EMU enlargement and convergence of price levels: Lessons from the German reunification

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Abstract

We analyse the possible impact of EMU enlargement on inflation rates in the accession countries. We establish two main points: first, using a theoretical model we show that if large initial differences in price levels occur, even under very favourable circumstances the optimal path for price adjustments should be asymmetric, i.e. occuring mostly in the candidate countries. Second, based on data from the German reunification we quantify the inflationary effect of price level convergence in the accession countries. Our findings indicate that (trend) inflation rates in the EMU candidate countries are likely to increase sharply, whereas the impact on the current euro area is likely to be small, albeit not negligible. Our results support the need to allow for some flexibility in the exchange rate arrangements with the candidate countries to facilitate gradual price level convergence prior to EMU enlargement.

Keywords: Price level differences, convergence, EMU enlargement
JEL codes: E50

1 Introduction

One of the hopes surrounding the introduction of the euro was that as transparency increases among the EMU members, prices will converge. Casual inspection shows that the euro area currently shares the same currency, but not similar product prices (see table 1). Differences in price levels between countries tend to equalise, but the adjustment can be very slow (Froot and Rogers, 1995). If price levels converge within a currency area, they result in differences in inflation rates. As the differences in price levels between the euro area and the accession countries far exceeds price level differences within the euro area, this potential cause of inflation differentials could be relevant in the context of EMU enlargement. Based on economic reasoning, we might

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	Germany	France	Italy	Spain	Greece
Coca Cola 0.33l	0.30	0.37	0.77	0.32	0.39
Nivea 150ml	2.04	2.21	2.76	1.79	2.27
Levis 501 Jeans	97.95	73.00	79.53	61.11	67.20
McDonald's Big Mac	-	2.97	2.53	2.49	2.11
Kinder Surprise	0.55	-	0.59	0.63	0.46

Source: *Frankfurter Allgemeine Zeitung*, 27.12.2001.

Table 1: Price differentials for selected goods (prices in euro)

expect that due to arbitrage prices for tradable goods converge faster than for nontradable goods. But due to lack of sectoral inflation data for many accession countries, the factors driving price level convergence are difficult to assess. How will price level convergence come about? Put differently, which prices are likely to rise when? And should the Single European monetary policy react – and if so, how?

Aim of this paper is to explore the link between price level convergence and inflation differentials. The German experience after the reunification might shed some light on these issues: At the time East and West Germany decided to form a currency union, considerable differences in price levels existed. We present a theoretical model to investigate the optimal monetary policy response in such a situation and using detailed data on regional inflation rates we show how price level convergence came about. As it turns out the monetary policy reaction is in line with our model, since the central bank aimed at keeping inflation low for the entire currency area. Given the nominal rigidities of the German economy, this implied high inflation in East Germany. Based on this analysis, we make inferences about price level convergence in an enlarged euro area. To preview the conclusions, we find that the impact of EMU enlargement on inflation in the euro area is small, but not negligible, but that inflation rates in the candidate countries are likely to increase considerably and for a sustained period.

The paper proceeds as follows: the next section outlines the relationship between price level convergence and inflation dispersion. Section 3 contains our empirical results for Germany, section 4 computes the effect of EMU enlargement on future and current EMU members. The policy implications are summarised in section 5. The final section concludes.

2 Inflation differentials and price level convergence

2.1 The law of one price

According to the law of one price '... absent natural or governmental barriers, a commodity should sell for the same price everywhere. The mechanism supposedly enforc-

ing the law of one price is arbitrage' (Obstfeld and Rogoff, 1996).[1] Following the law of one price, price differences between tradable goods sold in different locations should be fairly small, provided that market separation is not possible and product regulations are similar.

Froot and Rogoff (2001) have shown that the strict interpretation of the law of one price does not hold, and according to Engel and Rogers (1996) price levels can differ within a currency union. This finding also holds for the euro area price levels: using evidence from bar code scanner data collected from supermarkets, the European Commission (2001) states that 'price dispersion inside every Member State is always lower than price differences across countries for the same products. Generally, prices inside Member States vary 5 per cent round the national average; across the EU, prices vary 20 per cent or more.'[2] However, the differences within the euro area are decreasing: empirical studies have shown that price levels of tradable goods are converging in the euro area, and for a number of goods currently price level differences between certain cities in the euro area are not higher than in the US. Still, overall price level dispersion are still greater in the euro area (Rogers 2001).

There are a number of factors why price levels can differ across countries or regions within a currency area. The most important causes are differences in cyclical phases, differences in wage behaviour, product regulations, productivity or consumer preferences and inflation expectations. The Balassa-Samuelson effect is also widely cited: according to this effect catching-up countries might experience relatively high inflation rates, as productivity increases in the tradable goods sector outpace productivity increases in the nontradables sector. If similar wages are paid in both sectors, overall inflation will rise due to high inflation rates in the nontradable goods sector.[3] However, as Broda (2002) has shown, the BS effect might contribute to differences in price levels, but cannot be the only reason why price levels differ.[4]

[1] Note, however, that Campa and Wolf (1997) only find very limited support for correlations between real exchange rates and trade flows, which could imply that if price convergence takes place, it does not occur via arbitrage. Krugman (?) opposes this view, pointing out that the threat of competition can be sufficient for firms to equalise prices.

[2] This coincides with anecdotal evidence: 'A VW Golf IV that sells for EUR 13.588 in Belgium fetches EUR 18.801 in Ireland, Opium Eau de Toilette costs EUR 112.30 in Belgium but only EUR 50.23 in Portugal; and an IMac 'Indigo' computer will set you back EUR 1.731 in Greece, but only EUR 1.159 in Germany. ... You pay only 50 European cent for the same 20 Bayer Aspirin tablets in Greece that cost EUR 4.67 in France...' (Wall Street Journal, 11.1.2002).

[3] The theoretical foundation is given in Balassa (1964) and Samuelson (1964). Estimates of the Balassa-Samuelson effect for the accession countries are found in Cihák and Holub (2001), de Broeck and Slok (2001) and Backé at al. (2002).

[4] Broda (2002) uses the example of Panama and Colombia: 'the price level of Panama in 1990 was 60 percent that of the US, while Colombia's price level was less than 30 percent that of the US. This difference cannot be explained by the conventional Balassa-Samuelson effect ... because Panama and Colombia had similar income levels in 1990.' Moreover, one of the assumptions of the Balassa-Samuelson framework is that for tradable goods no prices levels differences exist between the candidate countries and the euro area. Detailed, disaggregated price level data for the candidate countries are often not available, yet the evidence presented by Cihák and Holub (2001) implicitly refutes this core assumption of the Balassa-Samuelson model: '...significant parts of the traditional "tradable" commodities (such as most foodstuffs, nonalcoholic beverages, clothing, floor coverings, home applicances etc.) are at 45-75 percent of the German level.'

As a main explanation for differences in price levels in the euro area the European Commission puts forward 'economic' factors such as industry or product-specific differences in manufacturer or distribution concentration or regulatory differences (as opposed to geographic factors such as transport costs, different consumption patterns or income differences).[5] From the perspective of an economist inflation differentials are in these cases 'benign', as the different prices reflect differences in underlying cost structures.

The flipside of this argument is that in a currency area, a single monetary policy applies to all participating regions or countries. The common central bank has to focus on price stability in the entire currency area and cannot respond to divergence of inflation rates. If one or more countries exhibit a positive inflation differential, to meet the desired inflation target of the currency area all other countries need to have inflation rates below the overall inflation target. Therefore, *persistent* deviation from the overall inflation target should be avoided. The same holds, of course, if a country joins an existing monetary union, but is likely to have structurally higher inflation rates because of lack of initial convergence. In other words, inflation differentials are only warranted to the extent that they contribute to allocative efficiency, but can impose costs on other members of the currency union if they result because of lack of (initial) convergence or because of inappropriate national economic policies.

