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Does One Currency Mean One Price?

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Abstract

European Monetary Union was expected to have many consequences for the economies of participant countries. Theory suggested that through a higher volume of trade and stronger competition in the Eurozone, a single currency would lead to a reduction in price dispersion. As far as prices are concerned, two effects were expected: an immediate effect due to the technical characteristics of the changeover process, and a long-term one leading to price convergence. Both Euro effects are evaluated using difference-in-difference (DD) methodology. DD estimation is commonly used in the evaluation of the effects of policy programmes. Applied to the issue of introducing a single currency, the Euro effects identified are the estimated differences in price changes, price dispersion and convergence rates pre- and post-Euro between two groups of countries: Euro and non-Euro.

Keywords

price convergence, EMU, changeover effects

JEL classification: E31, F36, F41

DOES ONE CURRENCY MEAN ONE PRICE?

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1 Introduction:

In 2002 after more than ten years of preparation[1], twelve European countries gave up their national currencies on behalf of the Euro. The theoretical bases of the single currency came from the sixties and originated in the ideas of Robert Mundell, Ronald McKinon and Kenen. These authors started the studies on the optimal currency area, and especially on the relationship between its size, the potential gains connected with the reduction in transaction costs, and the losses from asymmetric shocks. They recommended creating a union of regions that had already achieved a high degree of integration to eliminate the drawbacks of losing an exchange rate mechanism. The subject again became of interest in the nineties because of the aspiration of the member states to establish European Monetary Union (EMU), which was reaffirmed in the Treaty of Maastricht (1998).

Just before the final stage of the creation of EMU an intensive discussion about the effects of introducing a single currency arose. Views were highly divided, from highly sceptical ones arguing that the Euro would impose large costs upon its member countries without providing substantial economic benefits, e.g. Feldstein (1997), to optimistic ones such as Rose's gravital model, which showed that a common currency increases trade between a pair of countries threefold. The discussion not only concerned the effect of increasing trade between countries of common currency but also touched on the problem of price levels and price convergence.

The effect of EMU on prices shows in two dimensions: a short-term changeover effect, and a potential drop in price dispersion called the long-term dynamic effect[2]. The short-term effect is connected with the cost of changeover itself and the preparation of new notes and coins. Consumers were especially afraid of this, arguing that retailers would probably use the introduction of the common currency to raise prices. However, official statistics did not confirm these threats. The data we posses – the individual prices of almost 150 products – allow us to re-examine the potential changeover effect on price levels.

The other effect, that a single currency would narrow price dispersion in Europe, was for the first time shown in a 1990 publication titled One Market One Money[3]. The European Commission argued that only EMU could lower the degree of price dispersion among member

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[1] The first decisions about the establishment of European Monetary Union were taken in 1989-1990

[2] HM Treasury (2003), Prices and EMU, p. 7

[3] European Commission (1990) One market, one money: an evaluation of the potential benefits and costs of forming an economic and monetary union, European Economy, no. 44.

countries by removing transaction costs and exchange rate risks, and through higher price transparency.

This paper examines price differentials in the EU, and answers the question whether EMU has lowered the degree of price dispersion in the Eurozone and increased the speed of price convergence. The analysis of price convergence is based on the concept of sigma and beta convergence (this approach was originally applied to the dispersion of income (Barro and Sala-i-Martin 1992)). Sigma convergence occurs when the dispersion of prices declines over time. The most widely used measure of sigma convergence is standard deviation and so the name comes from its mathematical denotation (σ sigma). Beta convergence occurs when economies with an initially lower level of a given variable (price levels) grow faster than economies with a higher level. A common identical point can be reached (absolute beta convergence) or alternatively economies approach each other without reaching the identical point (conditional beta convergence). Both Euro effects, of the changeover and the decrease in price dispersion across countries, are evaluated using difference-in-difference (DD) methodology. This approach makes it possible to compare price changes, price dispersion and convergence patterns pre- and post-Euro adoption in Eurozone countries with non-euro countries. The treatment considered here is thus "introducing the Euro". The treatment group are countries that became members of EMU in 1999 or in 2002. The DD approach controls for constant differences in the countries in the treatment and control group. The estimations are robust whether Greece is included in the treatment group or is excluded from the analysis because of its Euro adoption in 2001. Sweden, Denmark and England constitute the control group. For completeness we distinguish between two phases of Euro adoption: from 1999 – non cash circulation; and from 2002 – after the introduction of Euro coins and notes.

The paper is organised in the following way. In section 2 we present the Law of One Price (LOOP) and its limitations. Section 3 examines the potential role of the Euro on price levels and on price dispersion. The theoretical part is complemented with the latest empirical studies. Following this, Section 4 describes our data. We utilise highly disaggregated data on the actual prices of almost 150 individual products over the period 1990-2005. Next, an overview of price dispersion is presented. Finally, the estimation of the single currency effects on price dispersion, speed of convergence and price changes is performed in section 6. This is followed by the conclusion.

2 The Law of One Price and its limitations

The Law of One Price (LOOP) states that when there are no impediments to international trade and no transport costs, prices of the same product should be equal when converted to a common currency regardless of the location. If an homogenous good has different prices in two locations it would be profitable to buy it where it is cheaper, and after transportation to sell it on the more expensive market. In consequence, there is a flow of products from cheaper regions to more expensive ones and the process will continue until the price is equalized on both markets, and there is no further motivation for arbitrage transactions. The LOOP applies to only one good, but it can be derived intuitively that if it holds for different goods, it should be true for the whole aggregate of goods. In this way the Purchasing Power Parity (PPP) hypothesis was derived. Both LOOP and the ensuing PPP only hold in strict circumstances. These are: perfect competition, no transport costs, and no trade barriers. Naturally, all of these are violated in the real world. All the costs that have to be undergone by someone who wants to sell the same good in different geographical markets will be called arbitrage costs (AC). They are the sum of transport costs,

information costs (due to different languages, different legislation etc.), trade restriction costs, exchange rate costs, and others. The arbitrage process is only profitable when prices differ between countries and this difference is greater than the arbitrage costs. Taking into account the arbitrage costs we can redefine the LOOP: *The price difference of the same product sold at two locations should not exceed the arbitrage costs*.

$$P^m{}_A - P^m{}_B \times E_{A/B} \leq AC\,, \tag{1}$$

where $P^m{}_A$ is the price of the good *m* sold in country *A* in currency *A*, $P^m{}_B$ is the price of the same good *m* sold in country *B* in currency *B*, and $E_{A/B}$ is the exchange rate between country *A* and *B*. On the other hand, there are also factors that in theory should speed spatial price convergence. The basic one is market integration. As far as the European Union is concerned, the removal of trade barriers and the realization of the four freedoms (the freedom of movement of goods, labour, capital and services) should cause more competition between firms, better allocation of capital, and higher production efficiency, leading prices to converge at a level "*better argumented in view of economic and technical efficiency*."[4] In the next section an overview of the potential impact on price levels and price dispersion of introducing a common currency will be provided.

3 The role of the Euro on price levels and price dispersion - theory and literature

3.1 The role of the Euro on price dispersion

Before the introduction of the Euro, the hypothesis that a single currency would have the effect of narrowing price dispersion in Europe was voiced mainly by European policy makers. The European Commission produced a number of publications in which the importance of EMU as a necessary complement to the single market, in view of price convergence, was stressed. In the report from 1990 "One Market One Money" the European Commission argued that only EMU could lower the degree of price dispersion among member countries. The Euro was expected to decrease price dispersion through three channels: by removing transaction costs, removing exchange rate risks, and by introducing higher price transparency. The EU Commission's studies claimed that the reduction in transaction costs should bring savings of 0.4% of GDP, and for countries with advanced banking systems of 0.1%. The elimination of exchange rate risk would reduce the cost of doing business across countries. Consumers' ability to compare prices directly due to price transparency was expected to lead them to buy in the places where the goods were the cheapest. All of these actions should in theory boost trade activity and competition, putting pressure on prices to converge.

The role of price transparency is underlined by the following market information model (Ulph and Vaughan 1999):

$$\frac{p_m - cm}{p_m} = \frac{1 + (p_m - c_m)\beta_m}{\alpha_m \eta_{mm}}\,, \tag{2}$$

where: p_m is the price of good *m*, c_m the marginal cost of production, η_{mm} the firm's perceived elasticity of demand, α_m the consumer transparency effect, and β_m the producer transparency

[4] Price competition and price convergence, The single Market Review Series, June 1996.

effect. The model takes into account three channels through which the role of price transparency can influence market equilibrium: consumer transparency, producer transparency and number of suppliers. An increase in the transparency of prices for consumers reduces the price-cost margin (higher α_m). The motivation to buy goods where they are the cheapest is justified for durable goods such as cars, and in situations where transport costs are low compared to the value of the goods. In contrast, this is not the case for basic goods, non-tradable services and perishable goods. But higher price transparency has an impact on suppliers as well (β_m). Easier monitoring of competitors' prices can lead to collusion, or the establishment of new techniques for price segmentation, for example not issuing a common European price list or allowing terms and conditions to vary from country to country. An increase in competition through a greater number of suppliers reduces the price-cost margin. In imperfectly competitive markets, a reduction in price-cost margins should lead to a reduction in profits and prices, but exchange rate costs are mostly barriers to small and medium-sized enterprises trading rather than to large firms, becoming less important as transaction value rises. There is a consensus that price convergence is strengthened by big retailers rather than by small ones. Additionally, EMU by itself cannot reduce other barriers to trade such as transport costs, yet these can be of greater importance to price convergence than a common currency. Table 1 presents the traditional view of the impact of a single currency on the price-cost margin and price dispersion.

