Price convergence in the euro area

The euro was expected to give an additional boost to the existing innate tendency in the single market towards convergence in the prices of comparable goods. By eliminating exchange rate risk in trade among the member states and making it easier to compare prices, the single currency was to stimulate cross-border competition and thus contribute to price convergence. The present article investigates the extent to which prices have converged in various member states of European monetary union in the first decade of its existence and how far the introduction of the euro affected developments in price dispersion. The empirical findings point, at most, to a marginal convergence of prices as an underlying trend. A Bundesbank study using a micro dataset even tends to indicate price divergences for the market segment examined. From an economic policy perspective, an analysis of remaining price differentials deserves attention, as they may reflect a price and cost situation of the country in question which signals a possible need for adjustment.

Reasons for price differentials and price convergence

The law of one price

The expectation that, in a fully integrated market, there will be price convergence is based on considerations of the law of one price. This law states that the prices of identi-

cal, internationally tradable goods at different locations would have to be the same when expressed in a single currency; otherwise, risk-free transactions would be possible, where the product would be purchased at the cheap location and sold at a profit at the expensive location. Such arbitrage transactions would therefore even out any price differentials.[1]

Price deviations resulting from transaction costs, ...

Admittedly, it generally cannot be assumed that exactly the same price is actually to be paid for a given good in all places. One argument against this is the existence of transaction costs. These include, in a broad sense, the costs of transporting a good to the specified destination, other distribution costs, information costs, as well as – if there is no single currency – the costs of converting proceeds into a different currency, including the related costs of hedging against exchange rate fluctuations. Numerous studies suggest that, above all, the process of the good crossing a national border accounts for a very large part of the transaction costs ("border effect").[2] This is generally attributed to the costs associated with currency conversion in the widest sense.

The fact that costs of this kind prevent price adjustments is particularly noticeable in the case of internationally non-tradable goods, such as services that have a strong local basis, like the often-cited visit to the hairdressers, or the provision of residential property or office buildings. The reason why services often lack tradability is also ultimately to be found in the level of transaction costs, particularly the high transport costs. This means that, in some cases, a reduction in such costs might trigger

cross-border price competition. However, this will generally lead only to an incomplete convergence of prices and, hence, to a continuing large degree of price dispersion, which is typical of non-tradable goods.

Nevertheless, for tradable goods, too, there are other reasons for enduring price differentials. These include tariffs and non-tariff trade barriers, such as import quotas or differing technical standards. Different rates of excise tax are a third cause. Other often-cited phenomena, such as differences in economic cycles, in stabilisation policy, in country-specific preferences, or exchange rate fluctuations may indeed affect price dispersion, but generally cannot prevent arbitrage, which means that ranges for price differentials due to transaction costs, customs duties and excise taxes should not be exceeded.

... tariffs, excise taxes and other causes

These factors make it clear that, with regard to the European Union, the process of economic integration has many diverse effects on price convergence in a single currency area. Besides a general reduction in transaction costs, the creation of a single market is likely, in particular, to have substantially reduced the significance of tariff and non-tariff trade barriers. Likewise, in the wake of single market integration, VAT rates among the EU countries have also converged. The resulting

---

1 This predominantly applies to arbitrage transactions by commercial enterprises. However, cross-border purchases by consumers can, of course, also contribute to price convergence.
2 The literature on the "border effect" goes as far back as J H Rogers and M Jenkins (1995), Haircuts or hysteresis? Sources of movements in real exchange rates, Journal of International Economics, 38, pp 339-360, and C Engel and J H Rogers (1996), How wide is the border?, American Economic Review, 86, pp 1112-1125.

deviations in gross prices within the euro area are therefore generally likely to remain rather small owing to the relatively similar rates of VAT, even though excise taxes can make a considerable contribution to price dispersion in specific cases, such as tobacco and refined petroleum products. As far as deviations from the law of one price can be identified in the European Union, it is therefore, above all, probably transaction costs which prevent arbitrage processes among the various countries, thus making price differentials possible.

Introduction of the euro and price convergence

The introduction of a single currency further lowers trade transaction costs in a single market and, as a result, increases the incentives to adjust prices. Furthermore, the single currency limits the possibilities for price discrimination and market segmentation. If the actual differences in the prices of individual internationally tradable goods were so large that they are greater than the given range of prices which has now been narrowed due to the lower transaction costs, prices among the countries should begin to converge.

The fall in transaction costs as a result of monetary integration represents a gain in efficiency and, to that extent, boosts welfare.[3] First, it eliminates a cost item for enterprises or consumers. Second, as a result of the more intense cross-border competition, allocative efficiency also increases. It may therefore be expected that the price level of tradable goods will fall during the convergence process because consumers in the former "high price" regions gain access to cheaper alternatives and because a larger market allows the exploitation of economies of scale and thus a

decline of marginal unit cost in production. However, for non-tradable goods it is also entirely conceivable that the hoped-for stimulus to the economic catching-up process associated with the introduction of the euro has the effect of raising the price level in the countries that are catching up (Balassa-Samuelson effect).[4] At the same time, these factors illustrate the difficulty of isolating the effects of the single currency as a catalyst for convergence developments from the effects of the economic integration process within the euro area as a whole.

