Producer Prices in the Transition to a Common Currency

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Abstract

This paper analyzes what happens to producer prices in the phase of transition from a national exchange rate regime to a monetary union. The focus of the paper is on the European Economic and Monetary Union (EMU). Stylized facts witness about an exploding gap between the lowest and highest producer-price inflation during the years immediately following the completion of the EMU in January 1999, opening up for many policy interpretations and worst-case scenarios for the cohesion of the European Union (EU). Our results point at three drivers of this producer-price development. Of the identified drivers, price convergence is important throughout the entire post-euro period (1999-2004), whereas for the other two drivers, productivity growth had its primary effect in the first years with the euro and effective exchange-rate changes in the later years of the post-euro period.

Keywords: producer prices, relative prices, price convergence, euro, Balassa-Samuelson.
JEL classifications: E31, E44, F15, F23, G34

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1. INTRODUCTION

Has the euro contributed to convergence in producer prices in the euro zone? An important argument behind the introduction of a common currency was that the euro would work as a vehicle for increased transparency and elimination of legal and institutional trade barriers. As part of this, the introduction of the euro was supposed to eliminate macroeconomic trade barriers (Obstfeld and Rogoff, 1995), or as expressed by the European Commission (2001) in an early ex-post review of the euro, "[t]he euro is a crucial component to the single market as it fosters competition and eliminates harmful exchange- and interest-rate friction" (ibid:8). The first few years with the euro have seen notably large spreads in producer-price inflation. Are they in line or at odds with the visions of increased price transparency, increased competition, and ensuing price convergence?

Between January 1999 and December 2005 (which we denote the post-euro period), Irish producer prices in the manufacturing sector rose by 1.0%, while Portuguese manufacturing producer prices rose by 39.0%.[1] In contrast, the period of economic convergence from the end of the crisis of the Exchange Rate Mechanism (ERM) to the introduction of the euro (the pre-euro period which we date from August 1993 to December 1998)[2] exhibited a dispersion of producer-price inflation in the manufacturing sectors of the eleven original euro countries of -1.9% (Finland) to 14.0% (Italy). Not only are the figures substantially smaller in this period, but exchange-rate changes also compensated the inflation

[1] For descriptions of data, see the next section.

[2] The floatation of the British pound, the Finnish markka, and the Italian lira in September 1992 marked the beginning of a period of large exchange-rate uncertainty that was not really resolved until the variation margins in the European Monetary System (EMS) was widened to ± 15% in early August 1993.

differences; expressed in ECUs inflation ranged from -0.3% (Austria) to 10.0% (Finland). The increasing dispersion in extreme developments is not an isolated observation; the standard deviation of producer-price changes among the eleven countries was 10.6% over the post-euro period, whereas it was 3.4% (in ECUs) over the pre-euro period.

These stylized facts admittedly only provide a piece of the puzzle towards understanding the impact of the euro – if any – on the behavior of manufacturing producer prices. Still, they suggest that relative producer-price developments have changed both in character and magnitude. This becomes even more obvious when compared to developments in consumer prices and unit labor costs. Consumer-price developments were more stable than producer prices in the post-euro period (s.d. 5.7% for changes in the harmonized index of consumer prices (HICP)), but at par with producer prices in the pre-euro period (s.d. 4.2%).[3] Unit labor cost developments, on the other hand, were as dispersed as producer prices in the post-euro period (s.d. 11.2%), but far more dispersed in the pre-euro period (s.d. 13.0%). It seems that pass through of labor costs to producer prices and of producer-price increases to consumers does not remain stable between these two periods. The question we ask is: can we make sense of the producer-price developments in the post-euro period?

1.1. Why investigate producer prices?

By introducing a common currency the monetary prerequisites for competition between companies and countries were supposed to become equalized. Success or failure in terms of increased price convergence would be most visible in the manufacturing sector due to its exposure to international competition. Producer prices play an essential role in the corporate decision-making (Oxelheim and Wihlborg, 2005) and by that for the overall economic

[3] CPIs and not HICPs were used between August 1993 and December 1994 for Germany, Ireland, and Luxembourg.

development of a country. Moreover, the manufacturing sector is more exposed to international trade than are consumer goods, thus constituting a better arena for evaluating the effect of the introduction of the euro on price developments. Nevertheless, producer-price inflation in connection with a common currency has received no or very little attention in published studies. Instead, prior research has focused on the impact of the euro on consumer prices.

Interpreting the stylized facts provided in the introduction, the Irish "euro" experienced 37.6% real depreciation relative to the Portuguese "euro" over the seven-year post-euro period *with a common currency*. Judging from this snapshot of price developments, Portuguese manufacturers could either have taken a severe blow from Irish competition (to the extent Irish and Portuguese manufacturers are actually competing), or have experienced the golden days of excess profits (from increasing output prices in less than perfect product markets). To add perspective, over the same period unit labor costs fell by 11.9% in Ireland and rose by 17.0% in Portugal. Part of the Portuguese price increases could thus be the result of cost-plus pricing, but there is an unexplained component that could either be a source of lost competitiveness or of increasing profitability. Production volumes supply further hints; Portuguese production rose by 6.7% over the post-euro period, compared to an increase of 71.3% in Ireland. Perhaps Portuguese manufacturers did not experienced excess profits, after all? Irish manufacturers, on the other hand, seem to have experienced a satisfying combination of growing production volumes, productivity increases, and profit margins.

1.2. Why might the euro influence producer-price developments?

If the euro increases price transparency, countries with initially low prices would, according to the law of one price (LOOP) experience relatively higher inflation than high-price countries during a transition period. This explanation implies that corporate managers suffer from money illusion arising from expressing prices in different currencies. Psychological

experiments by Mussweiler and Strack (2004) show that the euro was beneficial to consumers in this respect, but whether this is the case for corporate managers remains to be shown. From a producer viewpoint, reduction of money illusion reveals itself as reduced possibilities to price to market. There is a supply-side story here as well. Elimination of money illusion could result in producers redefining their home market from the domestic market to the euro market. Since pricing to market is positively related to the relative size of the foreign market, the result would be more uniform pricing across the euro zone (Knetter, 1993; Yang, 1998; von Furstenberg, 2003).

A common currency also contributes to price transparency by eliminating exchange-rate fluctuations. Exchange-rate fluctuations have been found to be detrimental to trade (see, for example, Goldberg and Knetter, 1997; Friberg, 2001). Given nominal price rigidities, elimination of fluctuations in nominal exchange rates reduces relative-price volatility. Stabilized relative prices can be expected to lead to price convergence, for at least two reasons. Firstly, studies have shown pricing to market to increase with exchange-rate volatility (see von Furstenberg, 2003 for a review). Secondly, exchange-rate stability may increase trade (Obstfeld and Rogoff, 2000; Rose, 2000), which in turn could reduce price differences (McCallum, 1995; Helliwell, 1996; Engel and Rogers, 1996). So far, experience seems to fulfill parts of these expectations. Barr, Breedon, and Miles (2003) and Micco, Stein, and Ordoñez (2002) find that the introduction of the euro increased trade within the euro zone by some 10-30% during the first three years of its existence.[4] This is a strong trade impact

[4] Barr et al (2003) refer the different results between the two studies to differences in sample periods; Barr et al, using data covering the period 1978-2002 find trade effects of the euro as early as in 1994, which they suggest could explain the smaller impacts found by Micco et al, who use data for 1992-2002.

from the monetary union compared to previous waves of economic integration in the EU (Midelfart, Overman, and Venables, 2003).[5]

A large literature has investigated economic convergence and found convincing evidence that low-productivity countries have the ability to grow faster than productivity leaders under certain conditions, in particular under trade liberalization (for example, Baumol, 1986; Sala-i-Martin, 1996; Rassekh, 1998). The inference is that trade impacts of the euro could be expected to promote further economic convergence within the euro zone. Canzoneri et al (2002) analyze productivity trends and real exchange rates in Europe between 1973 and 1997. They conclude that if productivity trends over this period were to continue in the post-euro period, euro-zone countries would exhibit trend CPI inflation between -1% and 2% from the EMU average. von Furstenberg (2003) discusses the potential for productivity-growth differentials in the euro zone at length and concludes that remaining catching-up potential when the euro was introduced could be expected to be a source of extra nontradables inflation.[6] In a Balassa-Samuelson world, countries experiencing high growth and accompanying productivity increases would experience wage-driven price increases in nontradables sectors. This would show up as real appreciation when calculating real exchange rates using aggregate price indexes. This would be reinforced if tastes are nonhomothetic and biased towards superior nontradables, because the increasing incomes that accompany the

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[5] For example, Bayoumi and Eichengreen (1995) estimate that trade among the founding members of the EEC grew 3.2% per annum faster than predicted by the gravity model between 1956 and 1973. The European Commission (1996) estimated that the single market increased intra-EU trade in manufactured products by 20-30% between 1985 and 1995.

