A Short History of Price Level Convergence in Europe

Riemer P. Faber, Ad C. J. Stokman

January 2008

JEL codes: E31; E50; F15; F40

Keywords: Economic integration; Price level convergence; EMU

We thank Robert-Paul Berben, Marco Hoeberichts, Lex Hoogduin, Maarten Janssen, Philipp Maier, Pok-sang Lam (editor), and in particular an anonymous referee for helpful comments. We thank Frank Verboven for providing micro data on European car prices.

Riemer Faber is a Ph.D. student at the Tinbergen Institute and Department of Economics, Erasmus University Rotterdam. E-mail: faber@few.eur.nl Ad Stokman is a senior economist with the Economics and Research Division, De Nederlandsche Bank. E-mail: a.c.j.stokman@dnb.nl

Abstract

We study the evolution of price level dispersion in Europe by combining time series information on consumer price indices with occasional observations of absolute price levels. We find that European price levels converged over much of the last 40 to 50 years. In the US, our benchmark, price level dispersion is more or less stable. A back-of-the-envelope calculation suggests that indirect tax rate harmonization, convergence of non-traded input costs and convergence of traded input costs (in the form of exchange rate stability and increased openness) are all important in explaining European price level convergence.

1. Introduction

During the last five decades, European countries made a huge effort to integrate their national markets. The signing of the Treaty of Rome on the establishment of the European Economic Community fifty years ago (1957), the completion of the Single Market (1993) and the recent introduction of the euro (1999) have been milestones in the process towards economic, monetary and political unification of Europe. The demolition of "border effects" (Engel and Rogers 1996) makes Europe a particularly interesting case for studying price level convergence. The two main objectives of this paper are (1) detecting general trends in price level dispersion starting from the earlier days of economic cooperation in Europe and (2) the identification of the main determinants behind this process. In other words: how successful has European integration policy been?

Due to limited availability of data on absolute price levels, little is known about the *long-term* development of European price level dispersion. Regular price data collected by national statistical agencies are mainly published in terms of indices and are for that reason not suitable for international comparisons. Since 1995 Eurostat publishes price level differences between countries (see Allington, Kattuman and Waldmann 2005), but this period is too short to answer our questions. Also from the OECD's International Comparison Project some comparable national price levels are known, but again country and time coverage are limited. To avoid these problems, several studies use micro data.

First of all, there are studies that focus on one specific product, like automobiles (Goldberg and Verboven 2005) or hamburgers (Parsley and Wei 2007). Although these studies produce interesting insights, such an approach does not help much in detecting general price level trends. The second type of research uses datasets that cover a broad set of products. Engel and Rogers (2004) and Rogers (2007) use a city dataset provided by the Economist Intelligence Unit (EIU) which is available from 1990 onwards. Crucini, Telmer and Zachariadis (2005) (afterwards CTZ) use an extensive Eurostat micro dataset that covers four individual years (1975, 1980, 1985 and 1990). Both studies provide interesting insights, but cover just parts of the European integration process.

For our historical investigation into the trends and determinants of price level convergence in Europe, long time spans are needed. To that end, we scale Harmonized Indices of Consumer Prices (HICP) back to 1960 on the basis of occasional measurements of price level differences between countries. So we convert Harmonized *Indices* of Consumer Prices into proxies of *absolute* price levels. Chen and Devereux (2003) use a similar method to construct price level data for US cities.[1]

The calculation of these long price level series allows us to construct time series on price level dispersion for almost the complete period of European integration and to uncover the determinants of price level dispersion over time. Moreover, we can compare developments in the European Union (EU) and the Economic and Monetary Union (EMU) with long-term developments in other regions like the United States (US). The US is a natural benchmark, as it has been a political, cultural and monetary union for a long period of time. We also compare European wide developments with those in the former DM-zone (Germany, Austria, Belgium, Luxembourg and the Netherlands). Such a comparison might help to understand the significance of monetary unions relative to customs unions since the DM-zone was already an area of monetary and exchange rate stability long before the EMU started. Our main result is that European price levels converged over much of the last 40 to 50 years, while in the US price level dispersion remained more or less stable. Moreover, price levels converged faster in the DM-zone than in the EMU.

To identify the determinants of price level dispersion and to get an indication of their contributions to the dispersion level and its decline, we use the model that CTZ apply to European cross-sectional micro price data. In that model, retail price dispersion is a function of dispersion of non-traded input costs (e.g. wages) and dispersion of traded input costs. Our dataset allows us to introduce a time dimension to the CTZ framework for price level dispersion. A back-of-the-envelope calculation suggests that indirect tax rate harmonization, convergence of non-traded input costs and convergence of traded input costs (in the form of exchange rate stability and increased openness) all contributed to European price level convergence.

The macro approach may be subject to a number of shortcomings. Consumption baskets are not completely identical across EU countries. Furthermore, the composition of consumption baskets changes throughout time, as products disappear or are replaced by new ones. Moreover, aggregate HICP might be subject to a *summation bias*, i.e. different price level movements in HICP sub-categories, which may average out or dominate. In this paper we take a closer look at these and other issues. We conclude that, as far as we can judge, our approximation of price levels is reliable.

As mentioned before, there are studies that investigated similar questions either in the context of specific markets using product level data, or for sets of products for only sub-periods of our sample. However, to our knowledge, this is the first study that provides reliable documentation of the evolution of price level dispersion in Europe and its determinants over a long period based on a representative basket of products.

The remainder of the paper is organized as follows. Section 2 introduces our dispersion measure and briefly discusses the (marginally) adapted CTZ model. Section 3 describes the data. In Section 4 new evidence of European price level convergence at the aggregate and one-digit HICP product level is presented. Section 5 studies the main factors driving price level convergence. The reliability of our methodology and comparisons with other studies are discussed in Section 6. Section 7 concludes.

2. Model

In this section, we introduce the price level dispersion measure and theoretical framework. These are based on CTZ, although some modifications are made to study developments over time instead of cross-country differences.

