In Search of a Euro Effect: Big Lessons from a Big Mac Meal?

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Abstract: We investigate whether the adoption of the euro was accompanied by an increase in prices in member countries, and whether it promoted goods market arbitrage in the form of faster convergence to a common price. By comparing the experience of eurozone countries to non-euro European countries in a 'difference-in-differences' specification we net out effects on prices unrelated to the euro. We conclude that (a) there is no evidence of significant price increases associated with the adoption of the euro *even for food items*; and (b) there is little systematic evidence of a significant improvement in goods market integration following the euro's introduction.

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1. Introduction

This paper addresses two questions related to the effects of the euro using highly disaggregated price data. First, was the change-over to the euro associated with an increase in prices; and second, does the euro promote greater product market integration by lowering cross-border transaction costs and speeding up arbitrage?

On January 24, 2002, in the same month in which the physical euro was rolled out in the eurozone, the International Herald Tribune reported that "the price increases are showing up at cafes and supermarkets and in taxis, leading economists to speculate that the countries sharing the single currency may be headed for a nasty inflation surprise …". Dziuda and Mastrobuoni (2006) note that around 70 percent of citizens in the 12 eurozone countries felt that prices had increased upon its introduction, and they provide some evidence of price increases. On the other hand, according to official sources (EUROSTAT, 2003), the price change after the introduction of the euro was either non-existent or very modest. This disagreement suggests another look at the data is warranted. In contrast to existing studies, which rely on a before-and-after comparison around the time of the euro changeover, our approach to addressing the first question utilizes a difference-in-differences framework - to compare the change in the price levels in the eurozone countries before and after the adoption, with other European non-adopters during the same period. This has the advantage of netting out global (e.g., oil price) or regional effects on prices that, e.g., Bergin and Glick (2006), find are important. This simple idea of using difference-in-differences turns out to make a significant difference in the conclusion: while there was indeed an increase in the prices of food items in the euro countries around the euro changeover, the increase was no greater than what could be observed in non-euro countries.

As a prominent euro-skeptic, Feldstein (1997) argued that the adoption of a common currency would impose large costs on its members in terms of the loss of flexibility of having separate monetary policies tailored to the needs of individual member countries. The question is whether the euro will promote goods market integration sufficiently and provide enough additional benefits to make it worth the trouble. Rose (2000), with data on the volume of trade, and Parsley and Wei (2003), with a metric of market integration based on price dispersion, conclude that currency boards or currency unions generally do provide a stimulus to goods market integration that goes well beyond merely reducing exchange rate volatility to zero.

By now, enough years have passed since the physical euro was introduced in January 2002 that a fresh examination of the data might bring more clarity to questions related to effects of the euro. Additional motivation for this study comes from the stated desires of several of the new European Union members to adopt the euro in the future. Existing evidence is mixed, in part because the physical launch of the euro was not the only development occurring around January, 2002. To name just a few, other potential influences on prices around this time include the spreading hoof and mouth and mad cow diseases, severe winter conditions, and the escalation of tensions in the middle-east subsequent to the terrorist attacks on the United States.

Crucial for a study like this, is to focus on price data which relate to products that are physically identical, or nearly so, across countries and over time. It is well known that a computer in 2004 was not the same thing as a computer in 2000; so, comparing the prices of computers to gauge the extent of price convergence over time would be tenuous at best. Similarly, a typical French four-door passenger car may not be the same as a typical Portuguese version. Consequently, our strategy is to focus on a narrowly defined set of products that are nearly identical across time and space, so as to minimize the effects of non-comparable products on our inferences.

Our strategy is to look at the prices of a Big Mac Meal and of its ingredients in twenty five European countries (twelve of whom adopted the physical euro by 2002, plus thirteen European countries using their own national currencies). The price of Big Mac Meals is informative and illustrative because it is itself a basket (the weights of its constituents can be easily inferred following the methodology in Parsley and Wei, 2007), and thus similar to national Consumer Price indexes (CPIs), but importantly it is an identical basket across countries, unlike CPIs compiled by national statistical agencies. An additional advantage of using the price of Big Mac Meals and the associated ingredients is the ability to compare price levels directly. Cross-country differences in price levels are impossible to measure using CPIs. Hence, the only cross-country conclusions one could make using CPIs concern relative inflation rates over time. Only under the very restrictive assumption that prices were equal in the base period, does information about inflation rates imply information about price levels.

In a related study that does not examine the effects of the euro (Parsley and Wei, 2007), we find that movements in Big Mac real exchange rates track CPI based real exchange rates reasonably well: that is, Big Mac real exchange rates are typically highly positively correlated with CPI-based real exchange rates – both in levels, and in first differences. That study's sample included countries in Africa, Asia, the Pacific, the Americas, as well as several European countries, and found that the high correlations are not driven by high-inflationary episodes/countries, and that one cannot reject the hypothesis that Big Mac and CPI based real exchange rates are cointegrated. In the current paper, we build upon these results and focus on the price and real exchange rate impacts of the euro introduction using a new data set which includes the prices of Big Mac Meals, and their ingredients, in twenty-five European countries since 1993.

Another important precursor to this paper is Engel and Rogers (2004), who find that much of the decline in European price dispersion occurred in the early 1990s, substantially before the introduction of the euro, and there is no additional decline post-1999 (when the prices began to be listed in both national currencies and the euro) or post-2002 (when the physical currency was introduced). It is important to note that their data set stopped in 2003, and the full effects of the euro may not have materialized in so short a time. Hence it is useful to see whether their conclusions continue to hold in the period since 2003[1].

The rest of the paper is organized as follows. Section 2 describes our data on prices across Europe. Section 3 investigates the question of whether the changeover to the euro was associated with a jump in prices. Section 4 examines whether the changeover to the euro is associated with any pickup in the speed of convergence toward the law of one price. Section 5 concludes.

2. Data description

The price data we use in this study was compiled by Mercer Human Resource Consulting.[2] While the price survey is similar to another produced by the Economist Intelligence Unit (EIU), there are also some differences. First, Mercer reports data semi-annually (for 257 cities as of 2006) as compared to only once per year in the EIU data, and the

[1] Beyond this question however, there are additional differences between Engel-Rogers (2004) and the current paper. Engel and Rogers do not examine whether there was an increase in the price level associated with the changeover to the euro, nor do they examine whether the speed of convergence to the law of one price has increased in the eurozone relative to the non-euro European countries.
[2] Information about Mercer and the Cost of Living Survey is available on-line at http://www.imercer.com/default.aspx?page=surveydetail&surveyid=2454&newRegionId=3

Mercer data report three observations per city according to where the data were collected: a low price outlet, a medium price outlet, and a high price outlet. We used the information from these three outlets as part of the data checking. In particular, we manually check the largest percentage price differences between the low- and medium-price outlets, and the medium- and high-price outlets. We also looked at all price changes that exceed 25% in absolute value, that were reversed in the following period. When we could find obvious typo (e.g., a temporary rise in the price level by more than 500%), we used the average of the prices at t-1 and t+1. Similarly, we linearly interpolated data for prices missing no more than two time periods using the valid before and after observations.