Measuring price convergence in the euro area

Empirical studies on price convergence in the euro area are confronted with a range of methodological challenges. It is especially important to identify the specific impact of the single currency taken in isolation. Thus, among other things, it is necessary to determine the key temporal points of reference. In principle, two points in time are crucial as triggers for price adjustment processes as a result of European monetary union. The first of these was the beginning of monetary union at the turn of 1998-99 when the euro

Establishment of the euro area and the euro cash changeover

3 See, for example, P B Kenen and E E Meade (2008), Regional Monetary Integration, Cambridge University Press, p 21.
4 For the Balassa-Samuelson effect, see Deutsche Bundesbank, Fundamental determinants of real exchange rate movements in the central and east European accession countries, Monthly Report, October 2002, pp 47-59, particularly p 53. The expectation that the prices of tradable goods will tend to fall as a result of the introduction of the euro, while those of non-tradable goods will tend to rise, is discussed, inter alia, in European Central Bank, Price level convergence and competition in the euro area, Monthly Bulletin, August 2002, pp 39-49.

exchange rates were irrevocably fixed, the participating countries switched to a single monetary policy through the Eurosystem, and the national currencies continued to exist as cash only as units of account of the euro. Second, the euro cash changeover at the start of 2002 should be considered. The transaction costs of trade within the new single currency area may have fallen as a result of both integration steps. The costs of currency exchange and of hedging exchange rates risks had already ceased to exist with the establishment of the euro area. However, information costs have also fallen, above all, as a result of the introduction of euro banknotes and coins and the consequent increase in price transparency.[5] It therefore seems prudent to consider both points in time in analysing price dispersion in connection with the introduction of the euro.

Lagged or anticipatory price adjustment possible

Identifying the specific impact of EMU taken in isolation is also made more difficult by the fact that the increasing competitive pressure due to the introduction of the euro might only gradually produce the expected effect. Studies which find that long-standing monetary unions, such as that between Belgium and Luxembourg, have comparatively small price differentials could indicate extremely long processes of adjustment.[6] On the other hand, enterprises may also have already adjusted their prices before the introduction of the euro as a consequence of the common market, the low exchange rate fluctuations in the ERM at that time, and in anticipation of the future monetary union.[7]

Price indices unsuitable for analysis

In addition, the data underlying the studies are of crucial importance in the empirical analyses of relative price adjustment processes. The price indices usually published in the official statistics cannot be used for such a study owing to their being normalised on a base period. In order to be able to determine whether prices converge or diverge, (relative) price levels are required. If, for example, the price levels differ in the base period selected for forming the index, diverging price indices may nevertheless coincide with price convergence.

Apart from the dataset, the available studies differ according to the level of aggregation of the price level used or the measures of dispersion. Price measures with a higher level of aggregation make it possible to derive more general findings, but have the potential drawback that the implicitly assumed homogeneity of the categories of goods considered is often not fulfilled. By contrast, more disaggregated approaches take greater consideration of the issue of comparability but, given the more restricted selection of goods, can only be used to a limited extent for drawing generalised conclusions. In the light of the specific advantages and disadvantages of each of the approaches for measuring price convergence, a broad range of methods has

---

5 Furthermore, from this point in time, consumers were able to use the euro for cash purchases in other euro-area countries.
6 See, for example, D C Parsley and S-J Wei (2001), Limiting currency volatility to stimulate goods market integration: a price based approach, NBER Working Paper 8468.
7 See C Engel and J H Rogers (2004), European product market integration after the euro, Economic Policy, 19, pp 347-384.

been developed in the empirical literature on this question.

Results for aggregated relative price levels

Highly aggregated relative price levels can be calculated from purchasing power parities, which may be found, for example, in Eurostat's AMECO database. These purchasing power parities state the local currency price of a given basket of goods, which is, in principle, uniform for all countries, in the country observed relative to a base region. At the highest level of aggregation, the basket of goods should represent the entire gross domestic product. Using a relevant nominal exchange rate, these relative price levels expressed in national currency can be converted into a price level index in currency units of the region that is relevant for the convergence comparison (in this case, the euro area).

Price level differentials in 1998 and 2007

The relative price levels of a number of euro-area member states calculated in this way deviated by double-digit percentages from the relevant average EMU price level in both 1998, directly before the introduction of the euro, and as recently as 2007.[8] However, during the nine years under consideration, it was only in Ireland that the price level departed noticeably from the euro-area average. According to these data, the price levels in the other countries moved closer to the average. As a general rule, however, the price adjustment remained slight. Starting from comparatively high price levels, it was only in Germany and, to a lesser extent, in France and Austria, that prices showed a considerable

decline compared with the other EMU member states. Finland's price level is still relatively high, while price levels in Greece, Portugal and Spain remain relatively low. Unlike at the beginning of monetary union, Italy no longer had a below-average price level in 2007.

