Euro's price dispersion

SUMMARY

Using a detailed data set of prices of consumer goods in European cities from 1990 to Spring 2003, we investigate the question of whether the introduction of the euro in January 1999 increased integration of consumer markets as reflected by consumer prices. In fact, we find no tendency for prices to converge after January 1999. This finding holds even when we control for a number of factors that might affect price dispersion. On the other hand, we find that there has been a significant reduction in price dispersion throughout the decade of the 1990s, suggesting that efforts to reduce economic barriers initiated early in the decade may have in fact had the effect of significantly increasing the integration of consumer markets.

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European product market integration after the euro

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1. INTRODUCTION

Has the introduction of the euro led to more highly integrated product markets in the Eurozone? The 'Statement by the Chancellor of the Exchequer on UK Membership of the Single Currency' (Chancellor of the Exchequer, 2003) lists the channels through which the euro is expected to increase integration:

> The first benefit is lower transactions costs for business and consumers. We estimate these as worth around 0.1 to 0.2 per cent of GDP . . .
>
> The second is diminished exchange rate volatility, with gains for both large and small companies especially in the manufacturing sector . . .
>
> The third benefit is greater cross-border trade and thus the potential for increased commerce and growth.

An empirical study by Rose (2000) has suggested that membership in a currency union is likely to have a very large positive impact on the volume of trade among

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union members. That study claims to show that 'countries with the same currency trade over three times as much with each other as countries with different currencies!' Rose's dataset predates the formation of the Eurozone, and so it offers no direct evidence on whether the euro currency union has led to more tightly knit markets. However, Micco *et al.* (2003) found that the advent of the euro did increase trade substantially among Eurozone countries (and even between Eurozone and non-Eurozone countries). The size of the effect is much smaller than the Rose study would predict, but still the effect within the first few years of the adoption of the euro was to increase the volume of trade within the Eurozone by 8% to 16%.

Here we examine whether Eurozone consumer product markets have become more integrated, using as a metric the dispersion of prices for consumer goods. One might expect from the evidence on trade volumes that the advent of the euro has led to greater market integration. Wim Duisenberg (2000) stated a conventional view shortly after the introduction of the euro that 'the completion of the internal market and increased cross-border price transparency contribute to eroding the scope for the existence of substantial price differentials for products which are easily tradable across borders.' It is still early days for the euro, but we give a preliminary assessment on whether the currency union has indeed led to more highly integrated product markets.

1.1. Why might a currency zone increase economic integration?

Rose (2000) draws no firm conclusions as to why currency unions might lead to such large increases in the volume of trade. There is a substantial empirical literature that has attempted to measure the effects of exchange-rate volatility on trade, but has reached ambiguous findings. In any event, Rose finds that it is not the reduction of exchange-rate volatility *per se* that leads to the increased volume of trade. While he does find that reducing exchange rate fluctuations by themselves have a modest impact on the volume of trade, it is much smaller than the effects of currency unions. Following the logic of his estimates, reducing the volatility of exchange rates to zero increases trade by only one-tenth of the effect from joining a currency union.

So, one of the effects of the currency union is to reduce exchange rate volatility, and that contributes to increased economic integration, but it apparently is not the only channel through which currency unions may work. The theoretical research on the effects of exchange-rate volatility on trade has pointed to the problems facing firms when there are insufficient instruments available to hedge exchange rate risk. But this consideration is probably not so important for the members of the Eurozone. Before the introduction of the euro, there was a wide variety of instruments that allowed firms to hedge exchange rate risk in the well-developed European capital markets.

Why else, then, might a currency union promote economic integration? One possible explanation is that by joining a currency union, countries have made a nearly

irrevocable commitment to macroeconomic policy coordination. It is very difficult to run monetary policy for a group of countries that face very different macroeconomic conditions. It may be reasoned that joining a currency union must entail a commitment to coordination by governments because otherwise the sacrifice of independent monetary policy would be too great.

Indeed, the commitment to a currency union might signal a willingness to commit to even broader economic integration – on issues of property rights, non-tariff trade barriers, labour policy, etc. For Europe, much progress on these issues has been made even prior to the introduction of the euro, especially with the Single Market Programme of 1992. Nonetheless, one might expect the euro to signal that the changes of the 1990s are more nearly irrevocable, and that there is a commitment toward even more harmonization in areas of regulation and social policy.

If producers believe there will be greater integration of macroeconomic and microeconomic policies, they may be more willing to undertake the large fixed costs involved with exporting products abroad. If they believe that markets will stay open, and the economic environment for trade will become increasingly stable, then they might expect that the investment in opening foreign offices, training foreign sales representatives, and monitoring foreign sales will have a sufficient payoff.

By thinking about prices as a measure of integration, one can surmise two more important reasons why the euro may have strengthened market ties in Euroland. One explanation is not entirely appealing to economists, but has received a great deal of attention in the press and popular analysis. It rests on a sort of money illusion. The argument is that so long as European countries have different currencies, citizens are discouraged from travel and businesses are discouraged from trade because of the added complexity of calculating prices expressed in foreign currencies.[1] This popular reasoning suggests that the forces of arbitrage – the market forces that try to take advantage of failures of the law of one price by buying products where they are cheap (and perhaps selling them where they are dear) – are undermined by the confusion introduced by different currencies. A single currency encourages travel, encourages businesses to engage in trade beyond their borders, and encourages arbitrage because it reduces the complexity of calculating prices.

The second argument for why a currency union might directly reduce law-of-one-price deviations applies to any fixed nominal exchange rate regime. A large body of evidence supports the claim that in the short run, nominal prices are sticky in consumers' currencies.[2] When nominal exchange rates are flexible, real price misalignments can occur. For example, if P represents the price of a product in France, and P^* the price of the product in Germany – and P and P^* adjust sluggishly – then their relative price, P/SP^*, will fluctuate as the nominal exchange rate (francs per mark),

[1] Asplund and Friberg (2001) offer some striking evidence in favour of the money illusion story, noting the substantial price differences for goods sold within Scandinavian duty-free stores where each good has price tags in at least two currencies.

[2] See, for example, Mussa (1986), Engel (1993, 1999), Engel and Rogers (1996) and Parsley and Wei (2001).

S, fluctuates. If nominal exchange rate movements are large, there can be currency misalignments in which price levels in one country differ from price levels in another when expressed in a common currency. Even if markets are otherwise well integrated, exchange rate misalignments can hamper market efficiency. This is precisely the core of the argument advanced in favour of adopting fixed exchange rates in Devereux and Engel (2003). Our previous papers, using aggregate price indexes for European cities (Engel and Rogers, 2001), and disaggregated price indexes for European countries (Engel, 2000), show evidence of this sort of currency misalignment and volatility in relative prices in pre-euro Europe.

For several decades, researchers have investigated the related phenomena of the law of one price, exchange rate pass-through, pricing-to-market and purchasing power parity (Rogoff, 1996; Goldberg and Knetter, 1997). Perhaps the major conclusion one can draw from all of this work is that some types of friction provide significant barriers to the integration of product markets across nations. Among the plausible candidate explanations are transportation costs, information barriers, implicit or explicit trade barriers, and currency fluctuations.

In many regions of the world, there is considerable momentum for countries to remove barriers to trade and reduce volatility between their currencies. The most significant example of this is certainly the integration of Europe's major economies. Trade barriers have been steadily reduced between many of the European countries for over 40 years, while in recent years, first fixed exchange rates and then in 1999, the introduction of the euro, have eliminated currency fluctuations. Surrounding the move to monetary union, there were widespread media reports of substantial common-currency price differentials for consumer goods across European countries. Presumably, the forces of arbitrage would work quickly to eliminate such differentials now that major policy obstacles had been removed. The goal of this paper is to examine detailed data on local currency prices in European countries to determine what impact the euro had on product market integration within Europe.

1.2. Our data

The most direct method for testing product market integration across space is to compare the levels of common-currency prices of identical products at a point in time. Usually this is impossible – the typical data sources are either price indexes (in which levels are arbitrary) or unit values (in which products are not identical). Fortunately, we are able to use data on local currency price levels for very similar, if not identical, products across the major European markets. These direct measures of actual prices will allow us to examine the behaviour of price differentials over time to determine the impact of the euro on product market integration.

Our data, which cover the 1990–2003 period, are from a survey conducted by the Economist Intelligence Unit, which includes data on 101 narrowly defined traded goods from 18 European cities in eleven Eurozone countries. The data are on actual

price levels of such items as pork chops, men's wool socks and 100-tablet bottles of aspirin. For purposes of comparison, we also use data on 38 non-traded items (e.g., apartment rents, taxi fares). In addition, we have data for 7 cities in Europe that are not in Eurozone countries. This set of cities can serve as a control group to analyse the influence of the introduction of the euro.

1.3. Our findings

We find there is unconditionally a decline in price dispersion over much of the 1990s but little evidence of further decline since 1999. That finding applies both to cities within the Eurozone, and to other European cities outside of Euroland. We then investigate what accounts for the dispersion, and what accounts for the change in dispersion over time. We consider a number of factors that vary over time and that might lead to deviations from the law of one price – income, VAT tax rates, local labour costs. We also allow for dynamics of price adjustment. Even conditional on these explanatory variables, we find little evidence of a reduction in violations of the law of one price after the introduction of the euro in 1999.

It would be easy to overstate the significance – both statistical and economic – of our findings. There was a significant decrease in price dispersion in Europe in the 1990s, though not much after 1999. The point may be that gains from euroization are not large precisely because Europe has made other important reforms that increased market integration prior to 1999.

2. THE DATA

An important reason for the relative lack of evidence on price convergence at the consumer level is that there are few data sets of actual prices, as opposed to price indexes, of comparable items across a sufficiently broad range of countries and years.

The consumer price data are collected by the Economist Intelligence Unit (EIU), whose survey teams record local prices of dozens of tightly specified items such as 'laundry detergent (3-litre container)' and 'women's sweater', in over 100 cities worldwide.[3] The data set also includes many items such as apartment rental and haircuts, which would most naturally be classified as 'non-tradable'. We use data from 18 European cities from the 11 original euro area members.[4] The data are annual from 1990 to 2003. All prices are reported in euros, with ECU exchange rates used to convert prices to euros prior to 1999.

[3] The EIU calculates cost-of-living indexes primarily for multinational corporations that move employees around the world. Some additional information about the database is provided on the CityData page at http://eiu.com/ (refer to the 'help' page for information). Hufbauer *et al.* (2002), Rogers (2002), Rogers *et al.* (2001) and Parsley and Wei (2002) also make use of the data set.

[4] Amsterdam, Barcelona, Madrid, Berlin, Dusseldorf, Frankfurt, Hamburg, Munich, Brussels, Dublin, Helsinki, Lisbon, Luxembourg, Lyon, Paris, Milan, Rome and Vienna.

