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On price convergence in Eurozone*

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Abstract

We investigate price level convergence with Germany in eleven countries belonging to the Eurozone between January 1970 and July 2011. Relying on smooth transition regression models, we show that the price convergence process is nonlinear, depending on the size of the price differential: for most countries, price convergence occurs only when price differentials with Germany exceed a certain threshold. Moreover, our findings put forward some heterogeneity across the Eurozone members in terms of price convergence speed, that can be explained by the evolution of price-competitiveness, rigidities in labor markets, but also by specialization patterns.

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1 Introduction

One controversial criterion to enter the EMU is the convergence of inflation rates, which is based on the similarity of inflation rates rather than on a convergence in price levels. After the efforts made in 1996-1997 to reach EMU criteria, inflation rates have diverged within the Euro area.

Though part of it may be explained by the Balassa-Samuelson effect, this divergence has involved significant real interest rate differentials within the zone; some countries experiencing negative real interest rates that have encouraged debt bubbles. Fleming (1971) was the first to highlight the importance of price level convergence between members of a monetary union under the Optimum Currency Areas' theory. According to him, the main optimality criterion rests in the similarity of inflation rates between members: spreads of relative costs that are not offset by productivity gains lead immediately to a loss in competitiveness *via* a deterioration in terms of trade. In turn, this leads to a demand reallocation from "high inflation" countries to "low inflation" ones, generating external disequilibria between economies (deficits for high inflation countries and surpluses for low inflation countries). This risk did materialized in

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the Euro area between 1999 and 2009, with a number of higher inflation countries undergoing internal imbalances (excess leverage, asset price bubbles) and external deficits. After the sovereign debt crisis of 2009-2011, the question is whether these countries will manage in adjusting their price levels without the help of a nominal exchange rate devaluation, and how long this is going to take.

The literature dealing with price convergence primarily relies on the empirical verification of the Law Of One Price (LOOP) or the Purchasing Power Parity (PPP). Four main approaches can be distinguished. The first one tries to circumvent the problems inherent to incomplete microeconomic panels by focusing on a specific market. Goldberg and Verboven (2005) pay a special interest to the price dispersion on the car market in five European countries (Germany, Belgium, Italy, France and United Kingdom). The results show that there is price convergence that tends to validate the relative—and to a lesser extent the absolute—LOOP hypothesis. As the authors point out, however, it is difficult to extend this conclusion to other goods. Lutz (2003) achieves a comparable study based on the Big Mac indicator of *The Economist*, and on the price of five varieties of cars within the Eurozone. The results are at odds with those of Goldberg and Verboven (2005), since the introduction of the euro seems to have only little effect.[1]

The second approach consists in transforming microeconomic panels to obtain comparable individuals (see Engel and Rogers (2004), Crucini et al. (2005) and Rogers (2007)). Using the *Economic Intelligence Unit* database, Engle and Rogers (2004) and Rogers (2007) analyze the price of "standard" goods measured in 18 cities belonging to the Eurozone. The results are broadly similar in the sense that a reduction in price dispersion is found before the launch of the euro, during the implementation of the European Single Act (1986). Crucini et al. (2005) test the existence of LOOP by relying on the Eurostat database for four different years (1975, 1980, 1985, 1990), and also provide evidence of price convergence.

The third approach uses inflation rates differentials (see Honohan and Lane (2003) and Arnold and Verhoef (2004) among others). Beck and Weber (2005) show that the convergence process is nonlinear: adjustment speeds seem to decrease after the introduction of the euro. Moreover, they find that the dispersion of inflation rates decreases only before the introduction of the European currency.

Finally, the last approach is based on the Consumer Price Index (CPI). Camarero et al. (2000) tackle the price convergence between peripheral countries of the EU (Spain, Italy, United Kingdom) and Germany through time series unit root tests, and find evidence of a catching-up effect. Cecchetti et al. (2002) assess the price convergence between 19 US cities using panel unit root tests. According to Faber and Stockman (2009), as well as Crucini et al. (2005), CPI may be useful only for testing the relative PPP (convergence in inflation rates) and not the absolute PPP (convergence in price levels). Recalculating CPI that take into account price differentials between countries, Faber and Stockman (2009) find that price dispersion has decreased through time for countries belonging to Eurozone. Allington et al. (2005) rely on the Comparative Price Levels (CPL) supplied by Eurostat, and put forward a significant effect of the euro which leads to a reduction of price dispersion in EMU.

[1] These results are very questionable as there is only one observation after the introduction of the euro.

Falling in this latter approach, our aim in this paper is to investigate price convergence among twelve countries belonging to EMU. To this end, we consider monthly data over the January 1970 to July 2011 period. Relying on cointegration techniques, we show that the underlying linear hypothesis regarding the price convergence process may be viewed as too restrictive. To overcome this limit, we account for potential nonlinearities in the price adjustment process through the estimation of smooth transition regression models. These models allow us to put forward a different behavior of prices depending on whether price differentials are above or below a certain threshold. In other words, while price convergence may not be observed in a standard linear framework, it can be at play only when price differentials are important in terms of size. Furthermore, from the estimation of these models, it is possible to deduce mean-reversion speeds in the case of convergence.

The paper is organized as follows. Section 2 presents the data and some stylized facts. Section 3 reports the estimation results, and Section 4 discusses our findings. Finally, Section 5 concludes the paper.

2 Data and stylized facts

Testing price level convergence amounts to testing absolute PPP. Accordingly, we use the definition of "external" real exchange rate:

$$RER = NER.\frac{P^*}{P} \tag{1}$$

where RER is the real exchange rate, NER the nominal exchange rate (expressed as the number of domestic currency units per foreign currency unit), P the domestic price level, and P^* the foreign price level. Obviously, within a currency union, NER is equal to one since the currency is the same for all the members.