As a measure of price dispersion, one may calculate the standard deviation of the relative price levels across countries at a given point in time. If this dispersion measure falls over time, this development is to be interpreted as price convergence.[9] Relevant figures actually suggest a reduction in price dispersion since the establishment of the euro area or also since the euro cash changeover. The price convergence is quite weak, however. This is especially true in comparison with the previous decade, during which considerable progress towards convergence had been made.[10] Other studies also confirm the finding of distinct price convergence before the start of monetary union.[11]
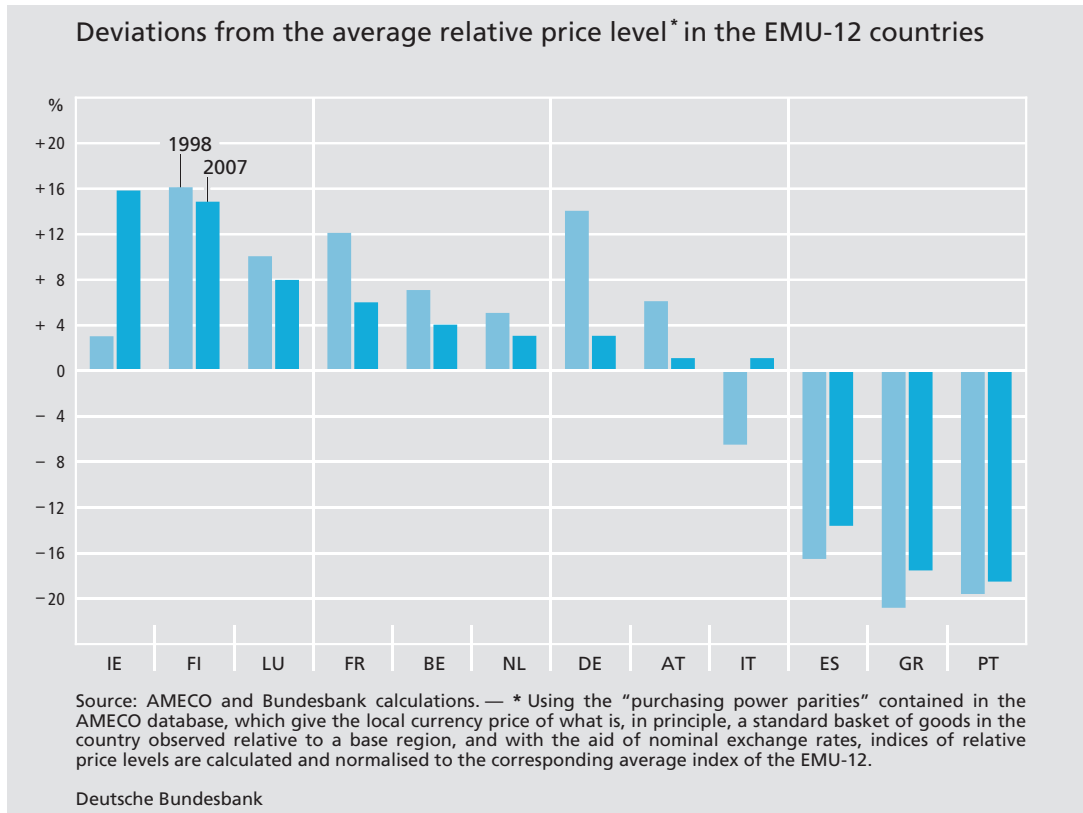
At most, weak macroeconomic price convergence in the euro area compared with marked progress towards convergence earlier

---

8 Relative price levels calculated in this way should not be confused with indicators of price competitiveness. They are not trade-weighted and their general suitability for allowing statements on competitiveness should also be questioned.
9 Such a form of price convergence is also known as sigma convergence.
10 The reduction in price dispersion was interrupted for a period of several years with the onset of the crisis in the European Exchange Rate Mechanism in 1992, but continued from 1995 onwards. Thus, with regard to relative price levels, the crisis developments in the first half of the 1990s appear not to have been accompanied by an adjustment of earlier undesirable developments, but rather to have been fraught with problems themselves.
11 See C Engel and J H Rogers, op cit, as well as R P Faber and A C Stokman (2005), Price convergence in Europe from a macro perspective: product categories and reliability, DNB Working Paper 34, and J Wolszczak-Derlacz (2006), One Europe, one product, two prices – the price disparity in the EU, Katholieke Universiteit Leuven Center for Economic Studies Discussion Paper 06.14.

Deviations from the average relative price level* in the EMU-12 countries

%
+20
+16
1998
2007
+12
+ 8
+ 4
0
− 4
− 8
−12
−16
−20

IE   FI   LU   FR   BE   NL   DE   AT   IT   ES   GR   PT

Source: AMECO and Bundesbank calculations. — * Using the "purchasing power parities" contained in the AMECO database, which give the local currency price of what is, in principle, a standard basket of goods in the country observed relative to a base region, and with the aid of nominal exchange rates, indices of relative price levels are calculated and normalised to the corresponding average index of the EMU-12.

Deutsche Bundesbank

Price dispersion for goods and services

A more disaggregated analysis affords additional and deeper insights. A first step in this direction is to consider goods and services separately. This is of interest because many services are internationally non-tradable, which means that, in these cases, price convergence as a consequence of the introduction of the euro can be expected only to a limited extent. The relatively low international tradability should also bring about a comparatively high dispersion of prices for services. Indeed, price dispersion measured by the variation coefficient over the period from 1995 to 2007 is roughly twice as high for services as it is for goods.[12]

However, clear progress towards convergence since the establishment of the euro area can be identified neither for goods nor for services. If the period since the euro cash changeover is examined, there is a slight tendency towards price convergence in the case of goods. If goods are, in turn, subdivided into consumer goods and capital goods, moderate progress towards convergence is apparent since 1998, with this development being somewhat more pronounced in the case of capital goods.

It is noticeable that the price dispersion in 2002 is greater for both the subgroup of consumer goods and the subgroup of capital goods than it is for the overall aggregate of all the goods. This is quite possibly a consequence of aggregation which results if, in

---

12 The use of the variation coefficient allows a comparison of the dispersion between the two product categories.
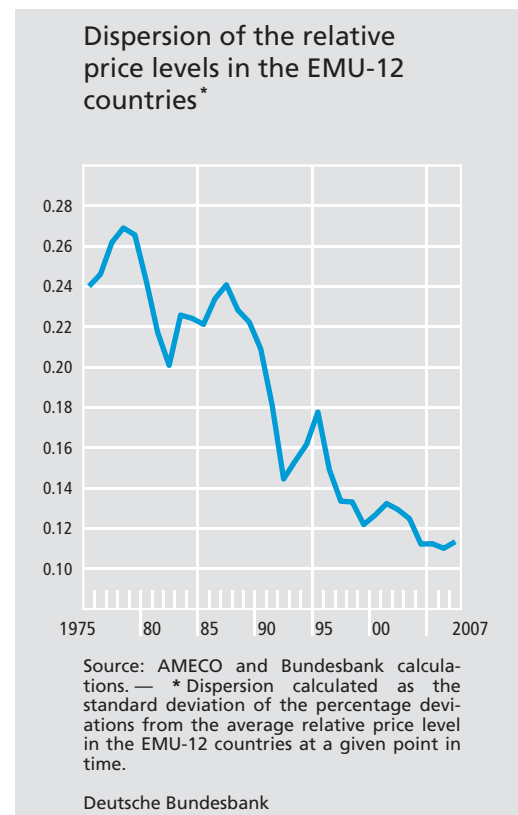
Results from the literature

some countries, for example, positive price deviations in one category of goods are offset by negative price deviations in others. For this reason, a low price dispersion in the aggregate does not imply that price dispersion in the subgroups will be equally low.