Box 1. Review of the recent literature

A few other recent papers have examined pricing behaviour and price dispersion since the introduction of the euro using data on price levels of narrowly defined goods: Rogers (2002), Lutz (2002), and Baye *et al.* (2002). Rogers takes a different approach to examining a similar data set to the one examined here. He investigates whether the introduction of the euro in 1999 has influenced national price and inflation convergence. Baye *et al.* examine the effects of the euro on a small set of homogenous goods that shoppers can purchase on the internet. They find that the introduction of euro currencies in January 2002 had little effect on price dispersion for their set of products (which are mostly electronics goods). Lutz (2002) examines a small set of goods (Big Macs, the *Economist*, automobiles, and a small survey by UBS with only one post-1999 price survey), and finds that the euro has not reduced price dispersion significantly. Beck and Weber (2001) also examine the effects of the introduction of the euro on price dispersion in Europe, but their data is disaggregated price index data. Boad (2004) uses data on *per diem* rates to examine border effects in Europe. Also, the European Commission has recently noted that price convergence has stalled since the mid-1990s. Using Eurostat data at the country level, the European Commission (2004) notes that the price index in the most expensive and least expensive countries were converging in the early 1990s, but stopped converging in the middle of the decade. It is notable that Lutz (2002) (using prices on a handful of goods), and Rogers (2002) and the European Commission (2004) (using aggregated price data) reach a similar conclusion to ours – price dispersion declined in the early 1990s, but there has been little convergence in prices across countries since mid-decade. Boad (2004), on the other hand, finds some evidence that the euro has slightly reduced price dispersion.

Prices for most items are sampled from two different outlets, a 'high-price' and 'low-price' outlet, and are reported separately in the survey. For example, food and beverage prices are sampled from convenience stores and supermarkets. We examine prices from both types of outlets, but report results from the supermarket type outlets, which are likely to be more comparable across cities.

The EIU database does not contain a price quote for every city and every item in every year. It would be misleading to use a sample whose composition changes substantially over time or were radically different between cities. Because of this, we include an item in the sample only if a price is recorded in every year for at least 15 of the 18 cities. Our principal focus is on the analysis of 101 products that meet this

criterion and are clearly tradable. However, we will compare the findings for another set of 38 products that are not traded. Tables A1 and A2 in the Appendix list all of the goods.

Many studies of cross-country price behaviour at the consumer level have used price index data, constructed by official statistical agencies. Since those data are indexes, they cannot be compared directly across countries to investigate differences in price levels. These studies frequently look at the differences in rates of change of prices, but one must interpret the findings with caution. For example, if there were large differences in price levels across the Eurozone 11 before 1 January 1999, but the introduction of the euro caused rapid price convergence, then we might expect to see very different rates of price change. The high rate of inflation in Ireland and the low rate of inflation in Germany may simply represent convergence in prices.

2.1. Measurement problems when using actual prices

In this study, our data are on actual prices, not price indexes. But there are potential measurement problems that cannot be ignored. In principle, these data are for identical goods in all countries, but:

- The data are collected from a small number of outlets compared to surveys conducted by national statistical agencies.
- Packaging is not uniform across countries, and it is not clear that the EIU methodology adequately accounts for packaging differences.
- Products are not always identical. The EIU attempts to measure prices of comparable goods, but makes no effort to price quality differences. This of course is an especially difficult task when consumers in different countries may have different perceptions of the quality of identical goods.

What are the implications of these measurement problems? We would like to know how the introduction of the euro has influenced price dispersion among the 11 countries that adopted the euro on 1 January 1999. We answer that by looking at how price dispersion within these 11 countries changed after 1999 compared to the 1990–98 period. Measurement error would only bias our conclusions if there were a shift in measurement error that coincided with the introduction of the euro. We cannot construct a plausible story of why that might have happened. On the other hand, even if measurement error did not change, if it is sufficiently large then inference is much more difficult.

2.2. How to estimate importance of measurement error by product

For this reason, our initial presentation of the statistics for price dispersion orders the goods by an estimate of their degree of measurement error. We posit that the goods that have the smallest measurement error are the goods for which price dispersion

among cities *within* countries is smallest. We measure this by taking the average dispersion from 1990–2003 for within-country relative price pairs. For example, we find that the price of foreign newspapers has the smallest measurement error on this scale: within each country, the price of foreign newspapers was nearly identical across all cities. Conversely, women's sweaters and women's raincoats are among the goods with the highest 'measurement error' according to our classification. This is reassuring, since clothing is exactly the type of item where it may be very difficult to make quality comparisons across locations, so we expect measurement error to be large.

There may be reasons other than measurement error for price dispersion within a country. Perhaps price dispersion within a country for some goods is not measurement error but really represents true internal price differences. Internal markets might not be integrated for some of the same reasons that international markets for some goods are not integrated. There may be high transportation costs for some goods, regulations (even internally) that hamper arbitrage, tastes differences (even regionally within a country) that encourage producers to differentiate products, etc. So it is possible that goods that have high within-country dispersion are really goods for which the internal market is not integrated. These very goods might have a tendency to show greater price dispersion both internally and across national borders.

Our classification might determine that there is high measurement error for a product when in fact there is some other reason why price dispersion is high within countries. But, in a sense, our scheme is helpful in determining whether price dispersion across countries is a useful yardstick for goods market integration. If within-country dispersion of prices for a good is high, then the cross-country dispersion is unlikely to be a good measurement of integration. Within countries there are, by definition, no international barriers to trade. If nonetheless prices are very different across locations within countries – whether from measurement error or for other reasons – then the amount of price dispersion across countries is less useful as a measure of international barriers. So it makes sense to order the goods by the degree of internal price dispersion, and to pay closer attention to how international price dispersion has changed for the goods with low intra-national price dispersion.

3. SUMMARY STATISTICS

We measure price dispersion across locations in Europe in the EIU city price data as the mean-squared-error (m.s.e.) of relative (logs of) prices. That is, let p_i^j be the price of good i in city j. (All prices are expressed in dollars.) Then define q_i^{jk} to be the relative price between city j and k: $q_i^{jk} = p_i^j - p_i^k$. We take the m.s.e. of q_i^{jk} (call it V_i) over all the city pairs where the cities are in different countries. We look for dispersion across cities in different countries because we ask whether the introduction of the euro has reduced national barriers to integration of goods markets.

Note that the m.s.e. of these relative prices (q_i^{jk}) across all cities (including city pairs that are in the same country) is simply proportional to the variance of the (log) price levels (p_i^j). While it would be simpler to compute the variance of the price levels, we only want to consider price dispersion across country borders. Our calculation of V_i only includes city pairs that are not in the same country, so we use it instead of the simple variance of the price levels. Obviously if we had observations of only one city per country, V_i would convey exactly the same information as the variance of price levels.

3.1. Dispersion declined 1990 to 2003

Figure 1 plots the change in V_i between 1990 and 2003, as well as the change over the sub-periods 1990–94 and the period of the introduction of the euro, 1998–2003 for tradable goods. The first chart in Figure 1 plots for each product i the difference between V_i in 1990 and V_i in 2003. Thus, a positive point represents a decline in volatility. The goods are ordered on the chart by the amount of measurement error, as described in the previous section. The good whose price is measured with the least error (foreign newspapers) is plotted on the left side of the graph, and the goods whose prices have the greatest measurement are plotted on the right side.

It is clear from Figure 1(a) that for the vast majority of the goods (72 of 101) in our sample, price dispersion across the Eurozone countries fell from 1990 to 2003. There are some products for which V_i increased over this period, but for a distinct majority V_i declined. This seems to be true independent of the amount of measurement error. From this measure, we can conclude that goods market integration has increased in the Eurozone countries since 1990.

3.2. Was the euro responsible for decline in dispersion?

Has the introduction of the euro been responsible for this convergence in prices within Europe? Figure 1(b) and (c) help to answer that question. Figure 1(b) shows the change in V_i from the 1990–94 period. This was a period in which some major barriers to integration within Europe were reduced due to implementation of the Single Market Programme. The chart is very telling. For all but a handful of goods, V_i fell over the period. (That is, the points plotted are greater than zero.) Plainly, there was substantial integration of consumer product markets over this period.

However, we do not see such a pattern in the change in V_i since 1998. There are only 43 items for which V_i decreased over this period. This pattern is, again, independent of the amount of measurement error. So, Figure 1 shows that while there has been a decline in price dispersion over the 1990s in Europe, very little of that decline coincided with the introduction of the euro. Of course, there is an important caveat – we have not tried to control for other factors that might have affected goods

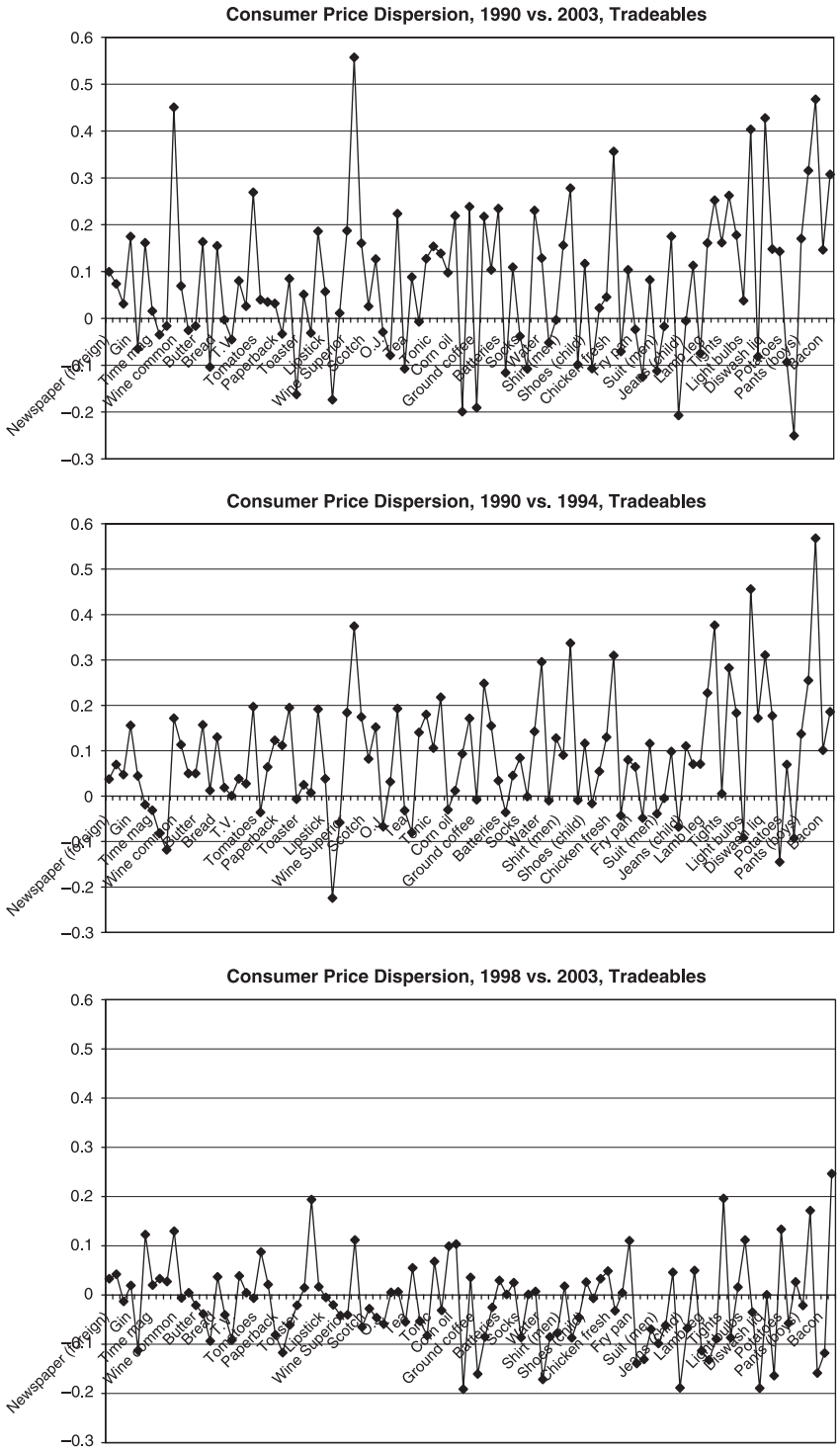

Figure 1. Consumer price dispersion for tradable goods (a) 1990 vs 2003; (b) 1990 vs 1994; (c) 1998 vs 2003