2.1 Data

Testing price convergence requires to select price series P and P^*. From a macroeconomic viewpoint, CPI is the key indicator. Although as an index it is useful to depict the evolution of prices (inflation), it gives no indication regarding the level of prices. CPI can thus not be used for testing the convergence of price levels. To overcome this issue, we rely on the International Comparison Program (ICP) carried by the World Bank that aims at providing comparable international prices. Based on this framework, Eurostat and OECD have computed Comparative Price Level (CPL) series for each European country. These CPLs are defined by the OECD as the ratio between purchasing power parity conversion factor for private consumption[2] and the nominal exchange rate. This ratio measures price level differences between two countries (in our case between a European country and the United States) and can be expressed as follows:

[2]Following the World Bank definition, the PPP conversion factor for private consumption is the number of units of a country's currency required to buy the same amount of goods and services in the domestic market as a US dollar would buy in the United States, the conversion factor being applicable to private consumption.

$$CPL_{i,t} = \frac{PPP_{i,t}}{NER_{i,t}} \times 100 \tag{2}$$

where $PPP_{i,t}$ stands for the PPP conversion factor for private final consumption of country i relative to the United States at time t, expressed in euros per US dollar, and $NER_{i,t}$ is the euro/dollar exchange rate at time t. Turning to data availability, CPLs are computed by Eurostat and OECD for each European country annually only since 1995. It is however possible to recover observations previous to 1995 using the price evolution relative to the US in each European country—i.e. using the relative CPIs corrected by the exchange rate variations. More specifically, we construct the monthly domestic price level series of country i on the period from January 1970 to July 2011 as follows:

$$P_{i,t} = \frac{PPP_{i,2005}}{NER_{i,2005}} \times \frac{\frac{CPI_{i,t}}{CPI_{i,2005}}}{\frac{NER_{i,t}}{NER_{i,2005}} \times \frac{CPI_{US,t}}{CPI_{US,2005}}} \times 100 \tag{3}$$

where $i = 1, ..., 12$ denotes the European country. $PPP_{i,2005}$ is the PPP for private consumption for country i relative to the US in 2005 (euros per US dollar). $CPI_{i,t}$, $CPI_{i,2005}$, $CPI_{US,t}$ and $CPI_{US,2005}$ are respectively the country i's CPI at time t and at year 2005, and the US CPI at time t and at year 2005. $NER_{i,2005}$ is the euro/dollar exchange rate in year 2005. 2005 has been chosen as the basis year because it corresponds to the year of the last ICP survey realized by the World Bank.[3] From Equation (3), we thus obtain 12 series of price levels that can be used to test for price convergence. Given the importance of Germany in the Eurozone, we retain this country as the benchmark, and investigate convergence between each domestic price level series and the German one.

2.2 Stylized facts

Figure 1 depicts German and domestic price levels (in logarithms) for each country over the period from January 1970 to July 2011. Price differentials and their evolution are quite different across countries during the period under study. Three groups can be distinguished. The first group is characterized by some price differentials at the beginning of the period that tend to fill over time. Countries such as Austria, the Netherlands, Belgium, France, Luxembourg, and Italy belong to this group. Within this group, some differences across countries have however to be mentioned. Austria and the Netherlands exhibit a similar pattern in the sense that price differentials with Germany tend to disappear at the end of the period—price level series being indeed very close in the 2000s. Belgium, France and Luxembourg experience some price differentials at the beginning of the period, that tend to be highly reduced after the implementation of the Single Act before exhibiting higher domestic price levels than Germany in the 2000s. Italy can be added to this first group of countries since its price differential with Germany, while being important at the beginning of the period, is also very weak in the 2000s. In the second group, made of Finland and Ireland, domestic prices are higher than the German price level most of the time. Important gaps are at play, that are not filled but tend to stabilize at the end of the period, specially for Finland. In the last

[3] PPP series are extracted from the OECD database. NER and CPI series are from IFS, except the German and the Irish CPIs that come from Datastream.

group, composed by Greece, Portugal, and Spain, important negative price differentials are at play, domestic prices being always lower than the German level. For these three countries, the price gaps tend to diminish across time, specially since the mid-1990s. Finally, all price series show a global upward trend and evidence of non-stationarity.

3 Testing price convergence: Empirical analysis

3.1 Cointegration analysis

To assess convergence between price series, we rely on unit root and cointegration techniques by estimating an ADF-type equation:[4]

$$\Delta x_t = k + \phi x_{t-1} + \sum_{i=1}^{p} \phi_i \Delta x_{t-i} + \epsilon_t \tag{4}$$

where x_t denotes the differential between domestic (P_t) and German (P_t^*) prices (in logs):

$$x_t = \ln P_t - \ln P_t^* \tag{5}$$

If the null hypothesis $\phi = 0$ in Equation (4) is rejected, the price differential is non-stationary, meaning that there is no price convergence. In the case where the null is rejected, it is possible to calculate the half-life of deviations ($-\ln(2)/\ln(1+\phi)$) which provides an indication regarding the speed of price mean reversion.

We divide our whole period into three sub-samples in order to account for the different steps of the EMU construction. The first period concerns the Common Market (established by the Rome Treaty in 1953) and ends in 1987 with the implementation of the Single Act. The latter defines the second period starting on July 1987 and ending in December 1998. The last period starts with the introduction of the euro in January 1999.

Results of cointegration tests are presented in Table 1 which displays the p-values relating to the ADF-type test[5] and the half-life of deviations (in years). With the exception of some few special cases,[6] there is no convergence at all since the tests fail to reject the null hypothesis of no cointegration between domestic and German prices. This absence of evidence of convergence may come from the assumption of linearity implicit in the ADF-type and Johansen tests, a hypothesis that may be too restrictive and strong. Even if economic integration of Eurozone members globally increased over time, some idiosyncratic characteristics remain (such as economic policy) that could prevent prices to converge at given times. However, this absence of convergence may be only temporary and dependent on the size of the price differential.