This may also affect the transferability of macroeconomic convergence results to a more disaggregated level. Therefore, in the literature, measures of dispersion are often calculated for individual goods or categories of goods and only then are they aggregated, if necessary. As far as this has been investigated, both methods produce very similar results on the question of price convergence in the euro area.[13] Nevertheless, other factors, such as the database used, the test procedure and the chosen observation period appear to have a perceptible influence on the results. This may explain the conflicting results between studies which, in some cases, have found marked price convergence for tradable goods in the euro area when compared with other countries and other studies which are unable to identify such a phenomenon.[14]

The single market as a catalyst for price convergence

The picture that emerges – despite all the differences in the results of the available studies – of major progress towards convergence in the decade before the introduction of the euro in comparison with only very moderate price convergence since may be due to the liberalisation and integration measures of the European Single Market Programme. Seen in this light, the single market – as well as the prospect of a single currency – released the impetus for price convergence, which was largely realised before the intro-

Dispersion of the relative price levels in the EMU-12 countries*

Source: AMECO and Bundesbank calculations. — * Dispersion calculated as the standard deviation of the percentage deviations from the average relative price level in the EMU-12 countries at a given point in time.

Deutsche Bundesbank

duction of the euro. There is therefore a distinct possibility that the potential for a further

13 See J H Rogers (2007), Monetary union, price level convergence, and inflation: How close is Europe to the USA?, Journal of Monetary Economics, 54, pp 785-796.
14 The first group of studies includes, in particular, N F B Allington, P A Kattuman and F A Waldmann (2005), One market, one money, one price?, International Journal of Central Banking 1, 3, pp 73-115, and P K Goldberg and F Verboven (2004), Cross-country price dispersion in the euro area: a case study of the European car market, Economic Policy, 19, pp 483-521. The second group of studies includes M Lutz (2004), Price convergence under EMU? first estimates, in A V Deardorff (ed), The Past, Present and Future of the European Union, Palgrave Macmillan, pp 48-73, C Engel and J H Rogers, op cit, as well as J C Cuaresma, B Egert and M A Silgoner (2007), Price level convergence in Europe: Did the introduction of the euro matter?, Monetary Policy & the Economy Q1/07. If these studies are classified according to the database used, it is apparent, for example, that studies using price data from the Economist Intelligence Unit tend to reject price convergence, while price convergence is confirmed when relative price levels for individual categories of goods from Eurostat are used. A micro dataset on car prices is used by two of the studies mentioned, one of which finds price convergence and the other not. However, the study that argues for convergence covers an obviously longer period after the introduction of the euro.

Variation coefficients for the
relative price deviations of
individual categories of
goods from the EMU-12
average
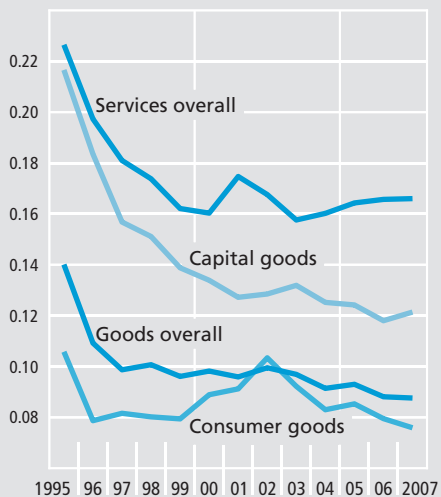
Source: Eurostat and Bundesbank calcula-
tions

Deutsche Bundesbank

lowering of price dispersion in the euro area was already largely exhausted at the end of the 1990s. Indeed, it can be demonstrated that price dispersion between pairs of cities within the euro area at that time was much the same in size as the price dispersion between pairs of cities in the USA.[15]

Limited informative value of results

It should generally be borne in mind that aggregated analyses assume the homogeneity of the goods in an international comparison. However, many products are comparable internationally only to a very limited extent. This applies especially to broadly based studies in which aspects of homogeneity cannot be included with a high degree of intensity for every product. Furthermore, the price data on which the analyses are based are often collected only at a few outlets in a small number of towns and cities. This means that the recorded prices may, in some cases, not be representative of the country in question as a whole. Finally, only list prices, and not actual transaction prices, are usually collected. For all these reasons, the cited results from aggregated approaches are to be interpreted with caution.

Results of micro data analyses

In principle, it is easier to ensure the homogeneity of the products and the representativeness of the prices when just one product or a certain category of products is observed. An early study adopting such an approach for the question of price convergence in the euro area looks at the prices of selected consumer goods and finds no evidence of price convergence since 1999.[16] Another study, which analyses one of these markets in more detail, finds small but significant progress towards convergence, although this only occasionally exceeds price convergence in non-euro-area countries.[17] Given the better comparability of the observed prices, the results of these studies may be more reliable than studies which attempt to depict developments in the average price dispersion of a large number of tradable goods in the euro area. However,

Advantages and disadvantages of micro studies

15 See J H Rogers, op cit. However, this finding does not necessarily imply that there was no longer any scope for convergence in the euro area. One argument against this, for example, is that, in the cited study, the average distance between the observed pairs of cities in the USA was twice as large as that in the euro area.
16 See M Lutz, op cit. The consumer goods investigated were the magazine "The Economist", the "Big Mac" and motor cars. Only data up until 2001 were taken into account.
17 See P K Goldberg and F Verboven, op cit.

this is countered by the potential drawback that the macroeconomic impulse may be obscured by sector or product-specific effects and that, as a result, the price dispersion of the product displays a pattern that is untypical of all tradable goods. There is an especially large risk of this occurring if the product in question is very narrowly defined, say, by looking at just one manufacturer, and if the chosen sector has special features, such as an untypical market structure or specific institutional regulations.