Firstly, we define the price level dispersion measure. Say a basket of products in country j at time t has price level P_{jt} (price levels from all n countries are expressed in the same currency, a product basket subscript is omitted for simplicity). Price level dispersion at time t is measured by the cross-country standard deviation of $\log P_{jt}$ (short notation $\sigma(x_t) = \sigma(\log X_{jt} \mid t)$):

$$\sigma(p_t) = \sigma(\log P_{jt} \mid t) = \sqrt{\frac{1}{n}\sum_{j=1}^{n}(\log P_{jt} - \frac{1}{n}\sum_{i=1}^{n}\log P_{it})^2} \tag{1}$$

Note that the choice of the common currency in which price levels are expressed does not affect the size of the dispersion measure. In Section 4 the evolution of price level dispersion will be studied.

Secondly, a theoretical framework is needed for studying the determinants of price level dispersion. Following CTZ, the production of a final product requires both traded and non-traded inputs. For example, a “traded good” like a car requires both traded inputs (iron) and non-traded inputs (sales person's labor and a shop). Similarly, a typical "non-traded good" like a haircut also needs traded inputs like a pair of scissors.

Production in country j at time t with traded and non-traded inputs is described by a Cobb-Douglas technology with constant returns to scale. There is perfect competition.

$$P_{jt}^{*} = W_{jt}^{\alpha} Q_{jt}^{1-\alpha} \tag{2}$$

P_{jt}^{*} is the price level P_{jt} in country j at time t corrected for indirect taxation (rate τ_{jt}): $P_{jt}^{*} = P_{jt} / (1+\tau_{jt})$. W_{jt} is the cost of the non-traded input in country j at time t and Q_{jt} is the cost of the traded input in country j at time t. α is the share of non-traded inputs required for production.

From Eq. 2 we can deduce the relation between the price level dispersion and its determinants, first by taking the logarithm of Eq. 2:

$$\log P_{jt}^{*} = \alpha \log W_{jt} + (1-\alpha) \log Q_{jt} \tag{3}$$

Next calculate the variance for given t across n countries (and rewrite):

$$Var(\log P_{jt}^{*} \mid t) = [\sigma(p_t^{*})]^2 = \left[\alpha\sigma(w_t) + (1-\alpha)\sigma(q_t)\right]^2 + 2\alpha(1-\alpha)\sigma(w_t)\sigma(q_t)\left[Cor(w_t, q_t) - 1\right] \tag{4}$$

where $Cor(w_t, q_t) = Cor(\log W_{jt}, \log Q_{jt} \mid t)$. We do not have data to calculate $Cor(w_t, q_t)$ and therefore we ignore the second term.[2] This gives the following expression for $\sigma(p_t^{*})$:

$$\sigma(p_t^{*}) = \alpha\sigma(w_t) + (1-\alpha)\sigma(q_t) \tag{5}$$

The dispersion of price levels (excluding indirect taxes) is higher if the dispersion of non-traded input costs and the dispersion of traded input costs are higher. The dispersion of traded input costs is expected to be higher if arbitrage costs are higher. In our further analysis arbitrage costs are broken down in (1) exchange rate volatility (vol_t) and (2) openness of a country group ($open_t$) which summarizes the development throughout time of all other trade costs like transportation costs, (non-)tariff barriers and information costs (Rogoff 1996):

$$\sigma(q_t) = f(vol_t(+), open_t(-)) = \beta_0 + \beta_1 vol_t + \beta_2 open_t \quad (6)$$

Substituting Eq. (6) into Eq. (5), we get the following testable relation:

$$\sigma(p_t^*) = \alpha\sigma(w_t) + (1-\alpha)[\beta_0 + \beta_1 vol_t + \beta_2 open_t] \quad (7)$$

In Section 5 the determinants of price level dispersion will be studied via this framework.

3. Data

Price level data

As mentioned before, European price level data are constructed via scaling standard HICP data. Aggregated HICP data for the former EU-15 members are available back to 1960.[3] Disaggregated HICPs are only available from 1995 onwards. To capture long-term price level developments at the one-digit product level, we connect HICP sub-indices to their CPI counterparts for the period 1980-1995.[4]

To compare levels of HICP across countries, we apply a similar methodology as Chen and Devereux (2003) for US city CPIs. First of all, all indices are converted into a common currency (DM/euro) using annual averages of market exchange rates. Next, we convert the HICPs into absolute price levels by using the price level differences between countries that Eurostat publishes from 1995 onwards.[5] We take these absolute price levels for one particular year and calculate back and forward in time the absolute price levels by using the national HICP time series. Formally, the HICP for product basket g in country j is scaled by the absolute price level P^g_{j1999} of product basket g in country j in 1999:

$$P^g_{jt} = (HICP^g_{jt} / HICP^g_{j1999})P^g_{j1999} \qquad g=1,...,G \quad j=1,\ldots,n \qquad t=1960,..,2003 \tag{8}$$

In Section 6, we show that this approximation of the underlying absolute values of HICP is reliable. Aggregate price levels from 1960 onwards for 20 US cities are constructed similarly.[6]

Supplemental data

Following the model specification, additional data is necessary on indirect tax rates, non-traded input costs, exchange rate volatility, openness and the share of non-traded inputs. Nine different US regions will be considered since for some of the determinants (notably openness) it is more suitable to compare European countries with nine US regions than with for example all individual states. These regions are often used by statistical agencies.

National and regional indirect tax rates (τ_{jt}) are calculated via total indirect taxes divided by private consumption.[7] To approximate non-traded input costs (W_{jt}), we take the per capita Gross Domestic (or region) Product (GDP) at factor costs converted to common units using PPP measures.[8] Long-term European exchange rate volatility (vol_t) is measured by the standard deviation of all monthly changes in the exchange rate of a country against the German mark in one year, averaged over all countries in the group and over eight years.[9] Of course, for the US there is no exchange rate volatility. Openness ($open_t$) is measured for Europe by the level of actual trade; namely the level of exports of goods from countries in the group to other EU countries (members in 2003), as a percentage of the group's GDP.[10] Unfortunately, long-term data on intra-US trade is not available. On the basis of the Commodity Flow Survey, which offers the most comprehensive nationwide source of freight data, the value of goods traded between regions is estimated for the years 1977, 1993, 1997 and 2002.[11] This value is expressed as a percentage of the US GDP. The share of non-traded inputs (α) is set at 0.6. Approximately 60 percent of the HICP basket consists of non-traded products (Maier 2004). If these non-traded products require a traded input of say 10 percent and if traded products require a non-traded input of 15 percent (CTZ, Data Appendix, Table A1), then it follows that $\alpha = 0.6 \cdot 0.9 + 0.4 \cdot 0.15 = 0.6$.