[4] Previous to the application of cointegration tests, a battery of unit root tests have been applied showing that all price series are integrated of order one. The detailed results are available upon request from the authors. Note that Equation (4) does not include a deterministic trend, the latter being non significant.

[5] Johansen (1988, 1991)'s tests have also been applied, leading to the same conclusions.

[6] At the 1% significance level, the null hypothesis of no cointegration is rejected for Portugal and Spain at the end of the period, and for Austria during the second sub-period. Note however that half-lives for Portugal and Spain are quite long, meaning that price convergence, when it exists, takes a long time.

Figure 1: **Price levels (in logarithms)**

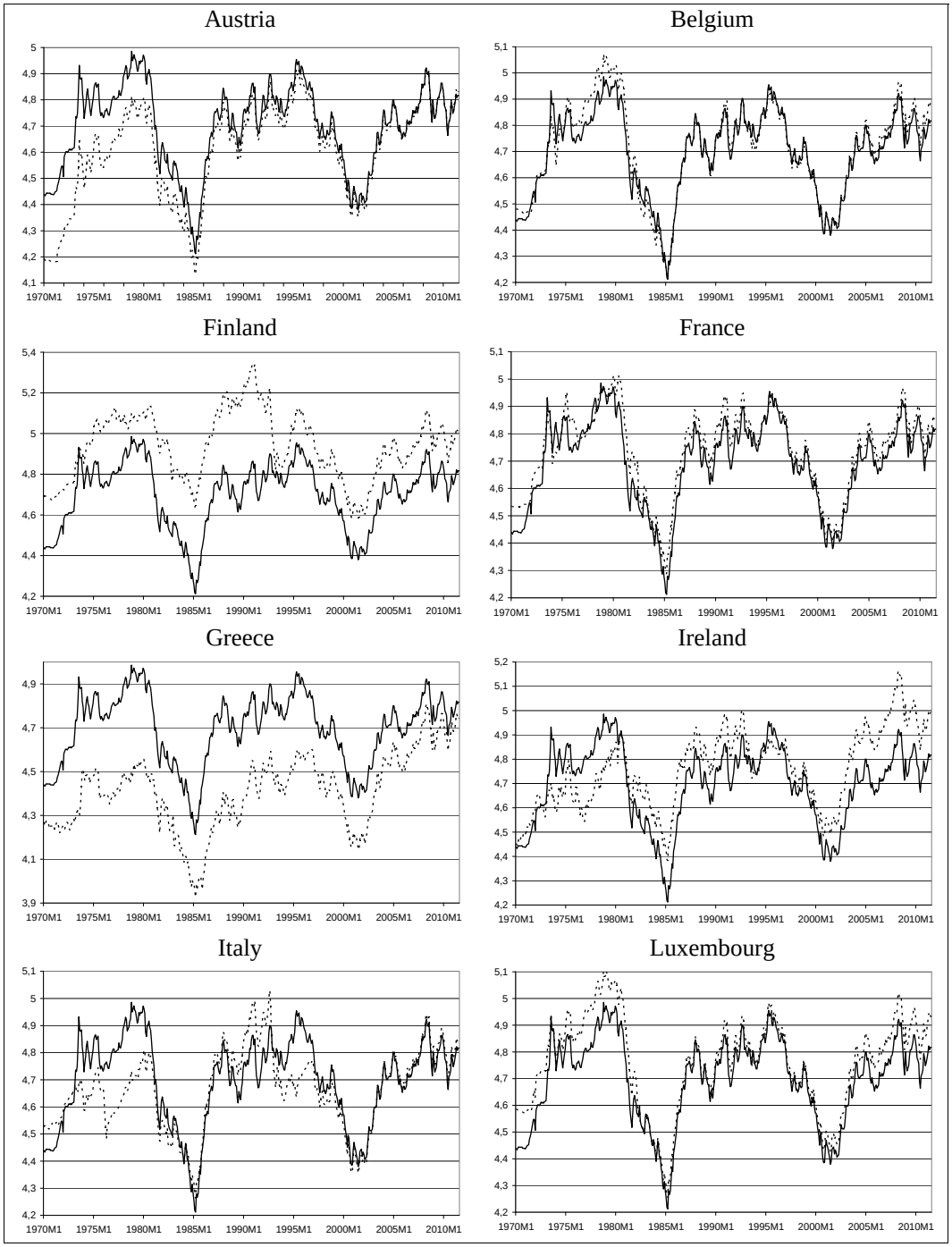
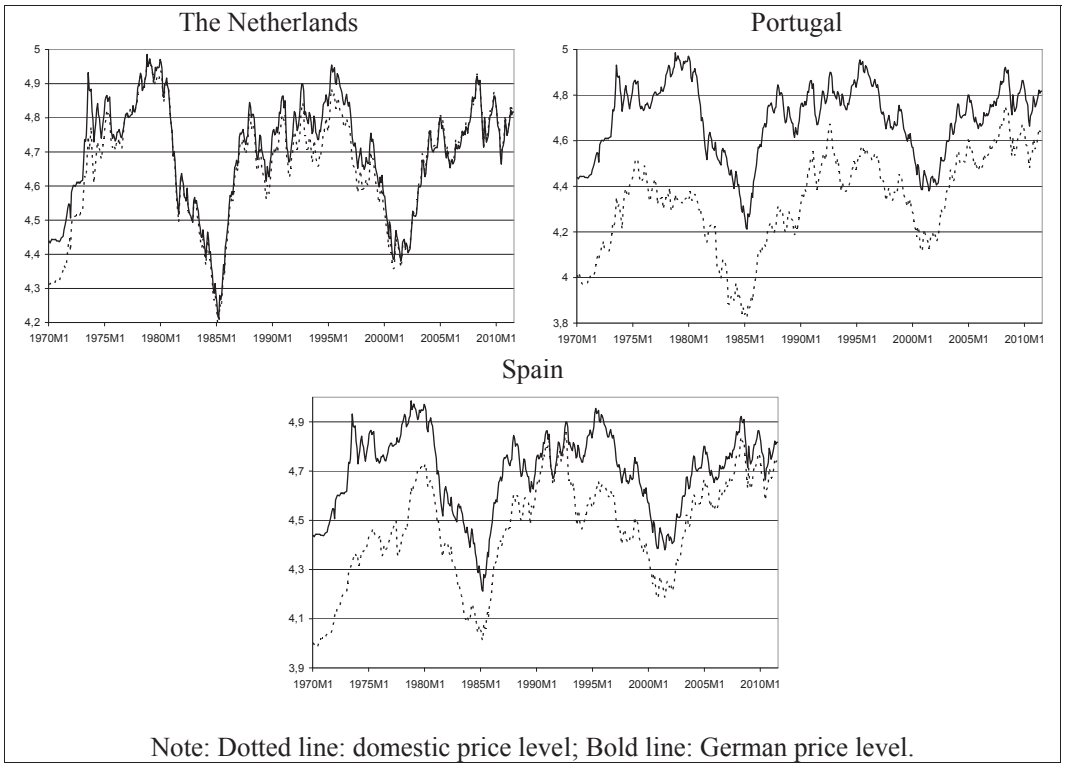