Table 1. The effect of introducing the Euro on the price-cost margin and price dispersion

Direct effect	Consequence	Price-cost margin	Price dispersion
Reduced cost of transactions	Increased market access Switch from segmented to integrated markets	↓	↓
Reduced consumer search costs	Producers less able to segment	↓	↓
Reduced consumer price uncertainty	Producers less able to segment	↓	↓
Reduced risk	Greater incentives for arbitrage	↓	↓
Increased transparency	More arbitrage Consumers better informed More information on competitors	↓ ↓ ↑	↓ ↓ ↑

Source: European Economy; European integration and the functioning of product markets, European Commission Special Report No2/2002, p. 50.

Greater price transparency arising from EMU may lead to a greater possibility for arbitrage, with an impact both on consumers and producers. The latter can react with collusive behaviour, market segmentation and product differentiation. The net effect on prices and price dispersion could thus be ambiguous. Another issue is when EMU effects on prices and price convergence should materialize. If we stress the nature and intensity of competitive interaction on the supply side, then the Euro effect should be expected from 1999 when the Euro went into non-

cash circulation. Otherwise, it may only emerge after the introduction of Euro notes and coins in 2002.

A review of the latest studies on price convergence due to EMU does not show a clear picture. Lutz's (2003) and Engel and Rogers' (2004) studies discount the impact of EMU on price convergence. Lutz applies difference-in-difference (DD) methodology to four sets of data: Big Macs, The Economist, different models of cars, and 13 categories of goods collected by UBS. His results refute a Euro effect. Engel and Rogers (2004) in their econometric analysis of city price data, come to the same conclusion. On the other hand, Isgut (2002), using the same data sources as Engel, finds a significant reduction in price dispersion resulting from the introduction of the common currency - 5%. Allington et al. (2004) summarize the first eleven studies dedicated to the Euro effect on price dispersion. Two of them found a positive effect – a drop in price dispersion due to the introduction a single currency, five a mixed Euro effect – price dispersion is lower in EMU countries, but most of the convergence had occurred before 1999, and four found either no effect or a negative one. In their own analysis, Allington et al. examined aggregated data on 115 categories of goods (with prices expressed in comparative price level indices, as opposed to retail prices) and concluded that the Euro has a robust integrating effect, but the results are no longer significant when non-tradable goods are also considered. Goldberg and Verboven (2004), analyzing the European car market, concluded that as a result of monetary union, price dispersion decreased by a small but significant percentage (about 1.5%) between 1999 and 2001. But the further decrease following the official adoption in 2002 cannot be attributed to the Euro, because an even faster drop in price differentials in non-EMU countries was observed. Additionally, they did not find that EMU increased the speed of convergence. Parsley and Wei (2007) found no evidence for a significant improvement in price dispersion of the ten goods that they studied, and also the persistence of deviation from the LOOP after the introduction of the Euro. This is despite the fact that the same authors in their previous work (Parsley and Wei (2001)) had argued that adopting a hard peg (a currency board or currency union) has a stronger effect than merely reducing exchange rate volatility to zero. They do, however, underline the fact that long-term currency unions exhibit greater integration than more recent ones. The volatility of bilateral exchange rates had commonly been used as a factor to explain the magnitude of LOOP deviation, or else identified as the cause of persistence in deviation. This is why a single currency, reducing the nominal exchange variability to zero, is the natural successor to currency pegging. Surprisingly, Anderson and Smith (2004) and Wolszczak (2008) conclude that the effects of a common currency are related solely to the reduction in exchange rate variability, and if this is controlled for, the Euro effect is not significant.

3.2 The role of the Euro on price levels – the changeover effect

According to model (2), the greater competition resulting from the introduction of a single currency should cause a decrease in price-cost margins and prices. These structural adjustments can take time. In the short term, there are no economic reasons why the changeover effect should cause a price rise (Dziuda and Mastrobuoni (2006)). However, consumers from the Eurozone were very critical about the changeover process. They had the impression that conversion to the Euro was used by retailers to increase prices. According to a Commission survey, almost 70% of consumers claimed that prices had been generally rounded up in all areas, and an additional 15% claimed that they had been rounded up in certain areas (Eurobarometer 2002).

In Germany the new currency was dubbed the teuro (the German word *teuer* means expensive), while in Greece and in Italy consumers' organizations called for a shopping boycott. However, retailers took a different view. 61% of managers said that the new prices in euros were identical to the previous ones in the national currency (Flash EFS 2002). They argued that if there was a price rise, it resulted from the technical effects of the changeover process that may have been passed on to the consumer in the form of one-off price increases. The following reasons are suggested:

- "menu and implementation costs" of adapting price tags, cash registers, software, payment systems, bar codes, accounting systems etc.;
- the adaptation of vending machines, for example parking fees that prior to the Euro had equalled 0.42 Euro would probably be rounded up to 0.5 Euro;
- the effect of converting prices to Euros and rounding to two decimal places, e.g. a price of 0.008875 Euro would be automatically rounded up to 0.01 Euro, which in fact means a price rise of 13% from the original price;
- psychological prices – the tendency to set prices in more attractive rounded figures e.g. 4.99 Euro instead of 4.65 Euro.

The last three of these reasons depend on countries' conversion rates, and in theory could act in both ways: increasing or decreasing the original price. Official statistics do not show price rises due to the introduction of the Euro, at least at an aggregate level. The Eurozone HICP (Harmonised Indices of Consumer Prices) for December 2001 was 2.0%, while in January 2002 it rose to 2.7%. However, after a maximum in January it began to fall, and in June 2002 it had the same value as in January. Moreover the month-on-month change in HICP from December 2001 to January 2002 was 0.5%, and Eurostat estimates that at most 0.16 inflation rate points can be accounted for by the introduction of Euro notes and coins. The remaining 0.34 inflation rate points of the change in the index are the result of poor weather conditions causing increases in vegetable prices, and some tax increases, especially on tobacco. Similar estimates come from national statistics offices, which estimate euro effects ranging from 0.2% in France to 0.6% in the Netherlands on national HICPs (ECB 2002).

The disparity between consumer feelings about price rises and statistics is usually explained by the disparity between perceived and actual inflation. Perceived inflation is an evaluation of price development based on individual experience. Consumers draw conclusions about prices from the limited number of goods and services which they purchase most often e.g. the espresso syndrome in Italy. However, it turns out that the impact of the price changes of these limited numbers of goods and services on the aggregate price level is not high, in fact, a breakdown of the HICP into detailed components for January 2002 shows unusual price increases mainly for services such as restaurants and cafes, repair services, and some health-related services, but their impact on the all-item index is of minor importance. Nevertheless, high perceived inflation can itself be a source of official inflation e.g. due to pressure to increase wages. Dziuda and Mastrobuoni (2006) suggest a decrease in price transparency (see equation 3) as a potential source of euro-induced inflation. Consumers have the additional cost of processing information connected to price conversion from the old to the new currency. The complexity of conversion rates hinders price comparison, and this is exploited by retailers. Dziuda and Mastrobuoni show that euro-related inflation decreases as price transparency increases and is a decreasing function of the initial price. They found that countries where consumers had more problems in adapting to the new currency (France, Spain, Italy) had higher inflation for cheap

goods An imperfect information model was also used by Ehrmann (2006) to explain a price rise for food items. He concludes that of three countries, Belgium, Greece and Luxembourg, euro-induced inflation was lowest for the one with the least complicated conversion rate. Angelini and Lippi (2005), analyzing cash withdrawals from automatic teller machine (ATM) terminals in Italy pre- and post-changeover did not find any evidence for consumer prices increasing more than was stated by official sources. Some interesting tests for a money illusion were conducted on the basis of charity and church donations, which increased unusually after the introduction of Euro coins and notes (Cannon and Cipriani (2003) and Kooreman et al. (2004)). Paul De Grauwe (2007) acknowledges substantial price rises for food products (in Italy up to 30%) and explains them through the collective action of suppliers. A price rise by an individual supplier acting in the highly competitive food market with low price elasticity is unreasonable, while collective action by a number of suppliers is usually costly and not possible. The changeover was an opportunity for such coordinated action. However, Gaiotti and Lippi (2004) examined data from 2,500 restaurants in Italy over 1998-2004 and showed that a price increase of only about 3-4 percentage points could be attributed to the new currency. Parsley and Wei (2007), comparing changes in EMU and non-EMU prices of the Big Mac and its ten ingredients did not find an association between price rises after 2002 and the adoption of the Euro.

The data we posses allow us to re-examine the potential changeover effect on price levels. Because of the rich diversity of the goods in our basket, we are able to analyse not only food items but clothes, household supplies, cars, and finally services.

4 Data

The data used in this study comes from the Economist Intelligence Unit (EIU). The dataset is composed of the actual prices of 173 products in 122 cities in 78 countries. To our knowledge this is the most extensive database of international retail prices. Primarily the data were collected for use as information for multinational corporations which move employees around the world. The product list consists of tightly specified items such as “bread'”, “coca-cola”, and a variety of services such as “laundry one shirt'”, “cost of developing 36 colour pictures'” etc. The prices are expressed in Euros with purchasing power parity exchange rates used in calculations, using the pre-1999 ECU exchange rate. In the original database the survey prices are listed for three types of store: supermarkets, medium-price retailers and expensive specialist shops. We only utilise the prices for supermarkets, which provide items of standard quality and are likely to be more comparable across international cities. We restrict the sample to the 15 capital cities of the EU. In the case of missing observations, the CPI was used to provide an extrapolation. Some items were excluded from the data as ``difficult to be compared across cities", for example a taxi ride from the airport to the city centre. After these exclusions and adjustments, the final sample of goods was reduced to 144 products (for the product list, see Table 8 and Table 9 in the Appendix). The goods are divided into traded (106 items) and non-traded ones (38 items). The distinction between traded and non-traded goods is a common sense one and it is a compromise between theory, the practice of international trade, and data availability. The division is not based on any universally accepted formal method, such as calculating the tradability of a good as the ratio of the total trade among the countries in a particular industry divided by the total output of the industry across the same countries. The same classification is used as in Engel and Rogers (2004). It should be pointed out that there is no purely traded or non-traded item because each one is a composition of tradable and non-tradable

inputs, for example for bread to be produced involves the services of baking and selling; and laundry cannot be provided without washing powder. Moreover, the traded goods are grouped into 8 categories following the EIU categorisation: food perishable (33 items), food non-perishable (15 items), alcoholic beverages and tobacco (13 items), clothing and footwear (16 items), household supplies (6 items), personal care (8 items), recreation (6 items), cars and petrol (8 items). The EIU dataset does have some shortcomings, however (see Engel and Rogers (2004)). The most important ones are as follows:

- the data are collected from a small number of outlets compared with surveys conducted by national statistical agencies;
- the data comes only from big agglomerations, which are not representative of whole countries;
- it is not clear whether the EIU methodology adequately accounts for package differences and quality differences;
- the product list does not represent a whole consumption basket.