The point of initial convergence can become relevant in the context of EMU accession. The main argument why price levels differ less within a currency area than between currency areas is that having a currency of one's own can have similar effect as other barriers to trade. This point was made by Engel and Rogers (1999), who compared variability of the real exchange rate between cities in the US on the one hand and US and Canadian cities on the other: their results could imply that if two countries decide to form a monetary union, the real exchange rate variability should be reduced by more than the nominal exchange rate variability. The results of Weber and Beck (2003) indicate that under EMU the elimination of nominal exchange rate volatility has largely, but not completely reduced both border and distance effects. If the same holds for the enlarged EMU, some form of price convergence between the current and future EMU members needs to take place.

2.2 The optimal inflation rate

If two countries with differences in price levels decide to form a monetary union, what is the impact for aggregate inflation? As the exchange rate disappears, price level convergence can either be achieved via an upward price adjustment in the country with the lower initial price level, or via a downward price adjustment in the 'expensive' mem-

[5]The IMF concluded that steady-state inflation rates to achieve full convergence in price levels over a period of 10 years within the euro area could differ up to 2.7 percentage points (IMF, 2002).

ber (both price adjustments can also occur simultaneously).[6] If the firms' production capacities in the 'cheap' countries face – at least in the short run – capacity restrictions, prices might rise in the 'cheap' country: After joining an existing currency area, individual firms in the new, 'cheap' member countries may not continue to supply the consumers in their country, they can also distribute their products in other countries of the currency area.

Then, these firms face the following decision: Do they continue to supply local customers at a relatively low price, or do they ship their products to the other member countries of the currency union, where the price level is higher? In the latter case, they can ask a higher price, but face additional transportation costs. If the transportation costs do not exceed the potential benefits resulting from selling at higher prices in the 'expensive' countries, a rational manager will opt for the second option. This limits the supply of 'cheap' goods in the 'cheap' country, which can lead to increasing prices. This indicates why arbitrage may lead to lower prices at the aggregate level, but not necessarily to lower (or constant) prices in all participating countries of the currency area.

The main point we want to establish in the section is that if large differences in price levels within a currency union lead to convergence of price levels, optimising central banks must allow for relatively high inflation in the 'cheap' countries, in order to prevent deflation in the 'expensive' countries. Abstracting from differences in monetary transmission, different types of rigidities etc., we show that the inflation differential between the countries can be related to the relative size of the two countries and the speed of the price adjustment.[7]

To establish this result we present the full version of a (highly simplified) model in appendix B. We sketch the outline of the model here. The model assumes a world consisting of two countries. The initial price level in country *A* is lower than in country *B* (due to a lack of market integration at the outset). The economies have standard Lucas supply curves. They experience downward nominal wage rigidity. Then trade barriers are lifted. As a result, there is a (not instantaneous, but staggered) convergence to the law of one price. As soon as trade barriers are lifted, both countries also enter a currency union. The common central bank aims at stable output growth and stable prices.

Based on this setting, the optimal path of price adjustment, reflected in the inflation rates in individual countries and the area as a whole, is as follows:

[6] It is implicitly assumed that the price level for the monetary union as a whole is roughly stable.

[7] While we cannot exclude the possibility that this result could change if we allow for differences in economic structures in both countries, we were not able to come up with meaningful assumptions leading to fundamentally different results.

$$\pi_t^A = \frac{\alpha(\beta+\gamma)(1-k)}{\beta(1-k)+\gamma}\left(p_{t-1}^B - p_{t-1}^A\right) > 0, \quad (1)$$

$$\pi_t^B = -\frac{\alpha\gamma k}{\beta(1-k)+\gamma}\left(p_{t-1}^B - p_{t-1}^A\right) < 0, \quad (2)$$

$$\pi_t^* = \frac{\alpha k}{1+\gamma/[\beta(1-k)]}\left(p_{t-1}^B - p_{t-1}^A\right) > 0, \quad (3)$$

where π_t^A and π_t^B are the inflation rates in the countries A and B, respectively. We see that inflation in country A – the country with low initial prices – is positive, whereas the inflation rate in the initially 'expensive' country is negative. However, area-wide inflation π_t^* is positive, which implies that the optimal price adjustment is asymmetric (i.e. prices rise more in country A than they fall in country B). The optimal path for price level convergence depends on the initial price level difference between both countries ($p_{t-1}^B - p_{t-1}^A$), the relative size of country A (k, with $0 < k < \frac{1}{2}$), the speed of price adjustment (α, more formally: the share of firms adjusting prices in each period), the degree of price rigidities (β) and the relative weight of inflation in the common central bank's loss function (γ).

- If the economic size of country A is relatively small compared to country B (i.e. k small), then it is optimal from the common central bank's point of view that the burden of price adjustment will fall mostly upon country A.
- The area-wide inflation is increasing in β: If the output loss associated with deflation is high, the central bank will raise area-wide inflation (and accept the loss related to a higher inflation rate in country A) in order to reduce the deflation rate in country B.
- The area-wide inflation rate is increasing in the initial price level difference between both regions ($p_{t-1}^B - p_{t-1}^A$) and in the speed of the price adjustment process, α. The area-wide inflation is decreasing in γ, i.e. the weight of inflation in the central bank's loss function (relative to output).

These results can be applied to EMU enlargement in a very straightforward manner: if the accession countries join the EMU without having achieved price level convergence prior to EMU accession, inevitable price adjustments need to occur in the accession countries, for two reasons: First, as the economic weight of the current member states is almost twenty times that of the accession countries, a sizeable price decline in the current member states would be incompatible with price stability in the enlarged area. Second, a decline in the general price level (i.e. deflation) in the current member states may cause substantial output losses in those countries. The policy implication

is that the ECB should allow for temporarily high inflation in the candidate member states, in order to facilitate price level convergence.

In what follows we first look at price level convergence following the German reunification. Based on these findings we then analyse the possible impact of EMU enlargement on inflation in the euro area and in the candidate countries.

3 The German reunification

Existing currency areas can provide information about price adjustment within a currency area, whereas international studies estimate deviation of price levels between countries. Both types of evidence, however, need not fully capture the situation of EMU enlargement, where two groups of countries with large *initial* price differences decide to form a monetary union. A comparable situation occurred in the early 1990s, when East and West German reunited.[8]

We use this historical evidence and analyse convergence of price levels and inflation rates after the German reunification. As in our model East and West Germany differed considerably in economic size (in terms of population East Germany is about 1/4 the size of West Germany and even smaller in terms of economic weight) and wages were downward rigid. We will show that asymmetric price adjustment – which was optimal according to our simple model – was also observed in practice in Germany after the reunification. Our results will then be used in our calculations of the impact of EMU enlargement on the current and future euro area members. Moreover, we provide empirical data on convergence of price levels between different CPI components after the German reunification, to give an idea how price level convergence might unfold in practice, i.e. to illustrate the different speed of adjustment per CPI component.

3.1 Convergence of price levels

Data on price level differences within Germany is relatively scarce. The German Federal Statistical Office (the *Statistisches Bundesamt*) has published an analysis in September 1993, comparing price levels in 50 East and West German cities.[9] The main results of this study are summarised in table 2: the three top rows show average figures for East and West Germany. In the lower part of the table we show the maximum and minimum observations at the city level and the resulting maximum price level differences.[10] According to this study, price levels in West German cities were

[8] A brief overview about the German reunification is given in appendix A.

[9] See Statistisches Bundesamt (1994). Until the late 1990s different consumption baskets have been used for both parts of Germany, which impedes direct comparison, as in particular the 'basic needs' such as nutrition, clothing, energy and water had larger expenditure shares in the budget of East Germans than in the West.