Figure 1: **(Continued) Price levels (in logarithms)**



Note: Dotted line: domestic price level; Bold line: German price level.

Table 1: Cointegration tests results

	1970.01-1987.06		1987.07-1998.12		1999.01-2011.07	
	p-value	Half-life	p-value	Half-life	p-value	Half-life
Austria	0.0700*	48	0.0001***	0.2	0.6677	
Belgium	0.3824		0.2513		0.8373	
Finland	0.7334		0.7609		0.1358	
France	0.0661*	2	0.5410		0.3531	
Greece	0.1180		0.5343		0.9717	
Ireland	0.6870		0.5132		0.1236	
Italy	0.3395		0.6533		0.1715	
Luxembourg	0.3450		0.1222		0.7061	
Netherlands	0.3198		0.3442		0.0969*	1.6
Portugal	0.1846		0.0402**	9.8	0.0050***	12.5
Spain	0.3441		0.6428		0.0008***	5.5

*** (resp. **, *): rejection of the null hypothesis of no cointegration at the 1% (resp. 5%, 10%) significance level. Half-lives are expressed in years.

Indeed, while convergence may not be observed for low price differentials, it can take place when domestic and German prices are highly different. In other words, it seems reasonable to think that convergence may occur only when the price differential exceeds a certain threshold since the loss of competitiveness, but also the regional commitments (such Maastricht treaty) exert a mean-reverting force. Domestic prices may thus depart from German prices until a given gap is overtaken, and the mean-reverting forces constrain members to adopt measures to ensure price convergence. This hypothesis will be tested in the next subsection, but the results of cointegration tests showing that convergence is observed for Portugal (for some sub-periods) which is typically characterized by important price differentials are consistent with our intuition.

3.2 Nonlinear analysis

To investigate the nonlinearity of the price convergence process, we proceed to the estimation of smooth transition regression (STR) models. These models are characterized by the existence of two regimes—corresponding respectively to low and high price differentials—the transition from one regime to the other being smooth and determined endogenously depending on the value of an observed, transition variable. They are particularly suitable for our purpose since they allow us to account for the fact that correction of disequilibria may be at play when price differentials exceed a certain threshold. More specifically, the STR specification is given by:

$$\begin{aligned} \Delta x_t = &\left[\alpha_1 + \beta_1 x_{t-1} + \sum_{i=1}^{p} \phi_{1i} \Delta x_{t-i}\right] \\ &+ \left[\alpha_2 + \beta_2 x_{t-1} + \sum_{i=1}^{p} \phi_{2i} \Delta x_{t-i}\right] \times F\left(\gamma, c; \Delta x_{t-d}\right) + \epsilon_t \end{aligned} \tag{6}$$

where ϵ_t is an i.i.d. process, Δx_{t-d} is the transition variable (d being an integer), and $F(\gamma, c; \Delta x_{t-d})$ is the transition function which is bounded between 0 and 1. c denotes the

threshold parameter, and γ is the slope parameter that determines the smoothness of the transition from one regime to the other. Two transition functions are commonly considered (Teräsvirta and Anderson (1992)):

- A logistic function (LSTR model):

$$F(\gamma, c; \Delta x_{t-d}) = (1 + exp(-\gamma(\Delta x_{t-d} - c)))^{-1} \tag{7}$$

- An exponential function (ESTR model):

$$F(\gamma, c; \Delta x_{t-d}) = 1 - exp(-\gamma(\Delta x_{t-d} - c)^2) \tag{8}$$

The LSTR specification accounts for asymmetric realizations: the two regimes are characterized by different dynamics, being associated with small and large values of the transition variable relative to the threshold value. In the ESTR specification, the two regimes have similar structures, but the middle grounds are characterized by different dynamics.

Following the sequential strategy developed by Teräsvirta (1994) for the specification of STR processes, we start by applying linearity tests using the lagged price differential as the transition variable.[7] The null of linearity is rejected in favor of the nonlinear alternative for all countries, but Finland. The LSTR alternative is retained for seven countries; France, Portugal and Spain being the countries for which the null hypothesis is rejected in favor of the ESTR alternative.