On the other hand, Rogers (2007) presents extensive evidence for the reliability of the EIU data. He shows a high correlation between EIU price changes and official annual CPI inflation, and also between PPP rates calculated on the basis of EIU data and the PPPs reported by the OECD.

5. Price dispersion in the EU - first impression

Since we are in possession of a rich set of data on actual prices, we are able to investigate the validity of the Law of One Price for a particular year. To assess the deviation from the LOOP our basic measure of price dispersion is the standard deviation of prices (expressed in logs) for each item across cities:

$$\sigma_t^m = \sqrt{\frac{\sum_{i=1}^{N}(\ln p^m{}_{it} - \frac{1}{N}\sum_{i=1}^{N} \ln p_{it}{}^m)^2}{(N-1)}}.$$

This measures the deviation of the price of good *m* from its geometric average price across all cities, where N is the number of cities. To provide a first impression of the price dispersion in the data, Table 2 presents the goods and services with the highest and lowest price dispersion in 2005, measured as a coefficient of variation.

Table 2 Price dispersion across goods in 2005

Lowest price dispersion	C.V	Highest price dispersion	C.V
International weekly news magazine (Time)	6.1	Hourly rate for domestic cleaning help	63.4
Lipstick (deluxe type)	12.4	Telephone, charge per local call (3 mins)	61.5
International foreign daily newspaper	12.9	Lemons (1 kg) (supermarket)	58.9
Regular unleaded petrol (1 l)	13.5	Frying pan (Teflon or good equivalent)	58.1
Compact disc album	14.1	Dry cleaning, woman's dress	54.4
Simple meal for one person	14.6	Taxi rate per additional kilometre (average)	54.2
Toothpaste with fluoride (120 g)	14.9	Furnished residential apartment: 2 bedroom	53.7
Television, colour (66 cm)	15.9	Pork: loin (1 kg)	53.3
Business trip, typical daily cost	17.9	Unfurnished residential apartment: 4 rooms	52.9
Boy's dress trousers (chain store)	18.2	Annual premium for car insurance (low)	49.3

The maximum price difference is observed for "hourly rate for domestic cleaning help", reaching 63% with the enormous value of 37 Euros in Stockholm and only 5 Euros in Lisbon. The lowest coefficient of variation - 6.1% - is for international weekly news magazines such as Time. Not surprisingly, eight of the ten goods with the lowest price dispersion are tradable, while seven of the ten with the highest dispersion are non-tradable. When we look more closely at each individual good, we note that in the EU15 105 out of 144 goods underwent price convergence (a drop in standard deviation) during the fifteen years studied, 99 in the EU12, and 76 in the EU3. To assess the extent to which there was price convergence across EU countries we calculated the unweighted cross-country standard deviation. In our opinion, although weight deviation might be preferred because larger member states have a more significant impact on price convergence than smaller ones due to their bigger share of transactions within the EU, it cannot be accepted because it reshapes the price dispersion. Another question is what should be used as weights. A first proposition is GDP per capita, but for example prices in Luxembourg, which has extremely high GDP, do not have any extreme influence on prices in the overall Union market. Other weighting choices could be population, or openness of the economy, but each of them can be criticized using similar arguments. We check the sigma convergence hypothesis by testing whether the variance of prices (expressed in logs) across countries decreases over time. The null hypothesis of no convergence is equivalent to $H_0 : \sigma^2{}_{m,1} = \sigma^2{}_{m,t}$, where $\sigma^2{}_{m,t}$ is the variance of the log price of a product *m* at time *t*. ($p^m{}_{it} = \ln(P_{it}^m)$). We test the hypothesis using the Likelihood Ratio Test (T_2) proposed by Carre and Klomb (1997) with the following testing statistic:

$$T_2 = (N - 2.5)\ln\left[1 + \frac{1}{4}\frac{(\hat{\sigma}^2{}_1 - \hat{\sigma}^2{}_T)^2}{\hat{\sigma}^2{}_1\hat{\sigma}^2{}_T - \hat{\sigma}^2{}_{1T}}\right],$$

with $\hat{\sigma}_{1T}$ the covariance of prices in the first and last period. This statistic has a limiting $\chi^2(1)$-distribution. Carre and Klomb proved in their simulation experiment that the T_2 statistic performs better than the traditional Lichtenberg (1994) test of the ratio between the variances in the first period and the last period. The procedure proposed by Lichtenberg leads to a low probability of accepting the hypothesis of convergence (because of a high probability of committing a type II error, especially for short time periods and a small sample)[5]. We computed T_2 statistics for each of the items in our sample, and the hypothesis of convergence was confirmed for only 25 out of 105. We also performed the analysis for the same period of time, but separately for the sub-groups of 12 member states and 3 non-Euro countries. For EMU cities, 23 goods underwent statistically significant sigma convergence, and for non-EMU only 11. We are especially interested in potential changes in price dispersion over time. We investigate whether the prices for individual items in our sample show convergence trends. To save space we report here only the results for average dispersion and for the 8 sub-groups. Figure 1 plots average price dispersion (mean standard deviation) for each year between 1990 and 2005. In calculating the

[5] In the literature we find more statistics concerning sigma convergence such as: $T_3 = \frac{\sqrt{N}(\hat{\sigma}^2{}_1/\hat{\sigma}^2{}_T - 1)}{2\sqrt{1-\hat{\pi}^2}}$ where π is estimated from equation: $p_{iT} = \pi p_{i1} + \mu_i$, which has asymptotically a standard normal distribution. Another procedure is to regress the yearly variance of the log prices against a trend and intercept.

mean standard deviation we do not use any weights for different products, our measure is just a simple arithmetic mean. There are three lines representing EU15, EU12 and EU3. Prices are less dispersed in the Euozone than in the full sample of 15 European countries, although the tendency is constant from the early 1990s onwards, so monetary union does not seem to explain the lower price dispersion. Over the whole period, price convergence results in a fall in the deviation by 15.5% for EU15, and 17% both for EU12 and EU3. Figures 2 and 3 present analogous calculations for tradable and non-tradable goods separately. Some differences emerge according to category of goods and country, for example for the whole period of time and for each country group price dispersion is always largest for non-tradable goods, but then the percentage decrease in dispersion was most pronounced for these products for EU15 and EU12, while for non-EMU countries the drop was only 10%.