[6] For a detailed exposition of productivity differentials in the manufacturing sector in the EU, see Inklaar, O'Mahony, Robinson, and Timmer, 2003.

catching-up process would lead to a demand-driven upward pressure on nontradables prices (Neary, 1988; Bergstrand, 1991; MacDonald and Wójcik, 2004).

The composition of the euro basket differs from each member country's effective, trade-weighted exchange rate. This means that a given change of the euro affects prices differently in the member countries (Honohan and Lane, 2003).[7] Even if absolute purchasing power parity were to hold perfectly for each country we would see differential inflation rates due to differing levels of import inflation, as long as product baskets used to measure relative price levels differ.

To summarize our euro story, increased price transparency, elimination of exchange-rate fluctuations and ensuing increases in trade and economic convergence could be expected to lead to converging price levels. This would show up as divergent inflation rates during the convergence period. On the other hand, differential imports of inflation could lead to differential – not necessarily converging – price developments, which would show up as divergent inflation rates in periods of asymmetric economic developments. The sources of dispersion of producer-price developments are of importance to corporate competitiveness. Inflation differentials stemming from price convergence would be harmful to competitiveness, with producers in previously segmented high-price markets would suffer from low-price competition. By contrast, a rise in inflation stemming from economic convergence would be neutral to the extent that it only derives from price increases of nontradables.

[7] Honohan and Lane (2003) show, for the years 2000-2001, that non-EMU imports as a percentage of total imports varied from 26% in Luxembourg to 79% in Ireland (the euro-zone average (standard deviation) was 49% (15%)).

1.3. Findings in prior research

A handful of studies have investigated the impact of the euro on consumer prices. Engel and Rogers (2004) find large reductions in price dispersions across countries between 1990 and 1994, especially for tradables, but small significant increases in price dispersion between 1998 and 2003. Isgut (2004) and Parsley and Wei (2001) show that sharing currency significantly reduces price dispersion, whereas belonging to the same regional trading area does not. Isgut (2004) finds the effect of the euro *per se* in reducing price dispersion to be significant. Goldberg and Verboven (2004 and 2005) study the impact of the euro on car prices and find a small but significant decline of price differentials in the euro zone after the euro was introduced. Beck and Weber (2001) find that the importance of borders on relative-price volatility has decreased substantially after the euro, though they still remain significant, whereas Foad (2005) finds that the importance of borders has not changed after the euro.

A few studies have instead modeled the impact of the euro on real exchange rate developments in the euro zone. Koedijk, Tims, and van Dijk (2004) find evidence of mean reversion of real exchange rates for a sample of nine euro-zone countries after 1992. The introduction of the euro did not increase the speed of mean reversion, however. They conclude that half-lifes (speed of convergence) differ across countries. Gadea, Montañés, and Reyes (2004) investigate real exchange rates of the euro countries against the dollar and find support for purchasing power parity (PPP) during the post-Bretton-Woods period up to 1996; when extending the period up to 2001, they fail to find support for PPP. Anotucci and Girardi (2006), using error-correction modeling of PPP and find the EMU, with the exception of Spain and Ireland, to be an integrated area. They fail to find any impact of the euro.

Sinn and Reutter (2000) and von Furstenberg (2003) conclude, for consumer prices, that the B-S effect is an important driving force behind observed relative-price changes in Europe. Engel and Rogers (2004) find a more pronounced price convergence for nontradables than

tradables in the early 1990s, which they interpret as a result of real-income convergence rather than reductions in restrictions in trade. Their empirical testing does not provide support for this interpretation, however. Isgut (2004) and Rogers (2002) find a positive relationship between GDP per capita dispersion and price dispersion, as suggested by B-S. Rogers (ibid) finds a negative relationship between productivity growth and annual inflation, whereas Honohan and Lane (2003) find no relationship. Honohan and Lane (ibid) further show that the average euro-zone consumer-price inflation rate, as well as the inflation rates of the individual euro-zone countries, closely follows movements in the USD/EUR rate.

1.4. Our findings

We find strong support for price convergence, even after controlling for other factors influencing producer prices. Price convergence is equally strong before and after the introduction of the euro and we do thus not find any specific "euro effect" on prices. We also find productivity growth and changes in the effective, trade-weighted "national" euro to influence prices. The impact of the trade-weighted euro is particularly emphasized during the period of strong euro appreciation experienced during 2001-2004.

The paper is organized as follows. In Section 2 we present stylized facts about the relative producer-price developments 1993-2005. In Section 3, we perform our empirical testing of price convergence and the impact of other potential explanatory factors. We also present the methods used. We analyze our results in Section 4, whereas Section 5 provides concluding remarks and assesses the policy implications of our findings.

2. PRELIMINARY DATA ANALYSIS

2.1. Data

We investigate developments in producer prices for the manufacturing sector (industry category D, ISIC revision 3), using data from OECD *Main Economic Indicators*, Database (vol 2005, release 02, series 045K) for ten of the eleven (excl Luxembourg) original euro countries.[8] A key issue when investigating price convergence is access to comparable price-level data. To be completely comparable, the composition of producer-price indices for different countries should be harmonized so as to measure price developments of the same goods and services. Unfortunately, harmonized producer-price indices do not exist, which means that the indices we use are not completely comparable across countries. This is the major weakness of studies of producer prices – and that one has to accept in – all studies of producer prices, and it is similar to the problems faced in studies of consumer prices not using harmonized price indexes. Still, manufacturing producer prices are commonly used as proxies for prices of tradable goods (see, for example, Alterman, 1997).

To the best of our knowledge, the only large-scale producer-price level dataset available is the University of Groningen *International Comparisons of Output and Productivity* (ICOP)

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[8] The target series for producer prices is producer price indexes (PPI) for manufacturing. Austria has not produced a PPI series for the entire study period and the OECD uses a wholesale price index as a proxy. Austria, Italy, and Spain produce PPIs that have a broader coverage than only manufacturing (the following series are used by the OECD as proxies: Austria: wholesale prices – all products; Italy and Spain: producer prices – mining, manufacturing, electricity, gas, and water supply). We have prices series for the entire study period for all countries except Italy (data from January 1981) and Portugal (from January 1990). The euro did not exist before January 1999, which requires specifying a synthetic euro before that. We follow Eurostat in using the ECU as our synthetic euro, using data from Eurostat's *NewCronos* Database (table EURER_MO, series Euro/ECU exchange rates - monthly averages).

Database. It provides unit value ratios (UVRs) for the manufacturing sector. UVRs are bilateral purchasing power parities relative to the US for manufacturing outputs, calculated on matched (relative to the US) samples of products, with the sample of products varying between country pairs. The number of sample products is relatively small, generally about a few hundred, and covers only about 20% of manufactured output (van Ark, 1993). Still, they tend to be representative of manufacturing producer prices (O'Mahony, 1996). UVRs have been used extensively in productivity comparisons, not least in the extensive analysis of EU productivity and competitiveness published by the DG Enterprise of the European Commission in 2003 as part of their program on analysis of competitiveness (O'Mahony and van Ark, 2003). UVRs are for 1997 and expressed in ECU, and we bring them forward and backward using each country's monthly manufacturing PPI (expressed in ECU in the pre-euro period) relative to the country's average PPI for 1997. Data is missing for Luxembourg, why we have to exclude this country from the testing.