[Insert Table 1 here]

For this study we focus on the twenty-five European countries listed in Table 1. The data is semi-annual (March and September) from September 1993, to March 2006. The ten (standardized by weight, volume, or by description) ingredients of Big Mac Meals we have data on are: beef, cheese, lettuce, onions, bread, coke, potato, labor, rent, and energy. To preview the results, these ingredients collectively account for 94% of the variation of Big Mac Meal prices in the sample.

3. Does the change-over to the euro raise prices?

Our goal in this section is to formally test whether prices increased following the introduction of the euro – as suspected by a majority of euro-country citizens according to Dziuda and Mastrobuoni (2006). What kind of economic theory could produce a price jump associated with the changeover the euro? One candidate is the "menu cost" theory of sticky prices a la Akerlof and Yellen (1985) and Mankiw (1985). If menu costs are what prevents firms from making continuous adjustments to prices in response to changes in supply and demand, a mandatory change in currency denomination may induce firms to go straight to their optimal prices, rather than simply converting an old price in a national currency to a new price using the pre-specified exchange rate. Note that the menu cost theory would imply that some prices could fall (if the previous prices were set on a forward looking basis), and in any case, any increase in the price level should be temporary. Menu costs, or transaction costs more generally, might also result in 'round number' pricing, especially at the retail level, since cash transactions using round numbers involve less change-making. Moreover, since it is often presumed that such pricing results in rounding up, rather than rounding down, the euro switchover may have acted as a coordinating mechanism whereby most prices simultaneously got rounded up.

Another source of euro-induced price effects has been suggested by Ehrmann (2006), who argues that prices might rise (at least in some sectors) due to information processing costs. The idea is that in areas (e.g., groceries) where consumers make a multitude of purchases, the costs of making price conversions from the old to the new currency can quickly rise. Since firms must make the calculations only once per item, while each individual consumer is confronted with a differing portfolio of calculations, consumers become rationally inattentive. Ehrmann argues that this disparity in information processing costs can be exploited by firms to extract higher prices.[3] Moreover these effects are increasing in the complexity of the currency conversion. He finds some support for this theory by comparing across eurozone countries (but not with non-euro countries).

[3] Post euro introduction however, it is not clear why a conversion is relevant. That is, after the introduction of the euro, consumers presumably compare prices, e.g., across stores in euros, thus obviating the need for conversion.

As an empirical starting point we first compute average prices (in U.S. dollars) for the twelve eurozone countries. The data set is a three-dimensional panel (twenty-five countries, twenty-six time periods, and eleven prices), which makes summarizing the price changes a bit challenging. Over the 1993-2006 sample period the non-traded components all recorded large cumulative price increases: energy costs (47%), rent (37%), and labor (46%). The traded components had much wider variation: beef (13%), bread (5%), cheese (4%), Coca Cola (22%), lettuce (33%), onions (29%), and potatoes (71%). Somewhat surprisingly (given the attention it gets due to the Economist magazine articles), the average price of a Big Mac Meal rose 66% over the time period.

Another useful way to summarize the data is to compare the Big Mac Meal with its ingredients. In particular, in Figure 1 we plot the trends in (average) prices of the Big Mac Meal, and of its' traded, and non-traded components separately. In order to construct the average traded-, and non-traded prices we rely on the fact that Big Mac Meals are the same across countries, and across time. Then, we estimate each ingredient's implied weight in the Big Mac Meal 'basket' using all the price data and all the time periods according to methodology outlined in Parsley and Wei (2007). Specifically, we estimate a cost function and apportion shares of a Big Mac Meal's price to each of its ingredients.[4] In particular, suppose there are <u>exactly</u> n inputs; and the production function is Leontief:

$$1 \text{ Big Mac Meal} = \min \{x_1, x_2, ..., x_n\} \quad (1)$$

Let $P_{k,t}^{\text{Big Mac Meal}}$ be the price of a Big Mac Meal in country k at time t, and $P_{k,j,t}$ be the price of input j in country k at time t. Then,

$$P_{k,t}^{\text{Big Mac Meal}} = \sum_j P_{k,j,t}\, x_j \quad (2)$$

[4] Parts of this section are based on Parsley and Wei (2007).

To be precise, here we use the term "input" broadly to also include an additive profit markup – which, without loss of generality, can be the last "input." That is, we could let x_n=1, and $P_{k,n,t}$ = the additive profit markup in country k at time t. Expressed in this way, equation (2) is an identity.

Suppose we observe $P_{k,t}^{\text{Big Mac Meal}}$ and $\{P_{k,j,t}\}$ for a sufficient number of time periods and countries, (or, to be precise, when the number of locations times the number of time periods ≥ n), then it is a matter of simple algebra to solve for all x_i, i=1,2,..., n. In fact, a convenient way to solve for $\{x_1, x_2, ..., x_n\}$ would simply be a linear regression of $P_{k,t}^{\text{Big Mac Meal}}$ on $\{P_{k,j,t}\}$. The regression in this case is not a statistical tool, but an algebraic one. Since equation (2) is an identity, the R^2 =100%. Of course, we do not literally have price information on every single ingredient of a Big Mac Meal. For example, we do not have information on cooking oil, pickles, sesame seeds, or "special sauce". However, we assume that, in terms of their shares in the total cost of a Big Mac Meal, these missing items are relatively unimportant when compared with the items for which we do have information, such as beef, labor costs, rent, bread, etc.

[Insert Table 2 here]

With these points in mind, we regress the price of a Big Mac Meal on the prices of the ten main inputs, and report the results in Table 2. According to the regression, 26% of the price of a Big Mac Meal is attributable to Beef. Collectively, tradable ingredients account for about 75% of the meal's price.[5] These estimated implied cost shares then are the weights we use when combining ingredients into traded-, and non-traded price indexes (September 2001=100), which are plotted in Figure 1 (*Panel a*). In the figure, there appears to be a clear

[5] The Big Mac Meal's traded ingredients include: Beef, Bread, Cheese, Coke, Lettuce, Onions, and Potatoes; its non-traded components are: Labor, Energy, and Rent.

increase in prices in the eurozone subsequent to the introduction of the euro, thus confirming the survey results that European citizens felt there were price increases. It is useful to note that these price increases cannot be attributed to quality, measurement, or aggregation issues that plague price indexes; that is, here we are computing the price indexes using identical constituents and identical weights on an unchanging, identical 'basket' and its inputs. However, it is not yet clear these price increases can be attributed to the introduction of the euro. That is, the euro is but one of many possible culprits for the observed price rises.