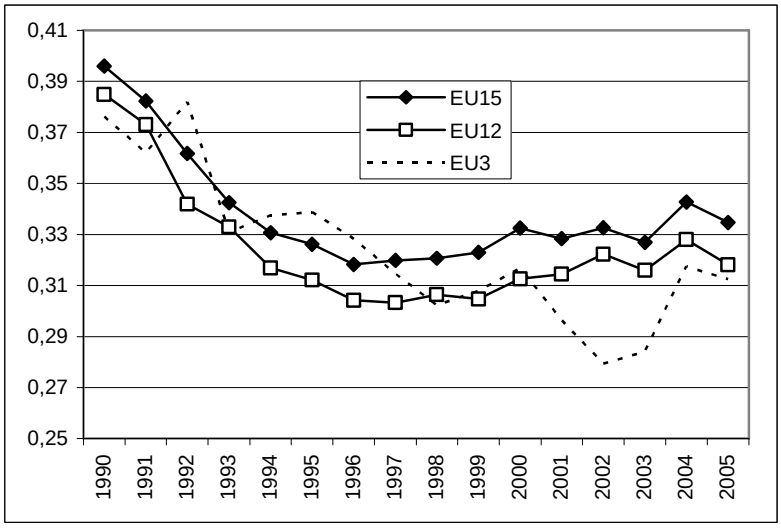

Fig 1. Price dispersion 1990-2005 for all products - EU15, EU12 and EU3

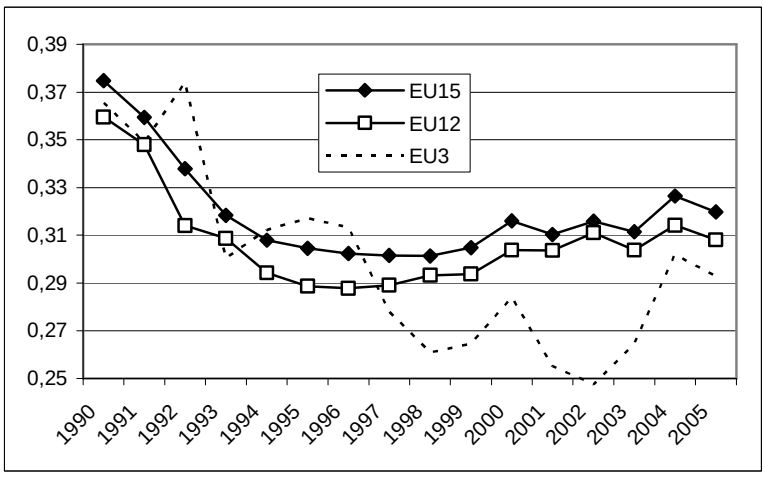

Fig 2. Price dispersion 1990-2005 for tradable products - EU15, EU12 and EU3

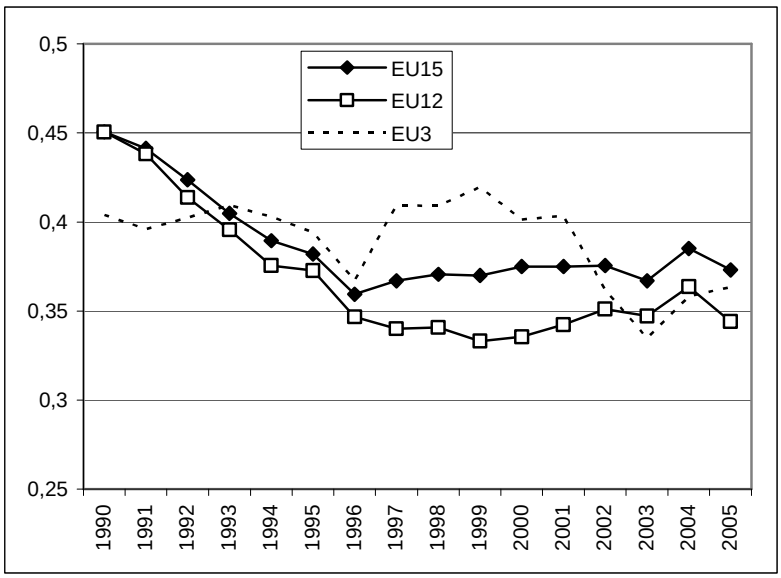

Fig 3. Price dispersion 1990-2005 for non-tradable products - EU15, EU12 and EU3

Most price dispersion occurred at the beginning of the 1990s. Figures 4, 5 and 6 show the changes for three sub-periods: 1990-1995, 1995-2000 and 2000-2005. In the charts the negative bars indicate a decline in average dispersion. Dispersion across each country group and each goods category declined over the earlier period. In the 1995-2000 sub-period, average dispersion decreased in non-EMU cities for all products and tradables, and in the Eurozone for non-tradables. After 2000 a drop in price dispersion was observed only for non-tradable goods in non-EMU and EU15 countries. In the Appendix, Figures 7, 8 and 9 present the changes in price dispersion for 8 categories of tradable goods. The general conclusion is the same: most of the decline in price dispersion across EU12 occurred in the early nineties. Dispersion increased for four out of the eight categories for EMU countries, and five for non-EMU in 2000-2005.

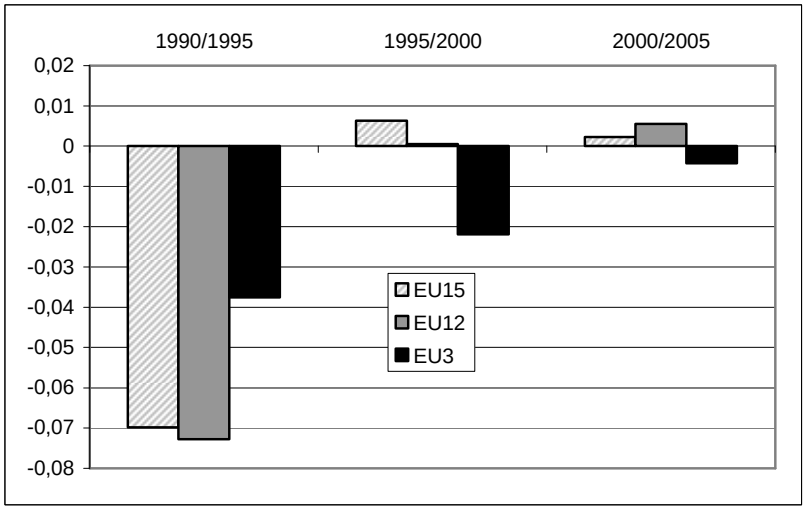

Fig 4. Price dispersion for sub-periods, all products, EU15, EU12 and EU3

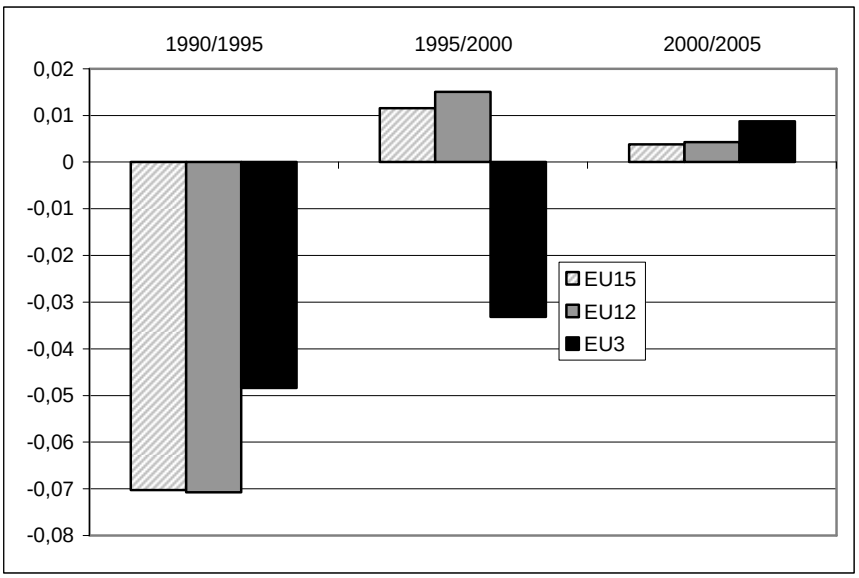

Fig 5. Price dispersion for sub-periods, tradable products, EU15, EU12 and EU3

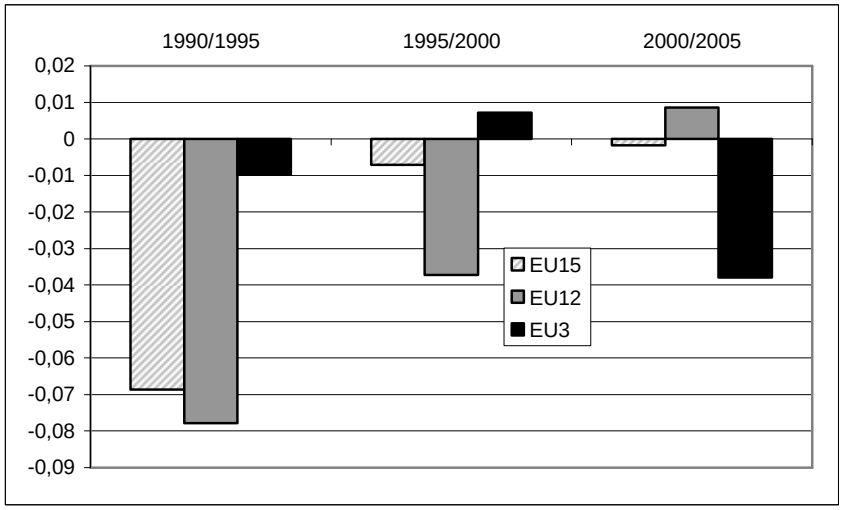

Fig 6. Price dispersion for sub-periods, non-tradable products, EU15, EU12 and EU3

In the next sections we undertake a number of further empirical analyses to explain the behaviour of price dispersion after the introduction of the Euro.

6 Evaluation of the Euro effect

The difference-in-difference method is commonly used to evaluate the effect of political or economic programmes. The basis of the DD approach is a comparison between the performance of the treatment group in the pre- and post-treatment period with the performance of a control group pre- and post-treatment. Applied to the issue of the Euro effect, this approach suggests comparing the characteristic of price patterns among Euro countries pre- and post-Euro introduction with the pattern of non-Euro countries pre- and post-introduction. The treatment is here understood as “introducing the Euro”.

The DD estimator combines a before-after approach with a cross-section approach. It compares price changes, price dispersion, or speed of convergence in the Euro area before ($X_{T'}^{euro}$) and after the Euro (X_{T}^{euro}) with the analogous price characteristics in the control group (non-Euro) before ($X_{T'}^{non-euro}$) and after the adoption of the single currency ($X_{T}^{non-euro}$).

$$EUR = \left(X_T^{euro} - X_{T'}^{euro}\right) - \left(X_T^{non-euro} - X_{T'}^{non-euro}\right) \tag{3}$$

The necessary condition is that there are no other factors than the Euro impacting differently on the two groups, or that these factors are controlled for. The constant different size of the Eurozone and non-EMU groups is captured by the DD estimator.

6.1 Price dispersion

The DD approach (3) can be written as linear regression:

$$\sigma_{it}^{m} = \alpha_0 + \alpha_1 D_t + \alpha_2 D^j + \alpha_3 D_t^j + \varepsilon_{it}^{m}, \tag{4}$$

where σ_{it}^{m} is price dispersion, and D_t, D^j and D_t^j are dummy variables: D^j equals one for the treatment group ($j = euro$) and zero for the non-treatment group ($j = non-euro$). Variable $D_t = 1$ for the treatment period $i = T$ (after 1999 or after 2002). Finally, D_t^j equals one when simultaneously $j = euro$ and $t > 1999$, otherwise it is zero. We assume that the residual ε_{it}^{m} has the expected properties.

