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One Market, One Money, One Price? Price Dispersion in the European Union*

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Abstract

The introduction of the euro was intended to integrate markets within Europe further, after the implementation of the 1992 Single Market Project. We examine the extent to which this objective has been achieved, by examining the degree of price dispersion between countries in the eurozone, compared to a control group of EU countries outside the eurozone. We also establish the role of exchange rate risk in hampering arbitrage by estimating the euro-effect for sub-groups within the eurozone, utilising differences among EU countries in participating in the Exchange Rate Mechanism. Our results, in contrast with previous empirical research, suggest robustly that the euro has had a significant integrating effect.

JEL Classification: E31, E42, F01

Keywords: euro, EMU, price dispersion, difference-in-differences, exchange rate risk

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1 Introduction

Over the past two decades markets within the European Union (EU) have become progressively more integrated as internal barriers to trade have been dismantled. Two crucial steps in this process were the completion of the Single Market Project in 1992 and the start of Economic and Monetary Union (EMU) in 1999. The first removed the remaining physical, administrative and technical barriers to integration and stimulated competition. The second introduced a common currency and eliminated exchange rate variations between the eleven, later twelve, members of the eurozone.[1] In the widely quoted and influential report, *One Money, One Market*, the European Commission (1990) argued that "without a completely transparent and sure rule of the law of one price for tradable goods and services, which only a single currency can provide, the single market cannot be expected to yield its full benefits - static and dynamic". The single currency would deepen integration by lowering exchange-rate-risk premia, lower uncertainty, make cross-border business much more profitable and lower transaction costs, thereby saving the equivalent of approximately 1% of EU15 GDP.

This viewpoint was re-iterated in the 1996 review of the single market: "increased price transparency will enhance competition and whet consumer appetites for foreign goods; price discrimination between different national markets (in the EU) will be reduced" (European Commission, 1996). When the euro actually became an accounting reality in 1999, the European Commission (1999) anticipated that it would "squeeze price dispersion in EU markets".

The recent publication of a newly revised, consistent and comprehensive data set on price indices for the period from 1995 has made it possible to undertake a detailed analysis of price convergence within the EU. We test the hypothesis that greater market integration, followed by a common currency has rendered the Law of One Price (LOOP) valid for the EU. Our results robustly suggest that the euro has had a positive effect on price convergence for tradable goods, among EMU members relative to non-EMU members, over and above a general EU-wide tendency towards price convergence. It is also evident that, risk, due to volatility of nominal exchange rates prior to the introduction of EMU, has had a significant bearing on the process of price convergence.

The structure of this paper is as follows. An overview of the relevant theory and the empirical literature is provided in Section 2, including the

[1]The 1999 members were: Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain. Greece joined in 2001.

benefits derived from a single currency. Section 3 describes the data and section 4 discusses the methodology used. Section 5 reports the results of our analysis. Conclusions are offered in Section 6.

2 Theory and Literature

2.1 Theory

In the international economics literature, the LOOP and its aggregate counterpart, Purchasing Power Parity (PPP), have provided a useful benchmark for the dynamics of relative prices. The Law of One Price states that prices of identical tradable goods priced in the same currency should, under competitive conditions, be equal across all locations, national and international. If prices differ, then arbitrageurs, subject to certain threshold effects, would profit from buying them where they are comparatively cheap and selling them where they are comparatively expensive. The price of non-tradable goods, normally excluded from the LOOP analysis, can also be expected to converge, with a sufficiently high degree of economic integration.

From a theoretical point of view the failure of LOOP and hence of PPP, has several explanations. In a common market like the EU, where tariffs, trade quotas and other informal barriers have been removed, one obvious reason that remains would be transport costs. Shipping costs permit price differentials between more distant markets without encouraging arbitrage. In a seminal article, Engel and Rogers (1996) found that distance, as a convenient control for transport costs, explains relative price dispersion across ten US and nine Canadian cities; this result has been confirmed by Parsley and Wei (1996 and 2001), Cecchetti *et al.* (1999) and more recently by Haskel and Wolf (2001). Engel and Rogers also reveal that the border effect is more decisive than distance, even when both countries share the same language and similar cultural and political traditions. They speculate that the EU could also be affected by similar border effects, and Beck and Weber (2003) report evidence for this.

The segmentation of countries by borders creates the potential for monopoly pricing and Feuerstein (2003) showed that firms could exploit markets exhibiting a home-product bias by setting higher prices in domestic than in export markets. Also, national variations in consumer preferences can, in general, foster price discrimination across countries. To the extent cross-border search costs are likely to be higher than their domestic counterparts, finding price dispersion across Europe will not be surprising. Technological advances such as internet price search engines should erode these information

barriers over time, but Baye *et al.* (2003), analysing prices of a selection of homogenous goods sold via internet price listing services found that, in fact, price dispersion within EMU countries increased, relative to price dispersion within non-EMU countries, after the introduction of the euro.

Another explanation suggests that highly traded goods contain significant non-traded components and this frustrates price convergence (Rogoff 1996). Consumer prices include the price of the product itself, but also imputed rents, shipping costs, labour costs, and insurance premiums from non-traded goods. These cost factors may affect the prices of non-traded intermediate goods as and thereby have an impact on the degree of price dispersion for traded final goods.

Exchange rate risk can also raise costs of cross-country arbitrage. An arbitrageur buying high-priced products in say Sweden, with the intention of selling them in the UK, faces the risk that profits are eliminated through exchange rate movements before the goods have been sold. The risk would be higher if long-term investments are necessary for seizing potential arbitrage opportunities, because exchange rate hedges with maturity dates longer than one year are hard to obtain (H.M. Treasury, 2003). Price dispersion between homogeneous tradable goods could arise due to transaction costs involved in cross-border payment, currency conversion or settlement delay.

Finally, arbitrage by consumers might be hampered by the lack of price transparency. Although comparisons of prices between countries need only basic calculations, the psychological effect of using a different yardstick could be large and potentially inhibiting. Money illusion cannot be ruled out, according to Fehr and Tyran (2001), but whether this applies in a single currency context is debatable.

2.1.1 The benefits of a common currency

A common currency eliminates transaction costs and exchange rate risks and through price transparency increases trade and competition, thereby contributing to lower price dispersion after adjusting for transport costs. Price convergence in turn further strengthens trade and competition in a two-way reinforcing process. In a series of controversial papers, Rose (2000, 2002 and jointly with van Wincoop 2001 and Glick 2001) established that countries with the same currency traded with each other twice as much as those with different currencies.[2] And Micco *et al.* (2003) provided evidence that the introduction of the euro increased trade among the members of the

[2]The relationship between market integration and the volume of trade would not be monotonic.

single currency and also those that remained outside, although the 8-16% increase in volume terms falls way short of the estimates of Rose.[3]

Beck and Weber (2003) attributed the failure of the LOOP to exchange rate volatility that impede price convergence, and Goldberg and Verboven (2004) demonstrated that such volatility contributed significantly to price dispersion in the European car market. But they argued that the EU could facilitate price convergence for cars by removing restrictions on competition that had previously been sanctioned by the European Commission as a concession to manufacturers. The threat of new entrants into the domestic market and hence greater competition would put downward pressure on producers' prices (Freeman, 1995).

Price convergence could also be stimulated by a common monetary policy and more particularly in the non-traded goods sector through the Balassa-Samuelson hypothesis (1964).[4] Furthermore, Elefteriou (2003) found that eurozone countries (including Greece, Portugal and Spain) for which the common interest rate was inappropriately low, were also poorer countries with low relative price levels. A low common interest rate led to an above EMU average inflation rate ('catch-up inflation') in these countries and thus to price convergence. The predictive power of the common interest rate in terms of future inflation rates has proved to be surprisingly robust (Honohan and Lane, 2003).

The EMU has the potential to remove exchange rate risk, transaction costs and the veil over price transparency. While price convergence will be stimulated, price dispersion will remain to a greater or lesser degree. United States' price convergence has been used as a predictor for the EU, given their similar size, structure and culture, although the EU has more languages. Begg *et al.* (2001) found substantially lower price dispersion in the US than in the EU and concluded that the potential for price convergence in the EU remained large (but see Mathä, 2003; Rogers, 2001 and 2002, below).