Table 2: Estimation results of STR models (whole sample)

	Model	β_1	β_2	$\beta_1 + \beta_2$	linear half-life	non-linear half-life	$\hat{c}_1$	$\hat{c}_2$
Austria	LSTR	-0.0012	-0.0130**	-0.0142		4.03	-0.0028	
Belgium	LSTR	-0.0124	-0.1527***	-0.1651		0.32	0.0141	
Finland			Null hypothesis of linearity not rejected					
France	ESTR	-0.0344***	-0.3061***	-0.3405	1.65	0.14	-0.0412	0.0251
Greece	LSTR	0.0818	-1.0155*	-0.9337		0.25	0.1567	
Ireland	LSTR	0.9063*	-0.9453*	-0.0389		1.45	-0.0762	
Italy	LSTR	-0.1801***	0.1706***	-0.0094	0.29	6.11	-0.0255	
Luxembourg	LSTR	-0.1094***	0.0953***	-0.0140	0.49	4.08	-0.0082	
Netherlands	LSTR	1.1419***	-1.1653***	-0.0233		2.45	-0.0233	
Portugal	ESTR	-0.0039	-0.3149***	-0.3189		0.15	-0.0501	0.0505
Spain	ESTR	-0.1380**	0.1685	0.1547	4.16		-0.0575	0.0589

*** (resp. **, *): significant at the 1% (resp. 5%, 10%) level. Half-lives are expressed in years.

Results in Table 2 put forward the interest of our nonlinear modelling: while results from standard tests globally revealed no evidence of price convergence, the findings from STR estimations show that this phenomenon is observed for all countries of our panel. Austria, Belgium, Greece, Ireland, the Netherlands and Portugal exhibit price convergence only in the nonlinear regime, whereas France, Italy and Luxembourg experience convergence in both linear and nonlinear regimes. The fact that price convergence is obtained for most countries

[7] The complete results are available upon request from the authors. Following Teräsvirta (1994), the number of lags for the transition variable has been selected by minimizing the p-values of the linearity tests.

in the nonlinear regime validates our previous hypothesis: the correction of disequilibria only takes place when price differentials exceed a certain level. The latter is given by the estimated value of the threshold parameter.[8] The value of $\hat{c}_1$ is quite heterogeneous accross countries. It is very low for Austria, confirming the graphical analysis (see Figure 1) showing very small price differentials between Austria and Germany. More generally, the value of $\hat{c}_1$ in the LSTR specification is lower for countries belonging to the first group of economies previously identified, varying between -2.55% for Italy to 1.41% for Belgium. Turning to Ireland, disequilibria are corrected only when price differentials are important, exceeding 7.62%, while Portuguese disequilibria are not corrected when price differentials are in the [-5%, 5%] interval. The case of Greece is particularly interesting since disequilibria are corrected only for (very) high values of the price differential, the estimated threshold value—close to 16%—being the largest of our sample of countries.

Mean-reversion speeds (or, equivalently, half-lives) are also quite heterogeneous across countries. More specifically, paying a special attention to the nonlinear regime, Belgium, France, Greece, and Portugal exhibit very fast convergence, i.e. half-lives below one year. In France, half-lives of deviations are lower in the nonlinear regime than in the linear one, indicating that corrections of disequilibria are more rapid when these deviations are high. Ireland and the Netherlands enhance a relatively fast convergence—with half-lives comprised between 1.45 and 2.45 years—while Austria, Luxembourg and Italy experience relatively low convergence (half-lives larger than 4 years) that goes against the PPP on the short run. Results concerning the mean-reversion speeds of Euroland core (Austria, Belgium, and France) are in line with the expectations. The rapid convergence speeds of peripheral countries, as Greece and Portugal, and to a lesser extent Ireland, is consistent with the current wisdom that these countries tend to converge too quickly in case of large deviations, a fact that may be linked to their fragile economic situations, specially for Greece (see below).

Finally, Finland is the only country that does not exhibit price convergence, confirming the long-lasting price differential observed in Figure 1. One possible explanation may come from the "Scandinavian model" involving that Finland's economic structures are quite different from those of Continental or Mediterranean countries, making this economy relatively more "independent" from the Eurozone than the other members. In other words, Finland may have experienced idiosyncratic economic fluctuations that are not correlated to the rest of the Eurozone, such as the banking crisis of the early 1990s. The entry in the European Union in 1995 and in EMU in 1999, may tend to erase this idiosyncrasy, increasing the correlation of the economy with the rest of the Eurozone. However, due to data availability issues, this long-run phenomenon is not caught by our study.

4 Analysis of the results

To explain and assess the relevance of the obtained mean-reversion speeds, we rely on the evolution of competitiveness in EMU. To this end, we (i) first review a panel of general

[8] Recall that, due to the non stationarity of the price differential, the transition variable x_{t-d} is expressed in first difference. Consequently, the value of the threshold parameter $\hat{c}_1$ in the LSTR specification should be interpreted in absolute terms, its sign depending on the sign of the price differential.

macroeconomic indicators that account for price-competitiveness, (ii) focus on labor market institutions since they may be the source of some rigidities that hamper price convergence, and (iii) then pay interest to the production patterns (specialization) because they partly determine non-cost competitiveness.

4.1 Price competitiveness

Price competitiveness can be simply defined as the capacity to defend or conquer market shares on domestic as well as on foreign markets by offering lower prices than competitors. One of the most important leverage of price-competitiveness is certainly productivity, as pointed out by Fleming (1971) when studying price convergence. However, several other indicators also exist, some of them being displayed in Table 3 together with productivity. The first four measures are real indicators and relate to the efficiency of production. The fifth indicator (current account) is a monetary indicator that allows to appraise the external competitiveness encompassing under/over-valuations of exchange rates. Finally, the last one is the productivity per hour in euros, which is a proxy of the productivity level.