Bundesbank study using micro data

A Bundesbank study which attempts to avoid the cited risks and, at the same time, ensure that the observed products have as high a degree of homogeneity and representativeness as possible, analyses the impact of the introduction of the euro on the dispersion of prices using a comprehensive micro dataset for a major consumer goods segment, ie the European washing machine market, which is especially suitable for this purpose.[18]

Price differentials for washing machines in 1998 ...

A glance at the situation towards the end of 1998, immediately before the establishment of monetary union, shows that the quality-adjusted price deviations from the (unweighted) average of the later euro-area countries were mostly quite small (for the methodology used, see the box on pages 42 and 43). A washing machine of a given quality in Germany, for example, cost only 1% more on average than the euro-area mean price of the same appliance. It was only in the Netherlands that washing machines were considerably cheaper, and they were most expensive in France (-10½% or +5½%, respectively, compared with the euro-area average). This

shows that the deviations from the law of one price in what was then the emerging euro area were still quite considerable for some pairs of countries. In a number of cases, the calculations produced noticeably more pronounced price deviations when euro-area countries were compared with non-euro-area ones.

... over the following years ...

Looking at developments in relative washing machine prices, what is initially striking is that, in the nine years since the start of 1997 (the available data go up until the end of 2005), there was a gradual decline in prices in the euro-area countries.[19] Towards the end of the observation period, the net prices in the "most expensive" country of the single currency area were some 20% lower and those in the "cheapest" country around 30% lower than at the start of the observation period. The most pronounced fall in prices was in Germany, which, at the beginning of 1997, was still one of the countries with the highest prices. From the end of 2000, however, it was invariably in the group of countries with the cheapest appliances. Moreover, the difference between the average price in the "most expensive" country and the "cheapest" country in the period between 1997 and

---

18 See C Fischer (2009), Price convergence in the EMU? Evidence from micro data, Deutsche Bundesbank Discussion Paper, Series 1, No 06/2009.
19 Price developments are shown from the beginning of 1997 because entry to monetary union required compliance with narrow fluctuation margins of the Exchange Rate Mechanism of the European Monetary System for at least two years without devaluing against the currency of any other member state. Small exchange rate fluctuations in 1997 and 1998 could therefore have been regarded in themselves as an indication of later euro-area membership, which, in turn, could have triggered an early price adjustment.

A comprehensive micro dataset on prices and sales volumes of washing machines

Empirical studies on cross-border price convergence require data on price levels of – as far as possible – identical goods in various countries. Using raw data from the market research institution GfK Retail and Technology, the Bundesbank has built up such a micro dataset for washing machines. In this market, any effect of the introduction of the euro on price dispersion should be easy to identify. This seems evident, first, because the product in question – a washing machine – is not only highly tradable internationally, but also actually traded intensively on a regular basis. Second, the product-specific quality features are easily captured, which means that comparability across different countries can generally be reliably ensured.

The data are available at a four-month frequency for the period from 1995 to 2005 and at a two-month frequency for the period from 2000 to 2005. The data cover transactions in 17 European countries. Ten of these, including Germany, France, Italy, Spain and the Netherlands became members of European monetary union during the observation period. The others are the United Kingdom, as well as Scandinavian and central and east European states.

The underlying data on transactions in washing machines are based, first, on GfK universe studies (which are carried out regularly roughly every two to three years and which capture the market structure). Additionally, the GfK collects samples stratified by distribution channel at considerably shorter intervals. The data collected in these samples are extrapolated separately for each distribution channel based on the results of the universe studies. Aggregating across the distribution channels then gives the country-specific average price and the volume of sales for each model of washing machine. The resulting dataset comprises, on average, 90% of all transactions in the countries mentioned and thus covers each of the markets almost completely. A further fact which indicates that

the data are highly reliable is that 90% of the information is collected electronically through the enterprise resource planning systems of the retail trade. In contrast to most other datasets containing the prices of identical goods in various countries, this dataset covers not only list prices but also actual transaction prices. Knowing the volumes of sales also allows the prices to be weighted accordingly, which further increases the reliability of an international price comparison.

In addition to the average gross prices of the individual models, the micro dataset also contains their net prices, which were calculated using data from the European Commission on the relevant rates of VAT in the countries under consideration. As a rule, net prices are more suitable for a cross-border price comparison, because the destination principle is usually applied in international trade, ie import products are freed from the VAT of the exporting country and subject to the VAT of the importing country. The net prices are therefore hardly affected by varying rates of VAT. [1]

The richness of the data is already apparent from the number of observations per country. For a given time period, this value corresponds to the number of models for which transactions were noted during this time in the relevant country. For a period of two months, these involved 1,138 models on average between 2000 and 2005 in Germany, for example, and 1,173 models for a four-month period on average between 1995 and 2005. For Germany, summing all 36 periods in the former case gives a total of 40,963 observations, and summing all 33 periods in the latter case gives a total of 38,707 observations. Across all the countries, the first dataset comprises more than 390,000 observations and the second dataset more than 330,000 observations.