2.2 Empirical evidence

Sifting evidence for price convergence requires some care. This stems from the different methodologies employed by researchers, as well as empirical issues such as data sources, and whether countries, cities or single commodities are the focus. Also important are factors such as differences in taxes,

[3]Rose's results have been challenged by, among others, Persson, 2001; and Melitz, 2001.

[4]Converging and higher productivity levels in the traded goods sector may raise output and wages, and these wage increase may spill-over into the low productivity non-traded sector fuelling inflation. Productivity gains are higher in the low-priced countries and their faster rising non-traded goods prices may force the country's prices to converge upwards.

transport costs, labour costs and nominal exchange rates. Combined, these allow only broad generalisations about price convergence. Common currency prices can differ for a number of reasons that might mask price convergence, if appropriate controls are not employed. In practice, data quality and availability frame the hypothesis to be tested, weakening it from the absolute nature of LOOP. Results from previous research on the LOOP, mostly in the European context, have been summarised in Table (2) in the appendix and are assessed below.

2.2.1 Macroeconomic studies

Firstly, borders prevent prices from converging. A number of studies have shown that prices are less dispersed within, than across national borders. In the European context it has been reported that intra-EU price dispersion has fallen with the implementation of the Single Market Project, and to a lesser extent with the introduction of the euro. Engel and Rogers (1996) documented border effects between US and Canadian cities between 1981 and 1995 and found that crossing the border was equivalent to adding 1,700 miles to the distance between them. Beck and Weber (2003) cut this distance dramatically to 74 miles in their study across sixteen countries, albeit on the basis of two goods, board and lodgings paid to US civil servants based overseas. The continued importance of borders received confirmation from Parsley and Wei (2001) with price dispersions across cities of 13-14%, and in Europe, from Beck and Weber (2003) who confirmed the importance of border effects and found that intra-national price dispersion fell by 80% after the introduction of the euro.

There are a number of studies on the impact of the Single Market Project on price convergence. Using the US as a baseline, Rogers (2001) showed that price dispersion fell by 50% in the early 1990s, using city data collected for three years; 1990, 1995 and 1999. Rogers (2002) situated most of the convergence before 1994, with the EU level close to that found in the US. Using city data for the period 1990-2002/3, Engels and Rogers (2004) confirmed this result, but found that price dispersion for tradables actually increased (perversely) after EMU, for those countries inside and outside the common currency (see also Baye *et al.* (2003)). Other studies provide contradictory results. Crucini *et al.* (2001), using Belgium as a numeraire, found considerable deviations from purchasing power parity among European countries, and in a subsequent study of cities, Crucini and Shintani (2002) found little evidence for price convergence in the EU. Haffner (1999) on the other hand, using a different data source, found for price convergence over the latter part of the 1990s for the EU countries, with the non-Deutschmark group con-

verging at a faster rate. Sosvilla-Rivero and Gil-Pareja (2004) also found convergence, more particularly for those in the original post 1979 Exchange Rate Mechanism (ERM).

Five studies use data that straddles EMU and all find varying degrees of price convergence within the scope of their models. A country study by Gajewski and Kowalski (2004) that did not specify the goods considered, report convergence post-EMU, as do Beck and Weber (2003) with a cross-country study that indicate a declining border effect rather than price convergence *per se.* Isgut (2004) in a study of 122 cities concluded that the same currency reduces price differences by 2-3%, and in EMU specifically, by 5% even when EU had been controlled for. A dollar or hard-currency peg also has favourable effects. A similarly extensive city study by Parsley and Wei (2001) reports lower price dispersion in EMU of 4.3% that equate to a drop in tariffs of 4%, but once EU membership is controlled for, the EMU effect is no longer significant. In a more restricted analysis of regions contiguous with Luxembourg, Mathä (2003) showed that monetary union led to price convergence, and specifically that if distance increased, then prices rose by 0.025%. He speculated that smaller distances across Europe compared with the US meant that price convergence in the EU had much further to go. Rogers (2002) results do not support this conjecture.

2.2.2 Microeconomic studies

A number of studies have taken a microeconomic, i.e., single or multi-product approach to price convergence. Haskel and Wolf (2001) revealed price convergence for 119 goods sold in stores operated by the Swedish retailer IKEA in twenty-five countries. Several researchers have looked at the price of cars that frequently feature in reports of price discrimination between countries within the EU, particularly the UK. Goldberg and Verboven (2004) consider five EU countries and 150 vehicle makes and report converging prices between 1990 and 1992, but divergence thereafter, specifically in the UK and Italy. Lutz (2004) find divergence to be associated with language, a common border and external trade barriers. Interestingly the Belgium-Luxembourg currency union meant a 4% lower price differential than found elsewhere in the EU even after controlling for other determinants of economic integration. In a later study, Lutz (2003) included a smaller sample of cars, but also *The Economist* magazine and Big Macs and 13 categories of goods collected by UBS over a thirty year period ending in 2000. Price convergence could only be identified for *The Economist* and the introduction of the euro had no significant effect.

In the first study of internet prices, Baye *et al.* (2003) collected the prices

of 28 products from the Kelkoo site for seven countries, four of which were in the eurozone. Although the EU had lower price dispersion than the US for comparable goods, by 2002 the goods were priced 10% higher in the eurozone countries than in the non-eurozone ones. Imbs *et al.* (2004) looked at the price of televisions sets in the EU and three eastward enlargement countries. They found price dispersion to be lower in EMU countries, although most of this had occurred before 1999. In a fascinating study, Friberg and Mathä (2004) using the Luxembourg contiguous regions again, examined psychological pricing (meaning pricing just below a round number of euros, typically ending 0.95 or 0.75) to examine price convergence immediately after the introduction of the euro. They found greater convergence in psychological prices than in fractional prices, contradicting consumers' perception that the introduction of the new currency became an excuse for profit making.

Two final studies looked at price convergence in a single country. Maier and Cavelaars (2004) examine the reunification of Germany through prices in fifty cities in East and West Germany. They find evidence of price convergence after reunification, but pessimistically report that after five and a half years, the process had petered out. Horvath and Vidovic (2004) reported price convergence across 38 districts of the Slovak Republic, but at a slower rate than that found in the US with little difference between tradable and non-tradable goods.

2.2.3 Relevance of the findings

What importance should be placed on these empirical findings? Firstly, they are mostly non-comparable and therefore present snapshot pictures of price convergence, in different periods and across different countries and cities. Because of differences in data, they do not build up an evolving picture of price convergence. Analysis of city price data is of particular concern, since the data often relate to prices in capital cities, which are unrepresentative. So also, product categories or goods are often not standardised, and the results from, for example, products such as *The Economist* or Big Macs, are too quirky to be generalisable. Only Isgut (2002) finds unambiguous price convergence beyond single products, but even here the results relate to cities rather than countrywide data.

This paper employs a consistent series of price indices for a large number of products and uses country, rather than city data. Unlike many studies we have four post-EMU date points, soon to be extended to five.

3 Data

3.1 Data description

3.1.1 Data collection and categorisation

The data used for our empirical analysis was provided by Eurostat. It contains comparative price level (CPL) indices for individual consumption expenditure[5] in 200 product groups for the 15 EU countries over the period 1995-2002.[6] The group categorisation follows the United Nations 'Classification of Individual Consumption According to Purpose'[7]. The data was published on 18th of December 2003 based on the European System of Accounts, 1995 (ESA95) regulation revision[8]. This is the most disaggregated level at which data is currently held by Eurostat. The revision makes the data comparable across the period 1995-2002, whereas previously this was only possible for *either* the period pre-1999 *or* post-1999.

The price of consumer goods and services are collected by Eurostat in cooperation with the national statistical agencies for the Eurostat-OECD comparison programme, every three years. Data is gathered for all goods and services at 6 collection dates; one every half year (using a rolling benchmark approach). Prices in between the three-year collections are extrapolated with the respective monthly Consumer Price Index. The data are used to construct a PPP series for the products, i.e. ratios of prices denoted in respective currencies.

The notion of comparing 'identical' products is constrained by consumption patterns in the relevant countries. For example, a mainstream product sold in supermarkets with a low retail price in Germany might only exist as a niche product with a high retail price in the UK. Eurostat attempts to ensure that the selected products are commonly found in as many participating countries as possible, but they do not necessarily have to be available in all the countries (Eurostat, 2003b).