The coefficients of equation (4) represent the following: α_1 measures factors that are stable over time e.g.: differences in distance and language; α_2 measures the effects of factors that influence both groups in the same manner after the Euro was introduced e.g. lower transport costs. The Euro effect is captured by α_3. However, α_3 only identifies the Euro effect as long as other factors that act differently on both groups have been taken into consideration. Equation (4) is enriched by variables that act differently on both groups and that are not stable over time. Following Lutz (2003) and Allington et al (2004), these variables are: the standard deviation of inflation rates (which indicates differences in the scope of local-currency pricing across groups, and the degree of similarity in monetary conditions), and the standard deviation of output growth rates (indicating the correlation of business cycles). A third proposed variable, the standard deviation of the growth rate of the nominal dollar exchange rate, is not included because of its high correlation with the EMU variable. To equation (4) the time trend is added. The final equation has the form:

$$\begin{aligned} \sigma_{ij,t}^{m} &= \alpha_0 + \alpha_1 EMU + \alpha_2 post99 + \alpha_3 EMUpost99 + \beta_0 t + \\ &+ \beta_1 tpost99 + \beta_2 tEMU + \beta_3 tEMUpost99 + \sum_{k=1}^{K} \beta_k Z_{kit}^{m} + \varepsilon_{it}^{m} \end{aligned} \tag{5}$$

The Euro effect is captured by α_3 and β_3. Negative α_3 captures a downward shift in the level of price dispersion in the Eurozone compared to non-Eurozone due to the introduction of the common currency. A negative value of β_3 indicates a change in the price dispersion trend

towards stronger convergence. The data for the additional variables Z^{m}_{kit} come from the IMF's International Financial Statistics database. The inflation rate is based on the CPI percentage change over the corresponding period, and the output growth rate is taken from Eurostat. The model is estimated using the Huber-White sandwich estimator, with product-fixed effects. The results for all goods, tradable and non-tradable, are presented in Table 3. Except for the additional variables (standard deviation of inflation and output growth rates) all the coefficients are highly significant.

Table 3. Difference-in-difference estimates of a Euro effect on price dispersion (equation 7)

	All products	Tradable	Non-tradable
EMU	-0.0039 (2.20E-14)	-0.028 (6.65E-15)	0.059 (1.43E-14)
*post*99	-0.0039 (2.79E-14)	-0.015 (2.42E-15)	0.026 (1.15E-14)
*EMUpost*99	0.0207 (4.98E-14)	0.037 (5.06E-15)	-0.021 (1.26E-14)
t	-0.0090 (2.75E-15)	-0.012 (5.44E-16)	-0.0004 (2.27E-15)
*tpost*99	0.0091 (1.22E-15)	0.017 (5.61E-16)	-0.011 (1.60E-15)
tEMU	-0.0014 (6.19E-15)	0.003 (1.14E-15)	-0.014 (2.76E-15)
*tEMUpost*99	0.0038 (5.47E-15)	-0.006 (4.17E-16)	0.029 (2.28E-15)
Product Fixed Effects	Yes	Yes	Yes
R-squared	0.41	0.39	38
Observations	4704	3393	1312

Robust standard errors in parenthesis

Pooling all goods together, both *EMUpost*99 and *tEMUpost*99 are positive, meaning that price dispersion increased in EMU countries after 1999 in relation to non-EMU. The *EMUpost*99 coefficient is negative for non-traded goods, and for two out of eight categories of traded products (Table 4), but for the same goods categories *tEMUpost*99 is positive. It can be concluded that although for non-traded goods a downward shift in price dispersion in EMU cities relative to non-EMU is detected, the opposite trend effect will cease Euro effect in a long-run. For most categories of tradable goods (5 out of 8) the situation is the opposite: an upward shift is accompanied by a negative trend effect. The results also confirm the suggestions from the previous section: price dispersion of traded goods is higher in non-EMU countries; most of the decline in dispersion occurred at the beginning of the 1990s, with a positive trend after 1999. The estimations are robust for the second phase of the Euro starting in 2002 and for the treatment group EU11 without Greece (which become a member of EMU in 2001) and also for the shorter period 1995-2005 excluding Austria, Finland and Sweden, which had not been EU members before then. The estimations have also been performed for each individual good[6]. Only for 14 of the products are both of the Euro-related coefficients of interest negative, and among these there is just one non-tradable product.

[6] Results available from the author on request

Table 4. Difference-in-difference estimates of a Euro effect on price dispersion for eight categories of tradable goods.

	Food perishable	Food non-perishable	Alcoholic bevgs and tobacco	Clothing and footwear	Household supplies	Personal care	Recreation	Cars and petrol
EMU	-0.026 (2.70E-14)	-0.112 (1.02E-14)	0.121 (2.72E-15)	-0.043 (2.63E-16)	-0.091 (5.09E-16)	-0.022 (2.68E-16)	-0.028 (6.01E-16)	-0.070 (3.00E-15)
*post*99	-0.028 (8.16E-15)	-0.020 (5.30E-15)	0.056 (1.95E-15)	-0.035 (1.81E-16)	-0.013 (1.17E-15)	0.015 (2.02E-16)	-0.010 (1.98E-16)	-0.055 (8.56E-16)
*EMUpost*99	0.057 (2.25E-14)	0.054 (7.88E-15)	-0.036 (1.74E-15)	0.039 (3.92E-16)	0.025 (1.24E-15)	0.000 (2.02E-16)	0.027 (8.87E-17)	0.083 (1.50E-15)
t	-0.009 (2.23E-15)	-0.020 (1.42E-15)	-0.016 (3.73E-16)	-0.023 (2..40E-17)	-0.016 (1.03E-16)	-0.010 (4.79E-17)	-0.006 (2.83E-17)	0.005 (3.37E-16)
*tpost*99	0.008 (2.13E-15)	0.033 (1.56E-15)	0.015 (2.45E-16)	0.035 (4.47E-18)	0.032 (6.97E-17)	0.001 (4.40E-17)	0.008 (1.48E-17)	0.009 (4.22E-16)
tEMU	0.006 (5.27E-15)	0.009 (1.94E-15)	0.000 (4.00E-16)	0.001 (6.29E-17)	0.012 (1.05E-16)	0.007 (5.15E-17)	0.004 (8.32E-17)	-0.011 (4.06E-16)
*tEMUpost*99	-0.005 (4.90E-15)	-0.023 (2.01E-15)	0.001 (3.11E-16)	0.006 (4.08E-17)	-0.032 (9.42E-17)	0.004 (5.58E-17)	-0.010 (1.05E-16)	-0.010 (5.52E-16)
Product Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.34	0.4	0.48	0.37	0.48	0.46	0.32	0.74
Observations	1056	416	416	512	192	256	192	288

Robust standard errors in parenthesis

6.2 Speed of price convergence

In this section we analyse the concept of beta convergence, which measures the persistence of deviation from the LOOP. The question we want to address is whether the introduction of the Euro increased the speed with which deviations in price differentials are eliminated. We define bilateral relative prices by computing them as price differences expressed in logs:

$$q_{ij,t}^{m} = \ln P_{i,t}^{m} - \ln P_{j,t}^{m}, \tag{6}$$

$P_{i,,t}^{m}$ is the price of product *m* in country *i* at time *t*, and $P_{j,t}^{m}$ the price of product *m* in country *j* at time *t*.

All prices are in logs, so their difference provides an approximation of percentage price differentials. The measure is computed for all possible pairs of cities in relation to Germany. The choice of base country is explained by its size and importance as a trading partner. If a country has a lower price for a given good than Germany, then the price differential for this country is negative. The distributions of price differences with the densities estimated using Gaussian Kernal are reported in the Appendix. Figure 10 shows two lines plotting the distribution for tradable and non-tradable goods, pooling all locations and all years. The lower the price difference, the closer the distribution's mass is to zero. A greater dispersion of prices for non-tradable goods is confirmed. Figure 11 compares distribution between 1990 and 2005. Surprisingly, price dispersion is quite stable, with only slight movement. Finally, Figure 12 presents the distribution of prices in EMU and non-EMU countries. Here again the change in the distribution is not very significant. Non-EMU countries have a larger proportion of price differentials situated on the right, meaning higher prices in relation to Germany. The basic equation is in the form:

$$\Delta q^{m}{}_{ij,t} = \alpha^{m}{}_{ij} + \beta q^{m}{}_{ji,t-1} + \varepsilon^{m}{}_{ji,t}, \tag{7}$$

where $\Delta q^{m}{}_{ij}$ is the first differential of the price difference defined in equation (6). The estimated coefficient on the lagged price differential is the indicator of the convergence process. The half-life of price shocks indicates the number of periods needed to halve the distance from the mean: $t^{*} = \frac{\ln 0.5}{\ln(1+\beta)}$. When a country-pair/product-specific effect ($\alpha^{m}{}_{ij}$) equals zero the absolute LOOP is tested for. We are going to test an alternative assumption, with the individual effects corresponding to the conditional version of LOOP. Because of the limited number of years in the sample we do not add the lag structure to the specification. The first step in the analysis is to check for unit roots in the panel. LOOP assumes that the price differences across locations must be stationary. The De Blander-Dhaene test is used. It extends the fixed T approach of Harris and Tzavalis (1999) and is based on the bias-corrected LS estimator of the autoregressive parameter. The test was chosen because the data in our panel has a large cross-sectional dimension and a limited time series dimension. Different versions with respect to the form of deterministic components, countries, period and goods cover were tested. Table 10 in the Appendix reports the parameters of unit root tests. The null hypothesis of unit root is rejected in most cases at standard levels of confidence. The exceptions are 4 out of 34 cases, namely for the sub-period starting from 1999 for non-tradable goods for EMU and non-EMU countries, tradables, and all goods for

non-EMU. We start testing equation (7) by estimating the model for each product separately, utilising a systemGMM estimator. Among the significant estimations of GMM, the highest half-life, 9.92 years, is for *Martini&Rossi* Vermouth *(1L)*, and the shortest, 1.51 years, for *Lettuce*. The mean half-life of statistically significant parameters is 4.986.[7] The results of the different estimators are reported for all products, tradable and non-tradable, in the Appendix (Table 11). Additionally, the regression is estimated utilising a Fixed Effects, Random Effects and Threshold Autoregressive model (TAR). The TAR model incorporates the non-linear effects due to the existence of arbitrage costs between markets (see section 2 for a discussion of AC). The idea is that price differentials have different dynamics according to whether they are inside or outside the threshold band. We rewrite equation (7) to form the simple TAR model:

$$\Delta q^{m}_{ij,t} \begin{cases} \alpha^{m}_{ij} + \beta_{out}(q^{m}_{ij,t-1} - c) + \varepsilon^{m}_{ji,t} & q^{m}_{ij,t-1} > c \\ \alpha^{m}_{ij} + \beta_{in} q^{m}_{ij,t-1} + \varepsilon^{m}_{ji,t} & if \quad -c \le q^{m}_{ij,t-1} \le c \\ \alpha^{m}_{ij} + \beta_{out}(q^{m}_{ij,t-1} + c) + \varepsilon^{m}_{ji,t} & q^{m}_{ij,t-1} < -c \end{cases} \tag{8}$$