Table 3: Macroeconomic indicators over 1987-1998 and 1999-2009

	Output growth		Productivity growth		Inflation		Unit labor cost growth		Current account		Productivity level
Period	87-98	99-09	87-98	99-09	87-98	99-09	87-98	99-09	87-98	99-09	2009
Austria	2.54	1.87	1.50	1.41	2.45	1.85	1.18	1.02	-2.75	1.65	38.1
Belgium	2.39	1.72	2.18	0.85	2.18	2.04	2.17	2.11	5.25	2.70	NA
Finland	2.20	2.26	3.12	1.59	3.04	1.61	2.01	2.16	4.75	5.90	39.1
France	2.21	1.61	2.30	1.21	2.31	1.61	1.19	1.79	2	0.49	45.6
Germany	2.51	0.95	2.48	1.09	2.45	1.46	1.80	0.61	-0.75	3.15	40.9
Greece	1.79	3.32	1.29	2,37	12.67	3.24	12.92	3.43	NA	-8.55	19.5
Ireland	6.30	4.33	4.53	2.91	2.57	2.69	1.47	2.76	2.25	-1.96	46.8
Italy	1.97	0.60	1.73	0.13	4.66	2.16	3.74	2.69	2.5	-1.25	31.4
Luxembourg	5.12	4.02	2.32	0.72	2.12	2.22	1.70	2.88	10.75	9.80	NA
Netherlands	3.09	1.86	1.88	0.98	1.95	2.06	1.38	2.42	5	5.10	45.2
Portugal	3.83	1.22	3.25	1.31	7.45	2.48	7.96	2.65	-4.25	-9.60	16
Spain	3.13	2.80	1.73	0.88	4.73	2.81	5.30	2.92	-0.25	-5.90	30
Average of the 12 countries	2.94	2.21	3.57	1.29	4.05	2.19	3.57	2.29	2.27	0.14	35.26

Source : OECD and Eurostat. This table reports the annual growth rates of GDP, productivity, unit labor cost, as well as the current account balances, the inflation rate and the productivity per hour in euros.

Focusing on the countries that belong to the core of the Eurozone, the evolution of the macroeconomic indicators between the periods 1987-1998 and 1999-2009 is mixed. In Austria, price-competitiveness has been preserved, while it has somewhat deteriorated in France and Belgium. Indeed, although all countries have experienced a decrease in the GDP as well as in the productivity growth rates, the fall is more marked in Belgium and France. Current accounts uphold this general picture with balances improved in Austria, and degraded in Belgium and France (even if they present surpluses indicating that they still are competitive). The Netherlands, the last country belonging to the core, is atypical. Despite showing fundamentals below the average in terms of output and productivity growth, inflation and unit labor costs, the Netherlands seems to be still price-competitive since it exhibits large current account surpluses

that tend to increase between the two periods, and also one of the highest productivity level of the zone.

Paying now attention to the peripheral countries, the situations of Greece, Ireland, Portugal and Spain are even more heterogeneous. The high GDP and productivity growth rates during the two periods markedly above the average of the zone, the increase of the costs (with inflation rates and unit labor costs slightly above the partners average) as well as the severe degradation of the current account denote a loss of price-competitiveness and are strong evidences that Ireland has experienced a Balassa-Samuelson catching-up phenomenon. The latter is moreover confirmed by the productivity level that is the highest of the Eurozone. Thereby, the relatively fast mean-reversion speed is not surprising. The case of the remaining countries is much controversial. In Greece, GDP and productivity growth rates are low and far under the Eurozone average in the first period, even if after 1999, there is a real improvement of these two indicators. However, the inflation level, the expansion of labor costs and the massive deficit of current accounts support the view that the convergence speed is too high for Greece. The convergence of prices is not due to an economic catching-up since the productivity level is far under the average of the zone, but rather to a tremendous loss of price-competitiveness. To a lesser extent, Portugal and Spain experience the same process. The productivity and GDP gains are not sustained enough within and between the two periods to evidence a Balassa-Samuelson effect, the productivity levels are low, especially for Portugal that enhances the lowest level of the panel. The pace of inflation and the increase in unit labor costs are much above the partners average. Moreover, current accounts exhibit deficits that boom in the second period, suggesting that the euro was probably overvalued for these two countries.

Concerning Italy, the indicators follow a downward slope. Economic performances are largely beyond that of the European average and have worsen between the two periods. Growth and productivity gains are apathetic, and even if inflation is controlled in the second period, it remains above or very close to the average, just as the unit labor cost. Moreover, the current account surplus of the first period turns to a deficit in the second period, and productivity level is below the average. In the light of these analyses, it appears that Italy has, just as Greece, Spain and Portugal, suffered from a harsh loss of price-competitiveness. The difference with the peripheral countries is that domestic price levels are higher, and the quite elevated half-lives previously found is consistent with the economic situation of the country.

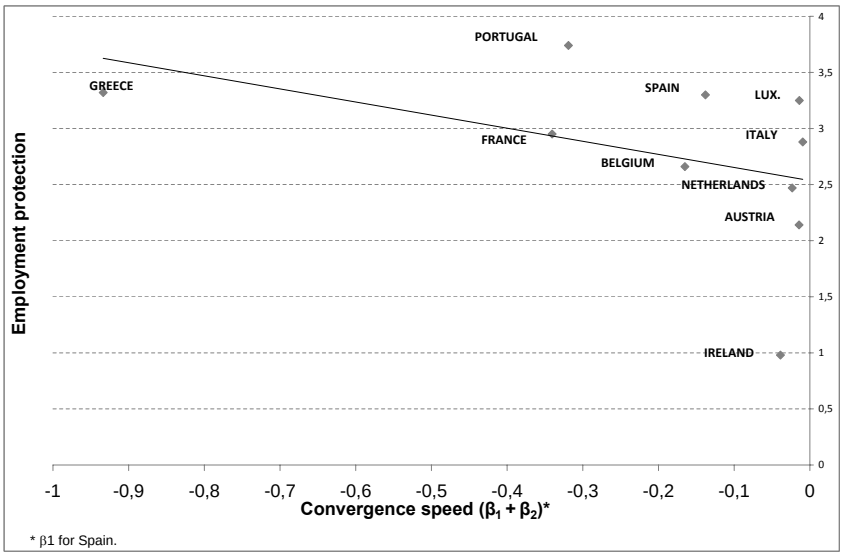
4.2 Labor market

Labor market institutions may also provide useful informations regarding competitiveness and convergence inside a monetary area. Indeed, in the tradition of the creative destruction literature (Schumpeter, 1942), Bartelsman and Doms (2000) and Lentz and Mortensen (2005) find evidence of a positive relationship between factor reallocation (especially labor) and productivity growth. Hence, labor market institutions that experience some rigidities as high levels of employment protection or high shares of long-term unemployment, may fail to fairly reallocate resources when innovations appear and technical progress is diffused within the economy, which in turn hampers productivity growth. Moreover, these kinds of rigidities are taken into account by companies when they decide to invest, and, other things being equal,