[Insert Figure 1 here]

As an initial check, we plot the same three indexes for the European countries which did not adopt the euro in our sample in *Panel b* of Figure 1. Immediately apparent is that, with the exception of non-tradeables, a similar phenomenon occurred among the non-eurozone European countries. Since it is implausible that the introduction of the euro is responsible for price increases in, e.g., Bulgaria, Cyprus, Norway, etc., the figure hints that something else may be behind the post-2002 price increases. That said, the figure is only suggestive, it could still be the case that prices in the eurozone rose by a greater amount than prices outside the eurozone. Hence we now turn to a formal analysis that compares price developments within the eurozone, to those in the other European, but non-euro countries. For this, we use a difference-in-differences specification to minimize the chance that our results are related to events unrelated to the adoption of the euro.

Formally, we do a sequence of standard t-tests over different annual horizons following the introduction of the euro. For completeness, we consider two events: the January-1999 use of the euro as an accounting currency alongside with national currencies, and the January-2002 actual introduction of the physical euro banknotes and coins. [For

Greece, the accounting euro was introduced in January 2001 but the physical euro was introduced at the same time as the other euro countries.] We look at the cumulative price change from 1998 to 1998+s, where s = 1, 2, …, 8 and compare the price change in the eurozone versus non-euro-zone. We do the same for the 2002 event. Specifically, for each product *j*, we define the change in price as: $x_s = p_{t+s} - p_t$., where p is expressed in natural logarithms, and p_t is the price at date t, just prior to the introduction of the euro (September 1998, or September 2001). There are eight years of post-euro experience using 1999, and five years using 2002. We repeat this computation for each good.

To implement a statistical test, we pool traded inputs and non-traded inputs separately, and for each horizon regress the percentage changes on good dummies and a euro dummy for countries adopting the euro. To be clear, at each horizon we pool the percentage price changes for all twenty-five cities, for goods (traded/non-traded) in that category. Thus the traded goods regression has 175 observations (price changes for 25 cities x 7 traded inputs); and there are eight horizons post 1998, and five horizons post 2001. Similarly, for each horizon, the pooled nontraded regression has 75 observations (25 x 3 non-traded inputs). We pool the data simply to increase statistical power, and pooling traded and non-traded goods separately allows the estimated euro effect to differ according to whether the input was traded or nontraded. For each horizon, the test statistic is just the coefficient on the euro dummy in this pooled cross-sectional regression.

[Insert Figure 2 here]

Our results are summarized in Figure 2 (*panels a - f*), where the percentage change in relative (euro/non-euro) prices is plotted (on the vertical axis) against the horizon on the horizontal axis). The results strongly suggest that the introduction of the euro was not associated with an increase in prices (at least none that was unique to eurozone countries), and our conclusion does not matter whether we date the introduction of the euro at 1999, or 2002.

Together, the results in figures 1 and 2 beg the question: if not the euro, what was the reason for rising prices in Europe post-2002? Though beyond the scope of this paper, we can gain some insight from figures 3 and 4 (both use data from the April 2007, World Economic Outlook data base). Figure 3 plots Crude oil prices since 1980, and Figure 4 plots world (non-fuel) commodity prices. Evident in the figures is a sharp rise both in oil, and in commodity prices, though the more rapid price increases seem to have begun later, perhaps as late as 2004. These figures suggest that the price movement in both euro and non-euro countries are consistent with global oil and commodity price movements; there is not a separate euro-changeover effect..

[Insert Figure 3 here]

[Insert Figure 4 here]

4. Does the euro promote faster price convergence?

A common currency can affect goods market integration by lowering transaction costs, eliminating exchange rate volatility, increasing trade and foreign investment, and promoting greater transparency in prices. In this section, we look at two different aspects of goods market integration. First, we ask how the cross-country dispersion of *prices* of the Big Mac Meal, and of its ingredients has evolved over time. One advantage of focusing on the Big Mac Meal as the aggregate here is that it allows us compare price dispersion of the aggregate, to the price dispersion of the constituents of that aggregate. In particular, we are interested in the dispersion of both traded and nontraded ingredients, and how they might differ from or contribute to overall price dispersion.

Convergence in dispersion closely corresponds to the idea of '$\sigma -$convergence', as described by Barro and Sala-i-Martin (1995) and Sala-i-Martin (1996) in their studies of cross-sectional income dynamics. The use of price level observations (as opposed to price indexes) makes an analysis of $\sigma -$convergence possible and informative. A second aspect of convergence that we study in this section is the persistence of deviations from the law of one price for the Big Mac Meal and for each of its ingredients. This type of convergence is related to the concept of $\beta -$convergence in economic growth empirics. Unlike studies of $\beta -$convergence using CPI-based real exchange rates however, in this study it is not necessary to presume a base year when parity held.

We compute the coefficient of variation for each of the Big Mac Meal's ten inputs separately, and then aggregate the traded and non-traded inputs separately using the input share weights determined in Section 3 above. In Figure 5, we plot cross-country price dispersion (as measured by the coefficient of variation) of prices for the Big Mac Meal *(panel a*), for the traded inputs (*panel b*), and for the non-traded inputs (*panel c*), over time.

[Insert Figure 5 here]

The first thing to notice is that the dispersion among the countries in the eurozone is uniformly lower than in other European countries even before the euro was introduced. This holds for the aggregate Big Mac Meal, as well as for its traded and non-traded constituents separately. This is consistent with larger differences in incomes, economic development, competitive conditions, information asymmetries, etc. among the non-euro European countries. Secondly, dispersion for the Big Mac Meal is very similar to that for its traded inputs, and the euro/non-euro differences are wide here as well. However, there appears to be more negative correlation in the trends in Big Mac Meal dispersion between euro and non-euro countries, than for either traded or non-traded inputs.

Two other trends appear evident from the figure. First, dispersion has fallen for non-traded inputs in the eurozone over the entire sample, and it has also fallen for the Big Mac Meal for non-eurozone countries, and the trend for both has accelerated since 2000. Overall however, there does not appear to be a clear shift in dispersion around the time of, or even subsequent to the introduction of the euro. Engel and Rogers (2004) report no tendency for prices to converge after January 1999 though their data set ends in 2003. There are some new twists in our more up-to-date data. Namely, (a) we find that non-traded input prices do continue to converge (for eurozone countries) after the euro introduction, and (b) we find that trends in dispersion in non-eurozone countries appear different from those in the eurozone, especially for the aggregate Big Mac Meal, and perhaps for non-traded inputs. All in all, however, the euro introduction is not systematically associated with a significant drop in price dispersion.