Table 1 presents relative UVRs a for original euro country (excl Luxembourg) relative to Germany. For comparison we also include relative unit labor costs (ULC), relative hourly compensation costs (HCC), and expenditure PPPs. As can be seen, relative price levels differ quite extensively depending on which price measure that is used; correlations range from 0.00 (UVR and ULC) to 0.74 (UVR and EPPP). The complete lack of correlation between UVRs and ULCs is perhaps most fascinating. It suggests a complete lack of relationship between price levels and labor costs. The correlation between UVR and HCC is much higher, 0.55, which suggests that price levels rather reflect actual than productivity-adjusted labor costs. The correlation between UVR and EPPP is also high, 0.74, showing a close correlation between output prices in the manufacturing sector and sales prices to consumers.

Table 1 Relative price levels in the Euro zone, 1997

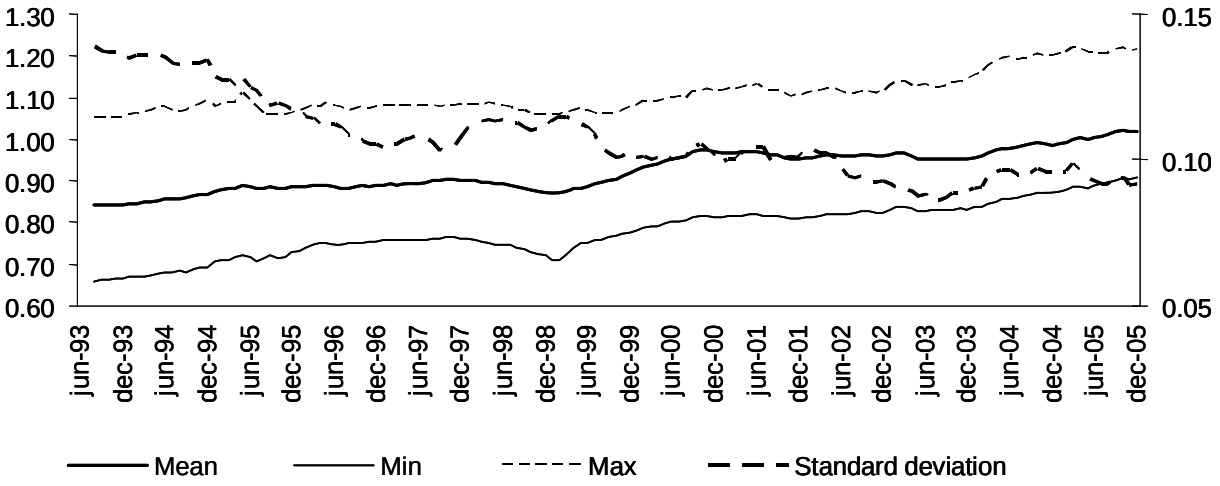
	UVR	*ULC*	*HCC*	*EPPP*
Austria	1.10	0.87	0.84	0.96
Belgium	0.90	0.85	0.86	0.90
Finland	0.94	0.77	0.90	1.01
France	0.97	0.85	0.83	0.99
Germany	1.00	1.00	0.66	1.00
Ireland	0.99	0.48	1.00	0.88
Italy	0.78	0.78	0.35	0.83
Netherlands	0.91	0.80	0.53	0.90
Portugal	0.80	0.81	0.62	0.60
Spain	0.77	0.86	0.76	0.75

Note: The table shows relative price levels for the euro zone members (excl Luxembourg) vs Germany for the year 1997. Relative UVRs are calculated from bilateral UVRs vis-à-vis the US. Relative unit labor costs (ULC) are calculated as labor compensation of employees in the manufacturing sector divided by value added at current prices in ECU. HCC is relative hourly compensation costs in the manufacturing sector. Expenditure PPPs are cross-rated from EPPPs vs the US.

Sources: UVRs from the University of Groningen *International Comparisons of Output and Productivity* database, labor compensation of employees and value added at current prices from the OECD *STAN Structural Analysis* database (tables LABR and VALU), HCCs from the US Bureau of Labor Statistics report *Hourly Compensation Costs for Production Workers in Manufacturing, 32 Countries or Areas, 22 Manufacturing Industries, 1992-2004*, and EPPPs from OECD *Economic Outlook* database.

The price divergences exhibited in the table as of 1997 might seem strange, given the political negotiations preceding the introduction of the euro. However, it seems to be common practice by countries opting for fixed exchange rates to choose fixings at undervalued rates (von Furstenberg, 2003; Halpern and Wyplosz, 1997; Oxelheim, 1990, 1996). As stated by von Furstenberg (2003:523), "[j]oining a multilateral monetary union, such as EMU, at an intentionally biased exchange rate is far more difficult and group-constrained than building in an initial bias when fixing the exchange rate unilaterally. Yet, small developing countries appear to have been given some leeway with regard to the choice of entry rate, even though multilateral negotiations were required."

Figure 1 Dispersion in producer prices, August 1993 to December 2005



Note: The table shows minimum, mean, and maximum producer prices in EUR (ECU before 1999) in the euro zone (all original members excl Luxembourg) rebased on UVRs for 1997 (left axis). It also shows the standard deviation of price levels (right axis) across the ten investigated countries.

Sources: Own calculations on data from University of Groningen *International Comparisons of Output and Productivity* database, SourceOECD *Main Economic Indicators* Database (vol 2005, release 02, series 045K), and Eurostat's *NewCronos* Database (table EURER_MO, series Euro/ECU exchange rates - monthly data, period averages).

2.2. Descriptives

Figure 1 and Table 2 report dispersion in producer prices in EUR (ECU before 1999) for the euro-zone countries in the pre- and post-euro periods using UVRs to define the average price level in 1997. The diagram shows the maximum, minimum, and average price level (left axis) and standard deviation of price levels (right axis). The spread between highest and lowest prices remain fairly constant in absolute terms over the pre- and post-euro periods; in relative terms, the minimum price level increases from 63% to 74% of the maximum price level. This is one indication of converging prices. During the same time, the standard deviation falls from 14% to 9%. This suggests that the euro countries have experienced σ-convergence. Much of the convergence, both in terms of reduced maximum spread and dispersion took place during the pre-euro period (the minimum price level was 68% of the maximum in December 1998 and the dispersion was 11%).

Table 2 Cumulative change in producer prices in the pre- and post-euro periods, August 1993 to December 2005

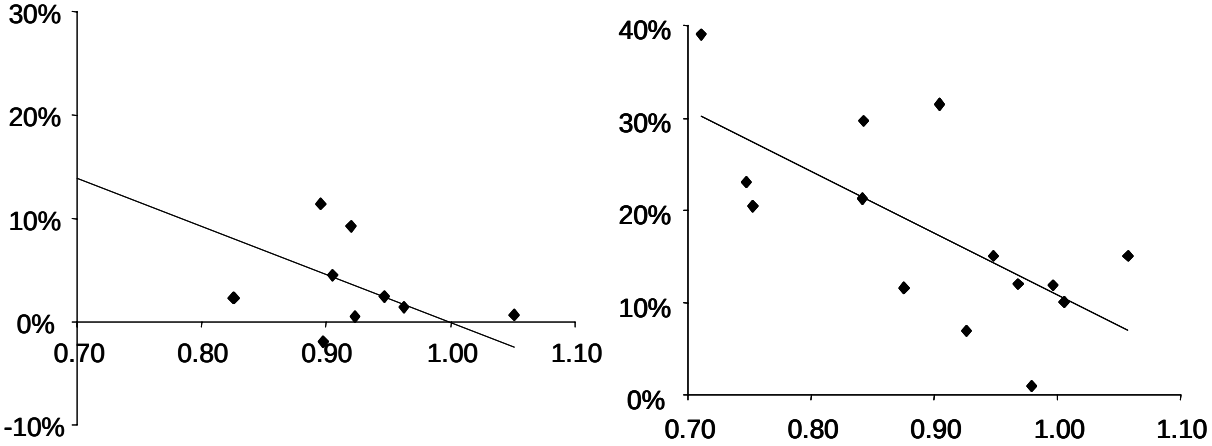
Austria	15.0% (-1.2%)	Ireland	1.0% (4.9%)
Belgium	21.3% (3.2%)	Italy	20.4% (7.0%)
Finland	11.6% (9.0%)	Netherlands	29.6% (0.2%)
France	6.9% (2.9%)	Portugal	39.0% (6.6%)
Germany	12.0% (0.6%)	Spain	23.1% (5.2%)
Denmark	1.6% (10.0%)	Sweden	-4.9% (7.8%)
Greece	24.9% (9.8%)	UK	0.6% (18.3%)

Note: The table shows annualized cumulative producer-price changes in the EU countries over the pre- (in parenthesis) and post-euro periods.
Sources: Own calculations on data from SourceOECD *Main Economic Indicators* Database (vol 2005, release 02, series 045K) and Eurostat's *NewCronos* Database (table EURER_MO, series Euro/ECU exchange rates - monthly data, period averages).

