Price dispersion and the Euro *

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Abstract

What is the impact of monetary unions on the integration of good markets? We address this issue by investigating the effect of the Euro on the price discrimination of French exporters. We adopt a difference in difference strategy and estimate that the single currency reduced the relative dispersion of export prices in the Euro area by 3 percentage points in comparison to the rest of the European Union. However, we show that the single currency has disproportionably affected large/more productive firms. When we take into account this heterogeneity, we find a much stronger impact of the Euro, of 17 percentage points.

Key words.

JEL Classification: F10; F15; F30.

*We would like to thank...

1 Introduction

More than ten years after the creation of the European Monetary Union (EMU), it becomes possible to empirically assess how the monetary integration has affected market equilibria in Europe. By furthering market integration, EMU was expected to impact trade patterns within the monetary zone as well as between EMU and the rest of the world; this is the well-known *Rose effect*.[1] Another manifestation that has been less investigated in the empirical literature is the impact of EMU on the dispersion of prices. According to the law of one price (LOOP), an integrated market should have a unique price for each (properly defined) product. And deviations from this unique price can be related to the degree of economic integration. Anything furthering market integration, notably the creation of a currency union, is expected to induce a convergence toward the LOOP.

This idea was one of the arguments that proponents of the monetary integration were pushing forward. On its website, the EU Commission was thus assessing that the Euro was going to increase price transparency, mute exchange rate fluctuations between members, and increase competition.[2] Altogether, those effects were expected to ease arbitrage behaviors, reduce markups, and in turn lower price dispersion. This paper proposes an empirical test of the previous price convergence effect, asking whether the introduction of the Euro has induced a reduction in the dispersion of prices inside the Euro area.

The test is conducted using export data describing the prices set by French exporting firms in each of their destination markets. The sample is quasi-exhaustive, covering the universe of French exporters over the period from 1996 to 2005. For each firm, detailed information is provided about its bilateral exports, including the price set in each single market, before any transportation cost is added. These "Free On Board" (FOB) prices are interpreted as reflecting the pricing strategy of the firm.

At the firm- and product-level, the data exhibits quite a huge amount of price dispersion across (OECD) destination markets. Surprisingly, the magnitude of price discrepancies is al-

[1] See Rose (2000) or Baldwin, DiNino, Fontagné, Santis & Taglioni (2008).

[2] See: $http://ec.europa.eu/economy_finance/euro/why/consumer/index_en.htm$

most unchanged once the sample is restricted to EU destinations. These price discrepancies are attributable to French exporters discriminating their foreign markets, even within a fairly well integrated area. Would arbitrage be perfect, such price differentials would be unsustainable. We thus interpret the dispersion of prices as evidence of deviations from the LOOP. Based on this, we ask whether the introduction of the European common currency has reduced such deviations, leading to a convergence of prices between European markets, within firms.

Our results indicate that the Euro adoption has significantly reduced the price discrimination of French firms toward EMU countries. Using a difference-in-difference strategy with the rest of the European Union as control group, we show that the relative price dispersion in the Euro area is reduced by about 5 percentage points due to the single currency. Though significant, the quantitative effect we obtain is thus small. However, we also document an heterogeneity across firms in the size of price discrimination and the effect of the Euro. In particular, we show that large firms have been more impacted by the single currency: while they tend to discriminate more than the average firm before EMU, the dispersion of their prices has strongly reduced after the Euro has been introduced. Given that these firms account for the lion's share of French exports, their behaviors are likely to matter at the aggregate level. When we account for the heterogeneity across firms, we indeed find a much larger impact of the Euro on price dispersion.

This empirical analysis is related to a large literature testing how market integration affects the magnitude of deviations from the LOOP. With respect to this literature, our main contribution is to provide empirical evidence that are directly interpretable in terms of micro-level price strategies. This is not the case of product-level studies[3] that are not able to identify the producer of the goods which prices are observed. In such studies, the price effect of the monetary integration identified in the data is related to mean prices of a given product category converging across countries after the common currency has been introduced. But the convergence can be due to two alternative factors: either did the common currency change the extent of price

[3]See among others Lutz (2003) and Engel & Rogers (2004). Both find that the introduction of the Euro has had a small to negligible effect on price dispersion and price convergence.

discrimination, or did it affect the composition of the local supply, with an end effect on mean prices. Both explanations are observationally equivalent at the product-level, while they are not at the firm-level. The price convergence we observe in our data can directly be interpreted as evidence of exporting firms adjusting their pricing strategies following the institutional shock.[4]

In the literature, a few papers are able to identify the identity of the producing firms, and test how EMU has affected their pricing policies. These studies focus on very specific products, the European automobile market in Goldberg & Verboven (2001) and Gil-Pareja & Sosvilla-Rivero (2008) and electronic products sold online in Baye, Gatti, Kattuman & Morgan (2006). These studies find contrasted results for the price impact of the Euro. Namely, EMU is found to increase the convergence of prices in the automobile industry but not for electronic products. While cars and electronics are interesting products, the drawback of using data on a single product is clearly related to the lack of generality for the results. Our results instead cover a very broad array of products.