[10] In all tables the maximum difference (the 'spread') indicates by how many percent prices were higher in West Germany than in East Germany.

	All items	Food	Utilities	Services	Durable goods	Non-durable goods
CPI weight	100.0	26.2	7.5	26.9	35.2	37.8
Av. West Germany	100.0	99.5	108.7	99.6	98.6	101.5
Av. East Germany	94.2	91.7	102.1	85.6	98.5	96.2
Av. spread (%)	6.1	8.5	6.5	16.4	0.1	5.5
Max. West Germany	103.1	104.8	116.5	109.1	100.0	104.7
Min. East Germany	91.4	86.8	93.3	78.1	97.0	94.5
Max. spread (%)	13.5	20.8	26.6	40.0	3.1	10.8

Source: Statistisches Bundesamt (1994) and own calculations

Table 2: Average and maximum price level differences between East and West Germany in 1993

on average about 6 percent higher in 1993 than in East Germany, but with considerable variation at the city level (the maximum difference of the All items CPI amounts to 13.5% in 1993). Compared with differences in price levels prior to the reunification this is actually quite low, but essentially the result of the 1:1 exchange rate.[11]

Distinguishing between sectors, the following emerges: On average, price level differences between East and West Germany in 1993 were small for durable consumption goods, whereas prices for non-durable consumption goods on average differed by about 5 percent between both regions. The highest price level differences can be observed in the service sector, where the differences on average amount to roughly 16 percent. This indicates that initial price level differences were larger for nontradable goods than for tradable goods. Finally, rents (which were not included in the study) were on average about 35% lower in East than in West Germany, which should further reduce the costs of living in East Germany, relative to West Germany.[12]

Using the price level data from September 1993 and the inflation rate per CPI category the initial price level differences in 1991 can be calculated. For the All Items CPI the difference between East and West Germany price levels amount to almost 30% (see the last column in table 3). However, the aggregate figures hide considerable variation in price level differences between sectors (the initial difference for the CPI Utilities, for instance, is over 140%). This is clearly the result of the distorted price system of the former East German regime, where prices did not always reflect underlying costs. All in all, it is probably safe to say that price differences in 1991 were almost 30% between East and West Germany.

How far have price levels converged? Using East and West inflation data we can compute aggregate price levels in East and West in 2002. The last row of table 3 reveals that current price level differences between the two parts have been reduced to about

[11] Recall that market exchange rates prior to the reunification were considerably lower, i.e. about 100 East German Mark for 12.5 West German Mark (see Appendix A). Under such an exchange rate regime, price level differences would have been considerably larger.

[12] See Statistisches Bundesamt (1994).

CPI All Items	West Germany	East Germany	Spread (in %)
1/1991	90.6	70.3	28.8
7/1993	100.0	94.2	6.2
7/2002	115.5	111.0	4.0

Source: Statistisches Bundesamt (1994) and own calculations

Table 3: Differences in price levels between East and West Germany in 2002

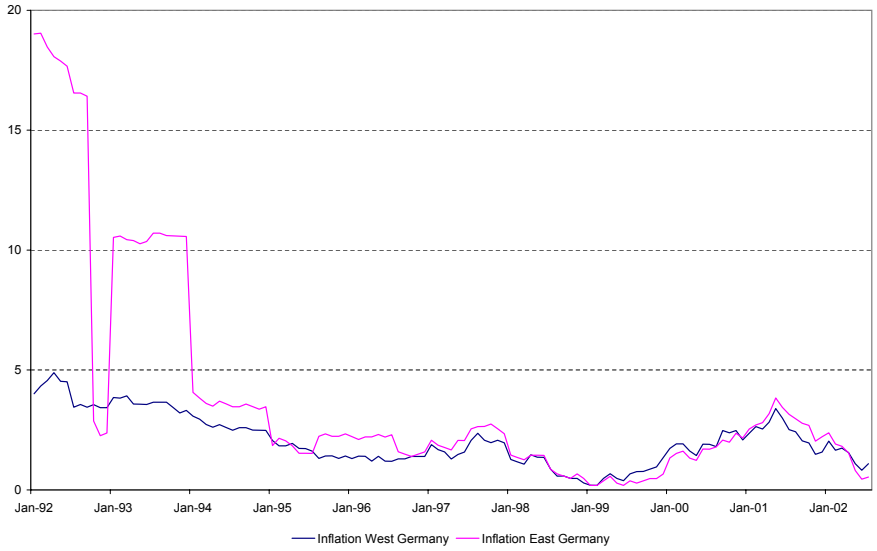

Figure 1: Inflation rate dispersion in East and West Germany

4% (CPI All items). This implies that initial price differences of almost 30% at the aggregate level have been reduced to about 6% within two years and 4% at the end of the ten-year period.

3.2 Convergence of inflation rates

In figure 1 CPI inflation (All Items) for both parts of the country are plotted. We can broadly distinguish two periods: From 1991 to 1995 substantial differences in inflation rates are observable. Since 1995 these differences in headline inflation rates have almost completely vanished.[13]

Using a time series *(East German CPI inflation) minus (West German CPI inflation)*, we test when this series no longer systematically deviates from zero. Table 4

[13] We have also checked whether the fact that the weights of the different sub-components of CPI inflation differed in both parts of Germany critically influences our results. The differences between the 'regular' East German CPI and East German inflation rates, computed with West German consumption weights, are very small. Therefore, the main differences between East and West German inflation were driven by underlying price increases, not by different weighting schemes.

	Sample: 1992:01 1996:01		Sample: 1996:01 2002:09	
Variable	Coefficient	P-value	Coefficient	P-value
C	28.6	0.43	1.2	0.64
T	−0.3	0.00	0.0	0.65
Oilprice	−0.3	0.36	0.0	0.32
Real exchange rate	−0.1	0.76	0.0	0.80
AR(1)	0.8	0.00	0.9	0.00
AR(2)	−0.3	0.88	0.0	0.91
AR(3)	−0.21	0.21	0.0	0.82
R^2	0.77		0.84	
Adj. R^2	0.74		0.83	
S.E.	2.37		0.17	

Source: Own calculations

Table 4: CPI inflation rate convergence

reveals that in a regression from 1996 onwards[14] neither the constant, not time trend coefficient differs significantly from zero. The only significant coefficient is an AR(1) error term, which implies that the time series exhibits a certain degree of stickiness. All together we can say that price level convergence came to a – at least temporary – halt after about 5.5 years. By January 1996 the differences in the CPI All Items had been reduced to 4.2%. This implies that once the (aggregate) price level differences were reduced to about 5%, price level convergence has not progressed substantially.

The model of section 2.2 postulates that in the presence of nominal rigidities the price level adjustment should be asymmetrical. In that case, prices in the 'more expensive' region do not fall, but the central bank accommodates high inflation in the 'cheaper' region. Since the main characteristics of our model were present in the German case (i.e. large differences in size and downward rigidity in wages), was the reaction of the Bundesbank when confronted with high inflation rates in East Germany after the reunification compatible with the results of our model? If that is the case inflation in West Germany should have hardly accelerated since 1990.

To test for the impact on the reunification on West German inflation we regressed the West German CPI on a simple time dummy and ran a Chow test to test for structural breaks.[15] To get good estimates we covered a period of 20 years, such that roughly 10 years before and after the reunification are included in our sample, as breakpoint we use January 1991. Table 5 reveals that the null hypothesis of a structural break is rejected.[16] This implies that West German inflation did not increase or decrease due to the reunification. This indicates that price level adjustments have not lead to structurally lower inflation in West Germany.