Turning to individual countries in the post-euro period, the Portuguese-Irish divergence in producer-price inflation discussed in the introduction is extreme, but many bilateral relative-price changes have been large during the post-euro period. The two countries with the second largest and smallest price increases were the Netherlands (cumulative price increase of 29.6%) and France (6.9%). This divergence amounts to a 21.2% real depreciation of the "French euro" to the "Dutch euro", or 2.8% per annum. Figure 1 also shows that in the early post-euro period, prices rose sharply in most countries. In fact, annual price changes reached levels not seen since the early 1980s. This early period of price increases lasted between 1.5-2 years. From then on, prices have been more stable (though with a slight increase in inflation towards the end of the sample period); annual inflation rates observed during 2001-2003 fell to historically low levels, comparable to rates seen just prior to the introduction of the euro.

Figure 1 Relationships between cumulative price changes and initial price levels

Panel A August 1993 – December 1998 **Panel B January 1999 – December 2005**



Note: X-axis: initial price level; Y-axis: cumulative producer-price change in the manufacturing sector.
Source: Producer prices are from the SourceOECD *Main Economic Indicators* Database; price levels (UVRs) from the University of Groningen *ICOP* Database.

The post-euro price behavior stands in stark contrast to the pre-euro price behavior. It was during this period, after the ERM crisis had settled and the treaty on Economic and Monetary Union (EMU) had entered into force, that the economic convergence stipulated as a requirement for EMU membership reached the top of the priority lists of politicians in the EU. The period was characterized by economic convergence in the run-up to the EMU and inflation rates were low and fairly stable. During this convergence period, the maximum spread in cumulative producer-price changes, in local currency, was 16%. Due to accommodating exchange-rate changes, the maximum spread in producer-price changes, when expressed in EUR, was only 10%, reflecting an effective price decrease of 0.3% in Austria and an effective price increase of 10.0% in Finland. This amounts to a real appreciation of the Austrian schilling relative to the markka of 10.3%, or 1.8% per annum.

Figure 2 shows the bivariate relationships between cumulative price changes over the pre- (Panel A) and post-euro (Panel B) periods and the initial price levels as of August 1993 and January 1999. In both panels, we see negative correlation between the initial price level

and subsequent price changes. Producer prices have tended to converge over both periods, with countries with the lowest initial price levels having experienced the largest price increases. Also, the downward slope of the trend line for the post-euro period is greater than for the pre-euro period, which is to be expected if the euro resulted in increased price convergence.

To summarize, producer-price inflation shows considerable swings. Still, we find relative producer-price development after the introduction of the euro of a kind contrasting to the expectations formed by the EU view on the role of the euro in elimination of barriers to competition.

3. EMPIRICAL ANALYSIS

3.1. Methods

The main approaches to convergence analysis are absolute and conditional β-convergence and σ-convergence (see Sala-i-Martin (1996) for a detailed exposition). Absolute β-convergence prevails when low-price countries tend to experience higher inflation than high-price countries and the trend is towards complete elimination of any price differences. Let $\pi_{i,t,t+T} \equiv \log(p_{i\,t+T}/p_{i,t})/T$ be country i's annualized cumulative inflation rate between t and $t+T$, and let $\log(p_{i,t})$ be the logarithm of the country's price level at time t. We can then test for absolute β-convergence using a cross-sectional regression,

$$\pi_{i,t,t+T} = a + b\log(p_{i,t}) + \varepsilon_{i,t,t+T} \tag{1}$$

where $b < 0$ will be an indication of absolute β-convergence. The speed of convergence is then given by $|\beta|$ in $b = (1 - e^{-\beta T})/T$. β can also be estimated directly using nonlinear least squares,

$$\pi_{i,t,t+T} = a + \left(1 - e^{-\beta T}\right)/T \log(p_{i,t}) + \varepsilon_{i,t,t+T} \tag{1'}$$

where T is the length of the sample period in years. This will in addition yield standard errors for the speed of convergence.

One weakness of absolute β-convergence is its implicit assumption that all countries converge to the same price level. This is highly implausible, given that we are considering prices of traded and non-traded goods and services. For example, in a Balassa-Samuelson world, a country experiencing high growth would see its price level increasing, even if prices of tradables are completely converged. This means that we would expect different countries to be converging at different price levels. A more complete specification of convergence requires controlling for factors influencing the price level but not contributing to complete price convergence. This is the concept of conditional β-convergence. We test this by estimating

$$\pi_{i,t,t+T} = a + b\log\left(p_{i,t}\right) + \boldsymbol{\gamma}\mathbf{X}_{i,t} + \varepsilon_{i,t,t+T} \tag{2}$$

where $\mathbf{X}_{i,t}$ is a set of control variables. If $b < 0$ even after controlling for $\mathbf{X}$, we see evidence of conditional β-convergence. This is, with some variations in the exact specification, the methodology employed by most prior studies of convergence in consumer prices (see, for example, Honohan and Lane, 2003; Engel and Rogers, 2004).

Employing (1) or (2) on the euro zone means having to work with small samples and being forced to use non-parametric regressions. An alternative is to use a panel-data approach, which combines cross-sectional and time-series data. This means that the measurement period T is shortened to allow multiple observations, which will add noise to the price processes. On the upside, the power of the testing will be increased through more observations. An advantage of using a panel is that we can allow for influences of non-convergence control factors in the form of unobservable individual country effects. This allows controlling for unspecified structural differences in price setting across the investigated countries.

A second weakness of β-convergence, and one that is shared by absolute and conditional convergence, is that all countries are assumed to converge at the same rate. This can be avoided by estimating (1) and (2) on time-series data individually for each country. Individual estimation (which in effect would be a unit-root test) requires data at higher frequency (monthly or quarterly data), which introduces more noise into the modeling. Also, it does not exploit the cross-sectional dependence between individual countries' price levels. An alternative is to use seemingly unrelated regressions, which will explicitly take into consideration cross-sectional correlations among price series. Unfortunately, this will also greatly increase the number of parameters estimated, which will be detrimental to the power of the testing (Koedijk, Tims, and van Dijk, 2004).

A third commonly used convergence measure is σ-convergence. It measures the dispersion of price levels in a group of countries. Price levels are converging if

$$\sigma_{t+T} < \sigma_t \tag{3}$$

where σ_t is the time t standard deviation of log ($p_{i,t}$) across i. Countries will exhibit σ-convergence if they also exhibit absolute β-convergence; the opposite causality does not hold, though. Developments in price dispersion exhibited in Figure 1 suggest that the euro countries have experienced σ-convergence. Several prior studies of consumer-price convergence have used an extension of this specification to test gravity models (or conditional σ-convergence models), where distance is tested as a determinant of price dispersion (see, for example, Engel and Rogers, 1996; Parsley and Wei, 2001).