4. Trends in price level dispersion

In Figure 1A price level dispersion is plotted for several combinations of European countries. These are an EMU group consisting of all 12 EMU members in 2003, an EU group consisting of all 15 EU members in 2003 and the DM-zone. As a benchmark, US city price level dispersion is included as well.[12]

All European country groups show a declining trend in price level dispersion over much of the last 45 years. Roughly speaking, for the EMU and the EU three periods can be distinguished: 1960-1973 was a period of rapid decline in price level dispersion, 1974-1987 was a period of stagnation and 1988-2003 a period in which price level convergence regained momentum. Compared to 40 years ago, price level dispersion in the EMU has been halved. These findings make sense if we think about the history of European economic integration policy as briefly described in the Introduction. The 1960s, early 1970s and 1990s are characterized by cooperation, harmonization and several European milestones, while in the second half of the 1970s and first half of the 1980s European cooperation and integration policy stagnated.

Price level differences within the DM-zone have always been substantially lower and convergence has been stronger in relative terms. From 1960 on price levels steadily converged in the DM-zone. In the second half of the 1980s price level dispersion reached its lowest level, which is close to zero. At the beginning of the 1990s price level dispersion in the DM-zone rose somewhat, possibly as a result of the German reunification. In more recent years, price level dispersion declined again. The price level dispersion of the DM-zone in the early sixties is comparable to the EMU's present level.

Figure 1A also displays US city price level dispersion. First of all, price level dispersion rates in the EMU and the EU are structurally higher than in the US. However, the gap between the two has gone down substantially. This is mainly the result of price level convergence in Europe. In the US price level dispersion is relatively stable, although it increased a bit since the 1980s. In the DM-zone, price level dispersion was higher in the beginning of our sample compared to the US, but is nowadays below US price level dispersion. The comparison with the US suggests that European specific factors have been at work. To investigate this further we take the DM-zone, the EMU and the US as our starting point for a more detailed analysis in Section 5.

Trends at one-digit product level

Is the overall picture representative? Aggregate HICP may be subject to a summation bias. In this section, we take a closer look at this issue by applying our methodology to 7 one-digit HICP sub-categories. We first classify the sub-categories as traded or non-traded (Maier 2004).

Housing is classified as non-traded. *Alcoholic beverages and tobacco* is non-traded as well, as price levels are to a large extent determined by taxes. *Food* and *Clothing and footwear* are traded sub-categories. *Furnishings, Transport and communications* and *Recreation and culture* contain both traded and non-traded products. *Furnishings* is comprised almost completely of traded products. *Recreation and culture* has more or less an equal share of traded and non-traded products. *Transport and communications* contains relatively many non-traded products.

EMU trends of the one-digit sub-categories are depicted in Figure 1B. Price level dispersion patterns for sub-categories are in line with the pattern for aggregate HICP. For all sub-categories, price level dispersion was more or less stable up to 1986-1987, but started to decline afterwards. In the early 1990s, there is strong price level convergence for all sub-categories.

Although all sub-categories show a similar trend, there are differences. Firstly, in general traded sub-categories have a lower price level dispersion than non-traded sub-categories. For example, price level dispersion is three to four times smaller for the traded sub-category *Food* than for the non-traded sub-categories *Alcoholic beverages and tobacco* and *Housing*. Secondly, over the whole sample period price levels of the sub-categories *Food*, *Clothing and footwear*, *Furnishings* and *Recreation and culture* converge most in relative terms. So, traded sub-categories show a lower price level dispersion and more convergence than non-traded sub-categories. HICP sub-categories for other European country groups and at higher digit levels (for a smaller set of countries) show similar patterns.

The fact that traded and non-traded sub-categories follow roughly a similar trend suggests that a possible bias due to summation is perhaps not such a problem.[13] Moreover, these similar trends might make sense if one considers that both types of sub-categories have a traded and a non-traded input component, as argued in Section 2. If non-traded (traded) input costs converge, this has an impact on traded (non-traded) sub-categories as well. It is also possible that factor-price-equalization is at work.

5. Determinants of price level dispersion

Which factors may explain price level dispersion in Europe over the last 40 to 45 years? How important has European integration policy been? To investigate these questions we start with a qualitative, visual inspection of the determinants of price level dispersion and compare these with those for the US. Second, we use the adapted CTZ model to make a tentative quantitative assessment of the contribution each determinant has made to price level convergence in Europe.[14]

The model in Section 2 identifies differences in indirect tax rates (τ_{jt}), non-traded input cost dispersion ($\sigma(w_t)$), exchange rate volatility (vol_t) and openness ($open_t$) as determinants of price level dispersion, where the latter two represent traded input cost dispersion. Figure 2 shows the developments over time of these four determinants for the EMU, the DM-zone and the US (the standard deviation of the indirect tax rates is plotted). The figure shows that in periods of declining price level differences between the

EMU countries - the 1960s up to the early 1970s and the late 1980s and onwards - various factors operated simultaneously in the right direction. During both periods, indirect tax rates were harmonized and non-traded input costs converged. These periods are also notable for exchange rate stability and an increase of openness. In between, price level convergence stagnated. Remarkably, non-traded input cost dispersion also remained stable and the growth of openness stagnated in this period. Another factor was the turbulence on the foreign exchange markets following the collapse of Bretton Woods in 1971.

In the DM-zone, price level convergence proceeded at a steady pace, accelerated in the 1980s and was later interrupted at the time of the German reunification. Figure 2 shows that in the first three decades convergence of non-traded input costs, exchange rate stability and increased openness made a combined contribution. The figure also sheds light on why price level dispersion in the DM-zone was always smaller than in the EMU: more similar indirect tax rates, a lower dispersion of non-traded input costs, more stable exchange rates and a higher openness.