The paper is also in line with recent studies evaluating the gain from EMU integration using firm-level trade data (Fontagné, Mayer & Ottaviano 2009). The novelty of this approach is that it allows asking how institutional shocks are perceived by firms and whether their individual responses are heterogenous. In that respect, our paper is closely related to Méjean & Schwellnus (2009). They study the convergence of prices within and outside the EU and how it is affected by extensive versus intensive adjustments. We instead explicitly focus on the natural experiment of monetary integration that EMU provides and study price differentials across countries rather than the dynamics of relative prices.

Finally, our paper is related to Berman, Martin & Mayer (2009). Their estimates suggest that more productive exporters adjust more their markup and less their volume than less productive ones following an exchange rate shock. We also document such an heterogeneity in firms' pricing strategies following macroeconomic shocks.

[4] As a related advantage over the literature, our dataset provides us with price data which *level* is interpretable. Instead, a number of papers is forced to focus on the time path of relative prices, based on price indices (Engel 1993, Engel & Rogers 1996). Crucini, Telmer & Zachariadis (2005) emphasize that the LOOP is better suited for an interpretation in terms of levels rather than in terms of price changes.

The rest of the paper is organized as follows. The next section discusses the theoretical channels through which the introduction of the Euro may impact the extent of price discrimination. Section 3 describes the data and provides some stylized facts. Section 4 presents the empirical strategy and details the results. Section 6 concludes.

2 Theoretical background

This section details the different mechanisms through which the introduction of the Euro may impact firms' price discrimination. By definition, a firm price discriminates if she sets different prices depending on the market she serves. According to Knetter & Slaughter (1999), price discrimination is due to i) differences in characteristics of demand across markets that provide incentive to discriminate, and ii) the ability of firms to exploit those differences in presence of arbitrage costs. There is no obvious reason why the introduction of a single currency should affect consumer preferences, thus the incentive for firms to price discriminate. However, monetary integration is expected to affect the cost of arbitrage over markets, therefore the ability of firms to price discriminate.

Arbitrage behaviors are the main barriers to price discrimination. As noticed by Asplund & Friberg (2001), the introduction of the Euro is expected to enhance these behaviors for two reasons. First, price comparisons are made easier when prices are expressed in the same currency. Second, transaction costs, such as conversion costs, decrease or disappear. The strengthening of arbitrage behaviors should dampen the ability for firms to price discriminate and reduce price discrepancies.

These convergence forces may not be felt identically by all firms, however. In particular, the impact of reducing currency-related barriers to arbitrage is going to be all the stronger since these barriers are an important component of overall barriers to arbitrage for consumers of the firm's product. If, on the contrary, arbitrage is complicated because of physical reasons (high transportation costs), or the differentiation of products (e.g. instructions for the product to be edited in the local language), there is no reason to believe that price convergence will be severely

affected by EMU. Since the nature of barriers to arbitrage is product and even firm-specific, one can expect EMU to have a heterogenous impact on different firms.

This effect is potentially amplified by greater competition resulting from the monetary integration. If it pushes new firms to enter the market, monetary integration may have a pro-competitive effect.[5] This will force firms to price closer to their marginal costs, which mechanically reduces price dispersion. Once again, the impact of such a pro-competitive effect is likely sector- and even firm-specific.

In addition to its effect on the ability of firms to price discriminate, the Euro may affect the propension of firms to adopt such behavior. Friberg (2003) sketches a model in which firms have to pay a fixed cost to segment markets. In this framework, firms' optimal price is a function of the exchange rate and the option value of investing in the "segmentation" technology depends on the expected volatility of the exchange rate. The adoption of a single currency thus reduces firms' incentive to pay the fixed cost, and to price discriminate. Méjean & Schwellnus (2009) show that, in this context, price discrimination is not only a function of current macroeconomic conditions but also of the firm's characteristics. Once again, this suggests that the optimal reaction of firms to enhance market integration is likely heterogenous.

A last channel through which EMU may induce a convergence of prices across countries is the harmonization of psychological prices. This argument is discussed by Friberg & Matha (2004). The intuition behind is straightforward. Psychological prices differ depending on the currency in which the price is expressed. Adopting a single currency standardize those psychological prices, thus withdrawing this source of price dispersion.

The different mechanisms stressed in this section suggest that (i) the Euro should dampen firms' price discrimination and (ii) this effect may differ across firms. The remaining of the paper tests these two predictions.

[5] See Melitz & Ottaviano (2008) for the theory, and Chen, Imbs & Scott (2009) for empirical evidence on the pro-competitive effects of European integration.

3 Data and stylized facts

3.1 Data

We use an individual database of export flows provided to us by the French customs. The dataset covers the 1996-2005 period, which allows us to study export prices before and after the introduction of the Euro. Data are disaggregated by firm and product, at the 8-digit level of the Combined Nomenclature (CN8).[6]

Our measure of export prices is based on unit values, defined as the ratio of value over quantity for each bilateral flow:

$$P_{fkjt} = \frac{Val_{fkjt}}{Qty_{fkjt}}$$

where f, k, j and t respectively design a firm, a CN8 product, a destination market and a year between 1996 and 2005. Using firm and product data is particularly convenient when working on unit values because this price proxy is well-known to be biased by composition effects (Kravis & Lipsey, 1974). The more disaggregated trade data are, the more accurate the price proxy.