3.2. Absolute β-convergence

To evaluate absolute β-convergence, we estimate (1) (or (1')) over the full period and the two sub- (pre- and post-) periods. Results are reported in Table 3. Since we are looking at cumulative price changes over the entire post-euro period in the original euro zone countries we are left with only ten observations. To avoid bias from outliers in so small a sample, we

Table 3 Absolute β-convergence in the euro zone

	93:8 – 05:12			99:1 – 05:12			93:8 – 98:12		
	(a) OLS	(b) Rank	(c) Panel	(a) OLS	(b) Rank	(c) Panel	(a) OLS	(b) Rank	(c) Panel
b		-0.82 (-4.02)***	-0.13 (-2.63)***		-0.76 (-3.28)***	-0.39 (-4.99)***		-0.68 (-2.66)**	-0.65 (-6.75)***
β	-0.040 (-6.32)***			-0.061 (-3.89)***			-0.042 (-5.99)***		
SE regr	0.01	1.85	0.03	0.07	2.10	0.03	0.00	2.34	0.02
Adj R^2	0.73	0.63	0.05	0.50	0.52	0.27	0.75	0.40	0.47

Note: *, **, *** denote significance at the 10, 5, and 1% levels; *t*-statistics in parenthesis. Columns (a) contain nonlinear least squares estimates of (1'), Columns (b) robust rank-OLS estimates of (1), and Columns (c) panel OLS estimates of (1) on yearly data allowing for fixed country effects.
Source: Producer prices are from the SourceOECD *Main Economic Indicators* Database; price levels (UVRs) from the University of Groningen *ICOP* Database.

make robust estimations as a complement to ordinary OLS. Columns (a) present estimates of (1') using OLS, while Columns (b) present estimates of (1) using OLS on ranked data. Rank-based estimations have the advantage of being distribution free and not sensitive to outliers, but are on the other hand only considering rankings of observations and not the full information set.

Irrespective of method used, manufacturing producer prices exhibit absolute β-convergence; all convergence parameters are significant both over the full period and in each sub-period. Using the OLS coefficient, the speed of convergence was about 4% per year over the full sample period, 6%% per year in the pre-euro period, and 4% per year in the post-euro period. The convergence rate thus seems to have been fairly constant before and after the introduction of the euro.

For robustness, we perform two alternative robust estimations, (*i*) robust nonparametric rank-based regressions of (1) based on the Wilcoxon score function, with intercepts estimated by the median of the residuals and (*ii*) least-absolute-deviations regressions of (1). The least-

absolute-deviations estimations are parametric, but use the absolute value rather than the square of the residuals and are by that less sensitive to outliers than OLS. The results of both approaches confirm the results in Table 3, with all βs being highly significant.[9]

To increase the power of the testing, we increase the number of observations by using panels of yearly observations (T = 1 year) across all ten countries. Results of the panel regressions are reported in Columns (c). Using a panel increases the number of observations for each country, but also introduces more noise. Given the small size of our cross-section and the general lack of power in robust estimation, the increase in number of observations dominates. The conclusions are the same as for the long-low-frequency estimates in Columns (a) and (b) with significant convergence in both the full period and the two sub-periods. In the panel estimations, we control for fixed country effects. In the full sample, this does not add any explanatory value; the adjusted R^2 is even smaller after controlling for fixed country effects. In the two sub-periods the effect is much more marked with substantial increases in adjusted R^2s and larger coefficient estimates. The levels of significance of estimated coefficients are not influenced, however. Controlling for fixed time effects (that is, controlling for unspecified structural yearly differences) increases adjusted R^2 in all samples, but yields nearly identical coefficients and levels of significance.

3.3. Conditional β-convergence

We find strong evidence of absolute β-convergence. These tests do not control for other factors influencing price levels, however. To allow for a more complete specification of price developments, we instead turn to testing conditional β-convergence. Due to lack of data, we have to exclude restrict our testing to the 1994:1 to 2004:12 period.

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[9] Estimated bs using Wilcoxon-based estimation are -0.059***, -0.047**, and -0.082*** in the full sample, pre-, and post-euro periods; estimated bs using least-absolute-deviations regression are -0.042***, -0.052***, and -0.035* in the same three periods.

We have argued for several additional factors that could be expected to cause a link between the introduction of the euro and producer prices, namely elimination of exchange-rate risk, economic convergence and the Balassa-Samuelson hypothesis, and the composition of each member country's effective, trade-weighted exchange rate. To test these potential explanations, we add growth in labor productivity in the manufacturing sector (*PROD*) to test the economic convergence hypothesis and changes in the nominal trade-weighted exchange rate (*NEER*).[10] We control for standard (non-euro related) drivers of output prices. In a non-competitive market, increasing costs would be passed through to customers (cost-push inflation). Labor is a major production factor in the manufacturing sector, motivating inclusion of labor costs as a control. We would like to include unit labor costs, since that is what presumably drives prices, but since labor productivity is already in the model we include the growth in hourly compensation costs in the manufacturing sector (*HCC*). We also include the country's output gap as calculated by the OECD, (*GAP*), to control for the business cycle. Finally, we include beginning-of-period long-term (10-year government bond) interest rates (*INT*) to control for the impact of capital costs due to the often heavy usage on fixed capital in the manufacturing sector.[11]

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[10] *PROD* is (the log of) yearly labor productivity for the manufacturing sector from the European Commission *AMECO* Database (table Gross value added at 1995 prices per person employed: manufacturing industry). *NEER* is (the log of) monthly trade-weighted (based on export and import shares to the country's 41 main trading partners) effective exchange rates from the Eurostat *NewCronos* database (table effrt_m), expressed as FC/EUR (ECU).

[11] *HCC* is from the US Bureau of Labor Statistics report *Hourly Compensation Costs for Production Workers in Manufacturing, 32 Countries or Areas, 22 Manufacturing Industries, 1992-2004*; *GAP* is from the OECD *Economic Outlook* database (table Output gap), and *INT* is form the Eurostat NewCronos database (table mat_y10m).

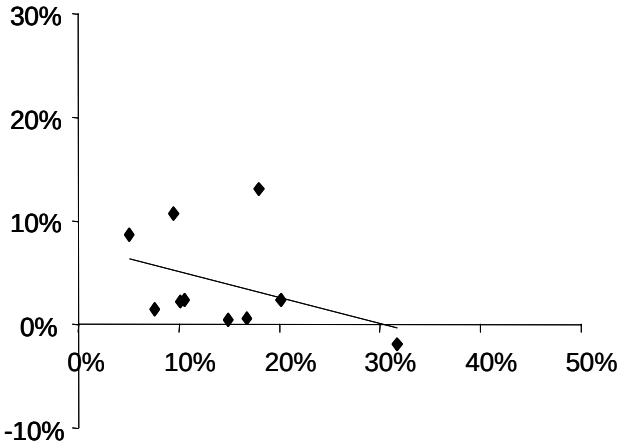
Our hypotheses about the impact of our five control variables on producer-price inflation in the transition to a common currency are the following. We expect *negative* coefficients on *NEER* (more imported inflation the more a country's effective euro depreciates) and *INT* (higher interest rates reduce investment activities and growth), and *positive* coefficients on *PROD* (productivity increases drive wages, which in turn drive nontradables prices), *HCC* (increasing labor costs passed through to output prices), and *GAP* (increasing prices in times of expansion).

A first look at the data

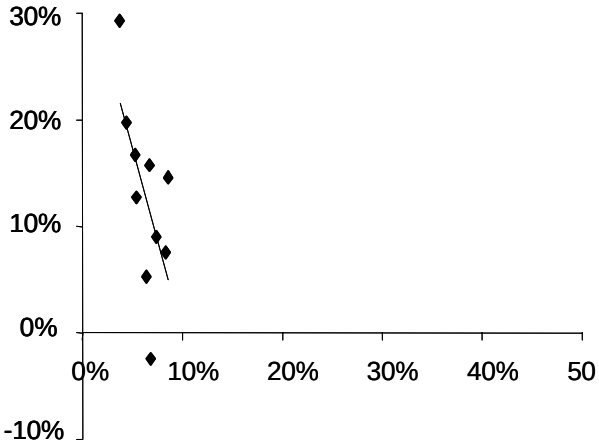
Figure 3 shows the bivariate relationships between cumulative price changes over the pre- (Panels A and C) and post-euro (Panels B and D) periods (up to December 2004) and (*i*) growth in the nominal effective trade-weighted (against 41 main trading partners) exchange rate (Panels A and B) and (*ii*) growth in labor productivity in the manufacturing sector (Panels C and D). Panels A and B show negative relationships between effective exchange-rate changes and prices. This is as expected from an import-of-inflation viewpoint; those countries that have faced the smallest effective exchange-rate appreciations (all effective country-specific euros have appreciated over both period) have seen the largest price increases. The relationships between productivity changes and prices are also negative. The positive correlation implied by the Balassa-Samuelson hypothesis is not present during the two periods. We see that one country, Ireland (experiencing falling prices and growth of labor productivity of 50%) influences the slope of the relationship in the post-euro period. This does not explain the negative relationship, however.