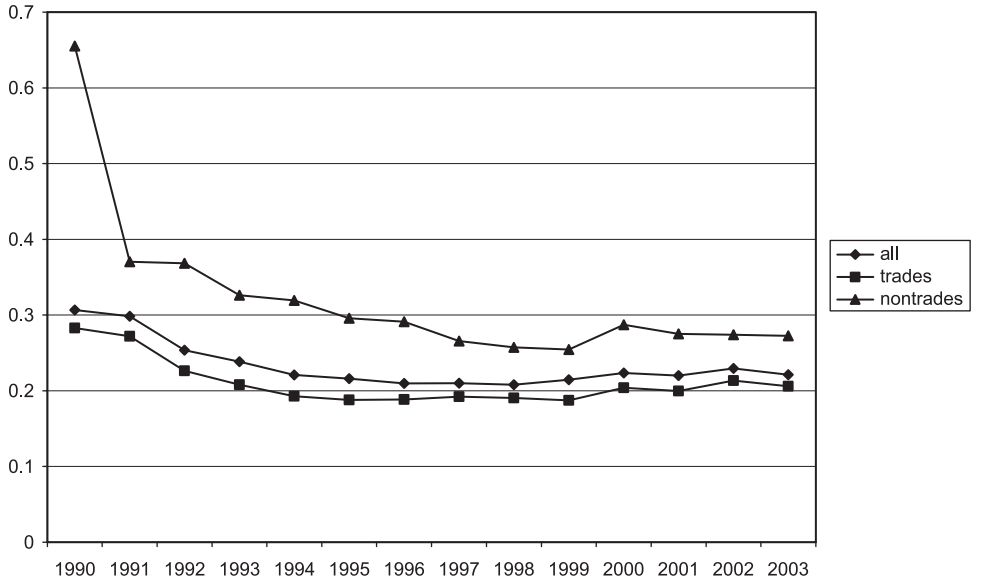

Figure 2. Consumer price dispersion, 1990–2003 (average mean-squared error)

market integration adversely in the euro period. That is, it is possible that there is some force that reduced integration that was partly offset by beneficial effects on integration from the euro. We attempt to control for this in Section 5.

Figure 2 plots for each year the average (across all goods) of the sample m.s.e. of the relative prices. In other words, it plots the unconditional mean-squared errors, as shown in Figure 1, averaged across all goods for each year. There are three averages plotted: the average for all traded goods, the average over 38 non-traded goods (which we discuss below), and the average over all goods. We note that by averaging these statistics across goods we have ignored any differences among the goods in the measurement error of prices. Still, the aggregates are revealing.

We focus here on the plot for the tradable goods, which demonstrates very precisely the message we draw from Figure 1: there has been a decline in price dispersion in Europe in the 1990s. However, most of that decline occurred early in the decade. There has in fact been, if anything, a slight increase in price dispersion since 1998. We note that there was a 27.2% decline in the average m.s.e. over the entire sample period (from 0.283 to 0.206). The decline in the 1990–94 sub-period was 31.8%, but the increase in the 1998–2003 sub-period was only 8.4%.

3.3. Hypothesis: slow price adjustment and exchange rate changes

One hypothesis advanced for why there are significant failures of the law of one price at any point in time is slow nominal price adjustment in consumers' currencies in conjunction with variable nominal exchange rates. That is, consider the relative price

of good i between city j and k. Expressing the price in country k in terms of country k's currency ($\tilde{p}_i^k$), we have $q_i^{jk} = \tilde{p}_i^j - s^{jk} - \tilde{p}_i^k$, where s^{jk} is the j-currency price of currency k. If each nominal price ($\tilde{p}_i^k$ and p_i^j) is slow to adjust, then q_i^{jk} will reflect the changes in the nominal exchange rate, s^{jk}. For example, this is the assumption in the open-economy macroeconomics literature that assumes local-currency pricing (e.g., Betts and Devereux, 1996 and 2000, and Devereux and Engel, 2003), and is one interpretation that has been given to empirical findings on deviations from the law of one price for consumer goods (e.g., Engel, 1993 and 1999, and Engel and Rogers, 1996 and 2001).

This unequivocally cannot be the explanation for our findings in Figures 1 and 2. The euro period obviously was a period of no nominal exchange rate changes. If this were the correct explanation, then we should have found the largest decline in dispersion during the euro period. While much of the 1990s saw very stable exchange rates among the Eurozone countries, one notable exception occurred in September 1992. The crisis and near collapse of the ERM should have led to greater price dispersion in the 1990–94 period according to the local-currency pricing theory. But instead, we find the largest decline during that period. The drop in price dispersion that we find during the 1990–94 period probably instead reflects reduced barriers to market integration.

3.4. Does convergence differ across goods?

Figure 3 presents bar charts of the average dispersion (across goods) for seven categories of tradable goods within our data – clothing/footwear, alcoholic beverages, personal care, household supplies, perishable food, recreation and non-perishable food. It also presents the average dispersion for non-traded goods, which we discuss later. We see that the dispersion across each traded category has declined over the entire sample. (In this chart, a positive bar indicates a decline in average dispersion.) This is also true of each category in the 1990–94 sub-period. But in the 1998–2003 period, only alcoholic beverage prices show a decline in dispersion.

The overall pattern – declining dispersion in the early 1990s, but no further decline since the introduction of the euro – holds broadly. Our findings are not driven by price behaviour among special categories of goods. That is, it appears that the forces that led to price convergence in the early 1990s (and no convergence later) arise from widespread market changes.

3.5. Statistical tests

Table 1 reports formal statistical tests for whether the average m.s.e. of prices fell over the 1990s. The first panel of Table 1 reports the mean (across traded goods) difference in m.s.e. for three periods: 1990–2003, 1990–94 and 1998–2003. These are reported as the difference between the initial m.s.e. and the later m.s.e. (as in Figure 1)

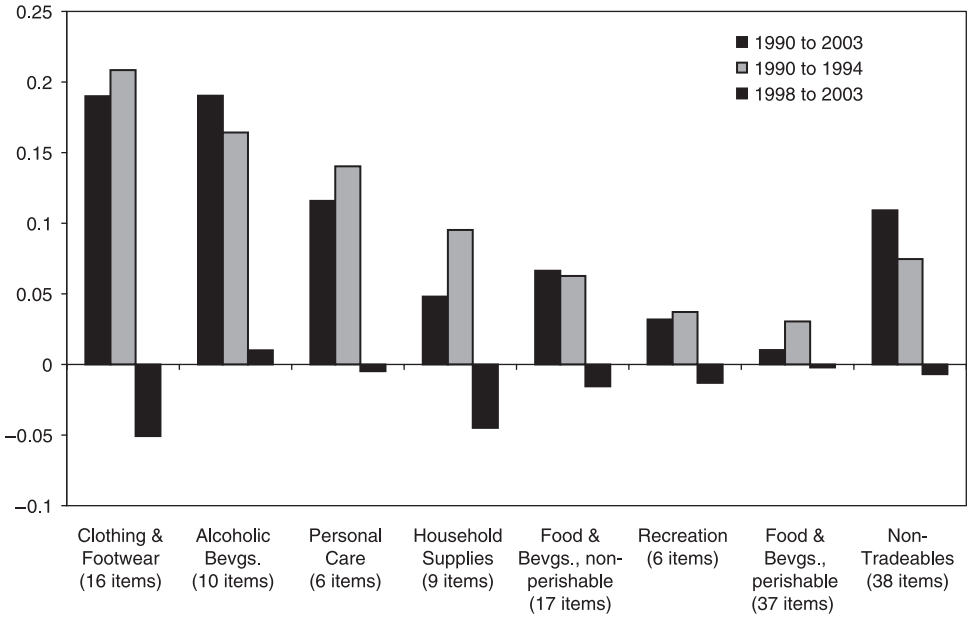

Figure 3. Breakdown by category: change in price dispersion in the Euro-11

Table 1. Statistical tests for change in price dispersion

	1990–2003	1990–1994	1998–2003
All traded goods	0.0769*	0.0900*	−0.0155*
(101 items)	(0.0155)	(0.0129)	(0.0086)
Perishable food	0.0101	0.0304*	−0.0021
(37 items)	(0.0216)	(0.0163)	(0.0148)
Non-perishable food	0.0663*	0.0627*	−0.0155
(17 items)	(0.0321)	(0.0296)	(0.0206)
Alcoholic beverages	0.1904*	0.1642*	0.0100
(10 items)	(0.0564)	(0.0317)	(0.0256)
Household supplies	0.0483	0.0953*	−0.0449
(9 items)	(0.0532)	(0.0330)	(0.0336)
Personal care	0.1158	0.1403*	−0.0049
(6 items)	(0.0832)	(0.0715)	(0.0531)
Recreation	0.0317	0.0372*	−0.0130
(6 items)	(0.0205)	(0.0188)	(0.0241)
Clothing and footwear	0.1900*	0.2085*	−0.0508*
(16 items)	(0.0351)	(0.0349)	(0.0159)
Non-tradables	0.1092*	0.0747*	−0.0069
(38 Items)	(0.0243)	(0.0241)	(0.0155)

Note: The table reports change in dispersion (standard error in parentheses). * denotes significant at 5% level in two-sided *t*-test.

so that a positive number represents a decline in dispersion. The table shows that the average m.s.e. declined over the entire sample period, 1990–2003, and over the early period, 1990–94. Indeed, the decline over the 1990–94 period was slightly greater than for the whole sample period. That is, there has been a slight increase in price

dispersion since 1994. The declines in dispersion for the whole sample and for 1990–94 are statistically significant at the 5% level.

In the post-euro period, 1998–2003, dispersion increased. The size of the increase is small compared to the overall decline in the 1990s, but is statistically significant at the 5% level. These aggregate statistics confirm the lesson from Figure 2; there has been an increase in integration in the 1990s, as measured by price dispersion across locations in the Eurozone. But most of that integration appears to have happened in the early part of the decade, and there is no evidence of greater integration after the introduction of the euro.