Interestingly, in the US, where there was hardly any change in the price level dispersion compared to Europe, dispersion of indirect tax rates and non-traded input cost dispersion were also stable over time. Figure 2 shows that in the 1960s indirect tax rates were more diverse in Europe than they were in the US, but differences in Europe steadily declined over time. Moreover, over the whole sample the dispersion of non-traded input costs is higher in the US than in the DM-zone, but lower than in the EMU. However, due to the strong decrease of non-traded input cost dispersion in the EMU, its levels are coming closer to those of the US in the early 2000s. Our approximation of openness suggests that the US regions have always been much more integrated than the EMU countries. For example, in 1977, the openness of the US was twice as large as the openness of the EMU (30 vs. 14 percent). In recent years, differences in openness between Europe and the US have become substantially smaller, but have not completely disappeared.

As a final remark it should be noted that the EMU and the DM-zone are geographically much more compact than the US. With almost 10 million square kilometers, the US territory is four times larger than the EMU and almost 20 times larger than the DM-zone.

Next, we use the adapted CTZ model from Section 2 to make a back-of-the-envelope calculation of the contributions of the various factors to overall price level dispersion in the EMU (see Eq. 7). Recall that the model is formulated in terms of price levels excluding indirect taxes and that the share of non-traded inputs (α) is known to be 0.6. As a robustness check we will also present results for $\alpha = 0.5$.[15] The elasticities belonging to exchange rate volatility and openness - for which a priori information is lacking - can be estimated freely. This gives the following equation:

$$\sigma(p_t^*) - \alpha\sigma(w_t) = (1-\alpha)[\beta_0 + \beta_1 vol_t + \beta_2 open_t] \qquad (9)$$

Our sample is 1960-2003. All variables under consideration have a unit root of order 1 (Table 1). To establish whether the combination of $\sigma(p_t^*) - \alpha\sigma(w_t)$, vol_t and $open_t$ forms a cointegrating relation, we apply the Johansen maximum likelihood procedure. Cointegration rank tests (maximum eigenvalue and trace) show the presence of one cointegrating relation at the 6 percent level of significance, which indicates the existence of a long-run relationship. As a robustness check we apply the Stock-Watson Dynamic OLS (DOLS) approach. This method is a robust *single equation* approach which corrects for regressor endogeneity by the inclusion of leads and lags of first differences of the regressors. Table 2 reports the summary statistics for the long-run relations. Both methods point in the same direction and deliver similar elasticities. Moreover, the results are not very sensitive to the choice of α.

Now, we take the long-run relation from Johansen with $\alpha = 0.6$ to decompose the price level dispersion in the EMU throughout the years. To identify the contribution of indirect tax rate harmonization we take the difference between the price level dispersion including and excluding indirect taxes. Table 3 presents the outcomes for five-year intervals. The exercise shows that the model is capable of identifying the main developments of price level dispersion and confirms the findings from the qualitative analysis. Non-traded input cost dispersion and openness are the most important factors for explaining the extent of price level dispersion. Moreover, indirect tax rate harmonization, convergence of non-traded input costs, exchange rate stability and increased openness have all been fuelling European price level convergence to substantial and varying degrees over time. In the period 1963-1973 changes in indirect tax rates, non-traded input costs and openness contributed to price level convergence. After 1973 the contribution of these factors stabilized, but after 1988 harmonization of indirect tax rates and non-traded input cost convergence decreased price level dispersion again. Openness contributed again to price level convergence from 1993 onwards. Over a time span of 40 years (1963-2003), indirect tax rate harmonization is responsible for almost 15 percent of European price level convergence, convergence of non-traded input costs for about 40 percent and the increase in openness for about another 40 percent. According to our calculation, rising exchange rate volatility explains much of the stagnation in the 1970s and early 1980s. Exchange rate stability made a substantial contribution to price level convergence in more recent years. In terms of the model: the dispersion of non-traded input costs and the dispersion of traded input costs are both important for explaining price level dispersion and its decline.

6. Comparisons and reliability

In this section, we discuss the results and reliability of our method by comparing our estimates of price level dispersion with (1) benchmarks from official statistical agencies, (2) trends from large micro datasets and (3) detailed micro data.

Official statistical agencies

For our sample we have a few benchmarks from several OECD publications. Data are available for 1980, 1985, 1990, 1993, 1996, 1999 and 2002 for all EMU countries.[16] There is a large degree of similarity of price levels. Figure 3A shows dispersion rates based on our data and the OECD data for the EMU from 1980 onwards. For each year, price level dispersion rates based on our constructed data have a small deviation from dispersion rates based on the OECD data. The results are also satisfying for the various sub-categories.[17]

As mentioned before, from 1995 onwards Eurostat publishes annually international price level differences for all product categories.[18] We use the data for 1999 to scale our HICPs. If we take one of the other years for scaling the HICPs, then our results do not change much. Moreover, our constructed data are consistent with Eurostat price levels for the aggregate HICP and sub-categories over the period 1995-2002.

Micro datasets

Interestingly, the overall picture that emerges from our macro approach also compares well to evidence from the large micro datasets mentioned in the Introduction. These datasets are much more detailed than our data, but cover shorter time spans. CTZ use Eurostat micro data for four individual years (1975, 1980, 1985 and 1990) and is authoritative in terms of coverage of a common basket of products across Europe. For example, for 1990 the dataset contains almost 1,900 different retail goods and services (54 percent of the goods are even branded) for 13 countries. Based on this dataset CTZ find no convergence between the four years considered, which is in line with our findings (see Figure 1A).[19] Rogers (2007) uses the EIU dataset that covers a significant number of items (157) with higher frequency (annually, 1990-2004) for 38 European and US cities. Figure 1A shows a downward trend with strong convergence in the early 1990s as does the EIU dataset for the period 1990-2003.[20]

Detailed micro data: a comparison with Goldberg and Verboven

One of the best-known and well-founded studies on European price level convergence is the project on European car prices (see Goldberg and Verboven 2001, 2004, 2005 and also Lutz 2004). Goldberg and Verboven collected an impressive dataset on individual car prices throughout the years. The authors make corrections for different tax regimes and differences in standard equipment across borders and car models. Based on this information, the authors are in a position to provide solid evidence of European price level convergence.