Among the 200 product groups, 39 are so-called reference PPPs, for which no data is collected directly (e.g. services of general practitioners, heat energy and life insurance). Their value is imputed entirely from other included product groups, and so they are excluded from our analysis. The scope of our analysis is given in Table (3) in the appendix. The data allows a distinction between tradables and non-tradables, shown in the column 'Category'. From

[5]Retail prices including VAT.

[6]Eurostat's uses the term "comparative price level" rather than relative price level to signify that price levels are comparable between countries at a defined level of aggregation.

[7]For details see UN Statistics Division http://unstats.un.org/unsd/cr/family2.asp?Cl=5.

[8]Commission Regulation (EC) 2223/1996 of 25 June 1996; see Eurostat (2003a).

the 161 product groups with good quality data, 115 tradable products can be identified. Non-tradables are categorised into low and high sunk-cost products in order to test the hypothesis that low-sunk cost products may converge faster due to lower barriers for arbitrage. Tradables can likewise be separated into broader categories of product groups, which are less or more tradable (e.g. perishable and non-perishable foods). The distinction is shown in Table (4)

Greece has been excluded from the analysis, because it did not join EMU in 1999 and treating it as a non-EMU member would bias the non-EMU group for 2001 and 2002.

3.1.2 Computations of the Comparative Price Level series

The PPP series that reflect the CPL is constructed by aggregating bilateral price comparisons of baskets of similar goods and services. A bilateral PPP exchange rate represents the hypothetical exchange rate that would be necessary to equalise price levels between two countries. The aggregation of the PPP series produces a set of PPP exchange rates relative to the EU average.[9] The annual CPL indices are computed as a ratio of the respective PPP exchange rate over the annual average of the respective nominal exchange rate (e) as shown in Eq. (1) for country c:

$$CPL_{c/EU} = \frac{PPP_{c/EU}}{e_{c/EU}} \cdot 100 \tag{1}$$

The CPL series can be used to test whether PPP holds, in which case the CPL equals 100, i.e. the ratio of the price levels equals the nominal exchange rate. Thus, deviations of a country's CPL index from the EU average (that always equals 100) provides information about the price level of the country relative to the EU. An CPL index of 105 indicates a price level of 5% above the EU average.[10]

A general feature of the CPL series is the differing importance of the PPP and of the nominal exchange rate in movements of the CPL index. Table (1) shows the UK CPL and the nominal £/€ exchange rate over time. The example indicates that the CPL series is dominated by changes in the nominal

[9]The price ratios are aggregated into the matrix of bilateral Fisher indices and made transitive by the Elteto-Köves-Szulc (EKS) method. For the aggregation, expenditure weights of the respective product groups are applied (Eurostat, 2003b). The resulting CPL indices enable comparison between countries at a some level of aggregation, given that the EKS formula is non-additive.

[10]Table (1) in the appendix provides an overview of the national CPL indices across time.

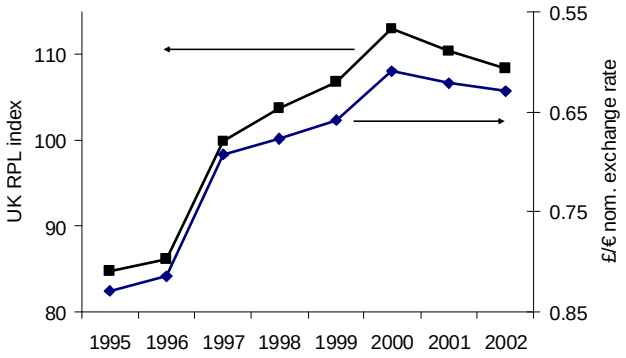

Figure 1: The UK CPL national average across all product categories) against the annual average of the nominal £/€ exchange rate between 1995 and 2002
Source: Eurostat, own calculations

exchange rate. It might be argued that the analysis of price convergence could be distorted by large movements in the exchange rate. However, when analysing the EMU-effect it does not matter whether price convergence is achieved by changes in PPP or in the nominal exchange rate.

3.2 Advantages and disadvantages of the data

Eurostat CPL series have been used in previous studies, e.g. HM Treasury (2003) and Sosvilla-Rivero and Salvador (2004). The advantage of using aggregated data is the highly representative nature of the information. Eurostat data has been collected for an adequate sample of goods (as discussed in Section 3.1.1). This makes for find more general patterns, as opposed to studies focusing on a single product (e.g. Big Mac series) or small product sets.

At the same time, valuable information is potentially lost by aggregation. Price deviations with opposite signs in a basket of products could cancel each other out. This would introduce a downward aggregation bias, thereby understating the actual level of price dispersion. The effect of the bias on the analysis is indeterminate, since it could potentially affect the price dispersion of both the EMU and the non-EMU group, at different times.

The relatively short time period covered by the data set could *inter alia* significantly reduce the precision of the regression analysis, but here we are constrained by Eurostat's revision exercise for pre-1999 data. On the other hand, while Rogers (2001) and Beck and Weber (2003), among others, use data from the Economist Intelligence Unit (EIU) that provides data only for European cities, Eurostat collected prices in a large number of cities to attain representative national comparative prices.

4 Modelling

In determining whether EMU significantly reduced price dispersion, the challenge arises from the impossibility of confronting the observed data with a counterfactual, i.e. price convergence in the eurozone without the euro. This necessitates a 'second-best' strategy to reveal the EMU-effect. The following section describes a tailored difference-in-differences (DD) model using EMU-related dummy variables as explanatory variables.

4.1 Measuring price dispersion

Price dispersion can be measured in various ways, e.g. as a range of minimum to maximum price, as a standard deviation (SD) across prices, or as a coefficient of variation (CV). The range is a less suitable measure, because it is affected by the extreme values and does not reflect average price dispersion. With CPL indices the latter two are equivalent for an EU-wide analysis, since the EU mean (μ_{EU}) is always 100.[11] For subsets of the EU, e.g. non-EMU countries, it is likely that $\mu_{non-EMU} \neq \mu_{EU}$, and therefore $SD_{non-EMU} \neq CV_{non-EMU}$. In order to avoid scale-effects the CV rather than the SD is used in the following analysis.

In computing the CV, its components - SD and mean - are computed for each country grouping - e.g. the EMU group, the non-EMU group and so on. No expenditure weights for the countries are used, since the potential for arbitrage is expected to arise irrespectively of the size of a country. The analysis therefore calibrates convergence towards group means, not the EU mean of 100, because the euro is expected to reduce arbitrage costs for intra-EMU trade - rather than EU-wide trade.

Fig. (2) depicts the CV of the EMU and non-EMU groups. The EMU group displays a lower degree of price dispersion only until 1997; the CV of the non-EMU group fell at a faster rate until 2000. But the trend reversal that has been observed since 2000, may indicate a euro-effect on price convergence.

4.2 Quantifying the euro-effect

A simple comparison of price dispersion among EMU members before the introduction of the euro and in the post-euro period does not help very much since it presumes that there were no events beyond the euro that affected price dispersion, post-1999: potential effects on price dispersion by advances in transportation or the internet, for example, are not taken into account.

[11] The CV of group i with SD_i and μ_i is defined as $CV_i = \frac{SD_i}{\mu_i} \cdot 100$; if $\mu_i = 100$, as in the case of an EU-wide analysis, then $CV_i = SD_i$.

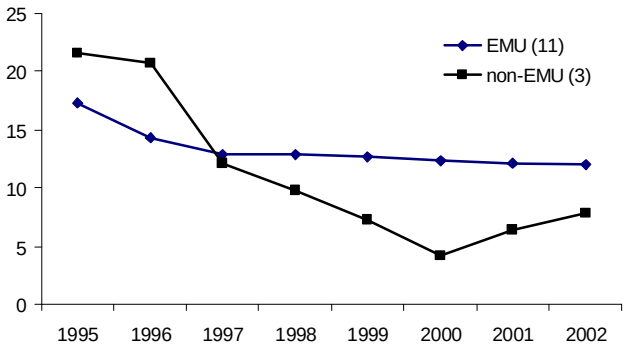

Figure 2: The CV of national CPL for the respective country groups over time
Source: Eurostat, own calculations

The restrictive nature of this assumption increases over time, when further data points should give greater certainty to the analysis.