We assume symmetric thresholds with a convergence parameter (β_{out}) outside the band. Inside the band $[-c;c]$, where the benefits of arbitrage are lower than the transaction costs (c), the convergence speed is zero $(\beta_{in} = 0)$. Estimation of the TAR model is via sequential conditional least squares[8]. The thresholds (c) are identified via a grid search with the minimum residual sum of squares as selection criterion. The estimated thresholds are 10,6% for all goods, 10% for tradables, and 12,5% for non-tradables. The results for half-lives are 3.4 (GMM) or 4.7 (TAR) years for tradable goods, and 12.75 (GMM) or 7.5 (TAR) for non-tradables. For all goods the value is 4.1 (GMM), 4.7 (TAR).

We now turn to the difference-in-difference approach and modify the regression (8) to quantify the euro effect:

$$\begin{aligned} \Delta q^{m}_{ij,t} = \alpha^{m}_{ij} + \beta_1 q^{m}_{ji,t-1} EMUpost98 + \beta_2 q^{m}_{ij,t-1} EMUpre99 + \\ \beta_3 q^{m}_{ij,t-1} nonEMUpost98 + \beta_4 q^{m}_{ij,t-1} nonEMUpre99 + \varepsilon^{m}_{ji,t} \end{aligned} \tag{9}$$

We can directly compare four different convergence parameters: *EMUpost98* -EMU countries subsequent to the introduction to the Euro; *EMUpre99* -EMU countries prior to the Euro; $non-EMUpost98$ - non-EMU countries subsequent to the introduction of the Euro; and $non-EMUpre99$ - non-EMU countries prior to the Euro (Table 5). The last row of Table 5 presents the statistic $DIFF = (\beta_1 - \beta_2) - (\beta_3 - \beta_4)$, which tests the hypothesis that Eurozone convergence increased more than in non-EMU countries after the introduction of the Euro. We perform bootstrap estimates of DIFF statistics. Bootstrap standard errors are presented in parenthesis.

There is no evidence for rejecting the null hypothesis of no difference between coefficients in any of the product categories. The speed of convergence, both for EMU and non-EMU countries, was greater in the period before the adoption of the single currency, and EMU countries converge faster than non-EMU before the Euro.

[7] Detailed results available from author on request.

[8] We thank Van Campenhout for delivering STATA codes for TAR model.

Table 5. Difference-in-difference estimates of the Euro effect on the speed of price convergence

	All products		Tradable		Non-tradable	
	β		β		β	
*EMUpost*98	-0.108	(0.004)	-0.123	(0.005)	-0.071	(0.007)
EMUpre99	-0.138	(0.004)	-0.156	(0.005)	-0.099	(0.006)
$non-EMUpost98$	-0.100	(0.007)	-0.131	(0.009)	-0.047	(0.010)
$non-EMUpre99$	-0.115	(0.006)	-0.137	(0.007)	-0.068	(0.009)
DIFF	0.014	(0.014)	0.026	(0.021)	0.007	(0.02)

Standard errors in parenthesis

The results for eight categories of traded goods are presented in Table 12 in the Appendix. The conclusion that there is no Euro effect on the speed of convergence is confirmed.

6.3 Price levels

In this section we examine the potential changeover effect on price levels. Price changes depend on several factors and it would be extremely difficult to control for all of them. We again employ the difference-in-difference approach to eliminate the effects on prices not related to the adoption of the Euro. The general picture is that over the period 1990-2005 a substantial price increase was observed both for EMU and non-EMU countries. The prices of traded goods rose both in the Eurozone and in non-Euro by 25% (good-country average), and the prices of non-tradables by 35% and 45% in the EMU and non-EMU countries respectively. For completeness we distinguish between two phases of euro adoption: from 1999 – in non-cash circulation; from 2002 – after the introduction of euro coins and notes. We analyse both phases. First we regress the percentage price change in relation to 1998: $ln\, p_t - ln\, p_{1998}$ on a Euro dummy and product dummies.

Table 6 Price change in EMU countries in relation to non-EMU, base year 1998

	All goods		Tradable		Non-tradable	
	emu/ non-emu		emu/ non-emu		emu/ non-emu	
1999	-0.034	(0.000)	-0.035	(0.000)	-0.030	(0.004)
2000	-0.069	(0.000)	-0.068	(0.000)	-0.073	(0.000)
2001	-0.038	(0.000)	-0.042	(0.001)	-0.027	(0.203)
2002	-0.043	(0.001)	-0.044	(0.003)	-0.043	(0.001)
2003	-0.038	(0.004)	-0.040	(0.011)	-0.034	(0.170)
2004	-0.030	(0.048)	-0.027	(0.123)	-0.039	(0.206)
2005	-0.031	(0.040)	-0.028	(0.127)	-0.042	(0.141)

p –values in parenthesis

In Table 6 the coefficient on the Euro dummy is presented for seven subsequent post 1998 horizons. All of the coefficients are negative, meaning that the change in prices was negative in the Eurozone in relation to non-EMU countries, but not all the coefficients are significant. If we calculate the price changes in relation to 2001, none of the price changes in the Eurozone versus non-EMU were statistically significant (Table 13 in the Appendix).

For completeness we evaluate the Euro effect for the period after 2001 using a difference-in-difference approach. We rewrite the regression (5), and instead of price dispersion we now have a price change as the dependent variable: $ln\, p_t - ln\, p_{t-1}$. Table 7 presents the results.

Table 7 Difference-in-difference estimation of price changes

	All goods		Tradable		Non-tradable	
	β		β		β	
EMU	0.037	(0.001)	0.041	(0.000)	0.026	(0.479)
*post*01	0.104	(0.238)	0.104	(0.066)	0.102	(0.728)
*EMUpost*01	-0.056	(0.570)	-0.054	(0.399)	-0.062	(0.850)
t	0.004	(0.004)	0.004	(0.000)	0.004	(0.361)
*tpost*01	-0.006	(0.000)	-0.006	(0.000)	-0.005	(0.322)
tEMU	-0.010	(0.094)	-0.010	(0.009)	-0.010	(0.621)
*tEMUpost*01	0.007	(0.287)	0.007	(0.094)	0.007	(0.761)

p –values in parenthesis

None of the Euro coefficients are significant. The same model was estimated taking into account the initial price on the right-hand side, but the results did not change. An additional conclusion is that there is a stronger relation between price change and the initial price for relatively cheaper products. This is in line with the consumer feeling that there was a price rise for cheap goods. The potential Euro effect was estimated for sub-groups and all individual products separately.[9] Again, none of the parameters are statistically significant.

7. Conclusions

At the time before the establishment of European Monetary Union, taking into account only price levels the EU could be considered fifteen different markets with significant price dispersion. EMU was expected to have many consequences for the economies of the participant countries. Theory suggested that through a higher volume of trade, and stronger competition in the Eurozone, a single currency would lead to a reduction in price dispersion. In fact, two price effects were expected to take place: an immediate one due to the technical characteristics of the changeover process and a long-term one leading prices to converge. We have re-examined the potential changeover effect on price levels and found no evidence for any significant price rise due to the adoption of the single currency (at least for the 144 products analysed). If there was a price rise after 2002 it was not connected with the Euro changeover.

To analyse the second potential Euro effect, we have checked whether the magnitude of price dispersion and the speed of price convergence increased in the EMU countries relative to a control group of non-EMU countries. An analysis of 144 products using the DD method gives no

[9] Results available from author upon request

support to the hypothesis of a long term Euro effect. There is no evidence of a positive Euro effect either on price dispersion or on the speed of price convergence.

Our findings support the view that most price convergence occurred in the first half of the 1990s. From 1999 on, a reverse trend of price dispersion for EMU countries is observed, especially in relation to traded goods. At the same time the degree of price dispersion in non-EMU countries has continued to decline. As a result, in 2005 the price dispersion of traded goods was lower in non-EMU than in EMU countries.

As far as the speed of price convergence is concerned, a decrease is observed after the Euro adoption both in EMU and in non-EMU countries.

There are two potential explanations for the lack of a Euro effect lowering price dispersion. The introduction of the Euro was preceded by years of preparation, together with the harmonization of monetary policy, and so a Euro effect on price convergence could have materialised prior to 1999. Alternatively, the Euro *per se* has not been successful in the abatement of other impediments to market integration in the EU.