Next we turn to the persistence of deviations from the law of one price for the Big Mac Meal and for its ingredients. Define the (log) real exchange rate – or percentage deviation from the law of one price in this case – at time *t* as: $q_t = s_t + p_t^* - p_t$, where s_t is the domestic currency price of foreign exchange, p_t^* is the foreign price of Big Mac Meals, and p_t is the domestic price of Big Mac Meals; all variables are expressed in natural logarithms, and all real exchange rates are measured relative to Germany.

Figure 5 and the discussion surrounding price dispersion indicate that absolute price dispersion in non-eurozone countries is larger than in the eurozone. If transaction costs are similar throughout Europe, this suggests that mean reversion may be different depending on whether a country is in, or out of the eurozone. We pursue this eurozone/non-euro distinction further in Table 3. Specifically, the equation estimated is:

$$\Delta q_{i,t} = \textit{country and time dummies} + \beta_1 \, q_{i,t-1} + \beta_2 \text{euro} * q_{i,t-1} + \varepsilon_{i,t} \tag{3}$$

[Insert Table 3 here]

This model is estimated by a fixed effects regression (with heteroskedasticity consistent standard errors in parentheses) for the Big Mac Meal real exchange rate, and each of the ten input-based real exchange rates. In this specification, $\hat{\beta}_1$ measures persistence outside the eurozone, and $\hat{\beta}_2$ measures the difference between persistence in the eurozone versus outside, hence the sum $\hat{\beta}_1 + \hat{\beta}_2$ measures persistence in the eurozone. Somewhat surprisingly, according to Table 3, persistence in the eurozone is similar to that in non-euro countries except for onions, potatoes, rent, and for the Big Mac Meal real exchange rate, where mean reversion seems substantially higher (except for potatoes). That is, despite the greater dispersion outside the eurozone, mean reversion does not appear faster. This suggests the euro may indeed promote greater goods market integration. However, these results may be misleading since we have not explicitly considered transaction costs and nonlinear adjustment. We turn to this next.

A major statistical progress in the literature on the law of one price and real exchange rate in the last decade is the recognition that the existence of arbitrage/transaction costs induces a non-linearity in the convergence speed: convergence tends to be faster for a bigger initial departure from the long run steady state. In Table 4, we estimate persistence by explicitly accounting for non-linearities in mean reversion. O'Connell and Wei (2002) and Sarno and Taylor (2002) argue that estimates of persistence obtained from a linear regression are biased upward, since such estimates are essentially averages of two regimes: very low speed of convergence for deviations smaller than the transaction costs, and possibly much faster convergence for larger deviations. These authors have addressed the problem of lumping data from two regimes by estimating a threshold autoregression (TAR) model. As O'Connell and Wei (2002) note, if transaction costs create a band of no-arbitrage, TAR models provide a more powerful way to detect global stationarity – even if the true price behavior does not conform to the TAR specification. Here, we follow Parsley and Wei (2007) and represent the non-linear process as an "equilibrium threshold autoregressive model" (or Eq-TAR for short). The basic Eq-TAR model takes the form:

$$\Delta q_t^* = \begin{cases} \beta q_{t-1}^* + \varepsilon_t, & \text{if } \left|q_{t-1}^*\right| > |c| \\ \varepsilon_t, & \text{if } -c \le q_{t-1}^* \le c \end{cases} \tag{4}$$

Since we reject the hypothesis that country fixed effects are zero in the linear specifications reported in Table 3, we remove the long run means from q prior to estimation, and designate the de-meaned variable as $q*$. According to the Eq-TAR model, convergence occurs toward the center of the band. TAR models allow the real exchange rate to have a unit-root inside the transaction cost band. Once the real exchange rate exceeds the transaction cost parameter (c), the real exchange rate reverts at rate, $1-\beta$. The Eq-TAR model would characterize behavior if fixed costs are an important part of impediments to arbitrage.

Since we are interested in differences between eurozone and non-eurozone persistence we modify equation 4, and allow for (i.e., estimate) four distinct convergence parameters: (1) non-euro countries prior to the euro, (2) eurozone countries prior to the euro, (3) eurozone countries subsequent to the introduction of the euro, and, (4) non-eurozone countries subsequent to the introduction of the euro. We use 2002 as the euro introduction date here; our results do not differ qualitatively if we use 1999 as the cutoff. Thus the equation we estimate becomes:

$$\Delta q_t^* = \begin{cases} \beta_1 q_{t-1}^* + \beta_2 q_{t-1}^* europre02 + \beta_3 q_{t-1}^* europost01 + \beta_4 q_{t-1}^* noneuropost01 + \varepsilon_t, & \text{if } q_{t-1}^* > c \\ \varepsilon_t, & \text{if } -c \le q_{t-1}^* \le c \\ \beta_1 q_{t-1}^* + \beta_2 q_{t-1}^* europre02 + \beta_3 q_{t-1}^* europost01 + \beta_4 q_{t-1}^* noneuropost01 + \varepsilon_t & \text{if } q_{t-1}^* < -c \end{cases} \quad (5)$$

Following the discussion in Franses and van Dijk (2000), estimation is done via sequential conditional least squares. Procedurally, we try out a set of possible values of *c* one by one (via a grid search) and, for a given value of *c*, estimate a pooled OLS regression. Starting with an initial value of *c* at 0.001, the search adds 0.001 in each successive round until *c* reaches the 75th fractile of the distribution of $|q^*|$. This results in roughly 200 estimations per good. The model with the minimum residual sum of squares is reported in Table 4. Overall, the estimates of convergence are faster in these non-linear specifications, as one would expect. Obstfeld and Taylor (1997) report thresholds of between 8 and 10% – while those in the table (for de-meaned *q*) are generally closer to those reported in Sarno and Taylor (2004) and Parsley and Wei (2007), who examine more disaggregated data.

[Insert Table 4 here]

In the first four columns, the estimates for $\beta_1, \beta_2, \beta_3, \beta_4$ are presented, along with their standard errors in parenthesis, for each of the ten inputs and for the Big Mac Meal real exchange rate. In the next two columns the estimate of the size of the band (c) and the number of observations are given. Among tradeables, the bands are smallest for potatoes and onions, but curiously they are roughly the same size for non-tradeables and for the Big Mac Meal. Finally, in the last four columns, test statistics and *p*-values are given. In particular in the first three columns, tests of the hypothesis that mean reversion is statistically significant in the period given are displayed.