Even when working at the firm and product level, it may be the case that export unit values are biased. For instance, mis-declarations by French firms or reporting errors by the customs transmit into unit value errors. To account for this, we first apply an outlier treatment procedure to the raw data. Namely, we compute the median unit value for each product declared by a given firm in a particular year. We then delete unit values that are 5 times higher or lower than the firm and product-specific median.

At this stage, the sample includes 205,689 firms declaring a total exported value of 2.91 trillion Euros. We however reduce it further, to OECD destinations. Since we want to compare export prices in the eurozone with that of an appropriate control group, it is convenient to keep countries of comparable development level. Besides, we drop Greece from our sample. Greece

[6]The CN nomenclature is regularly updated, which is an issue when we want to follow products over time. Before starting working on the data, we thus apply the Pierce & Schott (2011) algorithm to harmonize CN8 categories over time.

entered the Euro area in 2001 which raises issues when building our treatment and treated groups. The resulting database contains 12,997,607 observations, over 10 years (1996-2005), covering 28 countries (OECD less France, Greece, and Luxembourg, which is merged with Belgium in the customs data), 195,208 firms and 8,987 products. The total export value is 2.39 trillion Euros.

Our measure of price dispersion aggregates the previously described firm- and destination-specific unit values at the level of the region. Namely, we compute the coefficient of variation of prices within the Euro area and in a control group:

$$cv_{fkrt} = \frac{stdev(\{P_{fkjt}\}_{j \in r})}{mean(\{P_{fkjt}\}_{j \in r})}$$

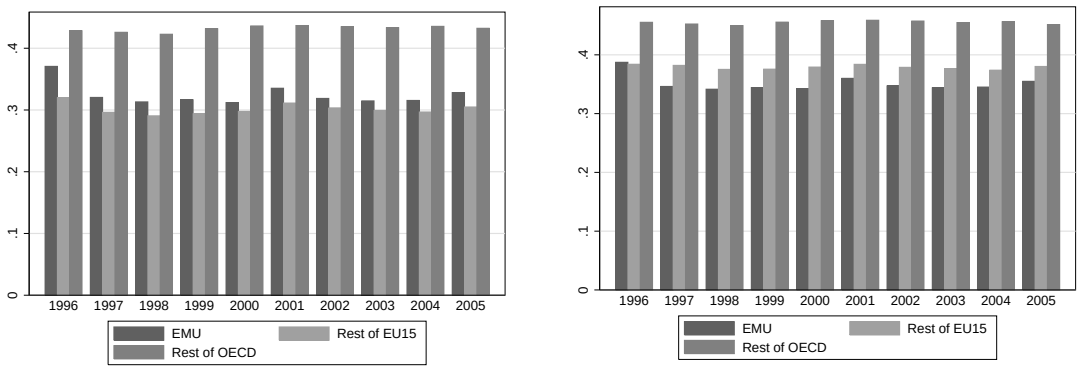
where r is the region under consideration (either the EMU or the control group), $stdev(\{P_{fkjt}\}_{j \in r})$ is the standard deviation of prices, computed over the set of countries in r, and $mean(\{P_{fkjt}\}_{j \in r})$ is the average price in r. This statistics thus indicates the extent of price discrepancies set by a given firm for a particular product across countries of the considered area, which we assimilate to a measure of price discrimination.

3.2 Stylized facts

As a first description of the extent of price discrimination, Figure 1 illustrates the time evolution of the average price dispersion for different geographic areas (namely the EMU, the rest of the OECD, and the rest of the EU15). Here, each bar corresponds to the simple average, computed over firms and products, of the price discrimination indicators obtained for the corresponding zone. Its size is thus correlated with the "mean" level of price discrepancies within the area.

This graphs shows that the dispersion of prices set by a given firm is low, on average, in the EMU. Namely, the mean coefficient of variation is equal to 43% outside the European Union. Price discrepancies are marginally smaller in the eurozone and even more in the rest of the European Union. On average, the mean coefficient of variation is equal to 32% in the EMU and 30% in the rest of the EU.