---

1 However, in most cases of non-commercial imports by consumers within the euro area, there is, for reasons of practicability, no border adjustment (origin principle), which means that gross prices are relevant in this regard. — 2 Database: four-month data for 1995:1 to 2005:3; countries included: Austria, Belgium (since 1997:1), Czech

Republic, Denmark (since 2001:1), Finland (since 2003:1), France, Germany, Greece (since 1999:1), Hungary, Italy, Netherlands, Poland, Portugal (since 1998:1), Slovak Republic, Sweden (since 1997:1), United Kingdom. Weighted least-squares estimation with the sales volume of each model as the weight. The base category of non-numerical

Deutsche Bundesbank

Hedonic regression of logarithmic net prices of washing machines [2]

Variable	Category	Coefficient	t-value
Constant term	–	5.72	1,096.28
Capacity in kg	–	0.0523	80.84
Spin speed (rpm)	–	0.000654	484.29
Degree of automation and possible integration of a dryer (base: fully automatic, no dryer)	semi-automatic, no dryer	– 1.122	– 152.01
	with dryer	0.261	218.82
	unknown	0.186	7.22
Front or top loader (base: front loader)	top loader	0.147	189.24
	unknown	0.125	2.97
Built-in or freestanding (base: freestanding)	built-in	0.317	120.61
	unknown	0.0058	0.58

Firm dummies	p-value[F(450;326638)]:	0.0000
Country-time dummies	Base: Italy, 2001:2, each p-value (for given i or t):	0.0000
R^2		0.875
Number of observations		327,583

In order to create as great a degree of international comparability as possible, the (logarithmic) washing machine prices can be adjusted for the differing quality features of the individual washing machine models in what is known as a hedonic regression. This includes the above-mentioned technical features, such as the machine's loading capacity or spin speed. Moreover, the brand name can be taken into account, which seems reasonable as this may affect the product's properties – such as its robustness – in the eyes of consumers. In a recently published study[3], a regression equation of this kind was estimated, according to which the price of model k in country i at time t, P_{ikt} is determined as
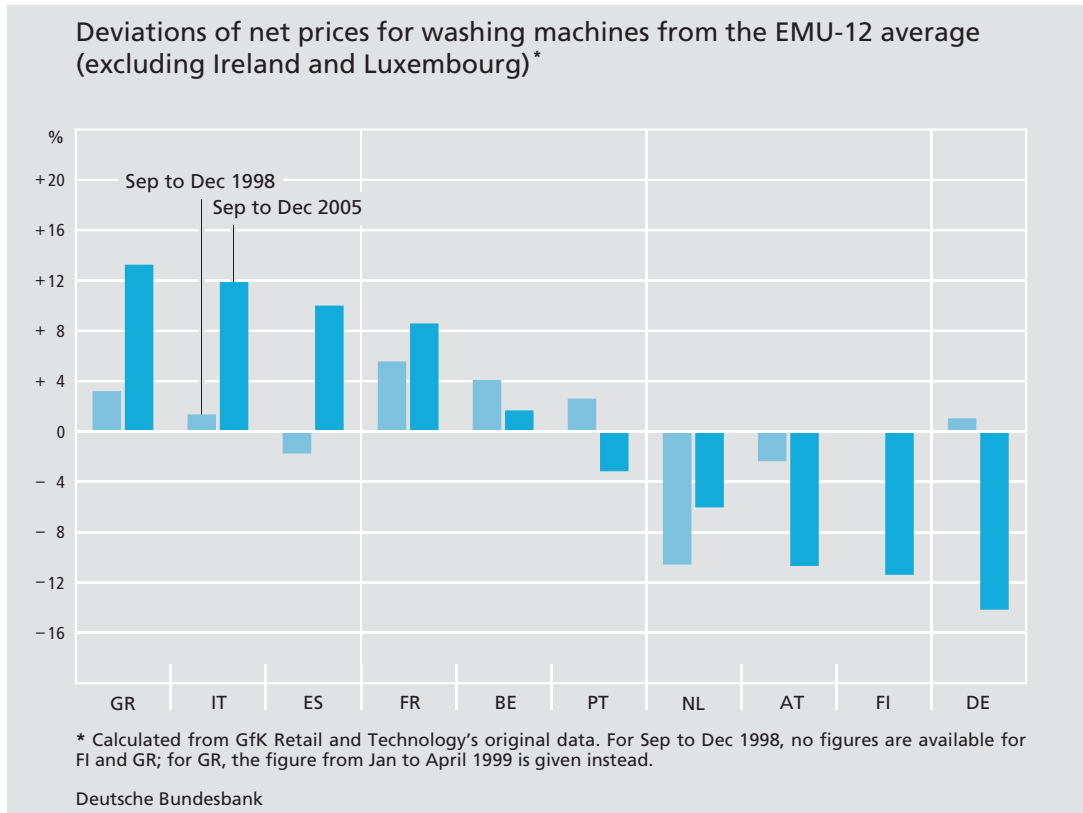
$$\ln P_{ikt} = \pi_0 + \pi'_\omega \omega_k + \pi_f + \pi_{it} + \varepsilon_{ikt},$$

where ω_k denotes the vector of the quality features of model k, π_ω the matching coefficient vector, π_f the coefficient of a firm dummy which has the value 1 for the products of the manufacturer of model k and otherwise the value 0, π_{it} the coefficient of a combined country-time dummy, and π_0 the constant term. The regression results of the study show, among other things, that an increase in the loading capacity of 1 kg raised the price of the washing machine by an average of 5% during the observation period in the countries under consideration; a built-in dryer, to give a second example, raised the price by an average of 26% (see the table above). With π_{it}, the hedonic regression provides an average percentage price premium for every point in time and each individual country, which states the percentage difference in the net price of a washing machine of a given quality between two countries. This coefficient may, for example, be used as basis for an international price comparison and for analyses of price convergence.

regressors is indicated in brackets in each case. For all the other categories, the regression equation contains a dummy variable, whose coefficient is shown in the next-to-last column. This coefficient shows the price premium or price reduction compared with the base category. The p-values for the significance of country-time dummies refer to F tests on all dummies for a given country i or for a given period t. — **3** See C Fischer, Price convergence in the EMU? Evidence from micro data, Deutsche Bundesbank Discussion Paper, Series 1, No 06/2009.