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APPENDIX

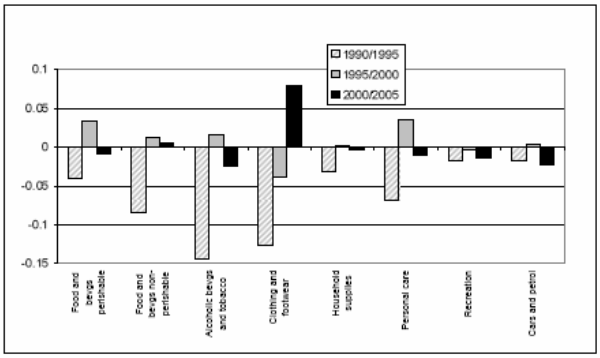

Fig. 7 Change in price dispersion by product categories, EU15

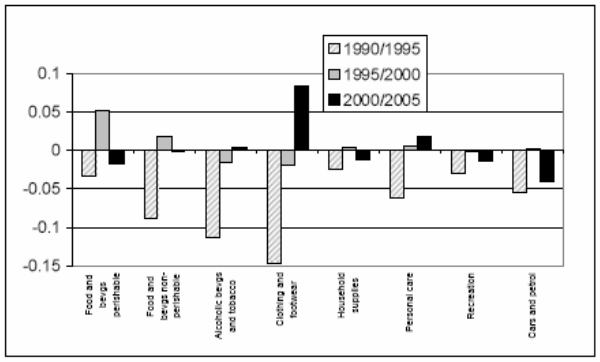

Fig. 8 Change in price dispersion by product categories, EU12

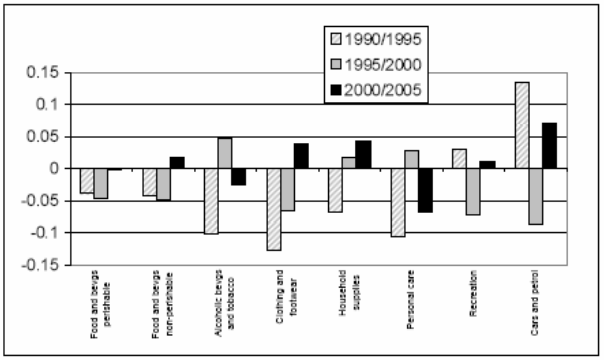

Fig. 9 Change in price dispersion by product categories, EU3

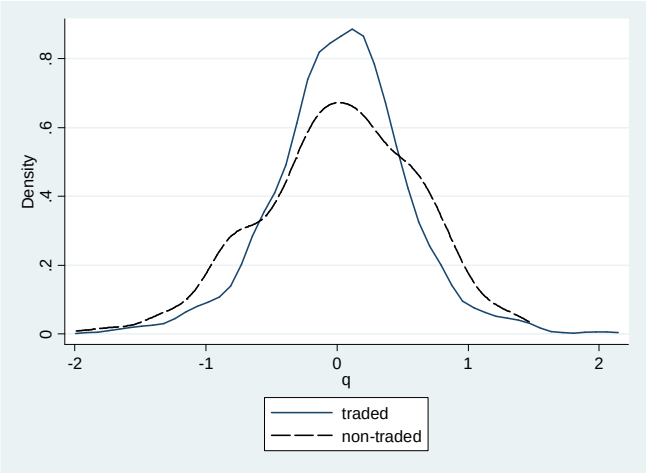

Fig. 10 Distribution of price differences for tradable and non-tradable goods

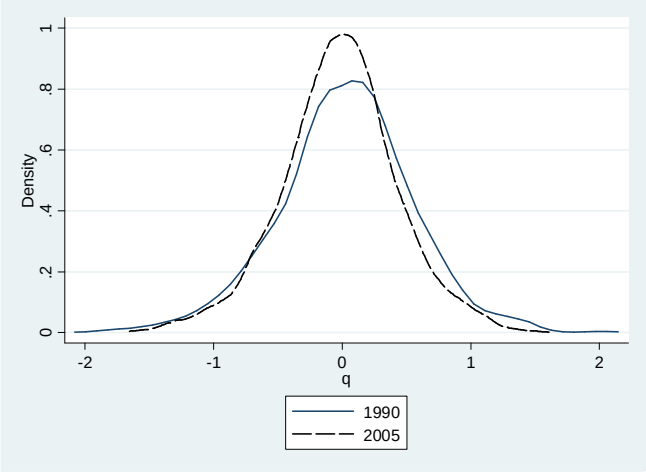

Fig. 11 Distribution of price differences for all goods in 1990 and 2005

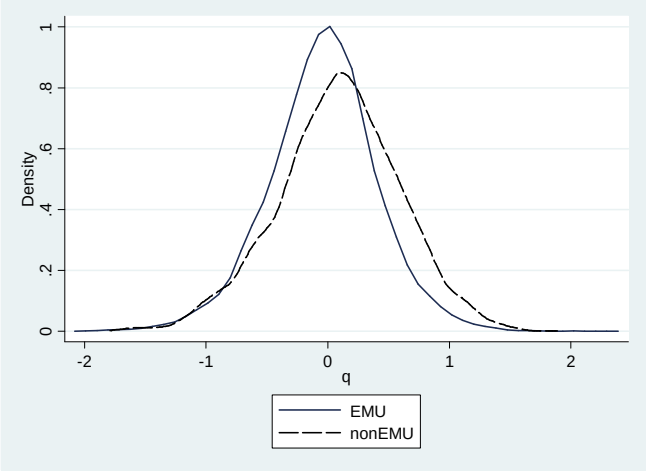

Fig. 12 Distribution of price difference in EMU and non-EMU

Table 8 Product list: Tradable goods

Food and bevgs. , perishable (33)		39	Sliced pineapples, canned (500 g) (supermarket)	77	Boy's dress trousers (chain store)
1	White bread, 1 kg (supermarket)	40	Frozen fish fingers (1 kg) (supermarket)	**Household supplies (6)**	
2	Butter, 500 g (supermarket)	41	Instant coffee (125 g) (supermarket)	78	Laundry detergent (3 l) (supermarket)
3	Margarine, 500g (supermarket)	42	Ground coffee (500 g) (supermarket)	79	Dishwashing liquid (750 ml) (supermarket)
4	Spaghetti (1 kg) (supermarket)	43	Tea bags (25 bags) (supermarket)	80	Light bulbs (two, 60 watts) (supermarket)
5	Flour, white (1 kg) (supermarket)	44	Cocoa (250 g) (supermarket)	81	Batteries (two, size D/LR20) (supermarket)
6	Sugar, white (1 kg) (supermarket)	45	Drinking chocolate (500 g) (supermarket)	82	Frying pan (Teflon or good equivalent) (supermarket)
7	Cheese, imported (500 g) (supermarket)	46	Coca-Cola (1 l) (supermarket)	83	Electric toaster (for two slices) (supermarket)
8	Cornflakes (375 g) (supermarket)	47	Tonic water (200 ml) (supermarket)	**Personal care (8)**	
9	Milk, pasteurised (1 l) (supermarket)	48	Mineral water (1 l) (supermarket)	84	Toilet tissue (two rolls) (supermarket)
10	Potatoes (2 kg) (supermarket)	**Alcoholic bevgs. And tobacco (13)**		85	Soap (100 g) (supermarket)
11	Onions (1 kg) (supermarket)	49	Wine, common table (1 l) (supermarket)	86	Aspirins (100 tablets)
12	Mushrooms (1 kg) (supermarket)	50	Wine, superior quality (700 ml)	87	Razor blades (five pieces)
13	Carrots (1 kg) (supermarket)	51	Wine, fine quality (700 ml) (supermarket)	88	Toothpaste with fluoride (120 g) (supermarket)
14	Oranges (1 kg) (supermarket)	52	Beer, local brand (1 l) (supermarket)	89	Facial tissues (box of 100) (supermarket)
15	Apples (1 kg) (supermarket)	53	Beer, top quality (330 ml) (supermarket)	90	Hand lotion (125 ml) (supermarket)
16	Lemons (1 kg) (supermarket)	54	Scotch whisky, six years old (700 ml) (supermarket)	91	Lipstick (deluxe type) (supermarket)
17	Bananas (1 kg) (supermarket)	55	Gin, Gilbey's or equivalent (700 ml) (supermarket)	**Recreation (6)**	
18	Lettuce (one) (supermarket)	56	Vermouth, Martini & Rossi (1 l) (supermarket)	92	Compact disc album (average)
19	Eggs (12) (supermarket)	57	Cognac, French VSOP (700 ml) (supermarket)	93	Television, colour (66 cm) (average)
20	Beef: filet mignon (1 kg) (supermarket)	58	Liqueur, Cointreau (700 ml) (supermarket)	94	Kodak colour film (36 exposures) (average)
21	Beef: steak, entrecote (1 kg) (supermarket)	59	Cigarettes, Marlboro (pack of 20) (supermarket)	95	International foreign daily newspaper (average)
22	Beef: stewing, shoulder (1 kg) (supermarket)	60	Cigarettes, local brand (pack of 20) (supermarket)	96	International weekly news magazine (Time) (average)
23	Beef: roast (1 kg) (supermarket)	61	Pipe tobacco (50g)	97	Paperback novel (at bookstore) (average)
24	Beef: ground or minced (1 kg) (supermarket)	**Clothing and footwear (16)**		**Cars and petrol (9)**	
25	Lamb: chops (1 kg) (supermarket)	62	Business suit, two piece, medium weight (chain store)	98	Low priced car (900-1299 cc) (low)
26	Lamb: Stewing (1 kg) (supermarket)	63	Business shirt, white (chain store)	99	Low priced car (900-1299 cc) (high)
27	Pork: chops (1 kg) (supermarket)	64	Men's shoes, business wear (chain store)	100	Compact car (1300-1799 cc) (low)
28	Pork: loin (1 kg) (supermarket)	65	Men’s raincoat, Burberry type (chain store)	101	Compact car (1300-1799 cc) (high)
29	Ham: whole (1 kg) (supermarket)	66	Socks, wool mixture (chain store)	102	Family car (1800-2499 cc) (low)
30	Bacon (1 kg) (supermarket)	67	Dress, ready to wear, daytime (chain store)	103	Family car (1800-2499 cc) (high)
31	Chicken: fresh (1 kg) (supermarket)	68	Women's shoes, town (chain store)	104	Deluxe car (2500 cc upwards) (low)
32	Fresh fish (1 kg) (supermarket)	69	Women's cardigan sweater (chain store)	105	Deluxe car (2500 cc upwards) (high)
33	Orange juice (1 l) (supermarket)	70	Women's raincoat, Burberry type	106	Regular unleaded petrol (1 l)
Food and bevgs., non-perishable (15)		71	Tights, panty hose (chain store)		
34	White rice, 1 kg (supermarket)	72	Child's jeans (chain store)		
35	Olive oil (1 l) (supermarket)	73	Child's shoes, dresswear (chain store)		
36	Peanut or corn oil (1 l) (supermarket)	74	Child's shoes, sportswear (chain store)		
37	Peas, canned (250 g) (supermarket)	75	Girl's dress (chain store)		
38	Peaches, canned (500 g)	76	Boy's jacket, smart (chain store)		