Table 1 also looks at seven categories of goods within our data – perishable food, non-perishable food, alcoholic beverages, household supplies, personal care, recreation and clothing/footwear. We first note that for all seven categories, the dispersion decreased throughout our entire sample as well as in the 1990–94 sub-period. Indeed, these declines were generally statistically significant, which is remarkable given the small number of goods in some categories. In the 1990–94 period, the decline in dispersion was statistically significant at the 5% level for all of the seven categories. However, dispersion increased for six of the seven categories in the 1998–2003 period. The increases in these sub-categories usually are not statistically significant.

We note, moreover, that the decline in dispersion in the early part of the decade was smallest in perishable food items, which is probably the category in which competition is greatest and products are least differentiated. The largest declines in the 1990–94 sub-period occurred in alcoholic beverages and clothing/footwear. Buigues *et al.* (1990) measure the degree of non-tariff barriers among EU countries prior to the Single Market Programme (SMP). They find that alcoholic beverages (beer and wine) have high non-tariff barriers, and there are moderate barriers in clothing. Head and Mayer (2000) also find relatively large 'border coefficients' for these categories of goods prior to the implementation of the Single Market Programme. Their border coefficients are measures of the degree of product market barriers among European Union countries in 1984–86. The decline in price dispersion in those categories in the early 1990s is support for the claim that the SMP had a major impact on market integration.

4. FURTHER EMPIRICAL INVESTIGATION

In this section we undertake a number of further empirical exercises to understand the behaviour of price dispersion in the Eurozone countries. We first investigate the behaviour of prices of non-traded goods within the Eurozone 11. Then we look further at the behaviour of traded goods prices within the Eurozone. The euro has had a smaller effect on reducing exchange-rate volatility within the 'DM-bloc' of countries. Has the behaviour of price dispersion been different within the DM bloc and outside? Has price dispersion also declined or risen within the borders of euro countries? Finally, what has happened to price dispersion among European cities that are not part of the Eurozone? Do they display similar patterns?

4.1. Non-traded goods

Figures 2 and 3 plot the change in dispersion in non-traded goods prices for the euro countries. The pattern is very similar to what we have seen with traded goods: There has been a large reduction in the price dispersion since 1990. Most of that reduction occurred early in the decade, however. In fact, just as with traded goods prices, there has been a slight increase in dispersion since 1999.

Table 1 reports on the statistical significance of these changes. The changes over the entire 1990–2003 period and over the 1990–94 sub-period were large and highly statistically significant. (A positive number in this table indicates a reduction in dispersion.) Since 1998, dispersion has increased slightly but with low statistical significance.

A striking thing in Figures 2 and 3 is that the decline in dispersion for non-tradable goods is even larger than for tradables. Figure 2 shows that dispersion for non-tradables is still larger in 2003 than for tradables, as we would expect. But there was a large decline in the first half of the decade.

This suggests that the integration of markets that occurred in Europe in the early 1990s worked through channels beyond merely the facilitation of greater goods trade. Prices of non-traded goods are determined by the prices of factors used to produce them – wages, rents, and return to capital. As factor markets become better integrated, prices of factors will converge, and so we see the decline in dispersion of non-traded goods. In addition, demand factors may play a role. Price convergence of non-tradables may in part be attributable to convergences in income within the Eurozone.

4.2. DM bloc

Our Eurozone cities include five within Germany – Berlin, Dusseldorf, Frankfurt, Hamburg, Munich – and four cities in the 'DM bloc' – Amsterdam, Brussels, Luxembourg and Vienna. The Benelux countries and Austria had exchange rates that were very rigidly fixed to the DM prior to the introduction of the euro. Clearly the euro did little to reduce exchange rate movements with the DM bloc.

Was the behaviour of cross-country price dispersion different in the DM bloc from the rest of the Eurozone? Figure 4 suggests that it was not. Here we plot the average (across traded goods) of the m.s.e. for between-country city pairs within the DM bloc. (We refer to the line labelled 'within DMBLOC' in Figure 4.) We find that dispersion mimics the whole sample; it declines in the early 1990s and increases slightly after 1998.

The overall level of dispersion is lower in the DM bloc than for the entire sample of Eurozone cities in every year. (Compare the Euro-11 line to the DMBLOC line in Figure 4.) But the size of the decline in dispersion from 1990–94 is a bit smaller. For the Eurozone sample as a whole, the average m.s.e. fell by 31.8% during this period (from 0.283 to 0.193.) In the DM bloc, the decline was only 24.5% (from 0.194 to 0.145.) The increase in dispersion from 1998 to 2003 was also slightly larger for the

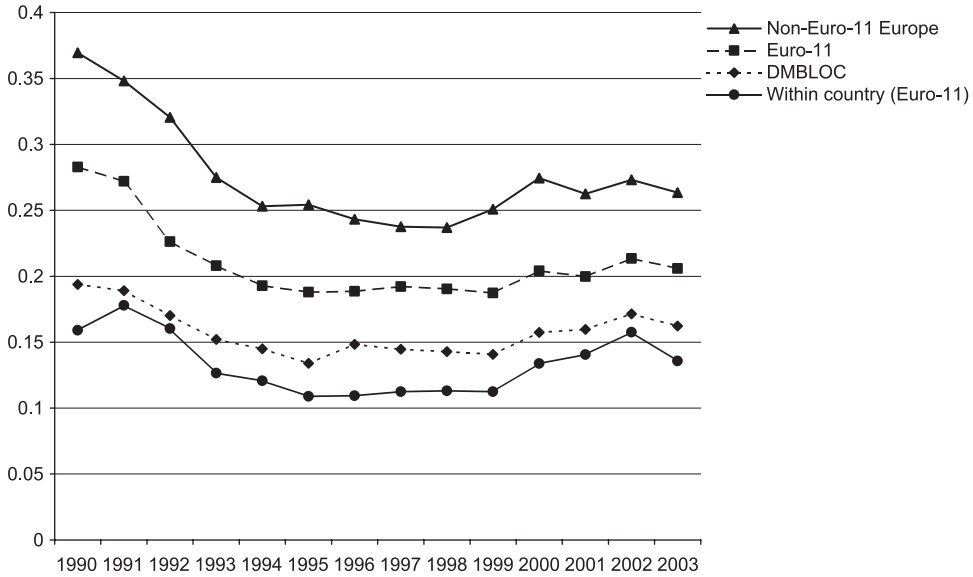

Figure 4. Consumer price dispersion, 1990–Spring 2003, tradables

DM bloc sub-sample than for the entire Eurozone sample. There was an 8.4% increase in dispersion for the entire set of Eurozone cities from 0.190 to 0.206, and an 11.7% increase from 0.143 to 0.162 in the DM bloc sub-sample. The decline in dispersion over the entire sample and over the 1990–94 sub-sample, and the increase in dispersion in the 1998–2003 sub-sample are statistically significant for the DM bloc countries (as they were for the entire sample of euro countries.)

Finally, we note that while Figure 4 reports dispersion of prices for traded goods only, the behaviour of dispersion for the non-traded goods is similar.

We tentatively infer that since the behaviour of price dispersion within the DM bloc is similar to the evolution of price dispersion in the Eurozone as a whole, exchange rate stabilization did not play a large role in the reduction of price dispersion in the 1990s.

4.3. Within country

So far, all of the results we have presented are for city pairs that do not lie within the same country. Figure 4, though, plots the average m.s.e. (across traded goods) for city pairs in the euro countries that are within the same border. (We refer to the line labelled 'Within Country (Euro-11)' in Figure 4.) We cannot attribute changes in dispersion to a reduction in national barriers to trade in goods and factors.

Figure 4 does reveal a pattern similar to what we have seen for our between-country city pairs: dispersion declined early in the 1990s and increased since 1999. We note that within-country dispersion is lower than cross-country dispersion in

every year in our sample. Indeed, as the chart reveals, it is even lower than cross-country dispersion within the sub-sample of DM bloc countries.

The average m.s.e. for our within-country city pairs fell in 1990–94 from 0.159 to 0.121. This represents a 23.9% decline in dispersion (compared to a 31.8% decline for our cross-border city pairs). The decline is comparable to the decline in dispersion within the DM bloc. This suggests that there are factors at work that led to falling price dispersion in the early 1990s that go beyond greater integration of national markets. Apparently integration was occurring also within regions of each economy.

On the other hand, the increase in dispersion in the latter half of the sample is relatively large. The average m.s.e. increased from 0.113 to 0.136 from 1998 to 2003, which is a 20.4% increase. This is much larger than for the between-country Eurozone city pairs (whose m.s.e. rose 9.9%).

The decline in dispersion over the entire sample was relatively small and statistically insignificant for the within-country city pairs. (However, both the decline in dispersion in 1990–94 and the increase in 1998–2003 are significant statistically.)

We do not want to overemphasize these findings, however, because our within-country sample is very limited. We use only the five German cities, along with prices for the city pairs Barcelona–Madrid, Paris–Lyon and Rome–Milan. That is, there are only 13 city pairs, as compared to 140 city pairs in different countries in our Eurozone sample.[5] But the findings are interesting, and suggestive, and deserve further study.

4.4. Non-Eurozone European cities

We also investigate the behaviour of price dispersion in European cities that are not part of the Eurozone. We have data on seven European cities – Athens, Copenhagen, Geneva, Zurich, London, Oslo and Stockholm. Inclusion or exclusion of the non-EU cities does not affect our results.

We consider price dispersion among these cities and all other European cities. That is, we look at price differences between each of these cities and all other European cities (within the Eurozone and outside) that lie in different countries. Figure 4 plots the average m.s.e. across the traded goods for these cities. We refer to the line labelled 'Non-Euro-11 Europe'.

Again, we see the same pattern: Dispersion does fall over our entire sample. However, that decline occurs in the first half of the 1990s. Since 1999, there has been an increase in price dispersion.

Price dispersion is greater for these cities than for city pairs within the Eurozone. That is true for every year in our sample. The percentage decline in price dispersion was almost identical for these cities as for our Eurozone sample for the 1990–94 period, 31.7% for this set of European cities, compared to 31.8% for the Eurozone cities. (The m.s.e. fell from 0.370 to 0.253.) The increase in dispersion from 1999 to

[5] There are 26 city pairs in the DM bloc. We investigate 163 city pairs in our non-Eurozone European city analysis.

2003 was 11.4% for these cities compared to 9.9% for the Eurozone cities. So, while the overall dispersion is greater for non-Eurozone cities, the evolution of dispersion has been very similar.

The decline in dispersion over the entire sample and over the 1990–94 sub-sample, and the increase in the 1998–2003 sub-sample are all statistically significant for these non-euro cities.

The implication from this set of cities is that the decline in price dispersion represents a general movement toward greater integration within Europe in the 1990s. This occurred within the EU, but also includes some European cities not in the EU (Oslo, Geneva, Zurich). This increase in integration is entirely separate from any influence of the euro, since none of these seven cities has adopted the euro.