There are three conclusions one can make from this table. First, mean reversion among eurozone countries was already quicker than non-euro countries in the pre-2002 period, for most items. Second, convergence increased for both eurozone and for non-euro countries in the post-2001 period. What we see is that there is generally more mean reversion in the post-2001 period than before (judging by the number of statistically significant coefficients). Finally in the last column in Table 4 we test the hypothesis that eurozone convergence increased by more than that in non-euro countries. As can be seen, in only two cases do we reject the hypothesis of no difference in the changes (before and after the euro introduction) between the euro and non-euro countries; in one case the good is traded (potatoes) and the other is non-traded (rent). Thus, even with the benefit of five years after the adoption of the euro, there does not appear to be any overwhelming evidence that mean reversion increased (or decreased) for eurozone countries more than other European countries. So all in all, the euro does not appear to be a watershed event in terms of promoting market integration among its member countries. After all, direct policies on dismantling trade barriers, which apply to non-euro European countries as well, are perhaps more important for market integration than the introduction of a common currency.

5. Concluding thoughts

The paper examines whether/how the adoption of a common currency in Europe affects the levels of prices and the speed of arbitrage. We ask two questions. The first is whether the changeover to the euro was accompanied, as many believe, by an increase in prices of member countries. We examine a three-dimensional panel of prices of Big Mac Meals and ten of its constituents, in twenty-five European countries since 1993. In order to net out global or regional effects on prices not related to the adoption of the euro, we compare the experience of eurozone countries to non-euro European countries in a 'difference-in-differences' specification. We perform statistical tests of this hypothesis for all years following the euro adoption and conclude there is no evidence of price increases that one can attribute to the adoption of the euro. Secondly, we ask whether there is evidence that the euro has promoted greater product market integration by lowering cross-border transaction costs. We examine trends in price-level dispersion as well as in persistence of good-level real exchange rates, again using a difference-in-differences specification. We find little evidence of significant increases in goods market integration following the introduction of the euro. In conclusion, the lack of a significant euro effect on prices suggests that the adoption of a common currency has no significant inflationary consequence and is perhaps not as important as direct trade policies in promoting market integration in Europe. Of course, the adoption of the euro may have other benefits (or costs) that are outside the scope of this paper.

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Figure Legends

Figure 1: Prices in the eurozone countries

(Panel a)

(Panel b)

Figure 2: Did the change-over to the euro raise prices?

(Panel a)

(Panel b)

(Panel c)

(Panel d)

(Panel e)

(Panel f)

Figure 3: Oil Price Trends

Figure 4: Commodity Price Trends

Figure 5: Dispersion of Price levels: Eurozone versus other Europe

(Panel a)

(Panel b)

(Panel c)

Table 1: Countries included

euro	*non-euro*
Austria (Vienna)	Bulgaria (Sofia)
Belgium (Brussels)	Cyprus (Limassol)
Finland (Helsinki)	Czech Republic (Prague)
France (Paris)	Denmark (Copenhagen)
Germany (Frankfurt)	Hungary (Budapest)
Greece (Athens)	Norway (Oslo)
Ireland (Dublin)	Poland (Warsaw)
Italy (Rome)	Slovakia (Bratislava)
Luxembourg (Luxembourg)	Slovenia (Ljubljana)**
Netherlands (Amsterdam)	Sweden (Stockholm)
Portugal (Lisbon)	Switzerland (Geneva)
Spain (Madrid)	Turkey (Istanbul)
	United Kingdom (London)

** Slovenia adopted the euro January 2007.

Table 2: Cost Function Estimation for Big Mac Meals: (1993 – 2006)

This table reports a panel regression of the price of a Big Mac Meal on its ingredients. [1]Coefficient estimates and standard errors (in parenthesis) are multiplied by 100, and the estimation method is random effects panel regression. [2]The share attributed to the ith ingredient is computed as: $\hat{\beta}_i \overline{P}_i / \overline{P}_{Big\ Mac\ Meal}$, where $\overline{P}_i$ is the average price of the ith input.

	Coefficient Estimates [1]	Implied Cost Share (%) [2]
Traded:		
Beef	15.520	25.9
	(2.260)	
Bread	34.985	17.4
	(7.277)	
Cheese	0.193	0.3
	(1.549)	
Coke	74.311	14.1
	(22.768)	
Lettuce	9.172	5.2
	(3.276)	
Onions	0.663	0.1
	(11.908)	
Potatoes	77.218	12.7
	(14.731)	
		75.7
Nontraded:		
Labor	7.091	12.1
	(2.260)	
Energy	0.097	4.7
	(0.061)	
Rent	0.002	1.7
	(0.004)	
	Total =	94.3
# of observations	547	
Adjusted R-squared	0.817	

Table 3: Persistence Estimates: Pooled Sample Euro and Non-Eurozone

This table estimates equation 3, i.e., $\Delta q_{i,t} = country\ dummies + \beta_1 q_{i,t-1} + \beta_2 \text{euro} * q_{i,t-1} + \varepsilon_{i,t}$ where q is the log real exchange rate (relative to Germany). The regression is performed for each ingredient as well as for the Big Mac Meal. Heteroskedasticity standard errors are in parenthesis.

	β_1		β_2	R^2	observations
Beef	-0.047		-0.010	0.026	590
	(0.021)		(0.033)		
		$\beta_1 + \beta_2$	-0.057		
			(0.025)		
Bread	-0.203		-0.027	0.161	587
	(0.024)		(0.044)		
		$\beta_1 + \beta_2$	-0.230		
			(0.037)		
Cheese	-0.235		-0.050	0.105	589
	(0.036)		(0.056)		
		$\beta_1 + \beta_2$	-0.285		
			(0.043)		
Coke	-0.228		-0.019	0.086	590
	(0.033)		(0.057)		
		$\beta_1 + \beta_2$	-0.248		
			(0.047)		
Lettuce	-0.622		0.143	0.245	590
	(0.055)		(0.076)		
		$\beta_1 + \beta_2$	-0.479		
			(0.052)		
Onions	-0.059		-0.155	0.049	590
	(0.019)		(0.053)		
		$\beta_1 + \beta_2$	-0.213		
			(0.049)		
Potatoes	-0.215		0.149	0.149	590
	(0.021)		(0.058)		
		$\beta_1 + \beta_2$	-0.066		
			(0.054)		
Rent	-0.121		-0.261	0.063	590
	(0.031)		(0.069)		
		$\beta_1 + \beta_2$	-0.382		
			(0.062)		
Labor	-0.279		0.018	0.114	588
	(0.037)		(0.059)		
		$\beta_1 + \beta_2$	-0.262		
			(0.045)		
Energy	-0.284		-0.043	0.145	503
	(0.034)		(0.057)		
		$\beta_1 + \beta_2$	-0.327		
			(0.045)		
Big Mac Meal	-0.289		-0.114	0.139	590
	(0.043)		(0.064)		
		$\beta_1 + \beta_2$	-0.403		
			(0.047)		