Figure 3 Relationships between cumulative price changes, productivity growth, and effective exchange rates

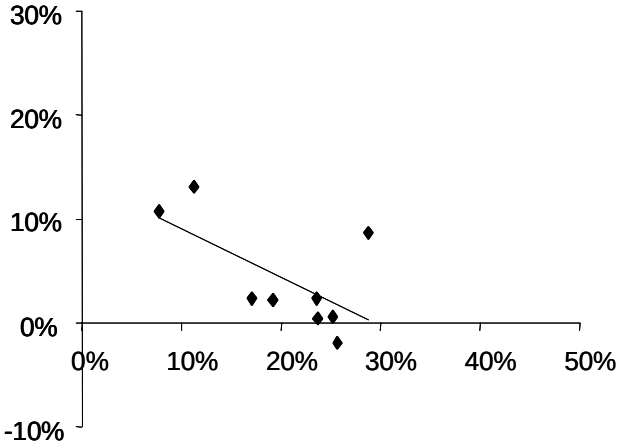
Panel A Effective exchange rates January 1994 – December 1998



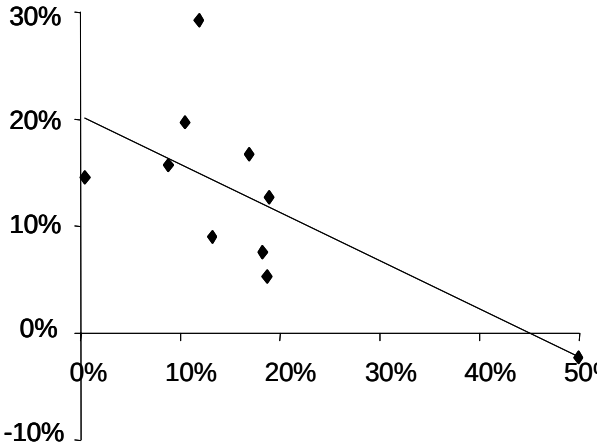
Panel B Effective exchange rates January 1999 – December 2004



Panel C Productivity growth January 1994 – December 1998



Panel D Productivity growth January 1999 – December 2004



Note: X-axis: cumulative changes in nominal effective trade-weighted exchange rate (Panels A and B) and labor productivity (Panels C and D); Y-axis: cumulative producer-price change in the manufacturing sector.
Source: Producer prices are from the SourceOECD *Main Economic Indicators* Database; price levels (UVRs) from the University of Groningen *ICOP* Database; labor productivity is from the European Commission *AMECO* Database; nominal effective exchange rates are from the Eurostat *NewCronos* database.

Formal testing

To formally test conditional β-convergence, we estimate

Table 4 Cross-sectional estimates of conditional β-convergence in the euro zone

	94:1 – 04:12		99:1 – 04:12		94:1 – 98:12	
	(a) OLS	(b) Rank	(a) OLS	(b) Rank	(a) OLS	(b) Rank
b		-0.65 (-2.63)**		-0.09 (-0.38)		-0.49 (-2.44)*
β	-0.034 (-4.96)***		-0.034 (-2.78)**		-0.032 (-2.80)**	
γ_1	-0.92 (-2.26)*	-0.29 (-1.30)	-3.14 (-5.27)***	-0.64 (-4.46)***	-0.12 (-0.96)	-0.39 (-2.07)*
γ_2	-0.12 (-1.68)	-0.19 (-0.79)	-0.32 (-3.61)**	-0.63 (-2.72)**	-0.11 (-1.04)	-0.50 (-2.51)**
SE regr	0.00	1.91	0.00	1.18	0.00	1.50
Adj R^2	0.83	0.60	0.89	0.85	0.68	0.76

Note: *, **, *** denote significance at the 10, 5, and 1% levels; *t*-statistics in parenthesis. Columns (a) contain nonlinear least squares estimates of (4'), and Columns (b) robust rank-OLS estimates of (4).
Source: Producer prices are from the SourceOECD *Main Economic Indicators* Database; price levels (UVRs) from the University of Groningen *ICOP* Database; labor productivity is from the European Commission *AMECO* Database; nominal effective exchange rates are from the Eurostat *NewCronos* database.

$$\pi_{i,t,t+T} = \alpha + b\log(p_{i,t}) + \gamma_1 \Delta_{t,t+T} NEER_i + \gamma_1 \Delta_{t,t+T} PROD_i + \varepsilon_{i,t,t+T} \tag{4}$$

or

$$\pi_{i,t,t+T} = \alpha + \frac{\left(1 - e^{-\beta T}\right)}{T}\log(p_{i,t}) + \gamma_1 \Delta_{t,t+T} NEER_i + \gamma_1 \Delta_{t,t+T} PROD_i + \varepsilon_{i,t,t+T} \tag{4'}$$

where $\Delta_{t,t+T}$ denotes cumulative log change between t and $t+T$. Results are reported in Table 4 with OLS estimates of (4') in Columns (a) and rank OLS estimates of (4) in Columns (b). To preserve degrees of freedom, we exclude *HCC*, *GAP*, and *INT* from these regressions. When interpreting the results, it is important to remember the small sample sizes (ten observations).

There is support for conditional β-convergence in the full sample and the pre-euro period, but not in the post-euro period. Estimated speeds of convergence, using the OLS estimates in Columns (a), are about 3% per year both over the full sample period and in the two sub-periods. For robustness, we perform non-parametric rank-based (Wilcoxon)

regressions and least-absolute-deviations regressions of (4). They yield slightly different results; the coefficient on convergence is still significantly negative for the full sample, but only near significant in the pre-euro period in the Wilcoxon test and insignificant in the least-absolute-deviations estimation. β-convergence is supported in the post-euro period, however.[12]

NEER is significant in the post-euro period, but not in the full sample or the pre-euro period. Coefficients are negative in all estimations, as expected. *PROD* is significant in both sub-periods, but not in the full sample. Estimated coefficients are negative, however, which is contrary to our expectations. In the non-parametric and least-absolute-deviations regressions, both *NEER* and *PROD* are significant in the post-euro period and near significant in the full sample.

To increase power of the testing, we once again estimate panel regressions on yearly price changes, allowing for fixed country effects and including all control variables. Results are reported in Table 5. Again, there is strong support for conditional β-convergence, with significantly negative coefficients in all periods and irrespective of model specification. *NEER* (γ_1) and *PROD* (γ_2) also turn out significant in all models (except for *NEER* in the complete model in the pre-euro period, and *PROD* being near significant in the post-euro period), and with the expected signs. Results for the remaining three control variables are mixed. *HCC* (γ_3) is significant and positive, as expected, in the post-euro period and near significant in the full sample, while *GAP* (γ_4) is insignificant in all periods. *INT* (γ_5) is significant in the two sub-periods, but with a positive sign. This means that a high long-term

[12] Estimated *b*s using Wilcoxon-based estimation are -0.04**, -0.03*, and -0.04*** in the full sample, pre-, and post-euro periods; estimated *b*s using least-absolute-deviations regression are -0.04***, -0.02, and -0.03* in the same three periods.