5. CONTROLLING FOR OTHER FACTORS THAT AFFECT DISPERSION

While the summary statistics from Sections 3 and 4 are revealing, the moments that are reported are unconditional. We have not controlled for factors that might explain changes in price dispersion over the 1990s, so it is more difficult to pinpoint the effects of the introduction of the euro in 1999. In this section, we tackle that problem. We build a model of price dispersion, and examine how price dispersion has changed over time conditional on various explanatory factors. We then ask whether, taking into account changes in these explanatory variables, there was a decline in price dispersion with the introduction of the euro.

5.1. A model of price dispersion

Let $\tilde{p}_{it}^{j}$ be the log of the price (expressed in dollars) of good i in city j. Let p_{it} be the average log price of good i across all of the cities. We follow Engel and Rogers (1996) and propose that all final goods sold to consumers are non-traded. While our focus on market integration has led us to examine trade in goods that can be shipped across borders, we must recognize that the final product that hits the shelf at the store is essentially non-traded. We think of the final good as a composite commodity that includes the tradable product, but also the non-traded components of marketing and distribution. Specifically, our model focuses on equilibrium prices in a given city j compared to the average price (averaged over all locations). The model says that prices in city j are proportionally higher than the average price,

- if the incidence of VAT is higher,
- if the local seller's mark-up is higher,
- if the wage bill is higher, and
- if transportation costs are higher in city j relative to the average.

We use the notation $\bar{p}_{it}^{j}$ and $\bar{p}_{it}$ to refer to the equilibrium price of commodity i (in location j and the average across cities, respectively). These equilibrium prices are not

constants. They are not to be interpreted as some long run steady state price. Instead, they are the equilibrium prices that would prevail given the state of the economy if firms adjusted prices instantly to changing market conditions. (See Box 2 for details.) We also need to consider the possibility of slow adjustment of prices.

Model 1: slow relative price adjustment

Actual prices may not adjust instantaneously to the target price, so we lay out an explicit adjustment process. This consists of a model of slow relative price adjustment where the gap between city j's price and the average price of a specific good, $p_{it}^{j} - p_{it}$, adjusts slowly to its equilibrium value, $\bar{p}_{it}^{j} - \bar{p}_{it}$. (See Box 2 for details.) Alternatively, we consider a model of slow *nominal* price adjustment.

Model 2: slow nominal price adjustment

Model 2 assumes that all the Model 1 factors are in operation but additionally allows changes in exchange rates (local currency per dollar), changes in the average price, and the local CPI inflation rate to affect the observed gap between city j's price and the average price of a specific good. (See Box 2 for details.)

Compared to Model 1, Model 2 adds a new reason why the price of i in location j may be out of line with the average price across all locations at time t. If inflation in dollar terms in location j is greater than average inflation of good i then $\tilde{p}_{it}^{j}$ is pushed up higher than the average price. Inflation in location j in dollar terms is the

Box 2. Modelling details

Our model of the equilibrium gap between the price of good i in city j and the average price of good i rests on a few assumptions. First, the tradable input and the non-traded marketing and distribution services are combined using a Cobb–Douglas technology. Second, each final product is sold by a monopolist in location j. Thus, the price of the final product is a mark-up over costs:

$$\bar{p}_{it}^{j} - \bar{p}_{it} = \eta_i \tau_t^{j} + \lambda_{it}^{j} + \theta_i w_{it}^{j} + (1 - \theta_i) r_i^{j}. \tag{1}$$

All variables on the right-hand side are expressed relative to the average across all cities. τ_t^{j} represents the VAT in city j (relative to the average VAT across cities for this particular good.) η_i is the fraction of the VAT that is passed onto consumers. λ_{it}^{j} is the mark-up over costs. w_{it}^{j} is the per unit cost of marketing and distribution. The marketing and distribution input has a weight θ_i in the production function. r_i^{j} is the cost of the traded intermediate good in location j relative to the average cost across locations, which has a weight of $1 - \theta_i$. This cost differential reflects transportation costs and other barriers. We take it to be time invariant because we do not have a time-varying measure of these barriers.

Model 1 of price adjustment is a simple model of price adjustment that assumes the gap between the city j price and the average price converges slowly to the predicted equilibrium difference. Namely,

$$p_{it}^j - p_{it} = \kappa_i(p_{it-1}^j - p_{it-1}) + (1 - \kappa_i)(\bar{p}_{it}^j - \bar{p}_{it}). \tag{2}$$

This equation says that the current price differential (the difference between the price in location j and the average Eurozone price) is a weighted average of the equilibrium price and lagged price differences. The weight on the equilibrium price is $1 - \kappa_i$.

In Model 2, we model a partial adjustment relationship which gives weight $1 - \kappa_i$ to the current equilibrium price and weight κ_i to the predetermined component. The predetermined component is $\tilde{p}_{it-1}^j + \tilde{\pi}_t^j$, where $\tilde{p}_{it}^j$ is the price in location j expressed in local currency. We assume that if $\tilde{p}_{it}^j$ adjusted instantly, it would equal the average price across locations, $s_t^j + p_{it}$ plus an adjustment for the difference between the equilibrium price in location j and the average equilibrium price, $\bar{p}_{it}^j - \bar{p}_{it}$. That is, market forces push $\tilde{p}_{it}^j$ toward the current price prevailing in the market, adjusted for the factors from the equilibrium model that make $\bar{p}_{it}^j - \bar{p}_{it}$ non-zero.

We have:

$$\tilde{p}_{it}^j = \kappa_i(\tilde{p}_{it-1}^j + \tilde{\pi}_t^j) + (1 - \kappa_i)(s_t^j + \bar{p}_{it}^j + p_{it} - \bar{p}_{it}).$$

Expressing prices in location j in dollar terms, we get:

$$p_{it}^j = -\kappa_i(s_t^j - s_{t-1}^j) + \kappa_i(p_{it-1}^j + \tilde{\pi}_t^j) + (1 - \kappa_i)(\bar{p}_{it}^j + p_{it} - \bar{p}_{it}).$$

Subtracting p_{it} from both sides and rearranging gives us:

$$p_{it}^j - p_{it} = \kappa_i(p_{it-1}^j - p_{it-1} + s_t^j - s_{t-1}^j + \tilde{\pi}_t^j - (p_{it} - p_{it-1})) + (1 - \kappa_i)(\bar{p}_{it}^j - \bar{p}_{it}) \tag{3}$$

In this equation, s_t^j is the local currency per dollar exchange rate, and $\tilde{\pi}_t^j$ is a measure of trend inflation in location j, which we take to be actual, *ex post* CPI inflation in location j (in local currency). $\tilde{\pi}_t^j$ is the same for each good i in location j.

In order to bring the model to the data, we recast the model as:

$$p_{it}^j - p_{it} = \alpha_i^j + (y_{it}^j)'\delta_i + \gamma(p_{it-1}^j - p_{it-1}) + u_t^j \tag{4}$$

when Model 1 is the price-adjustment model, and

$$p_{it}^j - p_{it} = \alpha_i^j + (y_{it}^j)'\delta_i + \gamma(p_{it-1}^j - p_{it-1} + \tilde{\pi}_t^j - (p_{it} - p_{it-1}) + s_t^j - s_{t-1}^j) + u_t^j \tag{5}$$

when Model 2 is the price-adjustment model. Here, α^j is a fixed effect for city j. y_{it}^j is a vector of time-varying city characteristics that measure the determinants of equilibrium price dispersion from equation (1).

sum of inflation in local currency, $\tilde{\pi}_t^j$, and country j's currency depreciation, $s_t^j - s_{t-1}^j$. Either high inflation in j or rapid depreciation will raise j prices temporarily relative to other locations.

The difference between the models is related to the notion of 'external exposure', introduced by Honohan and Lane (2003). In some countries, local factors may have little influence on prices. In these small open countries, prices may be strongly determined in world markets, so when expressed in dollar terms the prices would not be responsive to changes in dollar exchange rates. That is the implication of Model 1: nominal exchange rate changes do not influence relative prices. Conversely, if a country's internal prices are rigid in the local currency then prices (expressed in dollars) would be very sensitive to exchange rate changes, as in Model 2. However, we have not allowed for a differential response to exchange rates across countries, as Honohan and Lane's analysis suggests may be appropriate. Since 11 of the 18 cities in our analysis come from the larger countries, Germany, Italy, Spain and France, the differential response is unlikely to play a major role in explaining price differences in our sample.

5.1.1. The effects of introducing the euro. Our models do not specifically include a role for the introduction of the euro. We measure its effect as a residual. If the move to the euro reduces price dispersion, we should see a movement downward in the squared values of $p_{it}^j - p_{it}$.

To restate, our objective in this section is to try to understand why the decline in dispersion halted in the mid-1990s, as evidenced by Figure 2. Were there other changes that led to increased dispersion that masked the unifying effects of the euro? We control for several possible other factors and then ask whether there is evidence of further declines in price dispersion after 1995.

5.2. Empirical implementation of model

The only one of the explanatory variables for equilibrium prices that we observe directly is the VAT. We use various proxies to capture the effects of other variables.

We hypothesize that the mark-up will depend on income per capita in each city. Monopolists are able to charge a higher mark-up when the price elasticity of demand is lower. The price elasticity of demand, in general, is not constant. Luxury goods might exhibit a declining elasticity as income increases. That is, as income rises, households might consider their Martini & Rossi vermouth to be more a necessity. Some other goods might have the opposite property – as income increases, the price elasticity of demand might fall. Low-income households might have few substitutes for spaghetti, but as their income increases, their demand for spaghetti might become more price sensitive.

We use a measure of local wages in part to capture the costs of distribution and marketing. These services are highly non-traded, so their cost will be influenced by local labour costs.

So y_{it}^{j} consists of VAT rates (note that it is the 'standard' rate of VAT), log (per capita GDP in PPP dollars), and log (unit labour costs). The source for the VAT rate is the European Commission. Unit labour costs are from the OECD's Economic Outlook database. The variable is defined as 'unit labour costs for production workers'. It includes 'pay for time worked, other direct pay (e.g. holiday pay), employer expenditures on legally required insurance programs and other labour taxes', all expressed in euros.

Per capita GDP is calculated at PPP exchange rate by the IMF, and was obtained from the IMF's World Economic Outlook database, available at www.imf.org. We use GDP measured in PPP values rather than actual values because much of the annual variation in actual values (when all GDPs are expressed in dollars) comes from exchange rate variation. That might make prices highly correlated with GDP, but the correlation would arise mostly because of correlation with exchange rate movements.

To summarize, higher VATs in location j should increase the price. High-wage locations will have higher marketing and distribution costs, hence higher prices. GDP per capita may influence the mark-up, though the direction is ambiguous depending on the nature of the good.