Likewise, simple cross-section comparisons of the country groupings that attribute the difference in price dispersion between EMU and non-EMU groups for the post-1999 period to the euro, would also rest on the strong, unwarranted assumption that there are no structural differences between EMU and non-EMU countries.

4.3 The difference-in-differences approach

These drawbacks can be resolved to a large extent by the difference-in differences (DD) approach, which has been used for estimating the EMU-effect with a different data set by Lutz (2003).[12] "The basic intuition of the difference-in-differences approach is that to study the impact of some 'treatment', one compares the performance of the treatment group pre- and post-treatment relative to the performance of some control group pre- and post-treatment" (Slaughter, 2001). In our case, the DD method is useful in revealing the difference in the rate of price convergence after the introduction of the euro. The model's assumption is less restrictive: after the introduction of the euro, there are no other factors that affect the EMU and non-EMU groups differently.

[12]Panel unit root and co-integration techniques have also been used to test convergence towards the LOOP. The panel ADF test (Levin and Lin, 1992) takes advantage of the increased power provided by the panel structure, but these tests are prone to distortions when the assumption of the mutual independence of the series does not hold. While solutions have been proposed (see Beck and Weber, 2003; and Sosvilla-Rivero and Gil-Pareja, 2004), given the dimensions of our data, we leave this analysis for the future.

4.3.1 Analysis of the model

The DD approach is as shown in Eq. (2) where the subscripts g, p, and t denote the country group[13], the product group[14], and the time period[15] respectively. The EMU dummy takes a value of one or zero depending on whether a country belongs to the treatment or the control group respectively. The post99 dummy becomes one when $t \geq 1999$ and remains zero otherwise. The time trend τ takes a value of 1 to 8 for the respective time period. Γ assembles a set of three control variables, Θ represents the set of product fixed effects, and ϵ is the residual term with the usual desirable properties.

$$\begin{aligned} CV_{g,p,t} = \alpha &+ \beta_1 \cdot EMU + \beta_2 \cdot post99 + \beta_3 \cdot EMU \cdot post99 \\ &+ \gamma_1 \cdot \tau + \gamma_2 \cdot \tau \cdot EMU + \gamma_3 \cdot \tau \cdot post99 + \gamma_4 \cdot \tau \cdot EMU \cdot post99 \\ &+ \sum_{k=1}^{3} \delta_k \cdot \Gamma_{g,t,k} + \sum_{j=1}^{P-1} \eta_j \cdot \Theta_j + \epsilon_{g,p,t} \end{aligned} \tag{2}$$

Control variables and product dummies The DD method remains vulnerable to time-varying effects, post-1999, that may influence price dispersion of EMU members differently from non-EMU countries. The inclusion of Γ, the set of control variables minimises any potential bias. The factors that are assumed to vary across time and group, following Lutz (2003), are:

1. *the standard deviation of inflation rates*: to capture (i) differences in the degree of local-currency pricing across groups and (ii) the extent to which monetary conditions differ across countries[16]

2. *the standard deviation of the growth rate of the nominal dollar exchange rate*: to allow for different price movements as a result of import prices changing and the degree to which incomplete exchange rate pass-through matters

3. *the standard deviation of output growth rates*: to capture the degree to which business cycle movements are correlated

[13] $g \; \varepsilon \; \{0, 1\}$ denoting the control and the treatment group respectively.
[14] $p \; \varepsilon$ [1..P] where P denotes the total number of product groups used.
[15] $t \; \varepsilon$ [1..8] for the respective year between 1995-2002.
[16] Each of the 161 product groups are individually of small weight in the constitution of the aggregate, economy wide, inflation rate.

The data for the three control variables are taken from the IMF International Financial Statistics database.[17]

The product fixed effects Θ are included to account for any potential systematic differences between the product groups: one in case j=p; otherwise, zero.

Interpretation of coefficients The coefficient on EMU measures out the difference between EMU and non-EMU countries in price dispersion. The coefficient on $post99$ measures any step variation in price dispersion (shared by EMU and non-EMU groups) for the period after 1999. The coefficient on $EMU \cdot post99$ measures any additional difference in price dispersion among EMU countries, relative to non-EMU, for the period after 1999.

A similar interpretation applies to the variables constituted by interacting the time-trend with these same dummy variables.

The effect of the euro is captured by the shift (via $EMU \cdot post99$) and the time-trend break ($\tau \cdot EMU \cdot post99$) in dispersion. Distinguishing the shift and time-trend parameters in the model allows us to gain insight into the process of price convergence. If the introduction of the euro, by lowering arbitrage costs, yields an instantaneous adjustment of prices, we expect the shift to be negative and significant. The sticky-price assumption in macroeconomic models suggest that the shift effect will be muted. However, a structural break in the time trend (again, negative and significant) would be compatible with the presumption of slow adjustments in the price process.

Non-linearity in dispersion dynamics The linear model described postulates that the forces brought to bear on price dispersion by the euro are the same, whether price dispersion is high or low. However, price convergence is not necessarily a linear function of price differences (Mathä, 2003). It would be plausible to assume that CPL indices that diverge substantially from 100 would experience a higher speed of convergence. This is because the pressure from arbitrage could be stronger on these, compared to CPL indices close to 100. It is just as conceivable that price dispersion may be persistently high for some product groups, while others tend to converge rapidly.

To take these scenarios into account we modify Eq. (2) to allow for differential impacts of the euro according to the relative degree of price dispersion. Dummy variables $Q1_t, Q2_t, Q3_t, Q4_t$ mark out the quartiles into which price dispersion falls for each country group for each year. We use these dummy

[17] The code for the nominal dollar exchange rate is '..AE.ZF..' and the annual average was used. The inflation rate is based on the consumer price index code '..64..ZF..'. Output growth is based on real gross domestic product code '..99BV..'.

variables as categorised in the previous year (t-1) and interacted with the time-trend break in dispersion, as shown in Eq. (3). The relevant coefficient will capture the differential impact the euro may have on product groups with high and low price dispersion.

$$\begin{aligned} CV_{g,p,t} = \alpha &+ \beta_1 \cdot EMU + \beta_2 \cdot post99 + \beta_3 \cdot EMU \cdot post99 \\ &+ \gamma_1 \cdot \tau + \gamma_2 \cdot \tau \cdot EMU + \gamma_3 \cdot \tau \cdot post99 \\ &+ \gamma_4 \cdot \tau \cdot EMU \cdot post99 \cdot Q1_{t-1} + \gamma_5 \cdot \tau \cdot EMU \cdot post99 \cdot Q2_{t-1} \\ &+ \gamma_6 \cdot \tau \cdot EMU \cdot post99 \cdot Q3_{t-1} + \gamma_7 \cdot \tau \cdot EMU \cdot post99 \cdot Q4_{t-1} \\ &+ \sum_{k=1}^{3} \delta_k \cdot \Gamma_{g,t,k} + \sum_{j=1}^{P-1} \eta_j \cdot \Theta_j + \epsilon_{g,p,t} \end{aligned} \tag{3}$$

4.3.2 Challenges to the model

Statistical problems Bertrand, Duflo, and Mullainathan (2004) have pointed out a problem in estimating DD models. DD models estimate the effects of binary treatment on individuals by comparing before and after outcomes; they typically use many years of data, as we do, and focus on outcomes that tend to be serially correlated through time. Serial correlation in the error process can lead to biased standard error estimates in longer series. Bertrand *et al.* (2004) suggest a simulation-based method to overcome this problem, but its implementation is rather complicated. In estimating our equations we use another solution, and allow arbitrary covariance structures over time. Using the Huber-White sandwich estimator of variance and permitting auto correlation in observations within product groups is our preferred solution to this problem.

Another purely statistical problem arises because of the different size of the EMU and non-EMU groups: 11 and 3 countries, respectively. If, for example, the underlying distribution were normal, the variance of the EMU group would be distributed $\chi^2(10)$[18], whereas the variance of the control group would be distributed $\chi^2(2)$. That could distort the interpretation of the regression result, since the dispersion of the variance of the treatment group is greater. This potential bias is eliminated in our case because the numbers in the different groups are time invariant and the difference is absorbed by the EMU dummy along with any other systemic source of difference in dispersion between the two groups.