[14]Different sample periods have been tested, but this 'breakpoint' delivered the best results. The time series is stationary. Leaving out the variables 'oilprice' and 'real exchange rate' do not qualitatively change our results.

[15]The ADF test rejects the hypothesis of a unit root in the West German CPI series.

[16]Test for other breakpoints (i.e. different dates) yielded similar results.

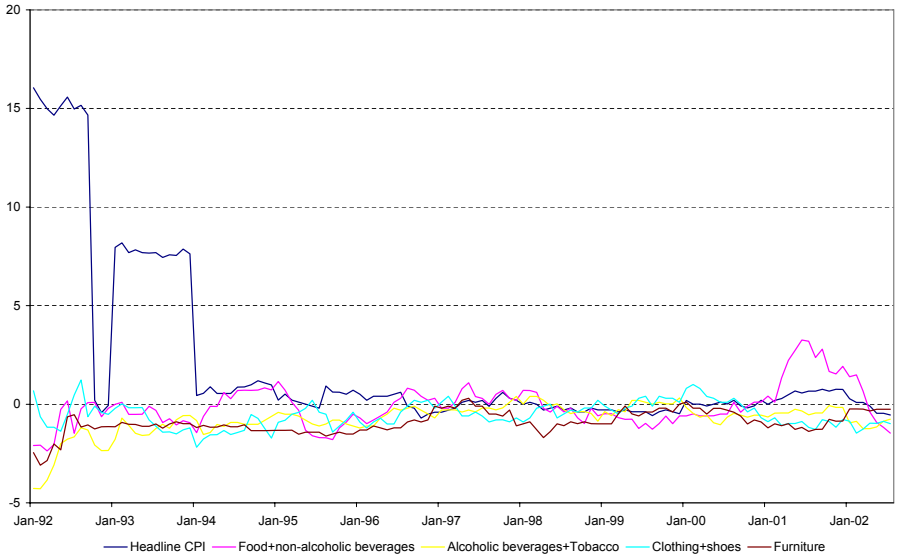

Figure 2: Tradables inflation differential

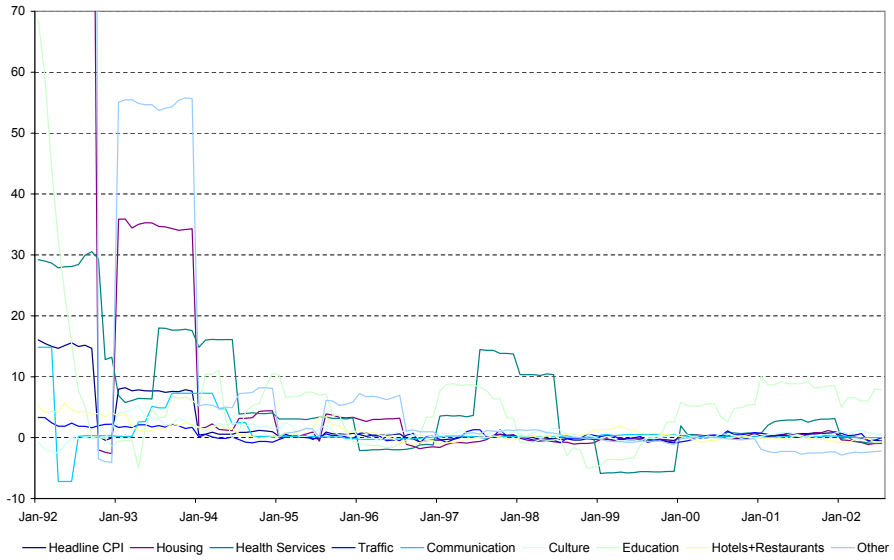

Figure 3: Nontradables inflation differential

Sample period: 1981-2001; Test for breakpoint in 1991			
F-statistic	2.15	Probability	0.14
Log likelihood ratio	2.16	Probability	0.14

Source: Own calculations

Table 5: Chow test for structural break in the West German CPI

To analyse inflation developments we plot the developments of all CPI categories. Figure 2 and figure 3 plots the inflation differentials between East and West Germany for tradable and nontradable goods, respectively.[17] We observe that inflation differentials in tradables are small, relative to inflation differentials in nontradable goods. Housing costs and rents paid for housing account for the largest price increases (more than 100 percent on an annual basis), but have been below 5 per cent since 1997.[18] Moreover, even 5 years after the reunification inflation differentials for certain CPI categories (notably Health Services and Education) are still around or above 10 percentage points. This indicates that price level convergence for these categories occurs only very slowly.[19] Finally, table 6 summarises the yearly inflation differential between East and West Germany for selected CPI components.

All in all, we can thus conclude that it took between 1 and 5 years for most East German CPI components to adjust to the higher West German price levels. In what follows we apply these findings to EMU enlargement.

4 The consequences of EMU enlargement

Following section 2.1, price level differences between the current euro area and the accession countries can partly be related to the fact that they have different currencies. If the candidate countries adopt the euro, this (implicit) barrier to trade is removed, possibly initiating further convergence of price levels. As the price level in the candidate countries is currently below its euro area equivalent, this could result in a positive trend

[17] Note that not all East German inflation rate series go back to 1991. However, the differences between the different regional inflation rates in East Germany is very small (details available upon request). We have therefore decided to concentrate on the East German region, where a maximum of data is available, i.e. Brandenburg. The figures 2 and 3 do not show East German inflation rates, but Brandenburg inflation rates. This region represents about 19% of East Germany, both in terms of GDP and population.

[18] Housing rents in the former GDR were essentially based on a system dating from 1936, which set a fixed rent for state-owned property (based on this system the rents were increased for the last time in 1981). After the reunification, rents in East Germany were considerably lower than in West Germany (more than the factor 10), so for social reasons special transition arrangements applied until the end of the 1990s. During this transition period rents could periodically be increased, normally at the beginning of the year. Newly build homes were treated differently, and as they were generally more attractive, the old houses became increasing unpopular. This explains why until the mid-1990s spikes in housing inflation can be observed, but the spikes become less pronounced, as more and more people moved to newly build houses, where rents could be increased in a more flexible way. By 1995 the East German housing rent system had been changed to the West German system, though the level of rents was still somewhat lower. In 2000/2001 the transition period ended, since then the regulated rent system of East and West Germany are identical and the level of rents in East Germany are roughly comparable to other areas in West Germany.

[19] Unfortunately, price level data is not available for these CPI categories.

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Food[a]	-1.1	-0.6	0.0	-0.6	-0.3	0.2	0.3	-0.3	0.1	1.6
Clothing/ shoes	-1.7	-1.6	-0.8	-0.8	-0.5	-0.4	-0.1	-0.5	-1.2	-1.5
Utilities	73.9	33.9	3.3	0.5	2.5	0.9	0.1	0.0	-0.3	0.7
Furniture	-1.0	-1.1	-1.1	-0.7	-0.4	-0.2	-0.5	-0.1	-0.4	-0.4
Health services	26.2	12.4	9.1	2.5	-1.6	9.0	4.2	-5.4	0.9	2.3
Trans- portation	1.8	1.0	-0.5	0.4	0.3	0.3	0.1	-0.1	0.0	0.2
Culture	-1.8	1.9	1.7	1.4	0.4	0.9	0.4	-0.2	0.3	0.6
Education	24.3	16.2	6.3	4.7	2.4	5.8	-2.5	-3.0	1.2	3.8
Hotels/ Restaurants	3.0	1.3	1.1	1.0	0.4	0.2	0.0	0.2	-0.4	-0.1
Other	1.5	3.0	2.2	0.8	0.9	0.2	0.3	-0.1	-0.3	0.1

Source: Own calculations

[a]Including nonalcoholic beverages

Table 6: Yearly inflation differentials between East and West Germany for selected CPI components

inflation differential in the accession countries. In what follows we estimate the effect of EMU accession on price level differences between the current and the future EMU members.