Deviations of net prices for washing machines from the EMU-12 average
(excluding Ireland and Luxembourg)*

* Calculated from GfK Retail and Technology's original data. For Sep to Dec 1998, no figures are available for FI and GR; for GR, the figure from Jan to April 1999 is given instead.

Deutsche Bundesbank

2001 remained more or less constant, whereas it widened noticeably thereafter.

... and at the end of 2005

At the end of the observation period, from September to December 2005, the prices for most euro-area countries actually deviated to a much greater extent from the law of one price than they did immediately before the establishment of monetary union. The average net prices of washing machines of a given quality were a two-digit percentage figure below the euro-area average in three countries (Austria, Finland and Germany) and more than 10% above the average in three other countries (Greece, Italy and Spain). The difference between the prices in the "cheapest" and "most expensive" country increased from 16% at the end of 1998 to 27% at the end of 2005.[20] All of this indicates that price

dispersion in the euro-area washing machine market – far from having decreased, as was expected – was increasing yet further after the introduction of the euro.[21]

Formal tests for price convergence confirm these results. Irrespective of the chosen observation period and the convergence test used, the hypothesis of a narrowing price dispersion in the euro area is rejected. Particularly since the millennium changeover, there has been a discernible tendency towards price

Statistical tests reject hypothesis of price convergence

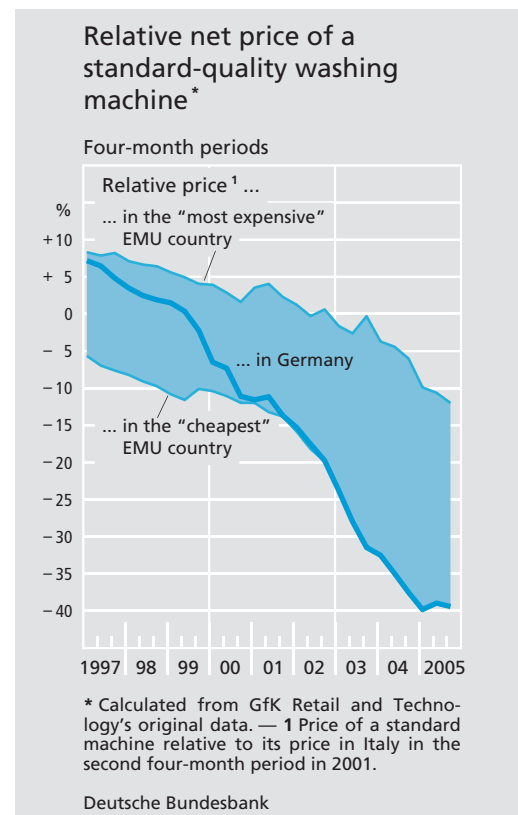**20** As the prices eased over time, the price differential widened less strongly in absolute terms.
21 A further piece of evidence argues against the hypothesis that the introduction of the euro, by intensifying competition, would lead to a general adjustment to a lower price level: towards the end of the observation period in 2005, the prices of washing machines in the "high price" euro-area countries cited are consistently higher than in all the non-euro-area countries that are considered.

44

divergence in the washing machine market (see the box on page 46).

However, in principle, these results could be due to price developments in individual countries, which possibly obscure the general picture. Whether this is actually the case is investigated using an econometric method, which identifies groups of countries, known as "convergence clubs", whose prices are converging. Countries which did not belong to the euro area during the observation period are also included. If the introduction of the euro had promoted the expected price convergence, such a method should establish a "convergence club" that contains a relatively large number of euro-area countries but, at most, very few non-euro-area countries. However, it emerges that most "convergence clubs" contain only a few countries and include both euro-area and non-euro-area countries. This result, too, confirms that, for the product in question, neither the establishment of the euro area nor the euro cash changeover has so far led to a perceptible price convergence in the euro area.

Possible causes The question arises as to what might be the causes of the identified cases of price divergence. Various hypotheses come into consideration for this, although their soundness cannot be assessed conclusively yet. It is conceivable, for example, that there have been differences in the development of distribution costs in the euro-area countries. In this connection, it is noticeable that, towards the end of the observation period, the price level is highest precisely in those countries where unit labour costs have risen most sharply

Relative net price of a standard-quality washing machine *

Four-month periods

Relative price[1] ...
... in the "most expensive" EMU country
... in Germany
... in the "cheapest" EMU country

1997 98 99 00 01 02 03 04 2005

* Calculated from GfK Retail and Technology's original data. — 1 Price of a standard machine relative to its price in Italy in the second four-month period in 2001.

Deutsche Bundesbank

since the launch of monetary union and that, conversely, a very low price level prevails in those countries where the growth in unit labour costs also remained small.[22] According to a second hypothesis, the mark-up on prices in the individual countries' distribution sector could have diverged, for example, as a result of aggressive price reduction strategies or the establishment of more efficient distribution channels in a subgroup of euro-area countries. Third, it is also conceivable that higher transport costs have played a role. After all, the period of increasing price dispersion coincides with a sharp rise in fuel prices, which means that the costs of cross-border

22 For unit labour costs in the euro-area countries, see European Central Bank, Monitoring labour cost developments across euro area countries, Monthly Bulletin, November 2008, pp 69-85.

Tests for price convergence in the euro area

Various methods are available for testing price convergence. An especially uncomplicated method is an F test, which compares the price dispersion in the form of its cross-border variance at two different points in time.[1] If it proves to be the case that price dispersion at the later point in time is significantly smaller than before, then price convergence exists. This method has the advantage of requiring price observations at only two different points in time for each country. By contrast, if price time series are available, an F test uses only a small part of the available information and therefore appears arbitrary. A further disadvantage of this method is that the test assumption that the two variances being compared with each other are mutually independent is often not met in time series.