Figure 1: Average coefficient of variation, EMU vs Rest of the OECD



(a) Raw data

(b) Controlling for market access and wealth

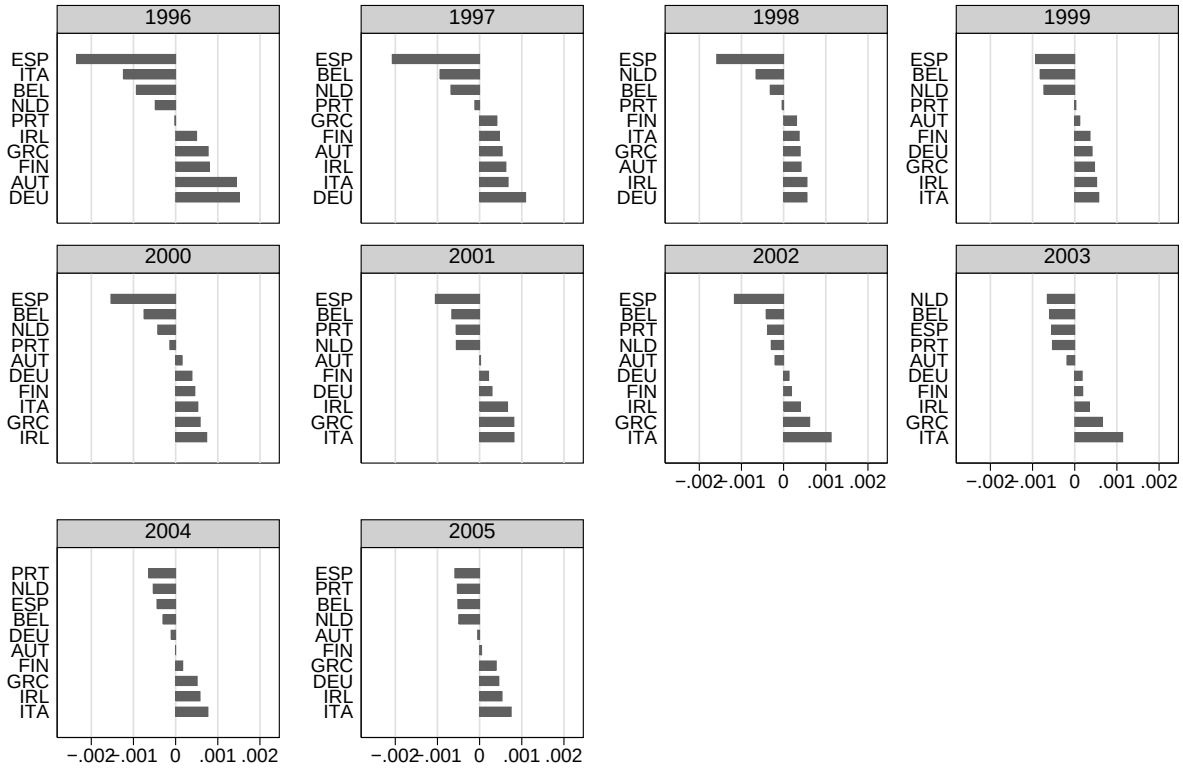
For every region the average coefficient is computed on the universe of French exporting firms. In panel (b), prices are purged from wealth and market access effects.

At first sight, it may seem surprising that the dispersion of prices is higher in the EMU than inside the rest of the EU15. Other sources of price heterogeneity, that are orthogonal to the monetary integration, may however explain the counter-intuitive result. Hummels & Lugovskyy (2009) thus show that export prices depend on both the size and the wealth of the destination country. Within a group of countries, heterogeneity in these two country-specific characteristics may thus create some price dispersion. We control for these determinants of price discrepancies in panel (b) of Figure 1. Namely, we first regress unit values on the country's GDP, its distance to France and its GDP per capita. The residuals of this regression can be interpreted as the component of prices that is unrelated to size, market access and wealth effects. They are used to compute price dispersion indicators that are orthogonal to the previously described structural determinants. Once the correction is applied, the counter-intuitive result disappears. Namely, the residual price dispersion is the lowest in the EMU, followed by the rest of the European Union and the rest of the OECD.

The ranking of areas in terms of aggregate price dispersion seems to hold throughout the period. However, Figure 2 depicting the distribution of *intra-EMU price discrepancies* over countries and time shows a process of gradual convergence. Here, each bar corresponds to the average price deviation with respect to the EMU average for the corresponding member of the

eurozone. The negative number obtained for Spain thus suggests individual firms tend to set lower prices, on average, on their Spanish market than in other EMU countries. Comparing these histograms over time shows that both negative and positive country-specific deviations reduce throughout the period. This suggests that intra-EMU prices tend to converge.