According to Eurostat, price levels in the candidate countries are approximately 40-65% of the price level prevailing in the European Union. This illustrates the potential for price level adjustments, although the channel through which this will come about is not entirely clear. To compute the impact of adjustment of aggregate price levels on inflation rates in current and future EMU members we need information about the magnitude of the expected price adjustment and the speed of the adjustment:

- First, we need to determine the degree of price level convergence compatible with convergence of inflation rates. We define this level as follows: price level convergence is achieved if trend inflation rates in the current and future EMU members are not systematically different.
- Second, we have to make an assumption about the speed of price level convergence, i.e. about the time frame during which the adjustment will take place.

4.1 How much and how fast will price levels converge?

1 How much convergence of price levels can we expect?

To make assumptions about both issues we first compare the German evidence to evidence from other currency areas. Regarding the degree of price level convergence

	2000	2001
Belgium	100.1	98.4
Germany	99.6	101.9
Greece	79.3	81.4
Spain	83.0	82.5
France	101.9	98.8
Ireland	107.8	112.8
Italy	88.6	91.6
Luxembourg	96.4	99.4
Netherlands	99.8	99.0
Austria	96.9	98.0
Portugal	72.3	73.9
Finland	116.1	116.0
Total spread within EMU (in %)	60.7	57.0
Max. deviation from EU15 average (in %)	38.3	35.3

Source: Eurostat and own calculations

Table 7: Relative price level data for the euro area

within monetary unions, Nenna (2001) shows that differences in price levels among Italian cities of more than 15 percent may persist over long time horizons. Data from the US point to similar magnitudes.[20] The differences within the euro area are even larger: table 7 indicates that within the euro area price level differences can be up to 60% and the maximum deviation from the EU15 price level amounts to roughly 38%.[21] The thick line in figure 4 displays the unweighted standard deviation of price levels in the euro area. From 1995 to 1997 a downward trend is observable, which temporarily stalled during the run-up to EMU in the late 1990s: the need to fulfil the Maastricht inflation criterion reduced inflation rate dispersion and has thereby prevented price levels from converging. Since the start of EMU in 1999 the standard deviation has again started to decrease (albeit at a much slower speed), which indicates that it is too early to say to what extent these differences will eventually persist, as we might suspect that the process of price level convergence is not finished yet.[22]

In other words, available empirical evidence from other currency areas is not conclusive in the sense that the degree of price level dispersion within currency areas can vary substantially. Therefore we have to make an assumption about what we can expect in terms of price level convergence. In order to set a 'target value' for price level convergence of the candidate countries, it is interesting to note that Beck and Weber (2001) have found evidence that EMU has drastically reduced inter-European price dis-

[20] See e.g. the ACCRA Cost of Living Index, according to which the costs of living (All Items index) between US cities can differ by more than 15%.

[21] When Portual and Spain entered the EU their price level were 60% and 72%, respectively (European Commission, 2003)). However, at that time they could use autonomous monetary policy.

[22] Eurostat price level data for 2002 are not yet available. The fact that price level differences within the euro area are considerably larger than within Germany is not very surprising, given different national product legislation etc. effectively result in barriers to trade between the different euro area member countries.

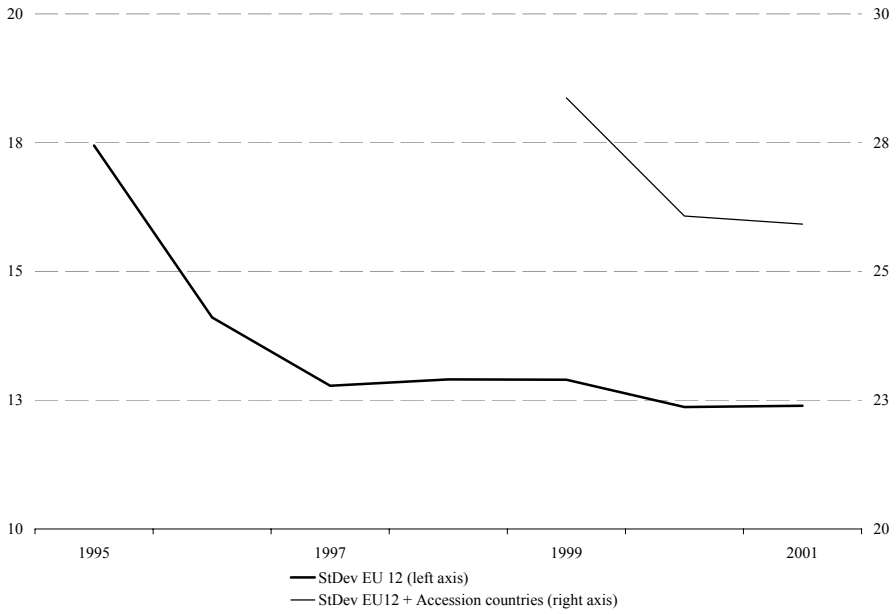

Figure 4: Price level dispersion across the euro area and the candidate countries

persion, although national borders and distance continue to be important determinants of relative price volatility.

We base our calculations on a 'best case' scenario: We assume that if the candidate countries join the EMU, most impediments to price level convergence are identical to those for the current members of the EMU. Therefore, we choose the country with the lowest price level in the euro area as benchmark and postulate that – over the medium term – the gap between the price level of the accession countries and the EU average will *on average* not exceed the current gap between the 'cheapest' EMU member and the respective average price level.

At present the country with the lowest price level within EMU is Portugal. Therefore, regarding the degree of price convergence we postulate:

Assumption 1
We assume that price levels in the accession countries will converge to the price level of Portugal in 2001 (the latest year for which we have euro area price level data), i.e. to about 74% of EU15 prices.

2 How fast will price levels convergence?

Next, we have to make an assumption about the speed of price level adjustments. According to the PPP literature deviations from the law of one price can be very persistent, Cecchetti et al (2000) estimate that half-lives of deviations from the law of one price

can last for up to nine years. However, Imbs et al. (2002) have challenged this view, claiming that half-lives of deviations of CPI *components* are varying and are on average considerably shorter than for the *aggregate* CPI. Ortega (2003) makes the distinction between tradable and nontradables goods and finds that half-lives of deviations from the law of one price between euro area economies are on average between 4 and 5 years. This is in line with our results for Germany of the last section.

What does this imply for convergence of price levels in an enlarged EMU? Germany probably fulfils more of the Optimal Currency Area criteria than the enlarged EMU, such as free migration of labour (not hampered by different languages!) and arbitrage is not hampered by different product regulations etc. Based on these considerations we might expect that in Germany price levels converged faster to levels compatible with convergence of inflation rates than it will happen in an enlarged EMU.

To be consistent with the evidence from previous studies, we have decided to base our calculations for EMU enlargement on three scenarios:

Assumption 2
We assume that price levels in the candidate countries will converge linearly to levels similar to Portugal in 5 years (fast convergence), in 10 years (medium convergence) and 20 years (slow convergence). This corresponds to half-lives of shocks of 2.5, 5 and 10 years, respectively.

3 How realistic are the assumptions we make?

To evaluate how realistic the assumption about the speed of convergence and the expected degree of price convergence are, we look at actual inflation and price level data for the candidate countries. Current price levels of the candidate countries are given in table 8. We observe that at present more than half of the candidate countries have price levels below 50% of the EU15 average.