5.2.1. Estimation and m.s.e. decomposition. We estimate Model 1 and Model 2 on data that tracks the prices of about 100 goods in all our cities for the period 1990 to Spring 2003 (OLS is the statistical procedure employed). For each period t, we calculate cross-sectionally the m.s.e. of $p_t^j - p_t^k$, and then look at how that m.s.e. moves over time. Here we decompose that m.s.e. into four components:

- Time-invariant component, 'component A' $\alpha_i^j - \alpha_i^k$. This is the m.s.e. of the time-invariant component. It cannot explain any of the change in m.s.e. over time, but we compare the time-invariant component relative to the other components.
- Time-varying equilibrium-price component, 'component B' $(y_{it}^j - y_{it}^k)'\delta_i$. This is the time-varying component explained by variables that alter equilibrium prices.
- Slow price adjustment component, 'component C' $\gamma(p_{it-1}^j - p_{it-1}^k)$ or, $\gamma(p_{it-1}^j + \tilde{\pi}_t^j + s_t^j - s_{t-1}^j - (p_{it-1}^k + \tilde{\pi}_t^k + s_t^k - s_{t-1}^k))$. This is the time-varying component that represents slow adjustment of prices (for each of our two models of price adjustment). It is transitory and should not influence the long-run deviations from the law of one price.
- Unexplained component, 'component D' $u_{jt} - u_{kt}$. This unexplained time-varying component is the part that we think might have fallen with the introduction of the euro.

These four components do not add up to the total m.s.e. There are the cross-components such as the average of the product of component 1 and component 2, etc. We do not report these because in fact they show little time variation.

5.3. Results

Our model for the equilibrium price deviation in location j, $\bar{p}_{it}^{j} - \bar{p}_{it}$ has limited success. We note that the VAT is significant and of the correct sign for only 8 out of 98 goods.[6] The average estimated response of $\bar{p}_{it}^{j} - \bar{p}_{it}$ to tax differences was essentially zero. GDP per capita is significant at the 5% level in about a quarter of the regressions (25 out of 98). On average, we find that the elasticity of $\bar{p}_{it}^{j} - \bar{p}_{it}$ with respect to GDP per capita in location j relative to the average is 0.083. For more than one-third of the items (36 out of 98), the unit labour cost is significant (at the 5% level) and of the correct sign. A 1% wage differential between location j and the average is estimated to increase $\bar{p}_{it}^{j} - \bar{p}_{it}$ by 0.090% on average. So the equilibrium model does not fit especially well, though it does uncover a statistically significant relationship for more than half of the goods (55 out of 98).

However, there is substantial evidence of lagged adjustment. The lagged price is always significant and positive (except for foreign newspapers). The average coefficient on lagged prices is 0.553, suggesting a half-life of price adjustment of just over one year.

When we use the model of nominal price adjustment (Model 2), relative wages along with the VAT have very little explanatory power. The VAT was significant at the 5% level and correctly signed for only seven goods and again the average measured effect on $\bar{p}_{it}^{j} - \bar{p}_{it}$ was very close to zero. In this specification, wages were significant and of the right sign for only eight goods, and the average elasticity of $\bar{p}_{it}^{j} - \bar{p}_{it}$ with respect to the wage difference was only 0.054. GDP was statistically significant for 31 goods out of 98. On average, when GDP was 1% above average, $\bar{p}_{it}^{j}$ was found to be about 0.065% larger than $\bar{p}_{it}$. The lagged price adjustment term was significant for all goods (except foreign newspapers), and the average coefficient was 0.508. In this model as well, the estimated half-life of price adjustment is just over one year.

We have noted that Figure 2 shows that the sample average m.s.e. of the relative prices has declined in the 1990s. That decline occurred early in the decade, and there has been a slight increase in price dispersion since 1999.

5.3.1. Even controlling for these other factors, the euro does not seem to matter. The question we want to answer in this section is whether we can explain that increase since 1999 by cyclical factors or slow adjustment, so that perhaps conditional on those factors price dispersion has decreased with the introduction of the euro. However, Figure 5 shows this is not the case. It plots the average value for each year of the sample of the m.s.e. components A, B, C and D from the model of relative price adjustment (Model 1). It is the unexplained dispersion in prices, and it too shows a slight increase since 1999. Line A plots the part of European price dispersion that is explained by the factors that are not time varying. Compared to the

[6] There were insufficient degrees of freedom to perform the test for three goods.

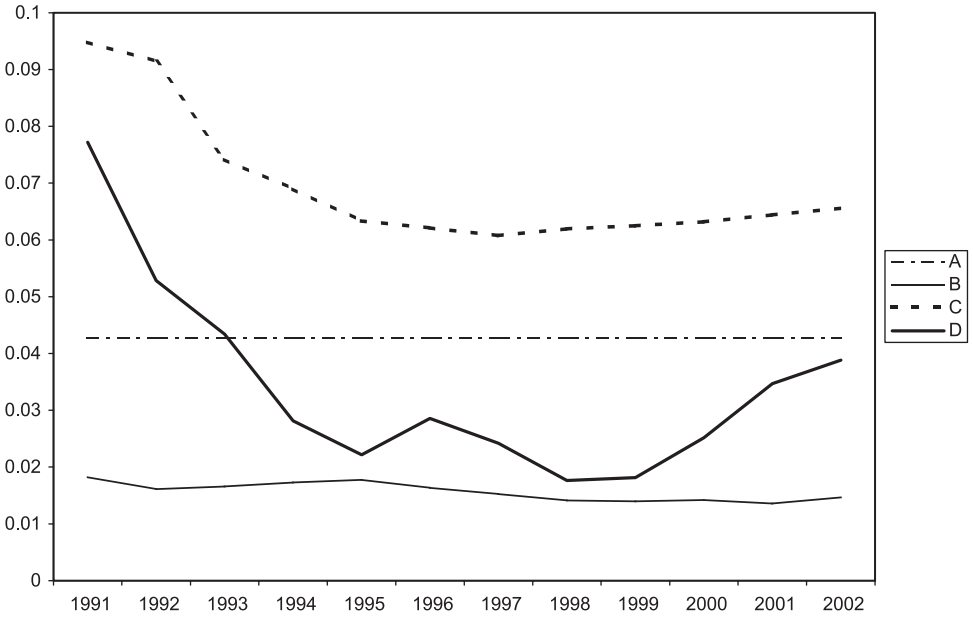

Figure 5. Relative price adjustment model: accounting for changes in price dispersion (m.s.e. of components)

cyclical time-varying component (B), the time-constant component accounts for a large fraction of the explained price dispersion. The 'cyclical' component – the part of the price dispersion explained by GDP per capita, unit labour costs, and VAT rates – in fact explains very little of price dispersion. It is small relative to the other components, and it does not vary much over time.

Of course, the dispersion of the lagged price term is declining over time just as the total price dispersion is declining. There are two notable points about the plot of component C. First, it is substantial. There seems to be a great deal of persistence in price dispersion, so that the C component is by far the largest of the three components meant to explain price dispersion. Second, the upturn we see in overall price dispersion in 1999 is not explained by a lagged adjustment to an upturn that occurred earlier.

The upturn in overall price dispersion is reflected in the upturn in the unexplained part of price dispersion plotted as line D. Line D is an aggregate measure of price dispersion not accounted for by our constant, time varying or adjustment components. It shows the same downward trend over the 1990s as the overall price dispersion, P. While we do not have direct evidence on this score (otherwise, this would not be 'unexplained' price dispersion), we hypothesize that the overall decline in the 1990s represents the effects of increased European harmonization and integration that occurred as a result of the reforms of the early 1990s. There is no evidence in either the unconditional dispersion of prices or the dispersion measured conditional

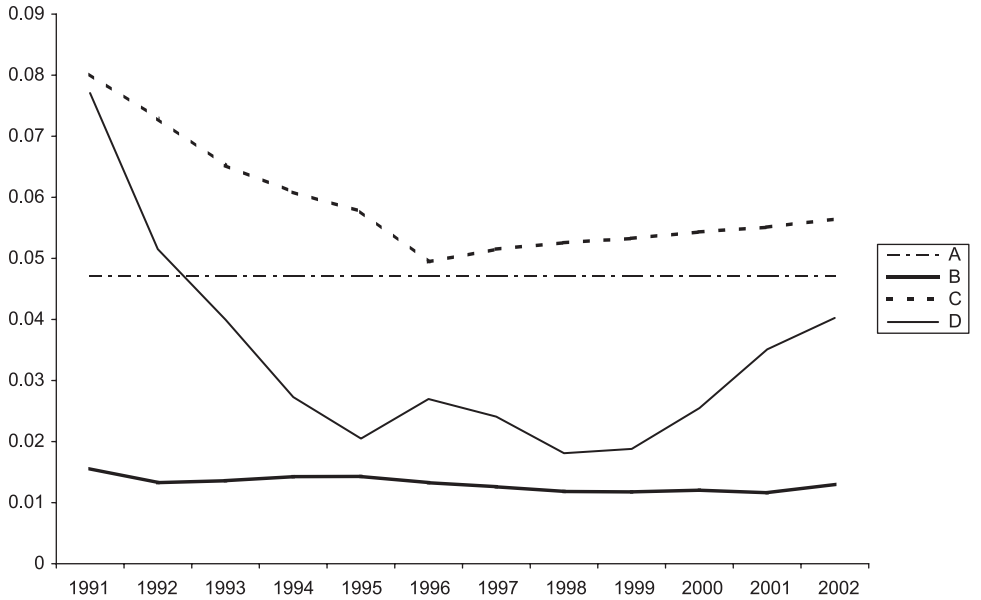

Figure 6. Nominal price adjustment model: accounting for changes in price dispersion (m.s.e. of components)

on the various explanatory variables, that the introduction of the euro reduced price differences across European cities.

Figure 6 shows that the same story emerges when the model of nominal price adjustment (Model 2) is used instead of the model of relative price adjustment. Each component of the dispersion in Figure 6 appears very similar to the corresponding component in Figure 5. The unexplained dispersion of prices still shows a marked increase since 1999.

5.4. Statistical tests

Table 2 reports formal statistical tests for the significance of the B, C and D components shown in Figure 5, for the model of relative price adjustment (given by equation (4)). For comparison, the tests for changes in the overall price dispersion, called P.

For the change over the sample (1991–2002) and for the early part of the sample (1991–94), all three time-varying components show a decline in m.s.e. In all cases, the decline is significant at the 5% level.[7]

But what has happened since the introduction of the euro? We have already noted from Figure 5 that overall price dispersion actually increased slightly over this period, but the change was not significant. Table 2 reports that the B component exhibits

[7] Our period of comparison starts at 1991 because the conditional model has one lag, which means we cannot calculate m.s.e. for 1990. The period of comparison ends in 2002 because that is the last year for which we have GDP data, wage data and VAT data for all locations.

Table 2. Tests for change in price dispersion for Model 1 (relative price adjustment)

Component of m.s.e. decomposition	1991–2002	1990–1994	1998–2002
Change in overall price dispersion (P)	0.0605*	0.0781*	–0.0198*
	(0.0146)	(0.0111)	(0.0080)
Time-varying equilibrium-price component (B)	0.0036*	0.0010*	–0.0005*
	(0.0005)	(0.0004)	(0.0002)
Slow price adjustment component (C)	0.0292*	0.0258*	–0.0036
	(0.0062)	(0.0041)	(0.0027)
Unexplained component (D)	0.0383*	0.0490*	–0.0212*
	(0.0054)	(0.0050)	(0.0025)

Notes: The table reports change in dispersion (standard error in parentheses). * denotes significant at 5% level in two-sided *t*-test.

increasing volatility. That is, the volatility that is explained by VAT, GDP per capita and most significantly, unit labour costs, declined slightly in the post-euro period. The change was significant at the 5% level.

