1	R=1	R=1
β_p, p	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
β_a, a	1.02	.997	.972	.988	1.00	.989	.978	1.09		1.08	1.02	.139
	(125.0)	(142.3)	(117.1)	(80.84)	(73.64)	(131.1)	(115.6)	(136.3)		(154.3)	(101.7)	(2.73)
β_C, cs									1.02			
									(46.2)			
const	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1.70
												(14.96)
α_p, Δp	-.206	-.099	-.132	-.119	-.061	-.107	-.190	-.473	-.075	-.109	-.164	-.245
	(-2.00)	(-2.63)	(-2.10)	(-1.92)	(-3.65)	(-1.83)	(-2.72)	(-3.46)	(-1.69)	(-2.19)	(-2.54)	(-2.84)
α_a, Δa	.00	.00	.00	.00	.00	.00	-.165	.00		-.097	.00	-.386
							(-3.23)			(-3.05)		(-2.88)
α_C, Δcs									.00			
"Half life" in years	3.0	6.6	4.9	5.5	11.0	6.1	3.3	1.1	8.9	6.0	3.9	2.5
restriction imposed	α_a =0	α_a =0	α_a =0	α_a =0	α_a =0	α_a =0	*const* =0	α_a =0	α_c =0	*const* =0	α_a =0	
	const =0	*const* =0	*const* =0	*const* =0	*const* =0	*const* =0		*const* =0	*const* =0		*const* =0	
LR-test (p-value)	.094	.633	.135	.072	.182	.138	.077	.163	.138	.077	.313	
Sample	72-03	63-03	63-03	62-03	63-03	63-03	62-03	62-03	62-04	62-03	63-03	63-03

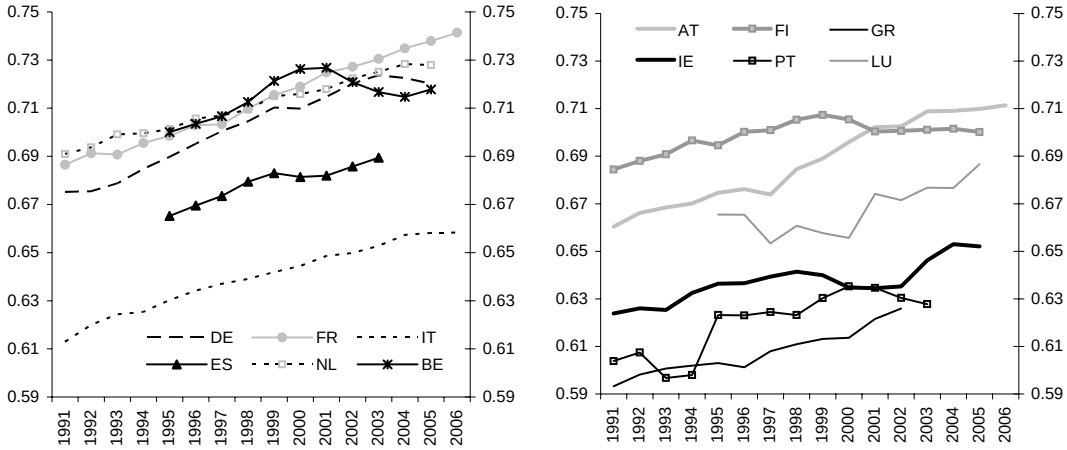
**, ** denote significance at 5 and 1% level. p-values are presented in parentheses. 1) There is a positive second cointegration relation between a and CS. "Half life" is defined as -log(2) / log(1+ α_p) and indicates the time in years for half of a shock to the relative price level to decay.*

Chart A3: Cointegrating vectors from $p = \beta_y y$ (CIYREA) and $p = \beta_a a + \beta_{cs} cs$ (CIACREA)



Source: own computations.

Chart A4: Share of non-tradable goods in total inflation



Source: own computations on Eurostat data.

Table A7: Pooled Mean Group Estimation, $p = \beta_a a$

	PWT 1950-2003	PWT 1960-2003	PWT 1975-2003	PWT 1960-2003 excl. GR,LU	Eurostat 1997-2006	Eurostat 1999-2006	Eurostat 1997-2006 excl. LU
LR							
a	.932**	1.26**	1.56**	1.28**	1.08**	1.11**	1.11**
	(8.10)	(8.96)	(8.11)	(8.92)	(5.93)	(6.44)	(6.26)
SR							
EC	-.147**	-.145**	-.163**	-.172**	-.283**	-.368**	-.281**
	(-3.23)	(-3.83)	(-3.38)	(-4.42)	(-3.31)	(-3.48)	(-3.01)
D.a	-.121*	-.214**	-.007	-.182**	.195	.050	.239
	(-1.85)	(-2.54)	(-.49)	(-2.04)	(.80)	(.16)	(.89)
half-life (years)	4.36	4.43	3.88	3.67	2.08	1.10	2.10
95% conf interval	0.71/1.16	0.99/1.54	1.19/1.94	1.00/1.57	0.73/1.44	0.77/1.44	0.76/1.46
Obs / year	603 / 52	517 / 44	348 / 29	429 / 44	114 / 10	94 / 8	104 / 10
Hausman		.74			1.73		
		(.390)			(.188)		

***, *** denote significance at the 5 and 10%.t-values in parenthesis. PWT: data from Penn World Table 6.2 (relative prices and productivities adjusted for purchasing power parities), Eurostat:*
data from Eurostat (relative prices and productivities not adjusted for purchasing power parities);
a: real GDP per worker (in PPP if PWT data) of each country relative to the euro area average,
EC: error correction coefficient; Hausmann test does not reject that the long-run cointegration coefficient is the same across all countries

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