Table 5 Panel estimates of conditional β-convergence in the euro zone

	94:1 – 04:12		99:1 – 04:12		94:1 – 98:12	
b	-0.12	-0.18	-0.37	-0.53	-0.58	-0.38
	(-2.19)**	(-2.79)***	(3.81)***	(-5.06)***	(-5.79)***	(-3.39)***
γ_1	-0.37	-0.45	-0.35	-1.27	-0.18	-0.12
	(-4.87)***	(-4.57)***	(-2.61)**	(-4.44)***	(-2.65)**	(-1.13)
γ_2	0.35	0.38	0.46	0.29	0.29	0.37
	(2.68)***	(2.95)***	(2.84)***	(1.92)*	(2.16)**	(2.91)***
γ_3		0.08		0.42		-0.06
		(1.76)*		(3.40)***		(-0.83)
γ_4		0.03		0.06		-0.20
		(0.20)		(0.17)		(-0.95)
γ_6		-0.01		0.20		0.05
		(-0.98)		(3.69)***		(2.31)**
SE regr	0.03	0.03	0.03	0.02	0.02	0.02
Adj R^2	0.28	0.30	0.57	0.65	0.56	0.64

Note: The table reports panel OLS estimates of (4) on yearly data allowing for fixed country effects; *, **, *** denote significance at the 10, 5, and 1% levels; *t*-statistics in parenthesis.
Source: Producer prices are from the SourceOECD *Main Economic Indicators* Database; price levels (UVRs) from the University of Groningen *ICOP* Database; labor productivity is from the European Commission *AMECO* Database; nominal effective exchange rates are from the Eurostat *NewCronos* database.

interest at the beginning of the year lead to higher inflation during the year in the pre-euro period. This is contrary to the standard assumption of high interest rates being contractionary.

4. ANALYSIS

Throughout the testing, we find strong support for β-convergence, both in an absolute and a conditional sense. We can safely say that producer prices are converging in the euro zone. The question is: did the euro influence this convergence? Here the answer must be no. The results are equally strong for both the pre- and post-euro periods and speeds of convergence are similar in both periods. The addition of control variables does not influence results in any way, which must be interpreted at support for absolute β-convergence. In the extension this means that price levels are actually converging towards a common equilibrium. The speed of

convergence has been estimated to be between 3% and 4%, which suggest convergence over a 20-year period.

Prior studies of price developments in the euro zone have focused on dispersion in consumer prices. The three studies most resembling ours are Engel and Rogers (2004), Honohan and Lane (2003), and Rogers (2002). Honohan and Lane and Rogers find a strong price-convergence effect in the post-euro period, whereas Engel and Rogers do not. Honohan and Lane's and Rogers' results are as strong as ours.

We also find support for Honohan and Lane's (2003) finding that the composition of the euro is asymmetric from an individual country viewpoint; the euro member countries' producer prices follow movements in the country's trade-weighted effective exchange rate. In line with Honohan and Lane, we interpret this as the import of inflation varies across countries.

Productivity growth also has a significant impact on producer prices. Looking at long-term price changes (the cross-sectional estimations), productivity growth seems to influence prices negatively rather than positively as predicted by the B-S hypothesis. Rogers (2002) and Honohan and Lane (2003) find the same result for consumer prices after the euro introduction. As they point out, several recent studies have found inverse relationships between productivity and prices. The negative coefficient suggests that countries that have seen the largest productivity increases have experienced the smallest price increases. One attractive explanation of this is provided by Benigno and Thoenissen (2003), who model the impact of total factor productivity shocks on real exchange rates under imperfect competition. In effect, what their model is saying is that firms that experience productivity increases can, under imperfect competition, reduce prices without affecting the profit margin. On the other hand, when testing on annual price changes, we find the expected positive relationship between productivity growth and inflation. This suggests that the Balassa-Samuelson effect is at work

at a yearly level, but not when extending the periodicity. This divergence in relationships in the shorter and longer run is intriguing.

4.1. Decomposing producer-price changes

To get a more detailed idea of how individual countries have been influenced by the different drivers of producer-price changes, we can decompose price changes into the effects of each of the six price determinants and a residual term. We do this by calculating fitted values on each explanatory variable in the full models (Columns 5 and 7) in Table 5. The results are presented in Figure 4. To perform the decomposition, we firstly calculate each country's average price level, *NEER*, *PROD*, *HCC*, *GAP*, and *INT* over the sub-period. Then we calculate the average price level, etc across all ten countries and then calculate the deviation of each country's average price level etc from the euro-zone average. Each component is calculated by multiplying each country's deviation from the euro-zone average with the corresponding regression coefficient in Table 5 (Columns 5 and 7). Summing these products yields the country's predicted price change. The residual is equal to the difference between the observed and predicted price change.

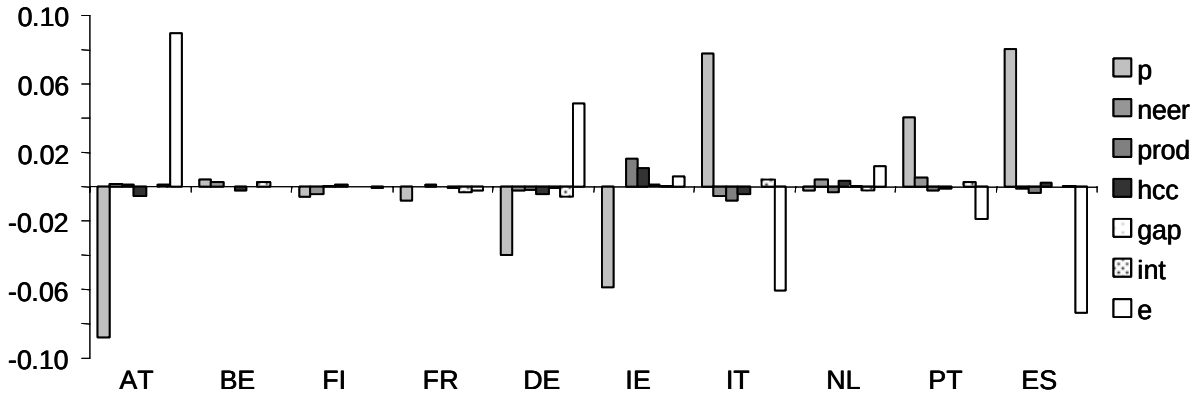
If we begin with the post-euro period, we see that two factors stand out as particularly important: price convergence (p) and the residual term (ε). The importance of the residual term reflects the fact that the explanatory value in Column (5) in Table 5 is less than perfect (R^2 = 74%). Austria, Germany, and Ireland have large negative components on p. All three countries have high producer-price levels, which contributed greatly to reducing producer-price inflation. Italy, Portugal, and Spain, on the other hand, are low-price countries, and are accordingly the countries that got the greatest push towards price convergence. Austria, Germany, Italy, and Spain are all greatly influenced by the residual term. The model seems not to capture price developments well in these countries. Productivity growth stands out slightly for Ireland, which experienced extraordinary productivity growth over this period.

Take a closer look at the two most extreme countries in terms of price changes, Ireland and Portugal, is revealing. In January 1999, Ireland had the second highest producer-price level among the investigated countries, some 11% above the average. This deviation, multiplied by the b-coefficient in Table 5 of -0.526 adds a component of -5.9% to the annual producer-price inflation. This is countered by the fact that Ireland experienced the highest productivity growth over the period, 8.3% per year. This is markedly above the average of 2.8%, but still only adds a component of 1.6% to inflation due to the small coefficient on *PROD*. The above-average growth in labor costs (highest in the euro zone) adds another 1.1% to inflation. The predicted annual inflation over the post-euro period is -3%, but the observed level of inflation was -0.4% per year. This explains the unexplained residual term of 0.6% per year. Portugal, on the other hand, experienced an average of 4.7% inflation per year over the period. This is almost exclusively explained by an initial low price level (third lowest in January 1999), which adds a component of 4.1% to inflation.