Does the increase in the volatility explained by these time-varying components account for the increased price dispersion we see in the unconditional statistics since 1999? No. The increase in volatility in the B component is small. The unexplained component, D, had a significant increase in volatility over the 1998–2002 period. If the introduction of the euro had an effect of leading to greater integration of consumer markets, this component should have exhibited a decline.

Precisely the same story emerges when we examine the components from the nominal-price adjustment model (equation (5)), as reported in Table 3. While the model accounts for some of the increase in price spreads since the introduction of the euro, the unexplained component still shows rising dispersion and this is statistically significant. The emergence of the euro does not appear to have led to a decline in price dispersion: to the contrary, there has been a statistically significant increase.

Table 3. Tests for change in price dispersion for Model 2 (nominal price adjustment)

Component of m.s.e. decomposition	1991–2002	1990–1994	1998–2002
Change in overall price dispersion (P)	0.0605*	0.0781*	–0.0198*
	(0.0146)	(0.0111)	(0.0080)
Time-varying equilibrium-price component (B)	0.0026*	0.0013*	–0.0011*
	(0.0004)	(0.0004)	(0.0003)
Slow price adjustment component (C)	0.0237*	0.0193*	–0.0039
	(0.0054)	(0.0036)	(0.0024)
Unexplained component (D)	0.0368*	0.0498*	–0.0221*
	(0.0055)	(0.0050)	(0.0026)

Note: The table reports change in dispersion (standard error in parentheses). * denotes significant at 5% level in two-sided *t*-test.

5.4.1. Results are similar with population-weighted least squares. The regressions we report treat each location equally. However, perhaps we should give more weight to major cities. We check the robustness of our results by examining whether they are especially driven by smaller cities. We re-estimated the models using weighted least squares. The weights for each city are given by the average population over the sample period. Our findings from these regressions are nearly identical to those from the unweighted estimation.

6. CONCLUSIONS

Our findings do not support a claim that the introduction of the euro has increased integration of markets in the Eurozone when we measure integration by the dispersion of prices across cities. Why has there not been such an effect?

One possible answer is that it is too early to tell. Our data on prices only go through the Spring of 2003, and the data on some of our explanatory variables are only available through 2002. This gives us a very small window for investigating the effects of the euro. Furthermore, there may have been large effects from the introduction of euro notes and coins in 2002 that we have not captured in our data.

A second possible explanation is that other developments in the European Union contributed greatly to market integration throughout the 1990s so that by 1999 the markets for consumer goods were already very highly integrated. While of course there are notable exceptions to this (such as the automobile market – see Goldberg and Verboven, 2003), the overall evidence is that there has been a gradual decline in price dispersion throughout the 1990s. Moreover, that decline is not explained by wages, taxes, or the business cycle, so that we infer it occurred as a result of the increased efforts at integration in the EU in the early part of the decade. In this respect, our conclusions are identical to those of Goldberg and Verboven (2003); while substantial deviations from the law of one price persist in the Eurozone countries, there has been much progress toward integration.

We have noted that most of the price convergence we observe in our sample occurred in the early part of the 1990s, concurrent with the implementation of the Single Market Programme. There were of course many other facets of convergence in the 1990s. Rogers (2002) notes that harmonization of fiscal and monetary policies played a role in leading to greater market integration. But we have not found any special role for the introduction of the euro in 1999. It may be that the greatest effects of market integration come not from the adoption of the euro *per se*, but from the commitment toward harmonization of monetary policy. Alternatively, it may be that firms, in anticipation of the euro, harmonized prices before 1999. Also, monetary policy in the Eurozone converged throughout the 1990s. Indeed a precondition for adopting the euro was convergence of monetary policy. In the end, one cannot rule out the possibility that the introduction of the euro led to greater integration and convergence of prices, but that its effects were felt prior to 1999.

Discussion

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Banca d'Italia

The question this paper addresses is quite relevant to policy-makers, and the ECB seems to attribute significant importance to the issue of price level convergence. This is evident in official publications ('the introduction of the euro and technological advances such as the Internet are further promoting cross border price transparency and lowering information costs, thus contributing to more integrated euro area product markets which, in turn, *should reduce price level dispersion in the euro area*', ECB *Monthly Bulletin* August 2002) as well as in key speeches by members of the ECB Executive Board (see, for example, Padoa Schioppa, 2002 on the EU enlargement and inflation differentials in a wider monetary union).

In my discussion, I wish to raise two general questions and a few specific comments on the empirical analysis.

General issues

First, I wonder whether it is meaningful to compare price level dispersion statistics across the exchange rate regimes that we had in the 1990s and since EMU. The first half of the 1990s was marked by large nominal exchange rate movements among Eurozone currencies, notably the exchange rate crises of 1992 and 1993. The second half was marked by the gradual fall in volatility along the glide path to the euro's launch in 1999, as Figure 7 shows. Given that nominal exchange rate movements usually imply real exchange movements (since prices are relatively stickier), I am not sure that the drop in real price level dispersion that we see in the authors' calculations can be entirely attributed to the Single Market Programme, as the authors suggest, and not instead to currency realignments.

Second, I would have liked to see some more discussion from the authors regarding the inflation divergence that the Eurozone has experienced since the launch of the euro, as shown in Figure 8. There are two points here, both of which are related to the natural connection between changes in price level dispersion and differences in nations' inflation rates. First, since nominal exchange rate fluctuations were disappearing in the run up to the euro's introduction *and* national inflation rates were converging, the slowdown in the pace of price convergence that the authors observe in the run up to the euro could be caused by a purely macro phenomenon – the convergence of inflation rates. Second, since Eurozone members' inflation rates did diverge post-euro, one might have expected to observe an increase in price dispersion. The absence of this effect suggests that euro pricing might well have had a convergent effect. In short, it might be that the authors observe no decrease in price

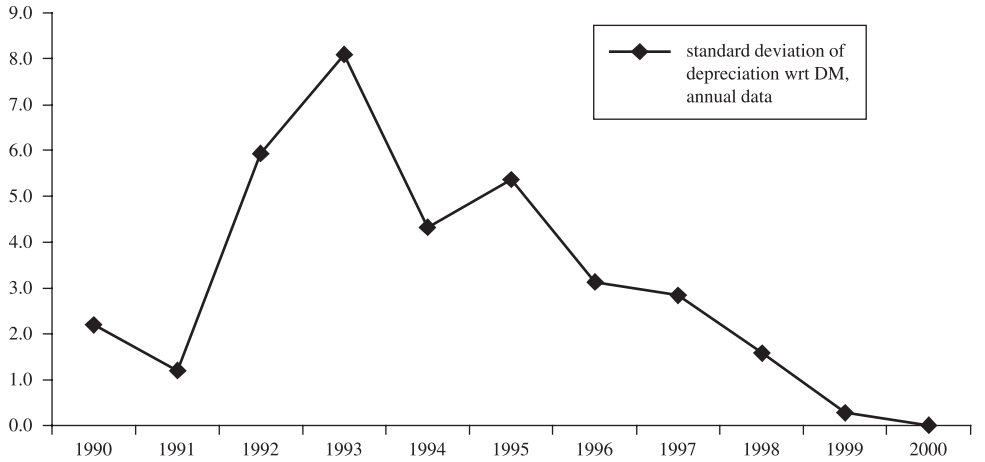

Figure 7. Volatility of Eurozone currencies, 1990–2000

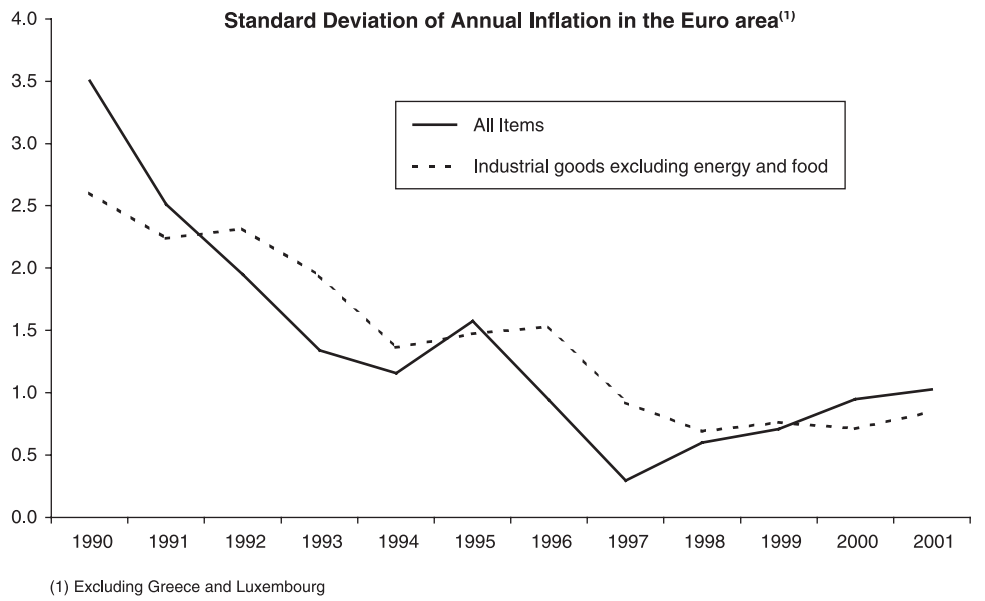

Figure 8. Convergence and divergence of Eurozone inflation rates, 1990–2001

dispersion because the euro had a convergent effect that offset the post-euro inflation divergence shown in Figure 8.

Their dataset would allow them to check this by constructing some 'pseudo-CPI' from their price levels, and check whether the same kind of inflation divergence is there too. I consider this a useful and simple extension that would be natural to undertake as a preliminary to any further and more structural investigation into the 'determinants' of inflation differentials (e.g. the Honohan and Lane 2003 paper on

inflation divergence in the last issue of *Economic Policy*, or previous papers by the authors themselves).

Detailed comments

Regarding the empirical analysis, my comments concerned mainly the lack of a clear motivation as to why they conduct a fully fledged regression analysis, after having found unconditionally that no price level convergence occurred after 1998. The authors seem to argue that controlling for 'other' factors in their regressions EMU might have played a positive role in the convergence of prices. However the factors they control for (income per capita, taxes etc.) are not *a priori* expected to play a counteractive role, and therefore to mask the effective role of EMU.

In particular their claim, 'Even controlling for these other factors, the euro does not seem to matter' (Section 5.3.1), seems out of place since, *a priori* I would have expected to find nothing new with respect to the unconditional results. The potential sources of divergence, such as differences in national inflation rates, are not included in their regressions.

In conclusion I believe that the paper is still important in providing some unique insights in a phenomenon that is relevant for policy, and to date, still little explored considering the scarcity of good data sets on price levels.