Table 4: Persistence Estimates: Equilibrium TAR Specification

This table presents estimates from the following equation:

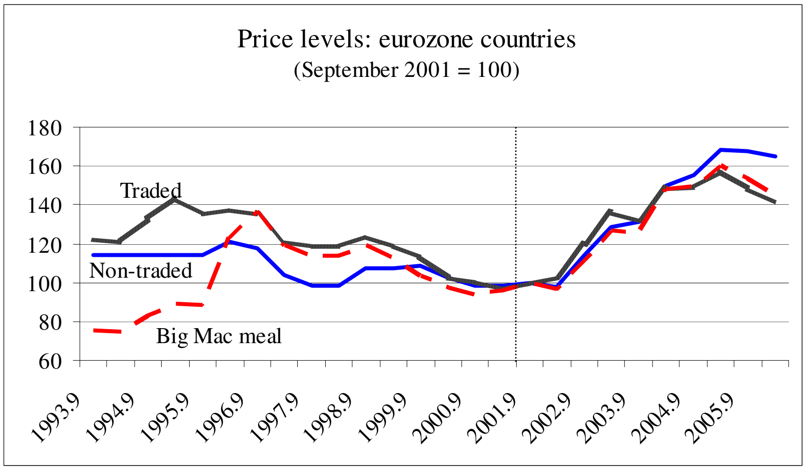
$$\Delta q_t^* = \begin{cases} \beta_1 q_{t-1}^* + \beta_2 q_{t-1}^* europre02 + \beta_3 q_{t-1}^* europost01 + \beta_4 q_{t-1}^* noneuropost01 + \varepsilon_t, & \text{if } q_{t-1}^* > c \\ \varepsilon_t, & \text{if } -c \le q_{t-1}^* \le c \\ \beta_1 q_{t-1}^* + \beta_2 q_{t-1}^* europre02 + \beta_3 q_{t-1}^* europost01 + \beta_4 q_{t-1}^* noneuropost01 + \varepsilon_t & \text{if } q_{t-1}^* < -c \end{cases}$$

*, ** = significant at the 5%, and 10% levels respectively.

	Coefficient Estimates (standard errors)						Test statistic (p-value)		Test statistic (p-value)	Test statistic (p-value)
	non-euro	euro	euro	non-euro			Euro countries		Non-euro countries	Ho: euro - noneuro
	pre-2002	pre-2002	post-2001	post-2001	BAND	OBS	pre-2002	post-2001	post-2001	change = 0
Beef	-0.010	-0.016	-0.092	-0.143 *	0.014	481	-0.387	-1.909 **	-3.294 *	0.350
	(0.030)	(0.076)	(0.061)	(0.057)			(0.699)	(0.057)	(0.001)	(0.555)
Bread	-0.266 *	0.003	-0.071	-0.050	0.023	448	-5.320 *	-4.301 *	-6.018 *	0.073
	(0.031)	(0.058)	(0.084)	(0.042)			(0.000)	(0.000)	(0.000)	(0.787)
Cheese	-0.302 *	-0.080	-0.056	0.014	0.031	450	-6.023 *	-4.146 *	-6.030 *	0.007
	(0.060)	(0.087)	(0.105)	(0.053)			(0.000)	(0.000)	(0.000)	(0.934)
Coke	-0.265 *	-0.083	-0.071	-0.053	0.018	477	-5.044 *	-3.273 *	-4.318 *	0.245
	(0.038)	(0.079)	(0.110)	(0.064)			(0.000)	(0.001)	(0.000)	(0.621)
Lettuce	-0.731 *	0.069	0.047	-0.051	0.060	421	-8.981 *	-6.988 *	-9.338 *	0.067
	(0.070)	(0.102)	(0.120)	(0.063)			(0.000)	(0.000)	(0.000)	(0.796)
Onions	-0.022	0.005	0.004	0.027	0.010	413	-0.609	-0.469	0.170	0.430
	(0.025)	(0.037)	(0.045)	(0.021)			(0.543)	(0.639)	(0.865)	(0.512)
Potatoes	0.021	-0.012	-0.016	0.063 *	0.008	483	0.378	0.176	3.385 *	4.823 *
	(0.021)	(0.032)	(0.036)	(0.017)			(0.706)	(0.860)	(0.001)	(0.029)
Labor	-0.046	-0.005	-0.029	0.005	0.007	528	-1.527	-1.684 **	-1.084	0.355
	(0.032)	(0.046)	(0.055)	(0.027)			(0.127)	(0.093)	(0.279)	(0.552)
Energy	0.074	-0.010	0.091	-0.012	0.007	555	0.944	1.751 **	0.769	1.169
	(0.068)	(0.096)	(0.116)	(0.058)			(0.345)	(0.081)	(0.442)	(0.280)
Rent	-0.146 *	0.161 *	0.154 *	0.124	0.011	370	0.319	0.136	-0.445	3.790 **
	(0.043)	(0.064)	(0.073)	(0.034)			(0.750)	(0.892)	(0.657)	(0.052)
Big Mac Meal	0.002	-0.056	-0.121	0.010	0.008	542	-0.828	-1.397	0.152	0.564
	(0.068)	(0.094)	(0.109)	(0.058)			(0.408)	(0.163)	(0.879)	(0.453)

Figure 1: Prices in the eurozone countries

(Panel a)



(Panel b)

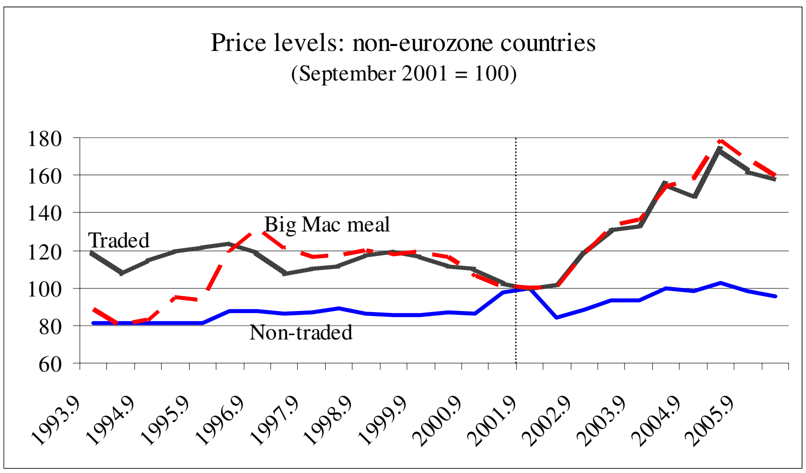
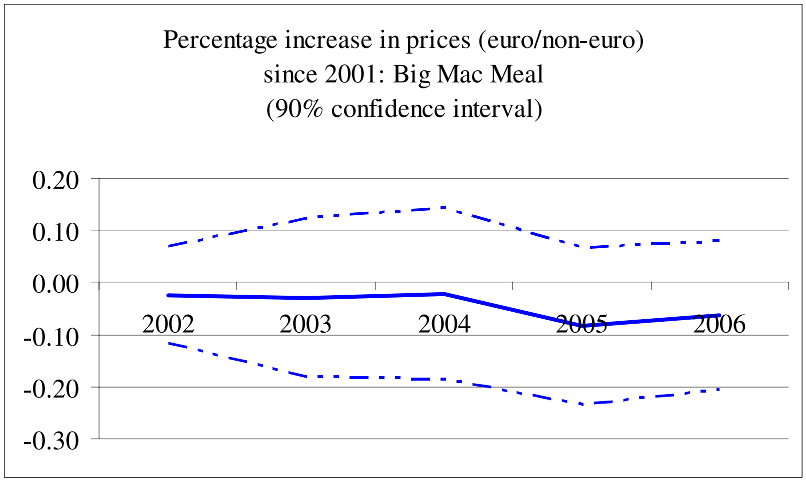