As a comparison, we take the two-digit HICP sub-category *Purchase of vehicles*. This sub-category is broader since it covers, next to cars, also bicycles and motorcycles. However, cars have the largest weight in this HICP sub-category. We compare our scaled

HICP data with annual national car price levels of the five largest car markets in Europe for the period 1980-1999. Since these price levels are without tax, we deduct taxes from our HICP price levels. We use the same group of countries. In Figure 3B, the trend line based on our data is depicted against the trend line based on Goldberg and Verboven. After an increase in price level differences in the beginning of the 1980s both datasets show price level convergence. Peaks and troughs are roughly found at the same moment. In the late 1990s, both approaches signal a sharp rise in price level dispersion. The resemblance is remarkable. All in all, there are strong indications that our methodology produces reliable estimates of price level dispersion at the aggregate level, as well as at disaggregated levels.

7. Conclusion

There are several studies on European price level convergence. Due to data limitations these studies cover just parts of the European integration process. Moreover, because these studies use relatively short sample periods with relatively little variation of price levels, it is difficult to identify the determinants of price level convergence.

We extend the period of investigation by scaling HICP data. This methodology provides price level data for almost the complete period of European integration (1960-2003) and puts us in the position to study the determinants of price level convergence. We find that over much of the last 40 to 50 years there is strong evidence of price level convergence in Europe towards levels that have been common in the US for a long time. European price level differences roughly halved. An analysis of the determinants of price level dispersion suggests that indirect tax rate harmonization, convergence of non-traded input costs and convergence of traded input costs (in the form of exchange rate stability and increased openness) all contributed to different extents and in varying degrees over time to European price level convergence.

It is important to note that price level dispersion between the EMU countries already converged close to US levels before the introduction of the euro. Although the back-of-the-envelope calculation shows that exchange rate stability contributed significantly to price level convergence over the decades, it has a smaller effect than the aforementioned real factors. A topic for further research is to what extent the introduction of the common currency contributes to long-term price level convergence.

Literature cited

Allington, Nigel F.B., Paul A. Kattuman, and Florian A. Waldmann. (2005) "One Market, One Money, One Price?" *International Journal of Central Banking*, 1, 73-115.

Asdrubali, Pierfederico, Bent E. Sorensen, and Oved Yosha. (1996) "Channels of Interstate Risk Sharing: United States 1963-1990." *Quarterly Journal of Economics*, 111, 1081-110.

Cecchetti, Stephen G., Nelson C. Mark, and Robert J. Sonora. (2002) "Price Index Convergence among United States Cities." *International Economic Review*, 43, 1081-99.

Chen, Lein-Lein, and John Devereux. (2003) "What Can US City Price Data Tell Us about Purchasing Power Parity?" *Journal of International Money and Finance*, 22, 213-22.

Crucini, Mario J., Chris I. Telmer, and Marios Zachariadis. (2005) "Understanding European Real Exchange Rates." *American Economic Review*, 95, 724-38.

Engel, Charles, and John H. Rogers. (1996) "How Wide Is the Border?" *American Economic Review*, 86, 1112-25.

Engel, Charles, and John H. Rogers. (2001) "Deviations from Purchasing Power Parity: Causes and Welfare Costs." *Journal of International Economics*, 55, 29-57.

Engel, Charles, and John H. Rogers. (2004) "European Product Market Integration after the Euro." *Economic Policy*, 19, 347-84.

Goldberg, Pinelopi K., and Frank Verboven. (2001) "The Evolution of Price Dispersion in the European Car Market." *Review of Economic Studies*, 68, 811-48.

Goldberg, Pinelopi K., and Frank Verboven. (2004) "Cross-Country Price Dispersion in the Euro Era: A Case Study of the European Car Market." *Economic Policy*, 19, 483-521.

Goldberg, Pinelopi K., and Frank Verboven. (2005) "Market Integration and Convergence to the Law of One Price: Evidence from the European Car Market." *Journal of International Economics*, 65, 49-73.

Koo, Jahyeong, Keith R. Phillips, and Fiona D. Sigalla. (2000) "Measuring Regional Cost of Living." *Journal of Business and Economic Statistics*, 18, 127-36.

Lutz, Matthias. (2004) "Pricing in Segmented Markets, Arbitrage Barriers, and the Law of One Price: Evidence from the European Car Market." *Review of International Economics*, 12, 456-75.

Maier, Philipp. (2004) "EMU Enlargement, Inflation and Adjustment of Tradable Goods Prices: What to Expect?" DNB Working Paper No. 10.

Parsley, David C., and Shang-Jin Wei. (2007) "A Prism into the PPP Puzzles: The Micro-Foundations of Big Mac Real Exchange Rates." *Economic Journal*, 117, 1336-56.

Reinhart, Carmen M., and Kenneth S. Rogoff. (2004) "The Modern History of Exchange Rate Arrangements: A Reinterpretation." *Quarterly Journal of Economics*, 119, 1-48.

Rogers, John H.. (2007) "Monetary Union, Price Level Convergence, and Inflation: How close Is Europe to the USA?" *Journal of Monetary Economics*, 54, 785-96.

Rogoff, Kenneth S.. (1996) "The Purchasing Power Parity Puzzle." *Journal of Economic Literature*, 34, 647-68.

Footnotes

[1] Cecchetti, Mark and Sonora (2002) and Engel and Rogers (2001) amongst others, also examine price level dispersion on the basis of Consumer Price Indices (CPI), but their studies are based on differences in national inflation rates, not absolute price levels.

[2] The second term is relatively small if there is a sufficiently high correlation between the logarithms of W_{jt} and Q_{jt}. We will come back to this point in Section 4, footnote 13.

[3] Source: OECD Economic Outlook (Number 75, June 2004).