Panel unit root tests are a second method of testing for price convergence.[2] Here, the time series of the price levels first have to be normalised vis-à-vis price developments in a base country. If the null hypothesis of non-stationarity is rejected for the resulting relative price series, this is usually interpreted as an indication of price convergence or, at least, the validity of the law of one price. Tests such as these are geared to a concept of convergence which differs from that of the other tests mentioned. Price dispersion, in particular, plays no explicit role in this context. These tests also focus more on the question of whether the relative prices always return to a fixed value in the long term, ie in a certain sense whether the prices have already converged. A prolonged, gradual convergence process, by contrast, may perhaps not be recognised as such.

The recently developed "log t" test should be mentioned as another method.[3] This test is independent of the stationarity properties of the time series analysed and allows temporary periods of divergence as well as different speeds of adjustment. As a first step within this test, the individual price series are smoothed and set in relation to the average price development. From this, across all the countries, a variance H_t is formed for each point in time t. Following this, the equation

$$\ln\left(\frac{H_1}{H_t}\right) - 2\ln[\ln(t+1)] = a \; + \; b \, \ln t + u_t \qquad (1)$$

is to be estimated using a heteroscedasticity and autocorrelation-consistent method. If the variance H_t decreases over time t, ie in the case of price convergence, coefficient b should be positive. The null hypothesis of price convergence is thus $b \geq 0$. Given a significance level of 5%, the one-sided test is to be rejected for t-values of $\hat{b}$ which are lower than −1.65.

If this method is applied to the time series of quality-adjusted washing machine prices, the values given in the table below are obtained.[4]

Phillips and Sul (2007) "log t" test: t-values for $\hat{b}$ [5]

Observation period starts at the beginning of the year ...	15 EU countries	9 euro-area countries
... 1997	− 45.61	− 41.86
... 1999	− 99.57	− 168.65
... 2000	− 71.21	− 72.25

In all cases, the computed value falls well short of the critical value. Price convergence can therefore be confirmed neither for the group of euro-area countries nor for the EU countries as a whole. The other two test methods mentioned, F tests and panel unit root tests, confirm this result.

1 F tests for price convergence in Europe may be found, for example, in M Lutz (2004), Price convergence under EMU? First estimates, in A V Deardorff (ed), The Past, Present and Future of the European Union, Palgrave MacMillan, pp 48-73, J H Rogers (2007), Monetary union, price level convergence, and inflation: How close is Europe to the USA?, Journal of Monetary Economics, 54, pp 785-796, and J Wolszczak-Derlacz (2006), One Europe, two prices - the price disparity in the EU, Katholieke Universiteit Leuven Center for Economic Studies Discussion Paper 06.14. — **2** Relevant studies on this are, for example, P K Goldberg and F Verboven (2005), Market integration and convergence to the Law of One Price: evidence from the European car market, Journal of International Economics, 65, pp 49-73, J Ceglowski (2003), The law of one price: intranational evidence for Canada, Canadian Journal of Economics, 36, pp 373-400, and D C Parsley and S-J Wei (1996), Convergence to the Law of One Price without trade barriers or currency fluctuations, The Quarterly Journal of Economics, 111, pp 1211-1236. — **3** See P C B Phillips and D Sul (2007), Transition modeling and econometric convergence tests, Econometrica, 75, pp 1771-1855. — **4** See C Fischer (2009), Price convergence in the EMU? Evidence from micro data, Deutsche Bundesbank Discussion Paper, Series 1, No 06/2009. — **5** The presented results are based on a Newey-West estimation of equation (1) where a lag of two periods is used; the estimation starting in 1997 refers to 13 EU countries and seven euro-area countries, respectively; the estimation starting in 2000 is based on a separate dataset. Given a significance level of 5%, the one-sided test is to be rejected for t-values of $\hat{b}$ which are lower than −1.65.

Deutsche Bundesbank

arbitrage operations are likely to have increased during this time.

Conclusion

The results of empirical studies on price convergence owing to the introduction of the euro differ individually depending on the methodology chosen, the goods or categories of goods observed, and the periods of time analysed. However, what is common to most studies is the finding that, during the past ten years, there has been, if at all, only a moderate tendency to further price convergence in the euro area. Especially in comparison with the decade before the introduction of the euro, there has been a marked slowdown in the pace of convergence. This suggests that monetary union's autonomous contribution to price convergence should not be overestimated. By contrast, the vast majority of the studies find that economic integration within Europe has given a substantial impetus to a levelling of existing price differentials.

These results are also confirmed by a Bundesbank study based on micro data using a new dataset for a specific group of products – washing machines – which is so far unique in the European context for the investigation of price convergence. This study shows that the introduction of the euro has hitherto had no perceptible stimulating effect on price convergence. Since 2000, the prices of washing machines in the single currency area appear to have tended to diverge, in fact. Caution should be exercised when drawing more far-reaching conclusions from this, however. First, it is unclear how far it is possible to generalise the results for the observed product. Furthermore, the results are preliminary insofar as the convergence process might still require more time. Finally, it also cannot be ruled out that potential convergence effects of the monetary union have been obscured by sector-specific developments. For example, unlike the micro-based results, macroeconomic variables point to slight price convergence within the euro area. Nevertheless, even this study found that convergence was noticeably weaker than before the introduction of the euro.

Despite the above-mentioned qualifications, the price trends found in the micro data study deserve a great deal of attention, since, in the countries observed, they are accompanied by matching divergences in unit labour costs within the euro area. In this respect, they could also reflect structural shifts in price competitiveness among the euro-area countries, which might call for adjustments.[23]

---

[23] Recent developments in the price competitiveness of individual euro-area countries are examined in detail in Deutsche Bundesbank, Current account balances and price competitiveness in the euro area, Monthly Report, June 2007, pp 33-53.