Figure 2: Did the change-over to the euro raise prices?

(Panel a)



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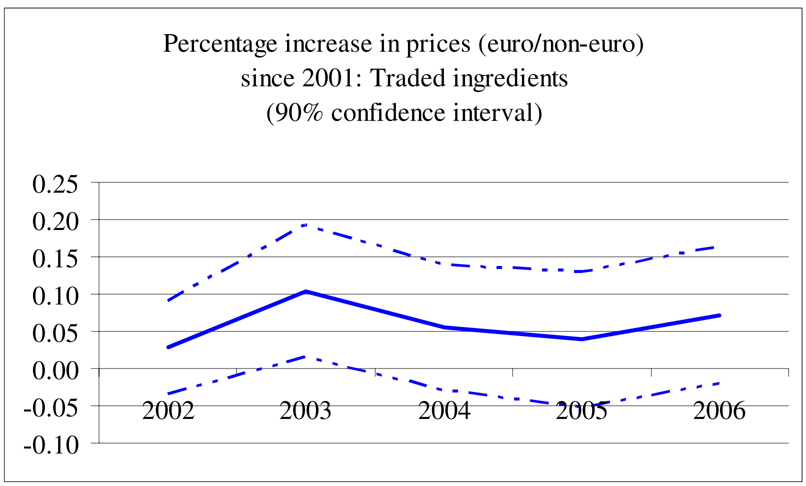


(Panel c)

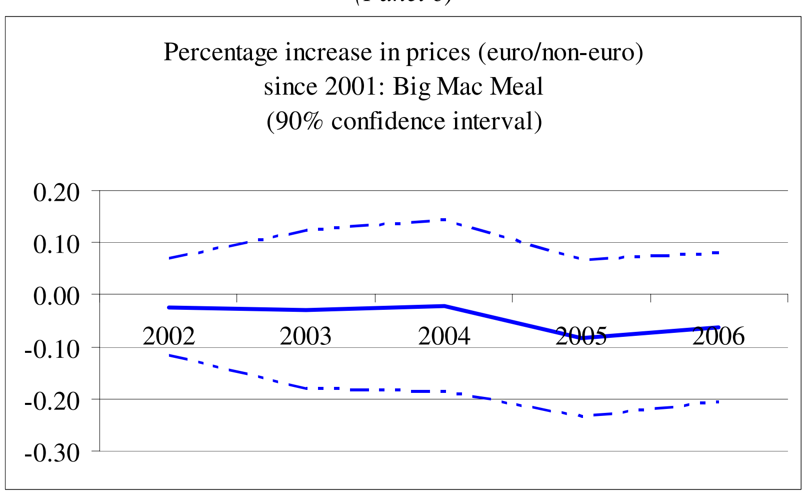
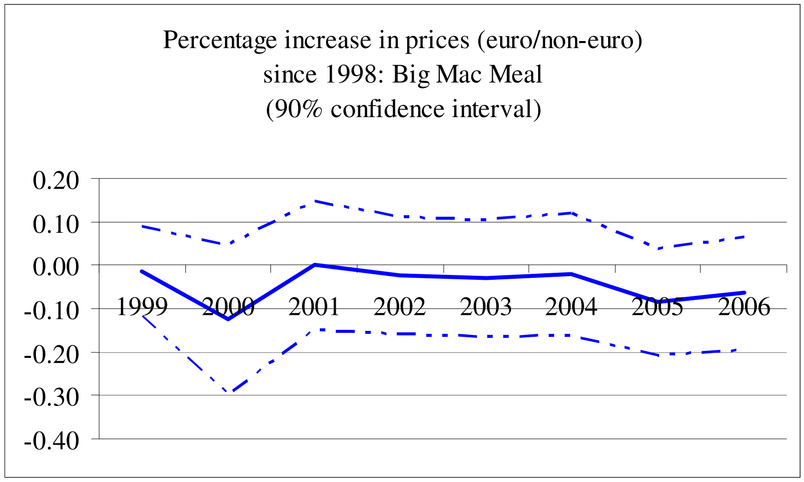
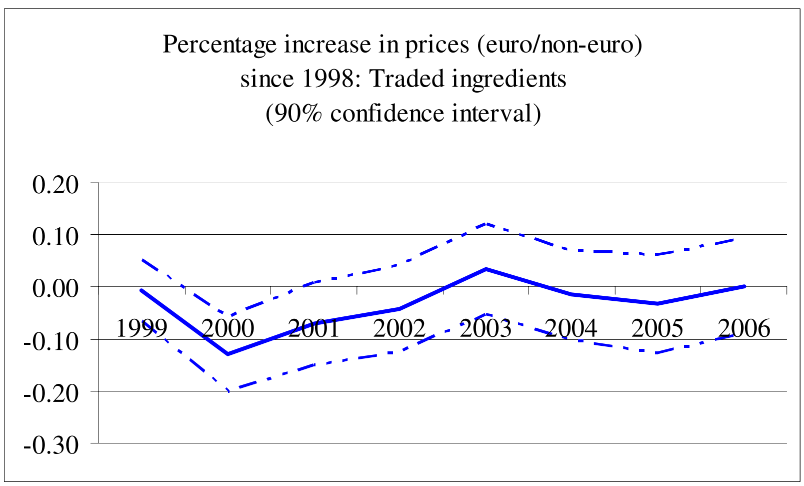


Figure 2: Did the change-over to the euro raise prices?