[4] Source: Eurostat Chronos. Missing data for Austria, Finland and Sweden over the period 1980-1985 have been obtained from the national statistical agencies. Extra data required for connecting the CPI and HICP were provided by the national statistical offices of Austria, Germany, Ireland, Finland and Sweden.

[5] Source: Eurostat Chronos.

[6] Source: Bureau of Labor Statistics and Cecchetti, Mark and Sonora (2002) for city CPIs. Koo, Phillips and Sigalla (2000) for comparable city price levels. See also Chen and Devereux (2003).

[7] Source: OECD Economic Outlook and additional data from the World Development Indicators database (Europe) / Asdrubali, Sorensen and Yosha (1996), Bureau of Economic Analysis and US Census Bureau (Statistical Abstract of the United States and State and Local Government Finances) (US).

[8] Source: OECD Economic Outlook and additional data from the World Development Indicators database (Europe) / Bureau of Economic Analysis (US). A correction is made for the German reunification.

[9] Source: IMF IFS and Reinhart and Rogoff (2004).

[10] Source: European Economy, The EU Economy: 2002 Review, No. 6 (European Commission 2002) and European Economy, The EU Economy: 2003 Review, No. 6 (European Commission 2003).

[11] Source: Commodity Transportation Survey 1977 and Commodity Flow Survey 1993, 1997 and 2002. A correction is made for exports from the US since these are included in the survey data.

[12] Since the 20 cities for which data are available are not evenly distributed over the 9 regions, the US line represents price level dispersion between these 20 cities. However, a rough approximation of the appropriate line for the 9 regions is similar.

[13] Disaggregated price level data may help us to get an impression of the possible error that arises from ignoring the second term in Eq. 4. We take a country's price level of housing (a sub-category with a relatively high share of non-traded inputs) as a proxy for W_{jt} and a country's price level of food (a sub-category with a relatively high share of traded inputs) as a proxy for Q_{jt}. The correlation between the logarithms of these two is on average 0.73 over the period 1980-2003. With $\alpha = 0.6$, the second term in Eq. 4 is about one tenth of the first term.

[14] Luxembourg is excluded from the analysis since it would have a disproportionate influence on the overall results.

[15] A value of 0.5 follows if we assume that non-traded products require a traded input of 25 percent instead of 10 percent.

[16] Source: several publications of the OECD series "Purchasing Power Parities and Real Expenditures". See Purchasing Power Parities and Real Expenditures: 1999 Benchmark Year (OECD 2002, p.7) for more information.

[17] Chen and Devereux (2003) use a similar method to construct absolute price level data for US cities for the period 1918-2000. They test reliability via two benchmarks (1935 and 1975) and conclude that their constructed price levels are close to these benchmarks.

[18] This data also serves as input for the OECD data.

[19] Note that the extent of the price level dispersion reported in our paper is not one-to-one comparable to CTZ dispersion levels.

[20] CTZ and Rogers (2007) argue that their datasets are consistent with CPI data. Moreover, they argue that for their results it does not matter much if products are CPI weighted or equally weighted.

Table 1 ADF unit root test statistics EMU 1960-2003 (p-values)

	Level	First difference
$\sigma(p_t^*) - 0.5\sigma(w_t)$	-2.81 (0.20)	-5.75 (0.00)
$\sigma(p_t^*) - 0.6\sigma(w_t)$	-3.02 (0.14)	-5.85 (0.00)
vol_t	-2.32 (0.41)	-4.14 (0.00)
$open_t$	-2.62 (0.27)	-7.39 (0.00)

Table 2 Estimated long-run elasticities EMU 1960-2003 (t-statistics)

$\sigma(p_t^*) - \alpha\sigma(w_t)$	$\alpha = 0.5$		$\alpha = 0.6$	
	Johansen	DOLS	Johansen	DOLS
$\hat{\beta}_1$	0.051 (2.0)	0.051 (2.6)	0.059 (1.9)	0.060 (2.6)
$\hat{\beta}_2$	-2.06 (6.4)	-1.59 (5.9)	-2.19 (5.5)	-1.63 (5.0)
cointegration	one cointegrating relation *	residual stationary *	one cointegrating relation #	residual stationary *

Note: * denotes 5% significance level, # denotes 6% significance level.

Table 3 How much each determinant contributed to price level convergence in the EMU

	Price level dispersion		Estimated contribution				
	(1) Measured	(2) Predicted	(3) C	(4) Ind. tax rate disp.	(5) Nt. input cost disp.	(6) Exch. rate volatility	(7) Openness
1963	0.281	0.298	0.156	0.033	0.183	0.012	-0.086
1968	0.243	0.253	0.156	0.032	0.153	0.010	-0.097
1973	0.209	0.220	0.156	0.022	0.133	0.026	-0.117
1978	0.241	0.230	0.156	0.025	0.134	0.035	-0.120
1983	0.224	0.214	0.156	0.016	0.148	0.027	-0.133
1988	0.233	0.198	0.156	0.020	0.140	0.019	-0.136
1993	0.151	0.194	0.156	0.016	0.124	0.016	-0.119
1998	0.148	0.153	0.156	0.013	0.114	0.018	-0.148
2003	0.134	0.112	0.156	0.009	0.107	0.004	-0.164
2003-1963	-0.146	-0.186	0	-0.024	-0.076	-0.008	-0.078

Note: Because of rounding, columns 3 to 7 might not add up to column 2.

Captions for figures

Figure 1A   HICP price level dispersion 1960-2003

Figure 1B   HICP sub-category price level dispersion EMU 1980-2003

Figure 2   Determinants EMU, DM-zone and US 1960-2003

Figure 3A   Price level dispersion HICP vs. OECD 1980-2003

Note: + (-) indicates a positive (negative) link to price level dispersion.