Figure 2: Price deviations with respect to the EMU mean, French sample

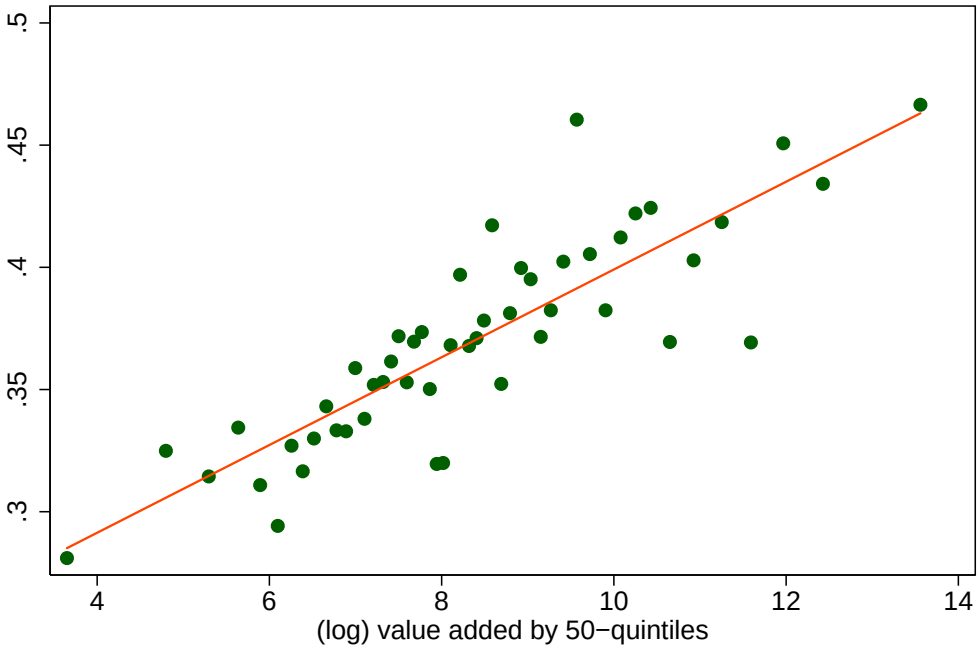


These average statistics thus suggest that French firms price discriminate across markets, that price deviations are lower toward EMU countries, and that, within the Euro area, price dispersion has decreased over time. Figure 3 goes deeper into the data, studying how these price behaviors vary across firms. Namely, we plot the size of price discrimination toward the Euro area by 50-quintiles of firms, ranked according to their value added, in 1996.[7] Within the population of French firms, more productive ones seem to have the most pronounced price discrimination strategies as measured by more dispersed prices. This is consistent with the pricing

[7]The relationship is robust to other firms characteristics such as TFP, employment or total sales.

behavior of firms being heterogenous, in our sample. The heterogeneity may also translate into a heterogenous response of firms to the monetary integration. We consider this possibility in section 4.2.[8]

Figure 3: Firms' size and price discrimination



This graph plots the average price dispersion toward the Euro area in 1996 computed by 50-quintile bins of value-added against the (logarithm of the) average value added of firms in those bins. Average dispersion is computed at the firm and product level and then average by bins. The linear fit indicates a positive relationship between firms' size and the size of price dispersion.

3.3 Estimation strategy

This subsection describes the difference-in-difference (DID) strategy we adopt to study the evolution of price discrimination.

The DID estimation is a useful tool when trying to measure the quantitative impact of a shock (here, the introduction of the Euro) on a specific group (EMU members). The method accounts for global trends that are disconnected from the shock using information on a control

[8]Note that the link between firms' size and price dispersion might be due to an omitted variable bias. In particular, large firms export to many markets which mechanically increases price dispersion. Firm-product fixed effects correct such bias.

group that is not directly affected by the shock. More precisely, the DID strategy we use compares the magnitude of price discrepancies in the EMU before and after the Euro with that of an appropriately defined control group. For the effect to be interpretable in terms of the monetary integration impact, the control group has to be as similar as possible to the treatment group (the Euro area). We successively take the non-EMU members of the European Union (i.e. Denmark, Sweden and the United Kingdom) and the rest of the OECD. In theory, the first group is better suited to serve as control group since these countries have experienced the same economic policies aimed at increasing market integration as EMU members. However, the number of countries composing the reference group is small, this explains why we also test the robustness of our results using the rest of the OECD as control.

In the DID methodology, the variable of interest (the coefficient of variation here) is regressed on an intercept and three binary variables. The first dummy variable, called Euro, is equal to one for EMU members. The second one (Post99) takes a value of one in the years following the introduction of the Euro.[9] Last, the third dummy (Euro$\times$Post99) interacts the Euro and Post99 binary variables. It is thus equal to one for EMU members since the introduction of the Euro. The estimated equation is:

$$cv^r_{fkt} = \alpha_{fk} + \beta EURO + \gamma POST99 + \delta EURO \times POST99 + u^r_{fkt} \tag{1}$$

The interpretation of estimated coefficients is the following. The constant gives the average size of price discrimination for non EMU countries before 1999. It is possible to let it vary over firms and/or products in order to account for pre-existing heterogeneity in pricing behaviors. The Post99 dummy corresponds to the general trend in the magnitude of price discrepancies, after 1999. The Euro dummy captures the characteristics shared by all EMU members that should make price discrimination different within this set of countries over the pre-1999 period. Last, the Euro$\times$Post99 dummy captures the impact that the introduction of the Euro has had on

[9]Here, we consider that the introduction of the Euro takes place in the beginning of 1999, i.e. when European exchange rates have been irrevocably fixed. An alternative date for the treatment could be January 2002, when bank notes and coins have been introduced. We ran the DID regressions with this treatment date. However, results are less accurate in this case because the treatment period is strongly reduced.

price discrimination toward EMU members.

4 Results

4.1 Difference in difference estimates

To evaluate whether the introduction of the Euro in 1999 has reduced price discrimination strategies of exporting firms, we apply the difference in difference method (DID) with the non-EMU members of the European Union as control group.