high rigidities may disincentive investments which restraints again innovation and technical progress diffusion. The case is particularly crucial for countries that have a low level of productivity and need technological transfers (through FDIs) to improve it, such as Greece or Portugal.

To investigate the relationship between labor market rigidities and convergence speed, we rely on the following indicators retrieved from the OECD database:[9] the level of employment protection (the higher the value, the higher the protection) displayed in Figure 2, the share of long-term unemployment in total unemployment, and the percentage of GDP devoted to programs of "active" unemployment policies (such as training, employment incentives, or supported employment) reported in Table 4.

Figure 2: **Employment protection (1985-2009 average) and convergence speed**



The employment protection indicator[10] is a synthetic index that *"measures the procedures and costs involved in dismissing individuals groups of workers and the procedures involved in hiring workers on fixed-term or temporary work agency contracts"* (OECD). According to Figure 2, three groups of countries can be distinguished. The first group includes countries that are characterized by high employment protection levels: Portugal, Greece, Luxembourg, and Spain. On the sole basis of this indicator, price convergence appears too fast in Portugal and, to a lesser extent, Spain and Luxembourg: the labor market fails to provide enough labor mobility to allow for price convergence without prejudicing productivity (and hence price-competitiveness). Greece is characterized by both a very high convergence speed and

[9]Except for Belgium for which data on employment protection were unavailable.

[10]The values for employment protection are the average on the 1985-2009 period, except for Luxembourg for which the 2009 value is considered.

low labor mobility, appearing as isolated from the rest of the countries regarding these statistics. In the second group, composed by Belgium, France, Italy, and the Netherlands, price convergence speeds seem to be consistent with the degree of employment protection: labor is mobile enough to maintain productivity growth, confirming the results found in Subsection 4.1. Finally, Austria and Ireland should have experienced a faster convergence speed given the labor rigidities.

Rigidities are a multidimensional phenomenon that cannot be approached only by a sole proxy. Variables listed in Table 4 aim at controlling the degree of reallocation from (i) the long-term unemployment share in the total unemployment, and (ii) policies favoring labor mobility. The interesting cases are those of Greece, Italy, Portugal and Spain. These countries are characterized by high long-term unemployment shares in the total unemployment (long-term unemployment is around or above 50% of total unemployment) combined with poor active programs destinated to improve mobility. With regard to employment protection, these countries suffer from a lack of labor mobility that harms their productivity.

Table 4: Long-term unemployment and active programs

	Share of long-term unemployment	Share of GDP dedicated to active programs
Austria	25.29%	0.48%
Belgium	53.50%	1.15%
France	38.87%	0.97%
Greece	51.92%	0.23%
Ireland	41.88%	0.97%
Italy	56.17%	0.51%
Luxembourg	27.76%	0.43%
Netherlands	38.96%	1.32%
Portugal	45.47%	0.51%
Spain	42.84%	0.66%

Source: OECD. The values are the averages of the period 1985-2009 except for active programs in the case of: Greece (1985-1997), Italy (2004-2009), and Luxembourg (2002-2009).

4.3 Specialization

Until now, we have only paid attention to price-competitiveness. There is however a second side in competitiveness that is likely to influence price levels: non-cost competitiveness. This kind of competitiveness consists for a producer in differentiating its products in order to evade market laws, and carry out a higher price than in perfect competition. At a country level, the main strategy is to specialize in high technological industries. The issue comes from heterogeneity in specialization among members of a single currency area, because there are two opposite price dynamics at play. On the one hand, countries specialized in low technology are rather the less advanced of the zone, and exhibit low price levels. They compete thanks to low prices and are very sensitive to costs increase and nominal exchange rate appreciation. On the other hand, countries specialized in high technological industries are the leaders of the zone and exhibit high price levels. Other things equal, they are less sensitive to costs increase and exchange rate appreciation. Since price convergence operates toward leaders' price levels, countries specialized in low technological industries have to "go upmarket" (i.e. specialize in

high tech industries), otherwise it entails a dramatic loss of price-competitiveness. This might be one of the explanation to the problems of EMU, in particular for Greece and Portugal.

Here, we aim at testing this hypothesis. It is however difficult to find measures of specialization. To overcome this issue, we construct a simple index of technological specialization on the basis of the revealed comparative advantages for the manufacturing CITI indicator (see Appendix 1 for the construction of the index). The underlying idea is that the technological content illustrates a non-cost competitiveness tendency.

Table 5: Technological specialization in 1987-1998 and 1999-2009

	Specialization	
Period	87-98	99-09
Austria	high technology	high technology
Belgium	medium technology	medium technology
Finland	high technology	high technology
France	high technology	high technology
Germany	superior technology	superior technology
Greece	low technology	low technology
Ireland	medium technology	medium technology
Italy	medium technology	medium technology
Luxembourg	NA	NA
Netherlands	high technology	high technology
Portugal	low technology	low technology
Spain	medium technology	medium technology

Source : OCDE. NA : non available.