To evaluate the consequence of the two assumptions we have made and to check how realistic these assumptions are, we compute future price levels of the candidate countries in 5, 10 and 20 years, based on their past inflation performance. The first column in table 9 shows price levels for the EU15, Portugal and the candidate countries. The second column provides average inflation rates over the past five years. The remaining columns show calculations of price levels in 5, 10 and 20 years, provided that inflation rates in the candidate countries remain at the same level as in the past five years. We see that based on part performance half of the candidate countries would have price levels exceeding those of Portugal within a period of 10 years, after 20 years only Latvia and Lithuania – both countries with very low inflation rates over the past 5 years – would still be 'cheaper' than the 'cheapest' EMU country.

European Commission (2003) shows that from 1999 to 2001 the price dispersion in EU25 has been reduced from 27.2% to 25.6%, while during the same period the price

	Price level	Deviation from EU15-average
Bulgaria	39.2	60.8
Czech Republic	46.9	53.1
Estonia	51.2	48.8
Hungary	48.7	51.3
Latvia	47.9	52.1
Lithuania	52.1	47.9
Poland	60.9	39.1
Rumania	41.1	58.9
Slovenia	66.6	33.4
Slovac Republic	42.1	57.9
(Unweighted) average cand. countries	49.7	50.3
EU15 Average	100.0	-
Portugal	73.9	26.1

Source: Eurostat and own calculations

Table 8: Price levels in the candidate countries in 2001

dispersion in EU15 has remained stable. They conclude that price convergence might proceed 'very quickly'. They also show that experience of past enlargement supports our assumption that convergence largely occurs in the new members, not in the old ones.

To summarise, the evidence of table 9 suggests that the assumptions we make are relatively benign in the sense that available data of the candidate countries rather points to faster price level convergence that we assume. In other words, our results are probably more likely to be biased downwards than upwards.

4.2 The effect of EMU enlargement on inflation in the current and future EMU members

Using the figures from table 8 we can compute the trend inflation differential in the candidate countries relative to the current euro area, if their price levels were to converge to the level of Portugal in 5, 10 or 20 years. The results are given in table 10. They can be regarded as a rough approximation of the inflationary pressure in the candidate countries, resulting from price level convergence and under the assumption that nominal adjustment of exchange rates is not possible.

As these figures are trend inflation differentials, we can compute actual inflation rates by adding the trend differentials to the average inflation rate of the currency union. Assuming that on average European inflation rates will not exceed the ECB's definition of price stability, the inflation rate in each country can be estimated by adding the corresponding value of table 10 to the 2% value the ECB considers as consistent with price stability. The interpretation is as follows: under the 'medium convergence' scenario, Poland, for instance, will for a period of 10 years have inflation rates of about 3.9%

	Average inflation last 5 years	Price level today	Price level in 5 years	Price level in 10 years	Price level in 20 years
EU 15	2.0[a]	100.0	110.4	121.9	148.6
Portugal	2.0[a]	73.9	81.6	90.1	109.8
Bulgaria	13.2	39.2	72.7	134.9	464.3
Czech Rep.	4.3	46.9	57.9	71.5	108.9
Estonia	5.0	51.2	65.5	83.6	136.6
Hungary	9.7	48.7	77.5	123.2	311.5
Latvia	1.7	47.9	52.0	56.5	66.7
Lithuania	2.7	52.1	59.6	68.1	89.0
Poland	7.3	60.9	86.6	123.1	248.6
Rumania	22.8[b]	41.1	114.9	320.7	2501.1
Slovenia	7.8	66.6	96.9	141.2	299.6
Slovac Rep.	8.0	42.1	61.7	90.4	194.4

Source: Own calculations

[a]For the calculations we set inflation in the EU15 and Portugal to 2%.

[b]The average inflation rate over the last 5 years was 42.6%, but with a declining trend. To not further inflate the estimates for Rumania, we have decided to base our calculations on the average inflation rate in 2002.

Table 9: Projected price levels in the accession countries, based on past 5-year inflation averages

(or 1.9% above the level the ECB considers consistent with price stability). These results indicate that relatively high inflation rates in the candidate countries might occur (under the scenario of 'medium' price adjustment, for instance, all but two candidate countries will experience inflation rates above 5% for a period of 10 years). Note, however, that actual inflation rates in the accession countries could, of course, deviate from these trend values, due to external shocks etc.[23]

Based on these figures we can compute the effect of quick accession on inflation for the enlarged EMU. We have calculated a baseline scenario where the candidate countries join EMU except for Bulgaria, the Czech Republic and Rumania, as these countries have indicated that they do not aim to introduce the common currency before 2007. In an alternative scenario we have assumed that all candidate countries join EMU. Furthermore, we have assumed that the inflation rates in the current euro area will average 2%, whereas inflation rates in the candidate countries are were determined by adding the trend inflation differential implied by table 3 to the 2 inflation rate compatible with the ECB's definition of price stability. In other words, the only factor driving inflation rates in the candidate countries is the convergence of their price levels.

As can be seen in the first row of table 11 inflation in the enlarged EMU could reach levels between 2.1 and 2.3 percent.[24] The second row computes inflation rates in the

[23]Our estimates for the Czech Republic are slightly higher than those of Cihák and Holub (2001), who estimate that inflation rates could reach levels of 2.7 to 4.7 percent.

[24]Note these figures are pure *trend* inflation rates, i.e. abstracting from any cyclical factors.

	Fast convergence	Medium convergence	Slow convergence
Bulgaria	13.5	6.6	3.2
Czech Republic	9.5	4.6	2.3
Estonia	7.6	3.7	1.8
Hungary	8.7	4.3	2.1
Latvia	9.1	4.4	2.2
Lithuania	7.2	3.6	1.8
Poland	3.9	1.9	1.0
Rumania	12.4	6.0	3.0
Slovenia	2.1	1.1	0.5
Slovac Republic	11.9	5.8	2.9
Total	7.1	3.5	1.7

Source: Eurostat and own calculations

Table 10: Trend inflation differentials in the candidate countries

current euro area members, provided that inflation in an enlarged EMU is maintained at 2 percent and inflation rates in the candidate countries are subject to the trend inflation differential suggested by table 3. We see that the faster price level convergence unfolds, the higher the need for inflation rates in the current EMU members to be below 2 percent (e.g. in the medium convergence scenario inflation in the euro area need not exceed 1.9% for enlarged EMU inflation to remain below 2%). In the most extreme case of rapid price level adjustment, inflation rates in the current EMU should for a period of 5 years be about 0.3 percentage points below the current maximum inflation rate considered to be consistent with price stability of 2% (the baseline scenario). In the alternative scenario (i.e. without Bulgaria, Rumania and the Czech Republic) inflation rates in the current euro area should not exceed 1.5% in order not to violate the ECB's definition of price stability.

Overall, the effect of price level adjustment on trend inflation in the euro area is estimated to be relatively small (albeit not negligible), provided the adjustment process does not unfold too quickly. However, relatively high trend inflation rates in the accession countries are likely to prevail.

4.3 Sensitivity analysis

All our calculations assume a constant relationship between GDP of the current and the future EMU members. Should the candidate countries grow faster than the current EMU members, our estimates of inflation for the euro area are likely to be too low, as the economic weight of candidate countries, relative to the current EMU members, will increase: if, for instance, we increase the weight of the accession countries, relative to the current euro area, by 20%, inflation rates in the current EMU would have to decrease from 1.7% to 1.4% in the fast convergence scenario and from 1.9% to 1.7% in th medium convergence, respectively.