[18]The number in brackets indicates the degrees of freedom (ν) of the χ^2 probability density function with mean ν and variance $2 \cdot \nu$.

The constraint for price convergence by arbitrage cost (AC) The model faces one other difficulty in measuring the euro-effect. Arbitrage only functions as a price-convergence device when prices lie outside the band of AC. Fig. (3) illustrates the movement of a hypothetical national CPL for an EMU member. The ACs are shown as a lower and upper band around the EMU average to which the CPL converges over time.[19] Once the CPL is within the band of AC, arbitrage is no longer profitable. At point A the CPL touches the AC band, but in an efficient market arbitrageurs step in and reverse the movement. Membership of EMU can be expected to reduce the AC range for intra-EMU trade (point B), and this triggers further convergence until the CPL is within the band again.

The analysis of the euro-effect on price convergence relies on the fact that the CPL indices are predominately outside the narrow band at the introduction of the euro as shown in Fig. (3). Price convergence might not be observed if CPL indices are already within the narrower (post-EMU) range of AC. The model should ideally test for convergence conditioned on the position of relative prices to the band of ACs. However the size of the band is unknown in reality.

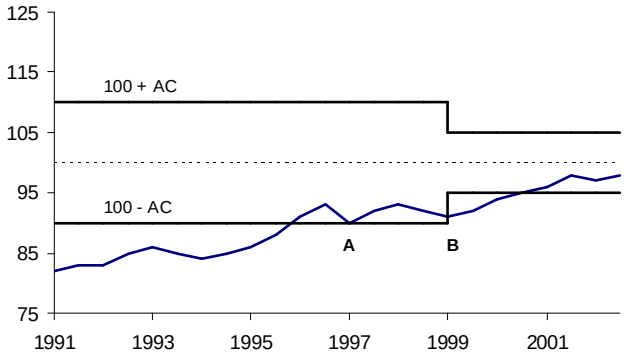

Figure 3: The movement of a hypothetical national CPL across time
Source: The diagram is adapted from Wolf (2003; p. 57)

5 Estimation

5.1 General results

Of the 161 product groups for which data is of sufficiently high quality, we focussed attention on the 115 in the tradable category. As discussed in Sec-

[19]The simplifying assumption in this example is that the EMU average is equal to the EU average of 100.

tion 2, price convergence ought to be most apparent among tradable goods. Our analysis of the 46 non-tradable product groups showed no evidence for a significant decline in price dispersion among EMU countries relative to non-EMU countries. This remained the case when the analysis was restricted to the 29 product groups characterised by relatively low sunk costs.

Following the approach laid out in Section 4.3, we begin quantification of a potential euro-effect by estimating Eq. (2) across the 115 tradable product groups. The results are presented in the column marked (1) in Table (5) in the appendix. The model is estimated with product fixed effects and employs the robust variance estimator. The relevant parameters are the shift coefficient ($EMU \cdot post99$) and the trend coefficient ($\tau \cdot EMU \cdot post99$). The former is insignificant, though negative, but the latter is significantly negative at the 1% level. As expected, we find no instantaneous downward shift in price dispersion in the eurozone relative to the non-EMU group, consequent to the introduction of the euro. But there is evidence of a downward break in the time-trend of price dispersion among EMU countries relative to non-EMU countries after 1999, supporting the hypothesis of a euro-effect.

We also note that the above patterns are overlaid on a significant negative trend coefficient which suggests price convergence across the set of all countries (and sub-groups of countries, in equations 3 to 6, discussed below) over the entire 1995-2002 period.

5.2 Extracting the importance of exchange rate risk

EMU incorporates certain exchange rate bands from the preceding ERM, and not all EMU countries were similar in terms of intra-group trading risk attributable to exchange rate variations in the run up to the euro. The ERM was hit by several speculative attacks in the aftermath of German reunification in 1990 that led to subsequent interest rate hikes by the Bundesbank in response to the fiscal expansion. The 'Black Wednesday' (16 September 1992) marked the expulsion of Britain and Italy from the ERM. Further crises in 1993 led to the adoption of wider ($\pm 15\%$) bands for acceptable fluctuations. Only Germany and Netherlands agreed bilaterally to remain in the original narrower band of $\pm 2.25\%$. Therefore, it could be argued that the exchange rate risk was substantially lower for the German/Netherlands subgroup (G+NL) compared with other EMU members before the introduction of the euro.

Another country grouping that had been in close synchronisation in terms of exchange rates, before EMU, albeit not as closely as G+NL, is the DM zone - comprising Austria, Belgium, Luxembourg, Netherlands and Germany. The exchange rate risk was lower for these DM-zone countries compared with

other EMU members before the introduction of the euro.

Separate comparisons of the G+NL and the DM zone against the non-EMU control group should be useful in revealing patterns in convergence. If exchange rate risk increases arbitrage costs significantly, the DM zone trend coefficient should be smaller (more negative) than the coefficient for the remaining six EMU members. We should expect the the G+NL trend coefficient to be negative and closer to zero compared to the coefficient for the remaining nine EMU members, and further, closer to zero than the coefficient for the DM zone. Indeed this is the pattern found in a comparison of the trend coefficients in regressions (3) to (6). The null that the coefficient of $\tau \cdot EMU \cdot post99$ is equal for EMU and for the DM zone is rejected decisively: $F(1, 114) = 42.72$, p-value close to 0. However, though the estimate of the coefficient for the DM zone (-0.036) is lower than the corresponding estimate for the German/Netherlands group (-0.031), the null that they are equal for the groups cannot be rejected: $F(1, 114) = 1.77$, p-value of 0.19.

Overall, these results support the hypothesis that exchange rate risk is a dominant factor in arbitrage costs.

5.3 Non-linearity in dispersion dynamics

We now relax the assumption of linearity in the effect of arbitrage on price dispersion. There are two possible ways in which there may be departures from linearity. One working hypothesis is that the forces of arbitrage will be stronger on (tradable) products that have higher degrees of dispersion. A counter hypothesis to this is that tradable goods may be characterised by differing degrees of 'tradability' and price dispersion may be persistently high in those product groups that are inherently 'less tradable'.

As a first step in resolving this issue we estimate Eq. (3) across all tradables. Table (6) in the appendix presents the results. The coefficients of interest are those on the lagged dispersion quartile dummy variables $Q1, Q2, Q3$ and $Q4$ interacted with the time-trend break for the EMU group. If lower arbitrage costs lowered price dispersion with greater force for products that had higher degrees of dispersion, then more negative coefficients will be associated with the higher quartiles. The results are the opposite. For EMU, and sub-groups of EMU, the interacted coefficients on the higher quartiles are very significantly (almost always at 1%) larger (closer to zero) than those on the lower quartiles.[20] The differentiated patterns in high and low price dis-

[20]It was in the case of the DM zone that the pattern was least strong: the coefficient on interacted $Q3$ was lower than that on $Q4$ at 1%, and the coefficient on $Q1$ was lower than that on $Q2$ at 5%, but $Q2$ was not significantly different from $Q3$.

persion product groups seem to be such that high dispersion product groups consistently converge less than low dispersion product groups.

To explore this further, we examine a select set of broad product categories to distinguish between the less and more tradable product groups. For example, food can be separated out into perishable food products (e.g. bread, fresh fish, fresh fruit) which are less tradable, and non-perishable food products (e.g. sugar, coffee). It might be expected that the pressure on prices to converge will be lower for perishable food products than for non-perishable food products. Again electrical appliances (e.g. washing machines, cookers, hand tools) are highly tradable. Alcohol and tobacco products while highly tradable in principle, are marked by country specific excise taxes. There is less reason to expect that reduced arbitrage costs will reduce price differences between countries for the latter. Table (7) in the appendix presents the results for the product groups (Table 4) in these broad categories.

The smaller number of observations at product category level reduces the resolution with which patterns emerge. In column (1) the results for perishable food show that the trend coefficient is not significantly different from zero. In contrast, for non-perishable food a significant (at 10%) tendency towards reduced dispersion can be observed (column 2). Alcohol and tobacco have no significant tendency towards reduced price dispersion, while electrical appliances show a strong convergent tendency (significant at the 5%; column 4).