Figure 3B   Price level dispersion HICP Purchase of vehicles vs. Goldberg and Verboven 1980-2003

Figure 1A HICP price level dispersion 1960-2003

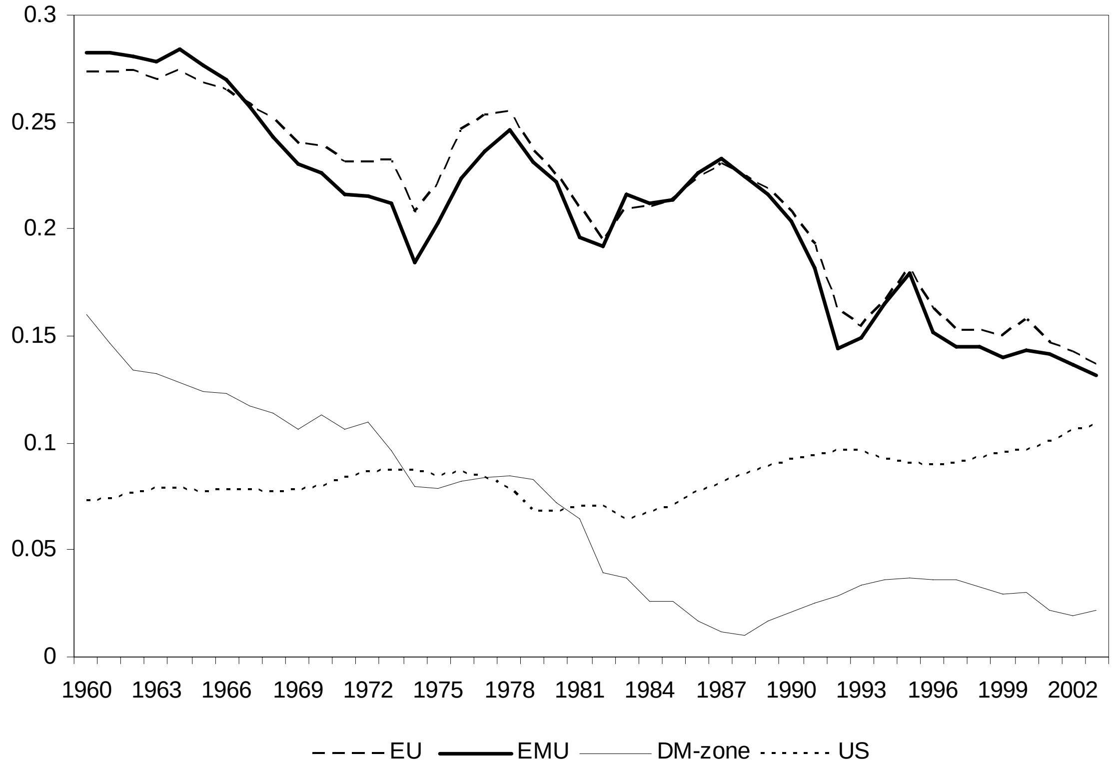


Figure 1B HICP sub-category price level dispersion EMU 1980-2003

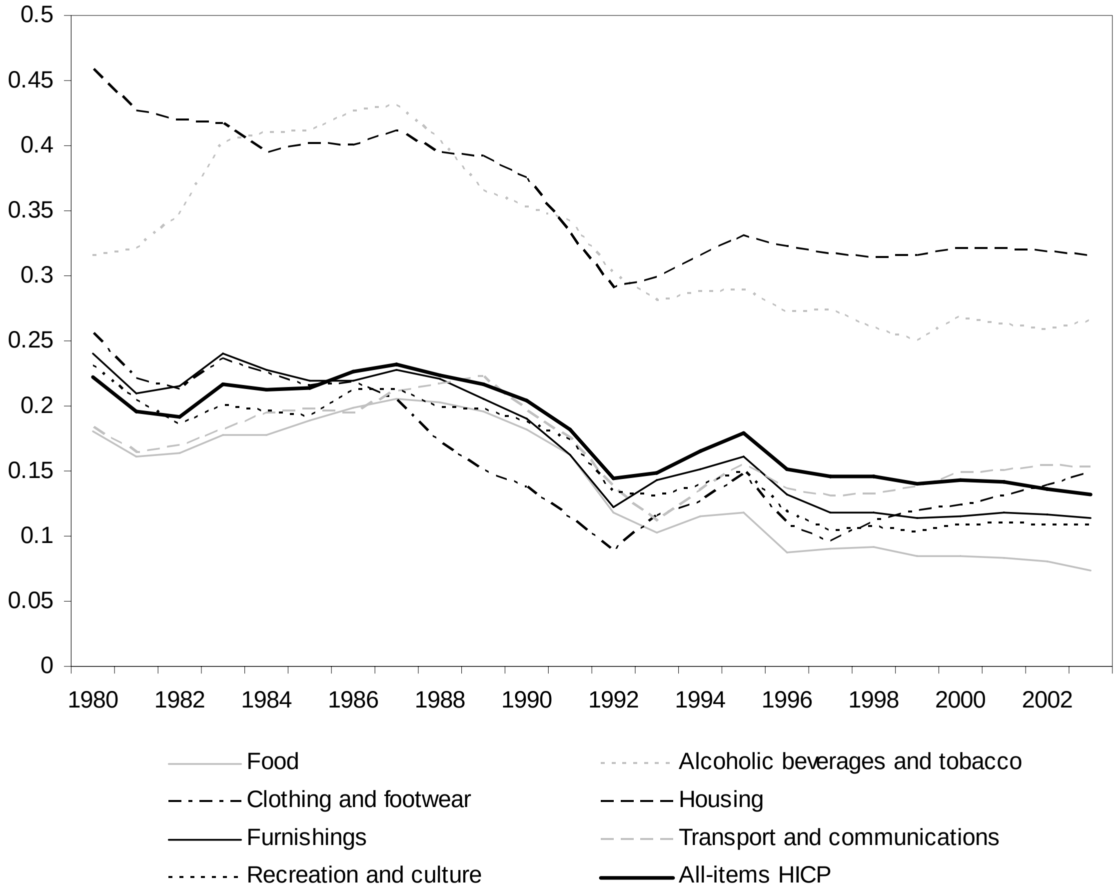
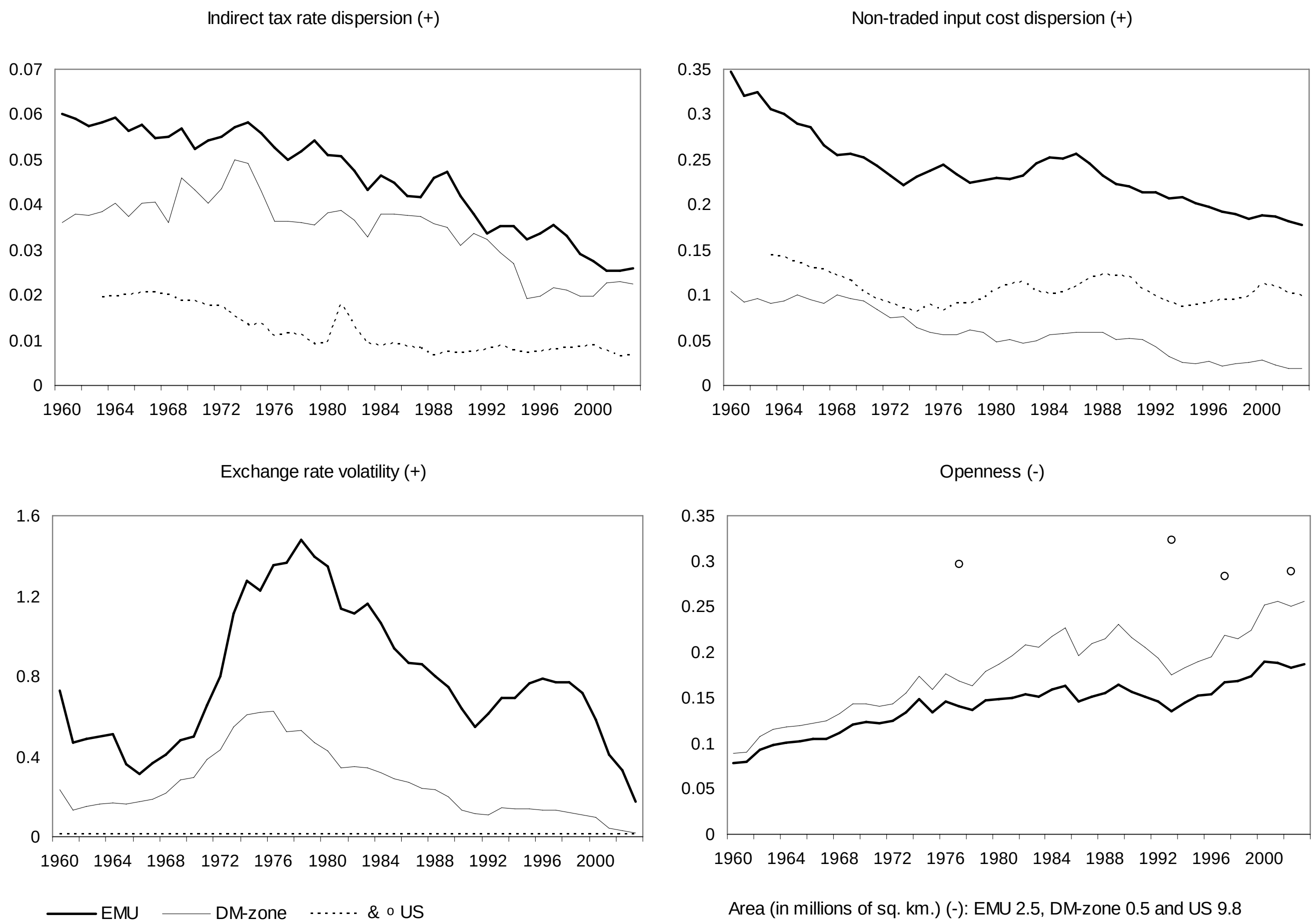