Source: Economist Intelligence Unit

Table 9 Product list: non-tradable goods

107	Laundry (one shirt) (standard high-street outlet)	126	Furnished residential apartment: 1 bedroom (high)
108	Dry cleaning, man's suit (standard high-street outlet)	127	Furnished residential apartment: 2 bedroom (high)
109	Dry cleaning, woman's dress (standard high-street outlet)	128	Unfurnished residential apartment: 2 bedrooms (moderate)
110	Dry cleaning, trousers (standard high-street outlet)	129	Unfurnished residential apartment: 2 bedrooms (high)
111	Man's haircut (tips included) (average)	130	Unfurnished residential apartment: 3 bedrooms (moderate)
112	Woman's cut & blow dry (tips included) (average)	131	Unfurnished residential apartment: 3 bedrooms (high)
113	Telephone and line, monthly rental (average)	132	Unfurnished residential apartment: 4 bedrooms (moderate)
114	Telephone, local call from home (3 mins) (average)	133	Unfurnished residential house: 3 bedrooms (moderate)
115	Hourly rate for domestic cleaning help (average)	134	Unfurnished residential house: 3 bedrooms (high)
116	Babysitter's rate per hour (average)	135	Unfurnished residential house: 4 bedrooms (moderate)
117	Cost of developing 36 colour pictures (average)	136	Unfurnished residential house: 4 bedrooms (high)
118	Daily local newspaper (average)	137	Business trip, typical daily cost
119	Three course dinner for four people (average)	138	Hilton-type hotel, single room, including breakfast (average)
120	Four best seats at theatre or concert (average)	139	Moderate hotel, single room, including breakfast (average)
121	Four best seats at cinema (average)	140	One drink at bar of first class hotel (average)
122	Cost of a tune up (but no major repairs) (low)	141	Two-course meal for two people (average)
123	Cost of a tune up (but no major repairs) (high)	142	Simple meal for one person (average)
124	Annual premium for car insurance (low)	143	Hire car, weekly rate for lowest price classification (average)
125	Annual premium for car insurance (high)	144	Hire car, weekly rate for moderate price classification (average)

Source: Economist Intelligence Unit

Table 10 Results of the De Blander-Dhaene unit root test*

Countries	Period	Products	0-absolute LOOP 1-relative LOOP	φ		ρ	
ALL	1990-2005	ALL	0	0.9113	(0.0024)	-0.0577	(0.0056)
All	1990-2005	ALL	1	0.8947	(0.0084)	-0.0126	(0.0110)
All	1990-2005	tradable	0	0.8998	(0.0030)	-0.0725	(0.0066)
All	1990-2005	non-tradable	0	0.9384	(0.0036)	0.0123	(0.0110)
All	pre EMU	All	0	0.9011	(0.0031)	-0.0498	(0.0070)
All	pre EMU	All	1	0.8500	(0.0145)	0.0337	(0.0152)
All	pre EMU	tradable	1	0.8306	(0.0170)	0.0215	(0.0164)
All	pre EMU	tradable	0	0.8918	(0.0039)	-0.0688	(0.0081)
All	pre EMU	non-tradable	0	0.9227	(0.0048)	0.0349	(0.0136)
All	pre EMU	non-tradable	1	0.8970	(0.0283)	0.1023	(0.0364)
All	EMU	All	0	0.9180	(0.0046)	-0.0647	(0.0110)
All	EMU	All	1	0.7202	(0.0458)	0.1930	(0.0445)
EMU	1990-2005	ALL	0	0.9106	(0.0027)	-0.0641	(0.0063)
EMU	1990-2005	ALL	1	0.8790	(0.0099)	-0.0143	(0.0128)
EMU	1990-2005	tradable	0	0.9017	(0.0034)	-0.0738	(0.0074)
EMU	1990-2005	tradable	1	0.8495	(0.0110)	-0.0095	(0.0135)
EMU	1990-2005	non-tradable	0	0.9313	(0.0042)	-0.0145	(0.0122)
EMU	1990-2005	non-tradable	1	0.9514	(0.0179)	-0.0068	(0.0357)
EMU	pre EMU	All	0	0.8997	(0.0036)	-0.0621	(0.0078)
EMU	pre EMU	All	1	0.8534	(0.0162)	0.0071	(0.0169)
EMU	EMU	All	0	0.9175	(0.0053)	-0.0617	(0.0124)
EMU	EMU	All	1	0.6740	(0.0525)	0.2451	(0.0534)
EMU	EMU	tradable	0	0.9020	(0.0066)	-0.0560	(0.0145)
EMU	EMU	tradable	1	0.6425	(0.0615)	0.2822	(0.0618)
EMU	EMU	non-tradable	0	0.9566	(0.0078)	-0.0788	(0.0236)
EMU	EMU	non-tradable	1	0.8060*	(0.0868)	0.0813	0.1233)
non-EMU	1990-2005	ALL	0	0.9132	(0.0049)	-0.0358	(0.0124)
non-EMU	1990-2005	ALL	1	0.9362	(0.0155)	-0.0027	(0.0211)
non-EMU	pre EMU	All	0	0.9051	(0.0063)	-0.0070	(0.0156)
non-EMU	pre EMU	All	1	0.8322	(0.0317)	0.1280	(0.0333)
non-EMU	EMU	All	0	0.9190	(0.0095)	-0.0744	(0.0236)
non-EMU	EMU	All	1	0.8487*	(0.0970)	0.0414	(0.0815)
non-EMU	EMU	tradable	0	0.8872	(0.0130)	-0.0832	(0.0280)
non-EMU	EMU	tradable	1	0.8469*	0.1126)	0.0168	(0.0925)
non-EMU	EMU	non-tradable	0	0.9769*	(0.0096)	0.0598	(0.0392)
non-EMU	EMU	non-tradable	1	0.8350*	(0.1603)	0.2337	(0.1562)

* Estimated equation: $q^{m}_{ij,t} = \alpha^{m}_{ij} + \varphi q^{m}_{ji,t-1} + \rho \Delta q^{m}_{ij,t-1} + \varepsilon^{m}_{ji,t}$

Table 11. Half-lives for different product categories (Equations 9 and 10)

	All products					Tradable goods					Non-tradable goods				
	OLS	FE	RE	GMM	TAR	OLS	FE	RE	GMM	TAR	OLS	-0.055	RE	GMM*	TAR
Beta	-0.137	-0.304	-0.096	-0.153	-0.136	-0.159	-0.337	-0.110	-0.183	-0.159	-0.088	0.027	-0.065	-0.055	-0.087
Std. Error	0.004	0.004	0.002	0.017	0.004	0.005	0.005	0.003	0.019	0.005	0.006	12.328	0.003	0.027	0.006
Half-life	4.719	1.916	6.854	4.174	4.738	3.999	1.689	5.936	3.434	4.016	7..540	2.816	10.271	12.251	7..575
Observations	30240	30240	30240	30240		22260	22260	22260	22260		7980	7980	7980	7980	

Note: All computation done using XTABOND2 for StataSE 9.0. Year dummies and individual effects included in all models. * =not significant at 90% confidence level, FE-fixed effect estimator, RE – random effects estimator, GMM – system estimator of General methods of Moments. Results are reported for two-step GMM estimator, TAR - Threshold Autoregressive model (Eq. 10)

Table 12. Euro effect on speed of convergence

	Food and bevgs perishable		Food and bevgs non-perishable		Alcoholic bevgs and tobacco		Clothing and footwear		Household supplies		Personal care		Recreation		Cars and petrol	
*EMUpost*98	-0.151	(0.011)	-0.100	(0.014)	-0.068	(0.012)	-0.129	(0.016)	-0.104	(0.017)	-0.127	(0.019)	-0.095	(0.027)	-0.091	(0.015)
*EMUpre*99	-0.193	(0.010)	-0.138	(0.015)	-0.099	(0.013)	-0.175	(0.014)	-0.105	(0.019)	-0.127	(0.027)	-0.221	(0.029)	-0.142	(0.018)
*nonEMUpost*98	-0.222	(0.024)	-0.072	(0.026)	-0.053	(0.014)	-0.208	(0.048)	-0.140	(0.038)	-0.112	(0.033)	-0.063*	(0.041)	-0.042*	(0.017)
*nonEMUpre*99	-0.209	(0.019)	-0.136	(0.021)	-0.086	(0.016)	-0.116	(0.016)	-0.152	(0.034)	-0.123	(0.031)	-0.169*	(0.042)	-0.055	(0.018)

* = not significant at 90% confidence level

Table 13 Price change in EMU countries in relation to non-EMU, base year: 2001

	All products			Tradable goods			Non-tradable goods		
	Emu/ Non-Emu	Std. Error	p-vale	Emu /Non-Emu	Std. Error	p-vale	Emu/ Non-Emu	Std. Error	p-vale
2002	-0.005	0.007	0.498	-0.001	0.009	0.870	-0.015	0.012	0.207
2003	0.000	0.009	0.991	0.003	0.011	0.808	-0.007	0.014	0.620
2004	0.008	0.012	0.498	0.015	0.015	0.293	-0.012	0.022	0.600
2005	0.007	0.013	0.585	0.015	0.016	0.345	-0.015	0.021	0.477