	Fast convergence	Medium convergence	Slow convergence
Baseline scenario:			
Inflation in enlarged EMU[a]	2.3	2.2	2.1
Inflation rates in EU12 if enlarged EMU inflation equals 2%	1.7	1.9	1.9
Alternative scenario:			
Inflation rates in enlarged EMU[a]	2.4	2.2	2.1
Inflation rates in EU12 if enlarged EMU inflation equals 2%	1.5	1.8	1.9

Source: Own calculations

[a] Inflation for the current EMU members is assumed to be 2% and inflation rates in the accession countries are based on table 10

Table 11: Effect of EMU enlargement on euro area inflation

Furthermore, we have assumed linear price level convergence. If convergence is increasing in the differences (i.e. if the price level differences decrease exponentially), higher initial inflation differentials can be expected. If prices for tradable goods rise in the accession countries, this can lead to losses in competitiveness; moreover high inflation in the accession countries reduces their citizen's purchasing power, potentially leading to high costs of price level adjustment at the individual agent's level.

5 Conclusion

In this paper we have analysed price developments in a monetary union. We establish two main findings: first, using a theoretical model we showed that if two countries with considerable initial differences in price levels and economic size form a monetary union, in the presence of downward rigidities the optimal path for price level convergence is not symmetrical. In the model we have assumed that the speed of price adjustment in both countries is equal and we did not further consider differences in monetary transmission, different types of rigidities etc. The model shows that if convergence to a lower price level would imply high output losses in the country with the higher price level, the central bank should allow relatively high inflation in the country with initially low prices.

Second, evidence from the euro area suggests that differences in price levels can be relatively large and persistent. This indicates that price level convergence in the EMU accession countries can be very long lasting. Using data from the German reunification we have made assumptions about the degree of price level convergence we can expect in Europe, and the speed of convergence. Then, our results show that inflation rates in the accession countries could be relatively high, whereas the impact on the current euro area members is likely to be small (though not negligible). At present we have aimed to

based our calculations on relatively 'conservative' estimates for all accession countries as a whole in order not to overstate the effect. We did not allow for country-specific factors, but have simply assumed that all countries will converge with the same speed. It remains the task for future research to allow different speeds of adjustment, based e.g. on country-specific information about the flexiblity of labour and product markets.

At this point we have to stress that we have treated all candidate countries equally in the theoretical and the empirical analysis. Evidently, in reality e.g. the degree of rigidities varies across the candidate countries, which implies that some will converge faster than others. Therefore, the policy recommendations regarding e.g. the transition period may vary across countries. Having these considerations in mind, the general picture that emerges is as follows: To foster price level adjustment prior to EMU accession a 'controlled' real appreciation of the candidate countries is needed. This can basically happen via two channels: first, rising product prices in the candidate countries, second via a nominal appreciation of the candidate countries' exchange rates.

European monetary policy must always focus on the entire currency area. Once the candidate countries have adopted the euro, their special situation can no longer be accounted for. Therefore, our results may have implications regarding the timing of the entry to EMU. Overall, the following conclusion emerges: to smooth the adjustment process it may be in the interest of the accession countries not to fix their exchange rate too early. Instead, by retaining monetary policy autonomy for a prolonged transition period they might be able to avoid high inflation rates as a result of price level adjustment once they have joined EMU.

Appendix A: The German reunification

After the Second World War, Germany was divided into West Germany, which implemented a market economy, and East Germany, which was essentially a planned economy of the Soviet type. Until the reunification one the main pre-requisites for the law of one price to hold was violated: trade was seriously hampered by the existence of two different political regimes. As a result, not only relative prices were heavily distorted in East Germany prior to the reunification,[25] but also price levels were considerably lower than in West Germany. This is reflected in bank exchange rates between the Deutschmark and the East German Mark prior to the reunification, which were about 12.5 West German Deutschmark in exchange for 100 East German Mark.[26]

East and West Germany entered a currency union on July 1st, 1990, when East Germany officially introduced the West German Deutschmark as legal tender . The ex-

[25] Relative prices were not based on scarcity of goods, but largely on political considerations. Basic goods such as bread etc. were heavily subsidised, whereas 'luxury goods' (such as cars or TV sets) were largely overpriced.

[26] See Deutsche Bundesbank, 1999, p. 23.

change rate between both parts was set on the basis of political, not economic considerations. As a result, the exchange rate set between Deutschmark and East German Mark was 1:1, despite the advice of the Bundesbank, who had opted for a lower exchange rate (for larger savings and debts a rate of 1:2 applied).[27] As a result of this political decision, the large price level differences between East and West Germany implied by the bank exchange rates prior to the unification were reduced, but not eliminated.[28]

Appendix B: A theoretical model of price and inflation convergence

The model primarily serves to study the optimal path of price adjustment. Although we want to capture the anticipated price dynamics following EMU enlargement as closely as possible, we do not attempt to model the entire catching-up process.[29]

The euro area and the accession countries are described in a two-country model. Differences between individual countries within each region may sometimes be substantial, but are ignored here. However, we allow for some differences between regions. In the model, the euro area and the group of accession countries are characterised by differences in size (the economy of the group of accession countries is small comared to the euro area) and initial price levels (prices in the accession countries are lower). The other model parameters are assumed to be equal for both regions: First, this simplifying assumption helps to keep the attention to the asymmetries we want to focus on. Second, it is not always clear how differences in economic structure would affect the other model parameters (speed of price level adjustment and steepness of supply curves). For instance, whereas the Polish economy is supposedly characterised by relatively little flexibility, the Estonian economy is said to be (much) more flexible than the euro area. For the model we therefore take as a starting point that the euro area and the group of accession countries are asymmetric only in terms of economic size and initial price level.

We assume two countries, A and B, of size k and $1-k$ respectively, where $k < \frac{1}{2}$, so that country A is the smaller country. Initially, country A has a lower price level:

[27] The question which exchange rate was most appropriate was widely-debated, as Bundesbank (1999) shows. Among others, the then President of the Deutsche Bundesbank, Karl-Otto Pöhl, did not support the government's decision of an exchange rate of 1:1 for wages and prices. As a consequence, once from a central banker's perspective the German reunification was (technically) completed, he resigned (Marsh, 1992).

[28] This decision not only reduced price level differences, but also hampered the competitive position of the East German economy. In what follows, however, we neglect this aspect and focus on the price developments.

[29] Obviously, chosing for a parsimonious model has a number of limitations, e.g. one of the sensitivity checks of section 4.3 was to allow for higher growth in the accession countries. Our model cannot provide a realistic source for a positive growth differential in the accession countries. But since our aim is to focus on the price dynamics following EMU enlargement, we do not regard this as a major shortcoming.

$p^A < p^B$.[30] The two countries decide to form an economic and monetary union. As a result, price levels start to converge. However, this does not happen overnight: the literature suggests that price level adjustment is a gradual process.[31] Here, we do not specify the underlying mechanisms (Balassa-Samuelson effect, more effective goods arbitrage). Instead, we restrict ourselves to a simple description of the path of price adjustment towards the law of one price. In each period, the new price level in each country depends on the price level in the previous period, the price difference with the other country in the previous period and the monetary policy stance (which is assumed to have an identical price impact in both regions). There is staggered price adjustment, as in Calvo (1983):[32]

$$\begin{aligned} p_t^A &= p_{t-1}^A + \frac{1}{2}\alpha\left(p_{t-1}^B - p_{t-1}^A\right) + m_t, \\ p_t^B &= p_{t-1}^B + \frac{1}{2}\alpha\left(p_{t-1}^A - p_{t-1}^B\right) + m_t. \end{aligned}$$

The parameter α ($0 < \alpha < 1$) can be interpreted as the speed of the price level adjustment,[33] m_t is the change in the monetary aggregate (assumed to be fully controlled by the central bank). To keep the model simple we have assumed similar speed of price adjustment in both countries (allowing for different α's does not change our results qualitatively). In the steady state, the equations above reduce to the law of one price. It follows directly from the equations above that

$$\begin{aligned} \pi_t^A &= p_t^A - p_{t-1}^A = \frac{1}{2}\alpha(p_{t-1}^B - p_{t-1}^A) + m_t, \\ \pi_t^B &= p_t^B - p_{t-1}^B = -\frac{1}{2}\alpha(p_{t-1}^B - p_{t-1}^A) + m_t, \end{aligned} \tag{4}$$

where π_t is the inflation rate. The inflation difference between both countries is determined by the price level difference in the previous period and the adjustment speed, but not affected by monetary policy: $\pi_t^A - \pi_t^B = \alpha(p_{t-1}^B - p_{t-1}^A)$.