(Panel d)



(Panel e)



(Panel f)

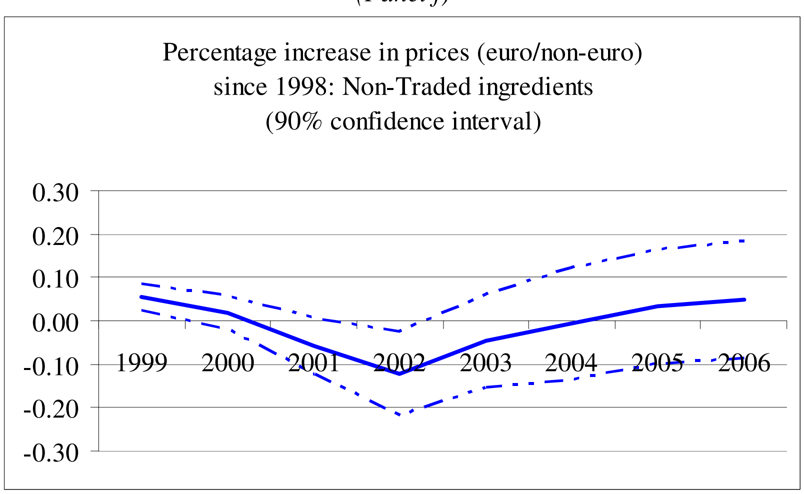


Figure 3: Oil Price Trends

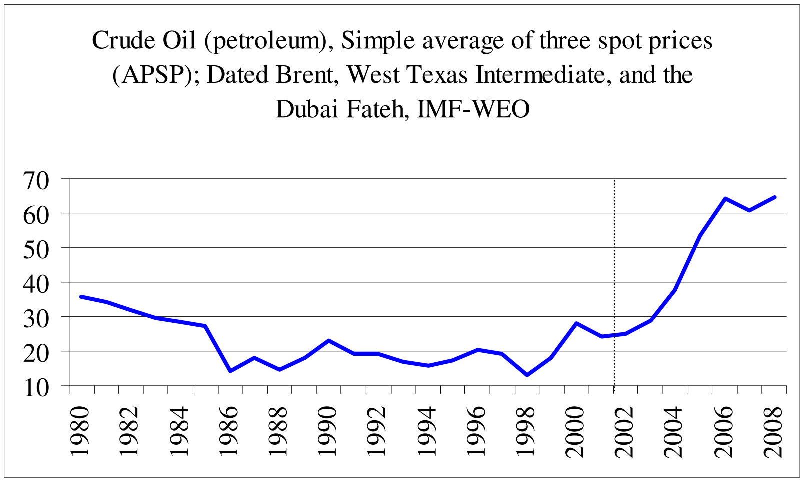


Figure 4: Commodity Price Trends

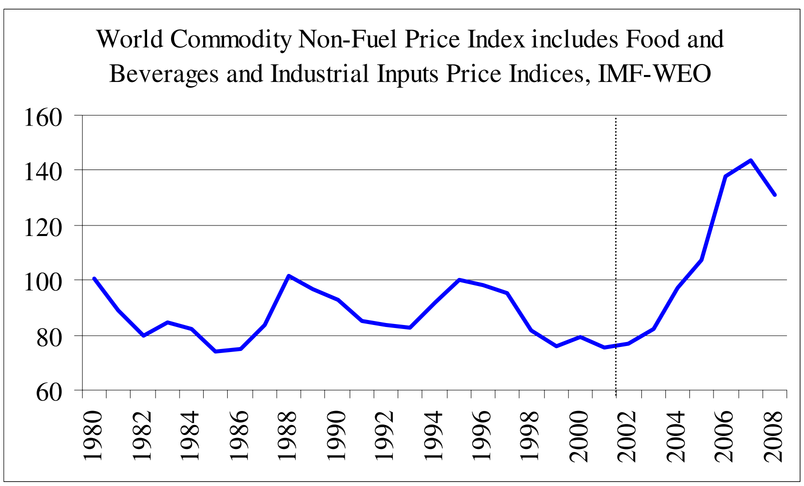
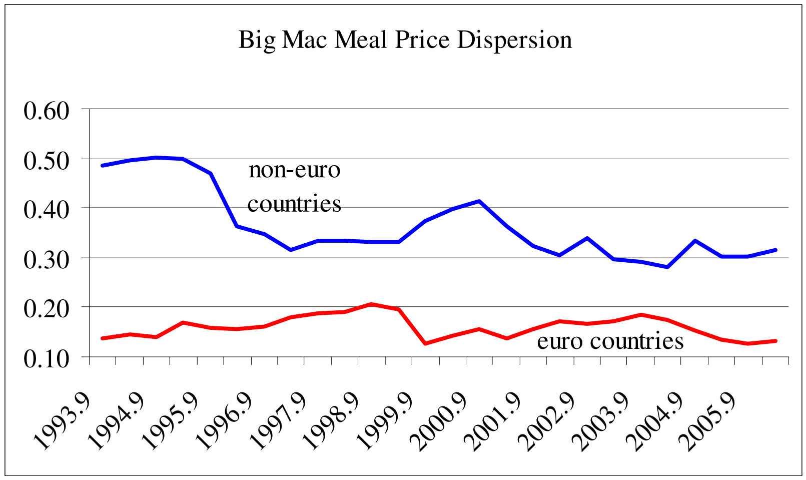
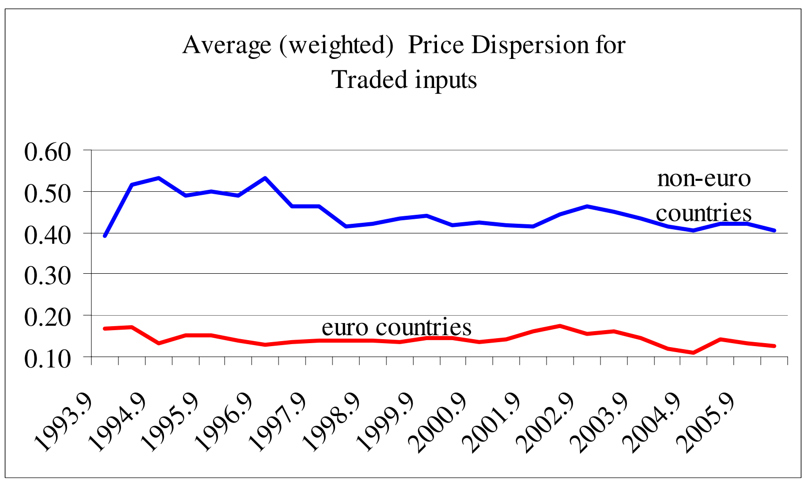


Figure 5: Dispersion of Price levels: Eurozone versus other Europe

(Panel a)



(Panel b)



(Panel c)