6 Conclusion

Our objective was to test the hypothesis that the euro has had a positive effect on price convergence among EMU members relative to non-EMU members. Our findings suggest that this is true. The process of convergence in the eurozone triggered by EMU appears in the form of a structural break in the time trend of price dispersion. For EMU, this break accelerates the evident general trend of reduction in price dispersion across all EU countries after 1995.

Variations in the ERM history of the EU members permitted us to examine the importance of exchange rate risk for arbitrage costs. We found that the magnitude of the euro-effect did depend on the extent of pre-EMU exchange rate risk.

We also found clear evidence of differences among product groups in their tendencies towards reduced price dispersion. While products that could be categorised clearly as non-tradables did not show any tendency towards convergence, it is clear that tradable goods differ in their degree of 'tradability',

either because of the nature of the good (perishability) or because of country specific tax differences that discourage arbitrage. This may explain why a number of product categories show no tendency towards reduced price dispersion.

Possible extensions of this project include the use of panel time series methods using random coefficient models. The analysis can be enriched by conditioning on bands of arbitrage costs. A clearer understanding of the welfare effects of EMU should follow from examining whether product prices converge to their respective lowest price in the EMU. It may be interesting to explore whether different expectations of EU members joining the euro in the run-up to the EMU are relevant.

A Appendix

National CPL (EU15=100)	1995	1996	1997	1998	1999	2000	2001	2002
Austria	111.8	107.7	103.4	103.4	101.7	99.5	101.2	101.6
Belgium	108.7	105.3	102.3	102.3	102.6	100.3	98.9	98.2
Denmark	132.1	129.8	126.8	126.1	123.5	122.8	123.3	126.1
Finland	115.0	110.6	107.6	106.9	107.3	106.6	107.4	109.8
France	108.7	107.2	102.5	102.1	101.3	99.6	99.0	98.7
Germany	120.8	115.6	111.1	110.6	109.6	106.8	107.4	106.8
Greece	73.4	76.2	78.0	75.9	77.8	75.4	76.4	75.7
Ireland	89.0	91.6	97.0	96.9	100.6	103.8	108.4	109.7
Italy	79.5	87.8	89.8	88.4	88.4	88.0	90.1	91.8
Luxembourg	118.3	115.4	112.3	111.2	107.3	107.6	109.8	110.5
Netherlands	106.9	103.5	99.7	100.1	101.1	100.7	101.1	102.7
Portugal	70.6	71.6	71.2	71.2	70.9	70.8	72.4	73.3
Spain	81.5	83.1	81.2	80.9	80.1	80.8	82.5	82.9
Sweden	113.8	122.2	120.1	117.6	115.8	118.5	111.0	113.9
United Kingdom	84.8	86.2	99.9	103.7	106.8	113.0	110.4	108.4

Table 1: The national Comparative Price Level (CPL) indices relative to the EU mean of 100.
Source: Eurostat

Author(s) and Date	Time Period	Data Source	Countries/Cities	Product(s)	Results	Specific EU Results
Engels & Rogers (1996)	1981-1995	Bureau of Labor Statistics	8 Canadian and 14 US cities	14 categories of goods	Crossing border equivalent to 1,780 miles between cities.	
Beck & Weber (2001)	1995-2002	Office of Allowances US State Department	201 cities in 16 countries	2 goods: meals/board and expenses	Border greater effect than distance -narrower than Rogers at 74 miles.	After EMU price volatility falls for large countries except UK, same for small countries.
Beck & Weber (2003)	1991-2002	SPAT-DATregional	81 European Cities in 7 Countries	Price index and 10 categories of consumer goods	Border effects greater then distance. Unit root test shows faster convergence.	After EMU intra-national price dispersion falls 80%.
Beck (2003)	1991-2002	SPAT-DAT	3 Continents, 9 Countries, 110 Regions/Cities	Price index and 7 categories of consumer goods	US more integrated than EU and convergence depends on distance and exchange rate volatility.	Border estimates fell after EMU.
Rogers (2001)	1990, 1995 and 1999	EIU	26 cities in 18 countries(EMU 11, further European 6 and Israel).13 US cities as benchmark	168 goods		Prices less dispersed over whole period, with most of reduction before 1995. Dispersion fallen more than in US and EU levels close to those in US now. Still large deviation for some tradables.
Rogers (2002)	1990-2001	EIU	25 EU and 13 US cities	139 goods		Fall in EU price dispersion mostly before 1994; EU level close to that in US 2001. EMU cities same result.
Engel & Rogers (2004)	1990-2002/3	EIU	18 cities (11 EMU, 7 outside)	139	Non-Eurozone mimics Eurozone and increase in dispersion larger.	Price dispersion falls during 1990s but little after 1999. After 1998 dispersion for tradables increases.
Crucini et al (2001)	1975, 1980, 1985 and 1990	Eurostat	EU countries (Belgium as numeraire)	3,545 goods and services		Deviations from PPP, except for poor countries, not large. Brand and country effects distinguished.
Crucini & Shintani (2002)	1990-2000	EIU	122 cities in 78 countries	270 goods	US variance of prices 5.5% traded 27.8% non-traded.	European integration demonstrated little price convergence

Table 2: A Survey of Empirical Evidence on Purchasing Power Parity and the Law of One Price.

Table 2: Continued

Author(s) and Date	Time Period	Data Source	Countries/Cities	Product(s)	Results	Specific EU Results
Haffner (1999)	1985-1999 (at five points)	OECD	OECD	200 categories of goods	For OECD prices converged continuously except 1990-93.	EU group prices more similar, half convergence between 1996 and 1999. Non-DN zone faster convergence (catch-up?).
Sosvilla-Rivero & Gil-Pareja (2004)	1975-1995	Eurostat	12 EU countries	26 product categories		Convergence for tradables half life of 9.5 years. Faster convergence for those in ERM than out.
Gajewski & Kowalski (2004)	1970-2002	OECD	13 EU countries	Goods not specified		Price convergence confirmed; half life of 23.5 years.
Isgut (2004)	1990-2001 especially 2001	EIU	122 cities in OECD	140 goods and services		Same currency reduces log of price differences across cities 2-3%, for EU group 5%. Dollar peg or hard peg same effect.
Parsley & Wie (2001)	1990-2000	EIU	83 cities	95 goods		Hard peg or common currency lowers price dispersion by 4.38%. Euro result smaller equal to tariff reduction of 4%.
Mathä (2003)	2001-2002 (four points)	Authors own	City of Luxembourg and contiguous regions in four countries	92 products from 6 super-markets		Monetary union shows price convergence. If distance rises 1% then prices rise 0.025%. Distances smaller in EMU than US so room for optimism.
Haskel & Wolf (2001)	1995-1998	IKEA	25 Countries	119	Convergence found. Time series showed mean reversion.	
Goldberg & Verboven (2004)	1970-2000	Authors' own	Belgium, France, Germany, Italy and UK	150 vehicle makes		Convergence of prices 1990-92 but divergence thereafter, particularly UK and Italy. Half life of 1.3 years (absolute version 8.3 years).
Lutz (2000)	1993-1998	EU Commission	12 countries	90 cars		Price differentials affected by language, common border and low trade barriers. Belgian/ Luxembourg currency union 4% lower price differential.

Table 2: Continued

Author(s) and Date	Time Period	Data Source	Countries/Cities	Product(s)	Results	Specific EU Results
Lutz (2003)	1987-2001 1995-2001 1995-2001 1970-2000	Economist, Economist, EU Comm., UBS	11 countries 20 countries 12 countries 19 cities	1 Big Mac 1 *The Economist* 17 cars 13 categories		Only Economist magazine showed price convergence. Euro did not speed convergence either.
Baye et al (2003)	October 2001-May 2002	Kelkoo internet prices	7 countries of which 4 in Eurozone	28 products	Price dispersion in EU slightly lower than for comparable goods in US.	End of period eurozone prices 10% higher than non-eurozone.
Imbs et al (2004)	1999-2002	GfK (French Survey Company)	15 EU plus Poland, Hungary and Czech Republic	3 categories of TV sets		Price dispersion lower in EMU but most of this achieved before 1999. Regions more integrated than countries.
Friberg & Mathä (2004)	October 2001-April 2003	Authors' own	Contiguous Regions to Luxembourgin 4 Countries	92 supermarket products		Psychological prices showed greater convergence after EMU.
Maier & Cavelaars (2004)	Regional 1991-2002 Annual 1995-1997	German Federal Statistical Office	50 East and 50 West German Cities	CPI Components		5.5 years after re-unification price convergence came to a standstill.
Horvath & Vidovic (2002)	1997-2001	Slovak Statistics Office	38 Slovak Districts	500 goods and services		Price convergence but at slower rate than in US. Less pronounced difference between tradables and non-tradables. Half-life of 5.2 months non-perishables.