[30] The initial price level difference is possible due to a lack of market integration at the outset.

[31] The assumption that price level adjustment occurs gradually is supported by several arguments: (1) catching up in terms of productivity (which underlies Balassa-Samuelson effect) is estimated to take about 30 years: see Fischer, Sahay, Végh (1998); (2) remaining trade barriers prohibit full goods arbitrage.

[32] In Calvo (1983), there is staggered price adjustment in continuous time, where a fixed number of firms receives a price-change signal per unit of time. Here, a fraction α of firms change prices in each period. One interpretation is that trade barriers are lifted sector by sector, affecting a share α of the economy in each period.

[33] In the case of zero money growth ($m_t = 0$): if $\alpha = 0$, then $p_t^A = p_{t-1}^A$ and $p_t^B = p_{t-1}^B$ (no convergence); if $\alpha = 1$, then $p_t^A = \frac{1}{2}p_{t-1}^A + \frac{1}{2}p_{t-1}^B = p_t^B$ (immediate and full price level convergence); for $0 < \alpha < 1$, there is gradual convergence to the law of one price ($p^A = p^B$).

We define a simple supply function:

$$y_t^j = \beta(\pi_t^j - w_t^j), \quad j = A, B, \tag{5}$$

with $\beta > 0$, so that output growth y depends negatively on real wage growth $w - \pi$. Combining equation (5) with a simple optimal wage setting rule $w^j = E(\pi^j)$ would yield the familiar Lucas supply function (see Blanchard and Fischer, 1989, chapter 7, page 358). [34] Here, we make the additional assumption that labour unions are unwilling to accept a decline in nominal wages. This assumption is in line with the empirical evidence on a downward nominal rigidity in wages presented by Akerlof, Dickens and Perry (1996). Their claim has been disputed by Gordon (1996) and Mankiw (1996), who argue forcefully that the findings by Akerlof et al. (1996) are subject to the Lucas critique. Responding to this critique, using Swiss regional data, Fehr and Goette (2000) provide evidence for the presence of a strong nominal wage rigidity in an environment with sustained low and negative nominal GDP growth, suggesting that the validity of the claim by Akerlof may extend to such an environment. However, the point here is not that wage rigidities are important, but that deflation can cause severe output losses.[35] We prefer to present a simple model, in which a downward rigidity is imposed on nominal wage growth:

$$w_t^j = \max\left\{0, E\left(\pi_t^j\right)\right\}, \quad j = A, B.$$

In the absence of shocks and policy surprises, expected inflation equals realised inflation, so that the wage setting process becomes entirely deterministic:

$$w_t^j = \max\left\{0, \pi_t^j\right\}, \quad j = A, B. \tag{6}$$

Area-wide output growth and inflation are weighted averages of national output growth and inflation rates:

$$\begin{aligned} y_t^* &= k y_t^A + (1-k) y_t^B, \\ \pi_t^* &= k \pi_t^A + (1-k) \pi_t^B. \end{aligned}$$

[34] The wage setting rule $w^j = E(\pi^j)$ can be derived in several ways. In Canzoneri and Henderson (1991, chapter 1), employment depends on the real wage rate and wage setters minimise the variability of employment. This leads to a simple optimal wage setting rule, where wages are set equal to the expected price level. In terms of growth rates, this implies that wage growth is set equal to the expected level of inflation, i.e. $w^j = E(\pi^j)$. An alternative approach would be to assume that workers minimise the expected square deviation of real wage growth from the wage growth target, which is set equal to zero for simplicity. This yields the same optimal wage rule. See for instance Cohen (1997).

[35] IMF (2002), p. 27, provides an overview over the degree of nominal rigidities in the euro area. We could use a more elaborate model with nominal debt contracts or with a zero lower bound to nominal interest rates to establish the same main point.

The common central bank implements a single monetary policy for both countries. It focuses on output growth and inflation in the entire currency area (y_t^* and π_t^*, respectively). The central bank seeks to set an optimal monetary policy in each period by minimising its loss function:

$$L_t^* = \frac{1}{2}(y_t^*)^2 + \frac{1}{2}\gamma(\pi_t^*)^2, \tag{7}$$

with respect to its policy instrument m_t, subject to equations (4), (5) and (6), where γ is the relative weight assigned to the goal of price stability by the common central bank.

From the first-order conditions we can derive the optimal monetary policy stance:[36]

$$m_t = \left(\frac{\alpha}{2}\right)\frac{\beta(1-k)+\gamma(1-2k)}{\beta(1-k)+\gamma}\left(p_{t-1}^B - p_{t-1}^A\right). \tag{8}$$

Combining this result with equation (4) yields the following path of price adjustment, implied by the inflation rates in individual countries and the area as a whole:

$$\pi_t^A = \frac{\alpha(\beta+\gamma)(1-k)}{\beta(1-k)+\gamma}\left(p_{t-1}^B - p_{t-1}^A\right) > 0, \tag{9}$$

$$\pi_t^B = -\frac{\alpha\gamma k}{\beta(1-k)+\gamma}\left(p_{t-1}^B - p_{t-1}^A\right) < 0, \tag{10}$$

$$\pi_t^* = \frac{\alpha k}{1+\gamma/[\beta(1-k)]}\left(p_{t-1}^B - p_{t-1}^A\right) > 0. \tag{11}$$

Equation (11) shows that initial price level differences cause an upward bias in area-wide inflation (i.e. $\pi_t^* > 0$) under optimal monetary policy. The area-wide inflation rate is increasing in the initial price level difference between both regions ($p_{t-1}^B - p_{t-1}^A$). Equations (9)-(11) also illustrate two main points:

- If the economic size of the accession countries (country A) is relatively small compared to the current member states (country B) ($k \to 0$), then it is optimal from the common central bank's point of view that the burden of price adjustment will fall upon the accession countries. This can be seen by noting that $\lim_{k\to 0}\pi_t^A = \alpha(p_{t-1}^B - p_{t-1}^A)$; $\lim_{k\to 0}\pi_t^B = 0$; $\lim_{k\to 0}\pi_t^* = 0$.
- If the output loss associated with deflation is high, the central bank will raise area-wide inflation (and accept the loss related to a higher inflation rate in country A) in order to reduce the deflation rate in country B. Mathematically: the higher β (i.e. the flatter the slope of the aggregate supply curve), the higher the area-wide inflation rate π^*.

[36] We can distinguish between several cases for the signs of π_t^A and π_t^B. However, it is straightforward to show that only the case $\pi_t^A > 0$; $\pi_t^B < 0$ is consistent with the initial condition $p_0^A < p_0^B$ and with the equations above. This helps to simplify equation (6) in the main text.

Appendix C: Data sources

Our data set consists of regional inflation time series for the period 1/1991-7/2002 for the Bundesländer Brandenburg, Mecklenburg-Vorpommern, Sachsen and Sachsen-Anhalt (monthly data) and annual data for the period 1995-1997 and monthly data for 1/1997-7/2002 for Thuringa. Data on sub-categories for Sachsen was provided since 1995. The Statistisches Bundesamt provided inflation data for East and West Germany for the period 1991-2002 (monthly data). We wish to thank all *Statistische Landesämter*.

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