Figure 2 Determinants EMU, DM-zone and US 1960-2003



Note: + (-) indicates a positive (negative) link to price level dispersion.

Figure 3A Price level dispersion HICP vs. OECD 1980-2003

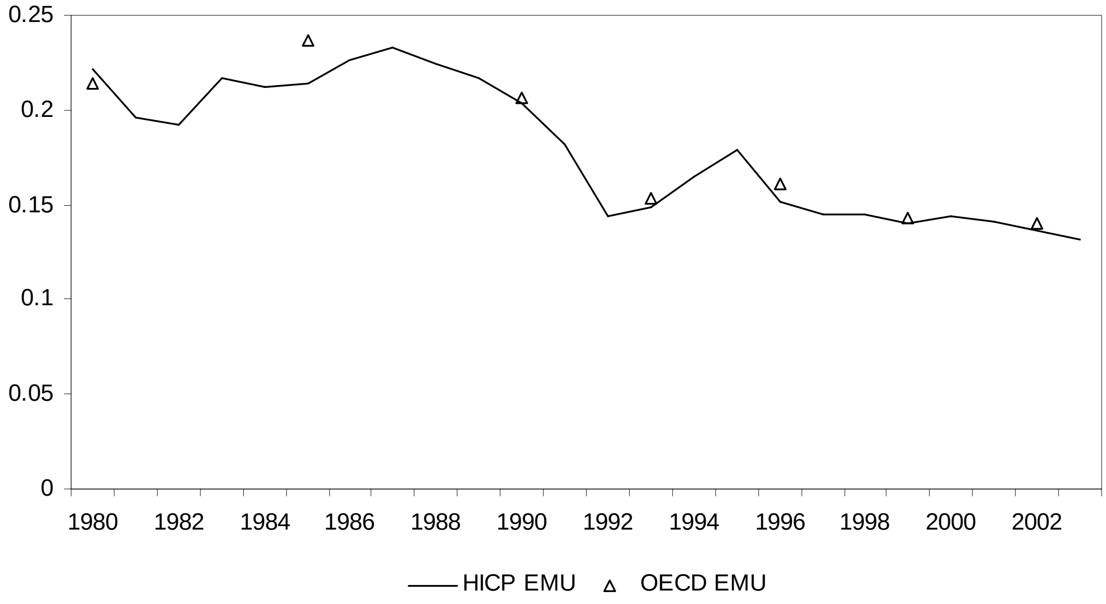


Figure 3B Price level dispersion HICP Purchase of vehicles vs. Goldberg and Verboven 1980-2003