Results are presented in Table 1. We first run benchmark regressions (columns 1 and 4) in which the DID dummies are the only control variables. In the second and fifth columns we control for the variance in market access and wealth of the bundle of countries served by the firm. Finally, Columns 3 and 6 cluster the standard errors in the area dimension. In all specifications we control for unobserved heterogeneity using product fixed effects (columns 1-3) or fixed effects for each firm $\times$ product combination (columns 4-6).

Consistent with panel (a) of Figure 1, results confirm that the dispersion of prices is higher in the EMU than in the rest of the EU. The first regression documents an average positive gap of 12% (0.036/0.294 + 1=1.12) before 1999. Without the introduction of the Euro, the gap would have reached 13% after 1999 ([0.036+0.001]/[0.294+0.001]+1=1.13). Instead the relative price dispersion within the Eurozone has declined. In the Euro period, price deviations are 7% higher in the EMU than in the rest of the EU ([0.036+0.001 -0.015]/[0.294+0.001]=1.07).

The effect is robust to the inclusion of control variables for the heterogeneity of countries within groups. In particular, when we control for the dispersion of group members' GDP and GDP per capita in column (2), we find that more dispersion in the characteristics of the destination countries increases the dispersion of export prices at the firm level. But those controls do not impact previous findings. The coefficient on the $Euro \times Post99$ dummy remains negative and highly significant. Finally, when we control for heteroscedasticity within areas (column 3), the coefficient of interest remains negative and significant at the 5% interval.

Controlling for unobserved heterogeneity in the firm-product dimension reduces the mag-

nitude of the estimated EMU effect (columns 4 to 6). Once heterogeneity across firms in the magnitude of the average dispersion of their prices is accounted for, the remaining difference between the EMU and the rest of the EU in terms of their relative price dispersion strongly increases. Namely, for a typical firm in the pre-Euro period, the dispersion of export prices is 18% higher in the Euro area than in other EU countries (column 4). After the introduction of the Euro, the relative price dispersion decreases to 14%. Compared with the product fixed effects specification, this represents a smaller decline in EMU relative price dispersion of 3.5%. The effect even becomes non significant when standard errors are clustered in the area dimension (column 6).

To evaluate the robustness of our results to the choice of the control group, Table A.1 in Appendix presents results obtained when EMU is compared to the rest of the OECD. Overall results are consistent to those of Table 1. Namely, the impact of the Euro remains negative and significant in all specifications. Before the introduction of the single currency, prices are 12% less dispersed in the Euro area than in the rest of the OECD (Table A.1, column 1). After the introduction of the Euro, the gap increases to reach 17%. Absent the Euro, the gap would have declined to 10%.

The comparison of the Euro effect estimated using different control groups suggests that the price dispersion reduction attributable to the Euro is stronger when the control group is the rest of the OECD than when it is the rest of the European Union. For instance comparing columns 5 of Tables 1 and A.1, we find a reduction in the relative price dispersion of 2.5% when the control group is the rest of the EU against 3.5% when the control group is the rest of the OECD. One reason for the limited effect of the Euro obtained with EU as a control group might be related to the integration of good and service markets within the EU that also reduced price dispersion while being orthogonal to the monetary integration.

Overall, the DID results suggest that the Euro significantly reduced the price dispersion of French exports toward Euro countries relative to other destinations. However, the magnitude of the effect is sensitive to the specification, and is small in the most restrictive ones. One explanation for this small effect is that most of the integration actually occurred along the nineties,

as notably argued by Engel & Rogers (2004). The limited effect of the Euro that we identify suggests that the remaining barriers to arbitrage did not entirely vanish with the Euro.

Another, potentially complementary, explanation is that the effect of the Euro has been felt differently by the firms depending on their characteristics. Given that the previous regressions implicitly assume the impact of the Euro to be the same across firms, estimates may be affected by a heterogeneity bias. We explore this possibility in the next section.

4.2 Heterogeneity and selection bias

Results of section 4.1 implicitly assume an homogenous impact of the Euro on the firms' pricing strategies. When we control for unobserved heterogeneity in the firm-product dimension, the impact of the Euro is however dampened. Figure 3 indeed highlights a strong heterogeneity across firms in the magnitude of price discrimination, with large firms' prices exhibiting more variance across markets. It is possible that this heterogeneity transmit into the effect of EMU on firms' pricing strategies. On top of this behavioral heterogeneity, it is possible that our results are biased by composition effects. In particular, the previous estimates are based on the pooled sample of exporters, without distinguishing firms that export throughout the whole period from firms that enter and/or exit the market during the period of observations. In the following, we test the robustness of our results in those two dimensions. We first consider whether they are sensitive to extensive margin effects, before accounting for heterogenous behaviors at the intensive margin.

Extensive margin adjustments. A number of recent papers discuss extensive margin adjustments related to market integration. Berthou & Fontagné (2008) thus show that EMU induced a net entry of firms/products in the European market. If those new firms have different pricing behaviors as incumbents, it may be that the effect captured in previous section's estimations is due to extensive adjustments rather than changes in the pricing strategy of stayers. Méjean & Schwellnus (2009) find an important effect of those extensive adjustments on the convergence

of prices induced by the EU integration.[10] To test whether such composition effects also trigger the previously described results, we estimate the impact of the single currency on an "intensive" sub-sample made of firms with positive export flows before *and* after the Euro has been introduced.