Product Group: basic heading	Category	Product Group: basic heading	Category
Rice	T	Cookers, hobs and ovens	T
Flour and other cereals	T	Air conditioners, humidifiers and heaters	T
Bread	T	Other major household appliances	T
Other bakery products	T	Small electric household appliances	T
Pasta products	T	Repair of household appliances	NT
Other cereal products	T	Glassware and ceramic ware for households, offices and decoration	T
Beef	T	Cutlery, flatware and silverware	T
Veal	T	Non-electric kitchen utensils and household articles	T
Pork	T	Major tools and equipment	T
Lamb, mutton and goat	T	Small electric accessories	T
Poultry	T	Hand tools, garden tools and other miscellaneous accessories	T
Other meats and edible offal	T	Household cleaning supplies	T
Delicatessen and other meat preparations	T	Other non-durable household articles	T
Fresh or chilled fish and seafood	T	Domestic services	NT
Frozen fish and seafood	T	Laundry and dry-cleaning	NT
Preserved or processed fish and seafood	T	Other household services	NT
Fresh milk	T	Pharmaceutical products	T
Preserved milk	T	Other medical products	T
Other milk products	T	Eye-glasses and contact lenses	T
Cheese	T	Other therapeutic appliances and equipment	T
Eggs and egg-based products	T	H - Compensation of employees: physicians	NT
Butter	T	H - Compensation of employees: nurses and other medical staff	NT
Margarine	T	H - Compensation of employees: non-medical staff	NT
Other edible oils and fats	T	Motor cars with diesel engine	T
Fresh or chilled fruit	T	Motor cars with petrol engine of cubic capacity of less than 1200cc	T
Dried fruit and nuts	T	Motor cars with petrol engine of cubic capacity of 1200cc to 1699cc	T
Frozen fruit, preserved fruit and fruit-based products	T	Motor cars with petrol engine of cubic capacity of 1700cc to 2999cc	T
Fresh or chilled vegetables other than potatoes	T	Motor cars with petrol engine of cubic capacity of 3000cc and over	T
Fresh or chilled potatoes	T	Motor cycles	T
Frozen vegetables	T	Bicycles	T
Dried vegetables	T	Spare parts and accessories for personal transport equipment	T
Preserved or processed vegetables and vegetable-based products	T	Fuels and lubricants for personal transport equipment	T
Sugar	T	Maintenance and repair of personal transport equipment	NT
Jams, marmalades and honey	T	Other services in respect of personal transport equipment	NT
Confectionery, chocolate and other cocoa preparations	T	Local passenger transport by railway	NT
Edible ice, ice cream and sorbet	T	Long-distance passenger transport by railway	NT
Food products n.e.c.	T	Local passenger transport by bus	NT
Coffee	T	Local passenger transport by taxi	NT
Tea and other infusions	T	Long-distance passenger transport by road	NT
Cocoa, excluding cocoa preparations	T	Passenger transport by air	NT
Mineral waters	T	Passenger transport by sea and inland waterway	NT

Table 3: Product groups divided into tradables (T) and non-tradables (NT).
Source: Eurostat

Table 3: Continued

Product Group: basic heading	Category	Product Group: basic heading	Category
Soft drinks and concentrates	T	Other purchased transport services	NT
Fruit and vegetable juices	T	Postal services	NT
Spirits	T	Telephone and telefax equipment	T
Wine, cider and perry	T	Telephone and telefax services	NT
Fortified and sparkling wine	T	Television sets and video recorders	T
Beer	T	Radios, CD-players and other electro-acoustic devices	T
Cigarettes	T	Photographic and cinematographic equipment and optical instruments	T
Other tobacco products	T	Information processing equipment	T
Clothing materials	T	Pre-recorded recording media	T
Men's clothing	T	Unrecorded recording media	T
Women's clothing	T	Repair of audio-visual, photographic and information processing equip	NT
Children's clothing	T	Major durables for outdoor recreation	T
Infant's clothing	T	Musical instruments and major durables for indoor recreation	T
Other articles of clothing and clothing accessories	T	Maintenance and repair of other major durables for recreation and cultu	NT
Cleaning, repair and hire of clothing	NT	Games, toys and hobbies	T
Men's footwear	T	Equipment for sport, camping and open-air recreation	T
Women's footwear	T	Gardens, plants and flowers	T
Children's and infant's footwear	T	Pets and related products	T
Repair and hire of footwear	NT	Veterinary and other services for pets	NT
Actual rentals paid by tenants living in apartments	NT	Recreational and sporting services	NT
Actual rentals paid by tenants living in one-family houses	NT	Photographic services	NT
Imputed rentals of owner-occupiers living in apartments	NT	Other cultural services	NT
Imputed rentals of owner-occupiers living in one-family houses	NT	Books	NT
Materials for the maintenance and repair of the dwelling	T	Newspapers and periodicals	NT
Services for the maintenance and repair of the dwelling	NT	Miscellaneous printed matter	T
Water supply	NT	Stationery and drawing materials	T
Electricity	NT	Restaurant services whatever the type of establishment	NT
Town gas and natural gas	NT	Pubs, bars, cafés, tea rooms and the like	NT
Liquefied hydrocarbons	T	Other catering services	NT
Liquid fuels	T	Canteens	NT
Solid fuels	T	Hotels, boarding houses and the like	NT
Kitchen furniture	T	Other accomodation services	NT
Bedroom furniture	T	Services of hairdressers and the like for men	NT
Living-room and dining-room furniture	T	Services of hairdressers and the like for women	NT
Other furniture and furnishings	T	Electric appliances for personal care	T
Carpets and other floor coverings	T	Other appliances, articles and products for personal care	T
Repair of furniture, furnishings and floor coverings	NT	Jewellery, clocks and watches	T
Household textiles	T	Travel goods and other carriers of personal effects	T
Refrigerators, freezers and fridge-freezers	T	Other personal effects n.e.c.	T
Washing-machines, dryers and dishwashers	T		

Table 4: Selected product groups

Food: Perishable	
Bread	Fresh milk
Other bakery products	Preserved milk
Pasta products	Other milk products
Other cereal products	Cheese
Beef	Eggs and egg-based products
Veal	Butter
Pork	Margarine
Lamb, mutton and goat	Other edible oils and fats
Poultry	Fresh or chilled fruit
Other meats and edible offal	Fresh or chilled vegetables other than potatoes
Delicatessen and other meat preparations	Fresh or chilled potatoes
Fresh or chilled fish and seafood	Frozen vegetables
Frozen fish and seafood	Preserved or processed vegetables and vegetable-based products
Preserved or processed fish and seafood	Edible ice, ice cream and sorbet
Food: Non-perishable	
Flour and other cereals	Coffee
Dried fruit and nuts	Tea and other infusions
Frozen fruit, preserved fruit and fruit-based products	Cocoa, excluding cocoa preparations
Dried vegetables	Mineral waters
Sugar	Soft drinks and concentrates
Jams, marmalades and honey	Fruit and vegetable juices
Confectionery, chocolate and other cocoa preparations	
Alchohol and Tobacco	
Spirits	Beer
Wine, cider and perry	Cigarettes
Fortified and sparkling wine	Other tobacco products
Electrical Appliances	
Refrigerators, freezers and fridge-freezers	Small electric accessories
Washing-machines, dryers and dishwashers	Telephone and telefax equipment
Cookers, hobs and ovens	Television sets and video recorders
Air conditioners, humidifiers and heaters	Radios, CD-players and other electro-acoustic devices
Other major household appliances	Photographic and cinematographic equipment and optical instruments
Small electric household appliances	Information processing equipment
Major tools and equipment	Electric appliances for personal care