Table 5 reports the technological specialization as well as the openness rate for each country during the periods 1987-1998 and 1999-2009. Again, we can classify the countries in different categories:

- Our benchmark country, Germany is specialized in industries with high technological contents: its products are innovative, or positioned on the high quality segment, which allows it to discriminate its prices.
- Austria, Finland, France, and the Netherlands own at equal shares high and medium technology industries. They have a lower market power than Germany, even if it remains substantial.
- Belgium, Ireland, Italy and Spain are mainly specialized in medium-technology sectors, and have very few high-tech industries. Moreover, low-technology sectors represent an important part of specialization in Spain and Italy.
- Greece and Portugal are mostly specialized in low-technology industries, facing a strong competition in prices.

The core of Eurozone (Austria, Belgium, France, the Netherlands, and Germany) is constituted by countries that are specialized in high-technology industries (except Belgium). It is interesting to notice that it surely might be thanks to its specialization that the Netherlands do not have experienced a greater loss of competitiveness. In contrast, Belgium succeeds to

maintain its competitiveness despite the lower technological content of its industries relative to the other core countries. Coming after these leaders, Ireland, Italy and Spain present medium technology industries. If Ireland is a special case due to strong evidence of a Balassa-Samuelson catching-up effect, Italy and Spain failed to evolve their industries to more technological contents, which has been detrimental to their competitiveness: the low mean-reversion speeds we found are then consistent. The case of Greece and Portugal is even more evocative: just as Italy and Spain, they failed to climb the technological ladder, but since they were below these latter, the loss of competitiveness is even greater, which supports the view that they are experiencing a too fast price convergence speed.

5 Conclusion

Very few studies analyze price convergence in the Eurozone despite the fact that this criterion conditions the optimality of any monetary union. To compensate for that lack, this paper investigates the convergence between price levels of twelve Eurozone members on the January 1970-July 2011 period. Relying on smooth transition regression (STR) models, we show that the price adjustment process is nonlinear, depending on the size of the price differential: for most countries, price convergence occurs only when price differentials across members exceed a certain threshold. Moreover, our findings put forward some heterogeneity across the Eurozone members in terms of price convergence speed, that we explain by relying on competitiveness indicators and countries' technological specialization patterns. The core group of countries composed by Austria, Belgium, France and the Netherlands is characterized by relatively high price convergence speeds relative to Germany, in line with their price-competitiveness indicators, their market labor structures, and their specializations in high-technology products. The high convergence speeds observed in peripheral countries, such as Greece and Portugal which are specialized in low-technology products, mainly come from their loss in price-competitiveness. Finally, our findings obtained for Ireland reflect that this country has experienced a Balassa-Samuelson catching-up phenomenon.

Appendix

The definition of the technological specialization is based on the revealed comparative advantages for trade micro-indicators in the manufacturing category (CITI database, available on OECD). Table 6 reports the sector associated to each number.

On the basis of the analysis of these indexes at a disaggregated level, we consider the following typology:

- Specialization in low technology sectors: indexes 15 to 21.
- Specialization in medium technology sectors: indexes 22 to 28 and 36.
- Specialization in high technology sectors: indexes 29 to 35.

Note that index 23 has a high technology industry, that of nuclear, in which only France is specialized. Accordingly, we consider that for France index 23 testifies a high technology specialization. In Table 7, we report for the two sub-periods the sectors in which countries are specialized.

Table 6: Definition of CITI indexes

Index	Definition
15	food products and beverages
16	tobacco products
17	textiles
18	wearing apparel ; dressing and dyeing of fur
19	dressing of leather ; luggage
20	woods and products of wood and cork (except furnitures)
21	paper and paper products
22	publishing, printing and reproduction of recorded media
23	coke, refined petroleum products and nuclear fuel
24	chemical products
25	rubber and plastic products
26	non metallic mineral products
27	basic metals
28	fabricated metal products (except machinery and equipments)
29	machinery and equipment n.e.c.
30	office, accounting and computing machinery
31	electrical machinery and apparatus n.e.c.
32	radio and television communication equipment
33	medical, precision and optical instruments
34	motor vehicles, trailers and semi-trailers
35	other transport equipment
36	furniture, manufacturing n.e.c.

Source : CITI, OECD.

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Table 7: Specialization of Eurozone members based on comparative revealed advantages

	Specialization	
Period	1987-1998	1999-2009
Austria	17, 19, 20, 21, 22, 25, 27, 28, 29, 31, 34, 36	15, 16, 19, 20, 21, 22, 25, 26, 27, 28, 29, 31, 34, 36
Belgium	15, 17, 23, 24, 25, 26, 27, 34	15, 17, 21, 23, 24, 25, 26, 27, 34
Finland	20, 21, 22, 27, 28, 29, 31, 32, 35, 36	20, 21, 22, 27, 28, 29, 31, 32, 35, 36
France	15, 22, 23, 24, 25, 26, 28, 31, 34, 35	15, 21, 22, 23, 24, 25, 26, 28, 29, 31, 33, 34, 35
Germany	21, 24, 25, 26, 29, 31, 33, 34, 35	16, 21, 24, 25, 29, 31, 33, 34, 35
Greece	15, 16, 17, 18, 26, 27	15, 16, 17, 18, 22, 25, 26, 27, 28
Ireland	15, 22, 24, 30	15, 22, 24, 30
Italy	17, 18, 19, 26, 28, 29	15, 17, 18, 19, 21, 26, 28, 29
Netherlands	16, 22, 23, 24, 25, 30, 33	16, 22, 23, 24, 30, 33
Portugal	15, 17, 18, 19, 20, 21, 26, 28, 31, 34, 36	15, 16, 17, 18, 19, 20, 21, 23, 26, 28, 31, 34, 36
Spain	15, 19, 23, 25, 26, 27, 28, 34	15, 19, 21, 23, 24, 25, 26, 27, 28, 34

Source: classification established by the authors on the basis of CITI and OECD data.

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