Results are displayed in Table 2. Overall, they are consistent with estimates provided in Table 1, obtained on the whole sample of exporters. Most of the time, the EMU effect is negative and significant, but small. Moreover, the magnitude of the effect identified in this sub-sample is not significantly different. This suggests that the results discussed in section 4.1 are not triggered by composition effects.

Firms' heterogeneity. Beyond the extensive effects, it may be that the *response* of firms to the Euro introduction is itself heterogenous. This is all the more likely since ex-ante pricing strategies are heterogenous, as illustrated in Figure 3. Moreover, this would be consistent with Berman et al. (2009) who show how firms' response to exchange rate shocks is strongly heterogenous across firms.

We thus pursue the analysis by studying the link between firms' characteristics and their strategic adjustment to EMU. In table 3, we interact the treatment variable of the DID regression with different measures of firm size. We use three different proxies, namely the firm's value-added, its total sales, and its export sales. We compute these different measures using firm-level data obtained from the fiscal administration for 1996. Table 3 shows that the negative effect of the Euro has been disproportionably felt by the largest firms. In particular, the effect is negative for firms that exhibit a value added greater than 148 (exp(0.010/0.002)). Since a bit less than 95% of the firms have a value added greater than this threshold, the effect of the Euro is in fact negative for almost all firms. But it is more pronounced for the largest ones. This finding is robust to other measures of firms' size.

To illustrate the quantitative impact of the single currency on firms of different size, compare two hypothetical firms, exporting toward the same set of countries but being heterogenous in

[10]The heterogeneity across firms in the length of their participation to export markets is somewhat controlled for in regressions with firm $\times$ product fixed effects, though.

terms of their size. The value added of the two firms corresponds to the first and the ninth deciles of the distribution of value added, namely 270 and 54,176, respectively. Our estimates predict the Euro to reduce the relative dispersion of prices by less than 1% for the less productive firm. On the other hand, the effect is expected much stronger for the most productive one, which relative price dispersion reduces by 3.8% (column 1).

A less parametric way to track down the impact of heterogenous behaviors consists in ranging firms in size groups and measuring how firms in those groups react to the single currency. In this spirit, figure 4 presents the effect of the Euro on price dispersion depending on firms' value-added where firms are grouped by decile of value added. Namely, we first estimate:

$$cv^r_{fkt} = \alpha_{fk} + \beta EURO + \gamma POST99 + \delta EURO \times POST99 + \sum_{i \geq 2} \eta_i \left(EURO \times POST99 \times D_i\right) + u^r_{fkt} \tag{2}$$

where D_i is a dummy equal to one is the firms belong to the i^{th} decile of value added. Firms in the first decile of the distribution of value-added are used as reference. The coefficient η_i thus measures the additional impact of EMU on the dispersion of prices of firms in the ith decile, in comparison with firms in the first decile. The total impact of the Euro for decile i is then measured by $\hat{\delta} + \hat{\eta}_i$.

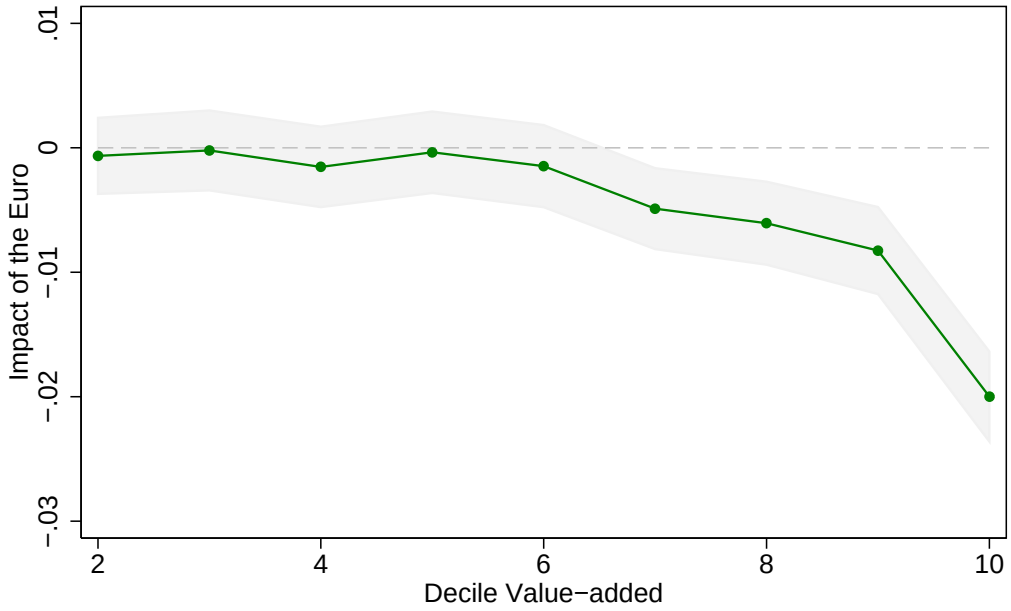
The figure offers a clear-cut message: the impact of the Euro on firms' pricing dispersion is significantly stronger for firms from the seventh decile of value-added. On the other hand, the impact is estimated non-significant for firms in smaller deciles of the value added distribution. This means that small firms do not adjust their pricing strategies because of the Euro, while the price dispersion of large firms shrinks.