Table 5: Regression results

Treatment group	**EMU**		**DM Zone: (A+B+G+L+N)**	**EMU less DM Zone**	**G+N**	**EMU less G+N**
Control group	**Non- EMU**		**Non- EMU**	**Non- EMU**	**Non- EMU**	**Non- EMU**
Equation	**1**	**2**	**3**	**4**	**5**	**6**
EMU [#]	-0.101	-0.101	-0.139	-0.106	-0.154	-0.103
	(3.60)**	(4.92)**	(10.19)**	(3.62)**	(8.98)**	(4.62)**
post1999	-0.004	-0.004	0.006	-0.012	0.002	-0.005
	(0.27)	(0.38)	(0.55)	(1.28)	(0.20)	(0.49)
EMU*post1999	-0.005	-0.005	-0.002	-0.006	-0.011	-0.003
	(0.32)	(0.41)	(0.14)	(0.41)	(0.75)	(0.23)
τ	-0.035	-0.035	-0.034	-0.039	-0.03	-0.036
	(6.04)**	(7.81)**	(8.08)**	(8.10)**	(8.80)**	(8.05)**
τ***EMU**	0.03	0.03	0.029	0.033	0.029	0.031
	(3.38)**	(5.15)**	(7.90)**	(4.59)**	(6.46)**	(5.09)**
τ***post1999**	0.05	0.05	0.043	0.06	0.036	0.052
	(4.07)**	(6.08)**	(6.34)**	(6.40)**	(5.70)**	(6.33)**
τ***EMU*post1999**	-0.04	-0.04	-0.036	-0.048	-0.031	-0.042
	(2.80)**	(4.30)**	(5.43)**	(4.31)**	(3.91)**	(4.47)**
Std Dev Real GDP growth rate	1.316	1.316	0.29	2.325	0.361	1.466
	(2.01)*	(3.85)**	(2.02)*	(3.91)**	(1.20)	(4.04)**
Std Dev CP Index growth rate	1.629	1.629	1.171	2.557	0.13	1.812
	(1.28)	(1.94)	(1.53)	(2.85)**	(0.28)	(2.20)*
Std Dev real exchange rate	-0.009	-0.009	-0.007	-0.012	-0.004	-0.009
	(0.39)	(0.86)	(0.70)	(1.18)	(0.38)	(0.93)
Constant	0.271	0.271	0.284	0.264	0.299	0.271
	(8.68)**	(22.99)**	(25.01)**	(21.71)**	(27.31)**	(22.91)**
Product fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.52	0.52	0.5	0.52	0.5	0.52
Observations	1840	1840	1840	1840	1840	1840
Estimation	Robust	Robust, premitting clustering by product groups				

Notes: Robust t statistics in parentheses; * significant at 5%; ** significant at 1%

[#] The EMU dummy denotes dummy of the treatment group; ie the DM zone comprising Austria, Belgium, Germany, Luxembourg and the Netherlands in equation 3, and relative to this grouping the remaining EMU countries in equation 4; Germany and the Netherlands in equation 5 and relative to this grouping, remaining EMU in equation 6

Table 6: Regression results: Non-linearity in convergence

Treatment group	**EMU**	**DM Zone: (G+A+B+N+L)**	**EMU less DM Zone**	**G+N**	**EMU less G+N**
Control group	**Non- EMU**	**Non- EMU**	**Non- EMU**	**Non- EMU**	**Non- EMU**
Equation	**1**	**2**	**3**	**4**	**5**
EMU [#]	-0.109	-0.144	-0.107	-0.176	-0.114
	(3.87)**	(9.65)**	(3.68)**	(8.23)**	(5.24)**
post1999	-0.002	0.008	-0.011	0.001	-0.002
	(0.14)	(0.70)	(1.19)	(0.11)	(0.22)
EMU*post1999	-0.007	-0.003	-0.005	-0.014	-0.005
	(0.40)	(0.24)	(0.38)	(0.97)	(0.40)
τ	-0.037	-0.036	-0.038	-0.033	-0.039
	(6.17)**	(7.90)**	(7.30)**	(8.22)**	(8.57)**
τ***EMU**	0.033	0.031	0.034	0.035	0.034
	(3.61)**	(7.54)**	(4.54)**	(6.40)**	(5.71)**
τ***post1999**	0.052	0.046	0.058	0.04	0.055
	(4.18)**	(6.53)**	(5.96)**	(5.96)**	(6.77)**
τ***EMU*post1999*Q1**	-0.056	-0.049	-0.067	-0.05	-0.061
	(3.89)**	(7.03)**	(6.04)**	(5.88)**	(6.73)**
τ***EMU*post1999*Q2**	-0.05	-0.045	-0.053	-0.044	-0.053
	(3.49)**	(6.70)**	(4.84)**	(5.11)**	(5.73)**
τ***EMU*post1999*Q3**	-0.04	-0.039	-0.046	-0.035	-0.044
	(2.76)**	(5.61)**	(4.35)**	(4.07)**	(4.82)**
τ***EMU*post1999*Q4**	-0.024	-0.02	-0.024	-0.015	-0.024
	(1.65)	(2.83)**	(1.85)	(1.50)	(2.42)*
Std Dev Real GDP growth rate	1.247	0.26	2.204	0.585	1.4
	(1.99)*	(1.92)	(3.69)**	(1.45)	(4.08)**
Std Dev CP Index growth rate	1.547	1.241	2.267	0.005	1.788
	(1.22)	(1.66)	(2.41)*	(0.01)	(2.18)*
Std Dev real exchange rate	-0.009	-0.008	-0.011	-0.005	-0.01
	(0.41)	(0.79)	(1.10)	(0.46)	(1.02)
Constant	0.284	0.296	0.271	0.303	0.287
	(9.19)**	(22.97)**	(19.61)**	(22.50)**	(21.73)**
Product fixed effects	Yes	Yes	Yes	Yes	Yes
R-squared	0.55	0.52	0.56	0.52	0.56
Observations	1786	1791	1767	1738	1795

Notes: Robust t statistics in parentheses; * significant at 5%; ** significant at 1%

[#] See Table 1 for intrepreation of the EMU dummy

All equations have been estimated with robust variance estimator, allowing for clustering by product group

Table 7: Regression results: Selected product groups

	Perishable Food	Non-Perishable food	Alchohol and Tobacco	Electrical appliances
Equation	**1**	**3**	**5**	7
EMU	-0.053	-0.158	0.106	-0.218
	(1.51)	(2.28)*	(2.28)+	(5.40)**
post1999	-0.013	0.006	0.007	0.012
	(0.83)	(0.20)	(0.21)	(0.52)
EMU*post1999	0	-0.038	-0.074	0.01
	(0.01)	(0.77)	(1.56)	(0.41)
τ	-0.02	-0.038	-0.011	-0.064
	(3.26)**	(3.52)**	(0.87)	(5.33)**
τ***EMU**	0.012	0.043	0.01	0.056
	(1.28)	(2.55)*	(0.79)	(3.59)**
τ***POST1999**	0.014	0.037	0.022	0.085
	(1.18)	(3.32)**	(1.43)	(2.52)*
τ***EMU*POST1999**	0.001	-0.031	0.004	-0.081
	(0.08)	(1.91)+	(0.18)	(2.19)*
Std Dev Real GDP growth rate	0.442	1.963	2.096	2.934
	(0.76)	(1.85)+	(1.16)	(4.01)**
Std Dev CP Index growth rate	-1.207	2.034	1.644	3.719
	(0.72)	(0.62)	(0.45)	(1.56)
Std Dev real exchange rate	0.006	0.018	-0.019	0.035
	(0.60)	(1.13)	(0.78)	(0.81)
Constant	0.289	0.21	0.268	0.322
	(11.71)**	(6.46)**	(3.69)*	(19.34)**
Product fixed effects	Yes	Yes	Yes	Yes
R-squared	0.4	0.53	0.67	0.48
Observations	448	224	96	224
Notes: Robust t statistics in parentheses; + significant at 10%; * significant at 5%; ** significant at 1%				
In all equations, the treatment group is EMU and the control group comprises the Non-EMU countries				
All equations have been estimated with robust variance estimator, and allowing for auto-correlation within product group				

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