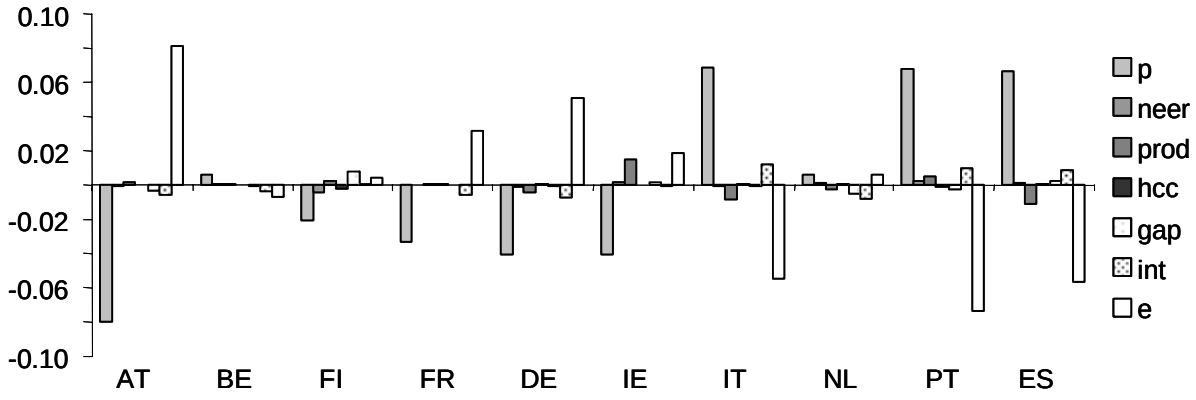
Patterns are similar in the pre-euro period, but with more countries experiencing marked effects from individual price determinants. In particular, the impact of price convergence influences most countries, whereas in the post-euro period the effect was more concentrated to a few countries. The residual effect is also more evenly spread out across countries. One component that shows up here, but not in the post-euro period is the interest rate. The effect is particularly marked for France, with several countries experiencing slight effects. As in the post-euro period, productivity growth shows up for Ireland.

Figure 4 Decomposition of annual producer-price changes

Panel A Post-euro period, 1999-2004



Panel B Pre-euro period, 1994-1998



Note: The diagram decomposes the cumulative producer-price change over the entire pre- and post-euro periods by fitting each country's observed deviation from the euro-zone average to Columns 5 and 7 in Table 5. The residual effect is equal to the difference between observed and predicted (excluding the constant) values.

4.2. Decomposing the post-euro period

If we turn back to Figure 1 and look more closely at producer-price developments in the post-euro period, it seems prices increased quite much during the first two years (1999-2000) and then stabilized. If we look more closely at individual countries, this becomes even more apparent (see Andrén and Oxelheim, 2002 for a more detailed overview). Inflation rates in the first two years for some countries reached levels not seen since the early 1980s. Annual

Table 6 Panel estimates of conditional *β*-convergence in the post-euro period

	99:1 – 00:12		00:1 – 04:12	
b	-0.22	-0.22	-0.08	-0.06
	(-3.12)***	(-2.94)**	(-1.62)	(-1.20)
γ_1	0.29	0.42	-0.72	-1.34
	(0.54)	(0.45)	(-2.86)***	(-3.39)***
γ_2	0.61	0.67	0.06	-0.10
	(2.15)**	(1.88)*	(0.36)	(-0.58)
γ_3		-0.13		0.30
		(-0.20)		(1.96)*
γ_5		-0.04		0.07
		(-0.29)		(0.68)
SE regr	0.03	0.03	0.03	0.03
Adj R^2	0.26	0.17	0.16	0.30

Note: The table reports panel OLS estimates of (4) on yearly data; *, **, *** denote significance at the 10, 5, and 1% levels; *t*-statistics in parenthesis.
Source: Producer prices are from the SourceOECD *Main Economic Indicators* Database; price levels (UVRs) from the University of Groningen *ICOP* Database; labor productivity is from the European Commission *AMECO* Database; nominal effective exchange rates are from the Eurostat *NewCronos* database.

inflation rates during the rest of the post-euro period have instead been historically low, being at levels comparable to those just prior to the introduction of the euro.

Considering these patterns, can we see two phases in the transition to a common currency? To investigate that, we divide our annual data into two groups, 1999-2000 and 2001-2004. Results from panel OLS regressions are reported in Table 6. To save degrees of freedom, we exclude *GAP*. Beginning with the first two years, the initial price level and *PROD* are significant. As for all other periods investigated, price convergence seems to important here. Both these effects disappear in the latter part of the post-euro period, where neither the price level nor *PROD* is significant. In this part of the period, *NEER*, in particular, turns out significant. *HCC* is also near significant.

To summarize our findings as regards annual producer-price changes following the introduction of the euro, price convergence, productivity growth, and effective euro changes seem to drive producer prices in the euro zone. Price convergence seems to have been more important in the first years of the euro, while exchange-rate effects were more important in the later years.

5. CONCLUDING DISCUSSION

After the introduction of a common currency real exchange rates may still fluctuate and give rise to real exchange-rate driven changes in competitiveness. Andrén and Oxelheim (2002) analyzed the behavior of real exchange rates after the introduction of the euro relative to their behavior prior to the introduction. In short, contrary to expectations, they find for a period of 40 years the first 30 months of the euro to exhibit extraordinarily large intra-EU gaps between real exchange rates as compared to most periods of the same length prior to the introduction of the euro. They conclude that the EU so far failed to level out the macroeconomic influence on intra-EU competitiveness. They emphasize that their result boils down to a matter of producer-price divergence.

Despite the short time period under investigation (six-seven years since the introduction of the euro) and thereby the fairly few data points available for the analysis we have – by using different techniques to mitigate that problem – found robust results as regards the relative inter-temporal influence from driving forces of producer-price developments. We find strong support for price convergence, both in an absolute and a conditional sense. We also find – though not formally tested – support for σ-convergence. We cannot attribute this to the introduction of the euro, however, since we find the same result for the period leading up to the introduction of the euro. We also find productivity growth and effective exchange-rate changes to be important drivers of producer-price developments both before and after the introduction of the euro. However, we also find inter-temporal shifts within the post-euro

period. Price convergence and productivity growth seems to have been of more importance in the first two years of the euro, while effective exchange-rate changes were more important in later years of our post-euro period. This periodicity closely reflects the valuation of the euro; during the first two years of existence, the euro depreciated by 25% against the dollar. It bottomed in February 2002 and then began appreciating. In December 2004 the euro reached its strongest after a 54% appreciation from the bottom. This result suggests that depreciations of the euro were not passed through to output prices, whereas appreciations (cost increases on imports) were. This asymmetric exposure to exchange-rate changes is also found when looking at individual firms' exposure to exchange rate risk (Andrén, 2001). This asymmetric response to changes in the value of the euro, combined with the fact that the composition of the effective trade-weighted euro differs across countries mean that changes in the euro could cause asymmetric shocks within the euro zone. Over the 2001-2004 period this asymmetry in fact surpassed the impact of price convergence, causing price converging to be insignificant during these years.

Our results may have profound policy conclusions for the current EU countries as well as for new countries considering the alternative of adopting a common currency. In the best of worlds, price convergence causing large and divergent producer-price increases could lead to a restructuring of the manufacturing sector in the euro zone. This would force firms to rationalize to stay competitive. Such beneficial developments would increase the competitiveness of the EU vis-à-vis the US and facilitate the achievement of the Lisbon agenda. The problem, however, is that this process could be slow and painful (few countries can match the Irish example of exceptional productivity growth over a long stretch of years). Portuguese companies, for instance, face the risk of pricing themselves out of the market. Sticky wages and low levels of labor mobility, which are well-known problems in the euro zone, would mean that restructuring causes unemployment, in particular in the most affected

countries. In this situation there is a considerable risk that exposed countries like Portugal will ask for the favor of being bailed out by the EU. An increased granting of structural support by the EU to the most affected countries or industries will hinder the restructuring. There is also a risk of increased competition among exposed member countries, like Portugal, for inward direct investments through social dumping and tax exemptions (Oxelheim and Ghauri, 2004). Both scenarios will erode the role of the euro in fostering competition and would probably have an adverse effect on the future economic growth of the EU. Hence, to avoid these adverse scenarios it is important for policy makers in countries in the phase of transition to a common currency to know the driving forces at work in order to handle them adequately from a policy point of view. In particular, the detrimental effect of large swings in the value of the euro on price convergence is important to keep in mind.

The implication of our results to policy on the EMU level is that asymmetric impacts of driving forces of producer-price inflation should be at least supervised, and at best moderated at the EU-level with better control over inflation as measured by a wider price index than the consumer-price index and by an enhanced understanding at the national policy level of the inter-temporal distribution of effects of the three driving forces as found in this study.

A topic for future research is the assessment of the gravity of the developments we have discussed. How large price gaps are sustainable under a single currency? Comparisons with the US could provide an answer. If price gaps are larger among countries in the euro zone than among states in the US, the euro zone with its markedly lower cross-border labor mobility will face difficulties (Forssbaeck and Oxelheim, 2003).

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