Karen Helene Midelfart

Norwegian School of Economics and Business Administration and CEPR

European integration, in terms of reduced barriers to trade and mobility, fixed exchange rates and eventually the EMU, is expected to allow the forces of arbitrage to eliminate price differentials for consumer goods across Europe's countries. With this as their point of departure, the authors analyse a detailed data set of prices of consumer goods in European cities in order to assess what impact EMU has had on product market integration within Europe. Their objective is thus to see whether introduction of the euro has led to elimination of price differentials across Europe.

The topic of the paper is highly relevant from a policy perspective, and the data set on hand without doubt is extraordinary suitable for the analysis undertaken.

Their findings are relative surprising: the authors conclude that price dispersion across the EMU countries fell from 1990 to 2001 for the vast majority of goods in the sample, i.e. goods market integration has increased in the EMU countries since 1990. However, very little – if any part – of the decline in price dispersion is found to coincide with the introduction of the euro. As they split the goods in the sample up into group, this does not change the major findings. Nor when they control for other factors that may have had an impact on the evolution of price dispersion, do the authors track any impact of the euro.

My comments relate to presentation and motivation for the paper, to the empirical analysis that is undertaken to control for the influence of other factors than the euro

on price dispersion, as well as to the particular product markets one has chosen to analyse.

The paper starts out with a relatively short introduction to motivate the analysis. The authors should provide a better motivation for exactly *why* the issues that are dealt with in the paper are of major interest from an economic policy point out view. They should moreover review existing empirical evidence in this area.

The introduction lacks clarity and structure. Although one does indeed understand what the issue at stake is, the authors should be much more explicit in formulating the main question that they are addressing, and what exactly their motivation is for asking this question. Does one want to develop a better measure of economic integration, or is the aim to measure whether the euro has implied enhanced integration?

The authors moreover compare their analysis to studies of the impact of the euro on trade. However, their comparison appears slightly confusing, since studies of price dispersion and studies of trade cannot be regarded as substitutes in the sense that they are just different ways of measuring economic integration. Introduction of the euro may impact on one or the other or both. And although the authors' findings suggest that the euro has not had any impact on price convergence in the EMU, this does not contradict recent results on its impact on trade – and the gains thereof.

In an earlier version, the paper lacked a theory section that could provide a basis for the empirical analysis undertaken to see whether taking into account other factors would reveal an impact of the euro that summary statistics did not allow to disclose. Such a theory section has now been included, but its value added is not obvious.

First, one might question whether the chosen theoretical specification is suitable for the analysis of price dispersion in Europe. The model is, for instance, based on the assumption that the final good is a composite of a tradable good and non-traded component, the latter taken to represent marketing and distribution. One assumes that the tradable and non-tradable elements have fixed cost shares, i.e. do not vary over time. However, as European integration is indeed expected to have an impact on cost related to transport and border crossing, this assumption seems inappropriate.

Second, as the authors take the model to the data the link between the theoretical model and the empirical model that is estimated is rather weak. A structured overview of the relationships between variables in the theoretical specification and those used for estimation seems to be a minimum requirement.

Third, one may indeed question the data employed to measure both the tradable as well as the non-traded element of final goods. To proxy for the former, the authors appear to be using (?) a measure for openness. But why openness should be correlated with price of the tradable element is not clear at all. It is in any case easy to come up with good examples of the opposite; this would typically apply to small, open but remote, economies in Europe. The authors use local wages (among others?) to proxy for the non-trade element. But since this element is supposed to pick up distribution which also has an international dimension, this choice is not necessarily well qualified.

Fourth, given the number of explanatory variables that are kind of thrown in, one would definitely want to see a correlation matrix, as one may indeed suspect the presence of multicollinearity.

Fifth, the authors use a data set of which represents a subset of the available data set on consumer goods, having excluded a range of non-traded goods. As also follows from the discussion about distribution costs above, the tradability of different goods has, however, changed over the period of observation. Hence, a more thorough discussion of the principles underlying the construction of the data set, and the issue of changing tradability would be required.

Turning to the results from the empirical analysis, we see that hardly any of the included variables turn out to have a significant impact on price dispersion. Hence, it can hardly be said to come as a big surprise when the authors in the subsequent analysis conclude that taken into account a set of (insignificant!) explanatory factors, does not change the results from the descriptive analysis.

Finally, if we accept the results presented in the paper on the (non-existing) impact of the euro on price dispersion in Europe, one is tempted to ask whether consumer markets are the one where we, *a priori*, would expect to see a significant impact. One may argue that effects are more likely to be traced in markets with professional buyers, i.e. markets for intermediates and capital goods. Further investigation of these markets would at least be a candidate for future research.

Panel discussion

Tito Boeri questions whether the date of currency adoption is the appropriate one to test against, or if rather the date when the parities were set might be more relevant. He suggests that there may be a learning period in either case and recommends a comparison with countries fixing currencies with the DM 15 years ago.

Richard Disney compared the analysis to an experiment with only one treatment and suggested that the authors might look at countries outside the euro-zone as a control group. Paolo Mauro and Stijn Claessens agreed with the need for a control group as did Jonathan Haskell, who observed that a control group would allow for the segregation of anticipation effects. Tullio Jappelli mentioned that Greece could function as a control. John Rogers agreed with the need for a control group, mentioning that this has been included in other analyses without changing the results.

Jonathan Haskell further wondered what, if not price convergence, was driving observed positive trade effects.

Tullio Jappelli would like to see further discussion of the comparison between the dispersion in prices in the US and the EU. In particular, that the dispersion on consumer goods prices was similar to that currently observed in the US, while there was much greater dispersion in financial goods. He speculated that this might be the

result of the diversion in regimes governing financial goods in the EU compared to the US. Richard Baldwin was also interested by the EU/US comparison, in his case that there seem to be an opposite phenomena to explain, that is the EU has a volume effect but no price effect, which is the opposite of the pass-through puzzles of the US.

Luigi Guiso questioned the absence of time effects in the regression, pointing out that there is an implicit assumption made that any changes in price levels during the period are due to the introduction of the euro, in particular mentioning inflation rate fluctuations over the period. Lorenzo Forni also wanted more discussion of the correlation between inflation dispersion and price dispersion.

In a second point, Luigi Guiso remarked that perhaps we are asking too much of the euro to end price dispersions, citing the large dispersions observed on one side of Rome versus the other. Paul Seabright picked up on this point, observing that prices bundle the price of the good with the implicit price of the service of providing the good in a certain area.

Marco Ottaviani questioned whether the data, exclusively from large cities, was representative.

APPENDIX

Table A1. List of traded items in EIU data

Food and non-alcoholic beverages: perishable	*Food and non-alcoholic beverages: Non-perishable*	*Alcoholic beverages*
White bread, 1 kg	White rice, 1 kg	Wine, common table (750 ml)
Butter, 500 g	Olive oil (1 l)	Wine, superior quality (750 ml)
Margarine, 500 g	Peanut or corn oil (1 l)	Wine, fine quality (750 ml)
Spaghetti (1 kg)	Peas, canned (250 g)	Beer, local brand (1 l)
Flour, white (1 kg)	Tomatoes, canned (250 g)	Beer, top quality (330 ml)
Sugar, white (1 kg)	Peaches, canned (500 g)	Scotch whisky, six years old (700 ml)
Cheese, imported (500 g)	Sliced pineapples, can (500 g)	Gin, Gilbey's or equivalent (700 ml)
Cornflakes (375 g)	Chicken: frozen (1 kg)	Vermouth, Martini & Rossi (1 l)
Milk, pasteurised (1 l)	Frozen fish fingers (1 kg)	Cognac, French VSOP (700 ml)
Potatoes (2 kg)	Instant coffee (125 g)	Liqueur, Cointreau (700 ml)
Onions (1 kg)	Ground coffee (500 g)	
Tomatoes (1 kg)	Tea bags (25 bags)	*Recreation*
Carrots (1 kg)	Cocoa (250 g)	Compact disc album
Oranges (1 kg)	Drinking chocolate (500 g)	Television, colour (66 cm)
Apples (1 kg)	Coca-Cola (1 l)	Kodak colour film (36 exposures)
Lemons (1 kg)	Tonic water (200 ml)	Internat. weekly news magazine (Time)
Bananas (1 kg)	Mineral water (1 l)	Internat. foreign daily newspaper
Lettuce (one)		Paperback novel (at bookstore)
Eggs (12)	*Clothing and footwear*	
Beef: filet mignon (1 kg)	Business suit, two piece, medium weight	*Personal care*
Beef: steak, entrecote (1 kg)	Business shirt, white	Aspirins (100 tablets)
Beef: stewing, shoulder (1 kg)	Men's shoes, business wear	Razor blades (five pieces)
Beef: roast (1 kg)	Mens raincoat, Burberry type	Toothpaste with fluoride (120 g)
Beef: ground or minced (1 kg)	Socks, wool mixture	Facial tissues (box of 100)
Veal: chops (1 kg)	Dress, ready to wear, daytime	Hand lotion (125 ml)
Veal: fillet (1 kg)	Women's shoes, town	Lipstick (deluxe type)
Veal: roast (1 kg)	Women's cardigan sweater	
Lamb: leg (1 kg)	Women's raincoat, Burberry type	*Household supplies*
Lamb: chops (1 kg)	Tights, panty hose	Toilet tissue (two rolls)
Lamb: stewing (1 kg)	Child's jeans	Soap (100 g)
Pork: chops (1 kg)	Child's shoes, dresswear	Laundry detergent (3 l)
Pork: loin (1 kg)	Child's shoes, sportswear	Dishwashing liquid (750 ml)
Ham: whole (1 kg)	Girl's dress	Insect-killer spray (330 g)
Bacon (1 kg)	Boy's jacket, smart	Light bulbs (two, 60 watts)
Chicken: fresh (1 kg)	Boy's dress trousers	Frying pan (Teflon or good equivalent)
Fresh fish (1 kg)		Electric toaster (for two slices)
Orange juice (1 l)		Batteries (two, size D/LR20)

Table A2. List of non-traded items in EIU data

Non-traded goods	Domestic cleaning help	Car insurance
Laundry (one shirt)	Maid's monthly wages	Regular unleaded petrol
Dry cleaning, man's suit	Babysitter	Taxi: initial meter charge
Dry cleaning, woman's dress	Developing 36 colour pictures	Taxi rate per additional kilometre
Dry cleaning, trousers	Daily local newspaper	Taxi: airport to city centre
Man's haircut	Three-course dinner	Furnished apartment: 1 bedroom
Woman's cut & blow dry	Seats at theatre or concert	Furnished apartment: 2 bedrooms
Telephone and line	Seats at cinema	Unfurnished apartment: 2 bedrooms
Electricity	Road tax or registration fee	Unfurnished apartment: 3 bedrooms
Gas	Tune-up	Unfurnished apartment: 4 bedrooms
Water	Moderate hotel, single room	Unfurnished residential house: 3 bedrooms
Business trip, daily cost	One drink at bar of hotel	Two-course meal for two people
Hilton-type hotel, single room	Simple meal for one person	Hire car

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