This phenomenon has two (complementary) explanations. First, in presence of exchange rate volatility, large firms have a stronger incentive to price discriminate. Therefore, their prices are more dispersed, everything else equal. This explains the heterogeneity observed before 1999. Provided that the introduction of the common currency reduces their ability to price discriminate, it is not surprising that the reduction in price dispersion is more pronounced for firms which ex-ante propensity to price discriminate is the stronger.

A second explanation relies on the behavior of arbitrageurs. One mechanism through which

the Euro was expected to impact prices was the strengthening of arbitrage behaviors. If the arbitrageurs' activity is featured by scale economies, one can expect them to be more active in trading products that are sold in larger volumes. In such case, large firms are also more likely to be subjected to arbitrage behaviors, which forces them to strongly reduce the dispersion of their prices.

Figure 4: Euro, price discrimination and firms' size



This graph plots the impact of the Euro on price dispersion by decile of firms' value-added. Reported coefficients are the linear combination of the Euro effect irrespective of firms'size and the specific impact of the Euro for each decile of value-added. The estimated impact is relative to the first decile. The underlying coefficients are estimated using a difference in differences augmented by interaction terms with value-added decile dummies. The grey area is the confidence interval at 10 percent.

5 Aggregate implications

We finish the analysis discussing the aggregate implications of the heterogeneity we just identified in the data. Previous section indeed shows that, in terms of price discrimination, large firms have been more impacted by the introduction of the single currency. From recent advances in international trade (Bernard, Jensen, Redding & Schott 2007, Mayer & Ottaviano 2007), we also know that those large firms account for the lion's share of international trade flows. In our

estimates we gave the same weight to all firms, irrespective of their contribution to international trade. Thus, we measured the average impact of the Euro on French firms. In terms of the aggregate consequences of the Euro, it however makes sense to put a larger weight on those firms that accounts for the bulk of international trade flows. In what follows, we propose two methods that use the relative weight of goods in the consumption basket to quantify the impact of the Euro on *aggregate* price discrepancies.

A first way to measure the aggregate impact of the Euro is to use the results of the DID regression with decile-specific coefficients, described in equation (2). This equation estimates the degree of heterogeneity in the response of different classes of firms to the Euro. The simple average of the coefficients obtained for each decile is equal to -0.006, once again a very limited effect. However, the weighted average implies a twice as large effect, equal to -0.012.

A second way to deal with heterogeneity relies on the comparison of OLS results with weighted least squares. This comparison is illustrated in Table 4. The weights used in the WLS regression correspond to the share of each firms in total exports in 1996.[11] Without weighting, the relative dispersion of export prices in the Euro area is found to drop from 1.23 to 1.20 because of the monetary integration. Once we give more weight to the behaviors of larger firms, however, we find a bigger effect. The relative dispersion of prices is found to fall from 1.27 to 1.1.

Both sets of results show that accounting for the heterogenous response of firms to a common macroeconomic shock modifies the quantitative assessment one can make of the shock's aggregate impact.

6 Conclusion

This papers studies the impact of the creation of a monetary union on the magnitude of deviations to the law of one price. We identify the impact of the single currency by measuring the relative dispersion of French export prices toward Euro countries before and after 1999, allows

[11] We are not the first ones to weight observations by sales to study price discrimination at the firm-level. Fitzgerald & Haller (2010) adopt this strategy in their study of pricing-to-market behaviors.

us to

We find that the Euro significantly reduced the relative dispersion of French export prices. Price were 24% higher in the Euro area than in the rest of the EU before 1999, and this dispersion drops to 21% after 1999. The effect is robust to the control group we choose as well as changes in the sample of firms and products we consider.

Moreover, we show that the effect has been felt differently by French exporters. Namely, more productive firms have been more strongly affected by the common currency. This heterogeneity is important in itself. It also has interesting implications in terms of the aggregate impact of the Euro. Since more productive firms account for a very large share of total exports, their behavior is crucial in determining the dynamics of aggregate prices.

We account for the heterogeneity in the behavior of firms as well as in their relative weight in aggregate exports to estimate the *aggregate* effect of individual firms adjusting their pricing strategies. Unsurprisingly, the estimated effect of the Euro is found larger once we account for the relative weight of different firms in aggregate exports. In this specification, the relative dispersion of within-EMU prices decreases from 27 to 10% following the introduction of the European common currency.

This results suggest that the response of firms to the introduction of the Euro is deeply heterogenous and that this heterogeneity has important aggregate consequences. The effect of the Euro is underestimated when the heterogeneity is not accounted for.

A Annexe

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Table 1: Difference in difference, control group: rest of the EU

	(1)	(2)	(3)	(4)	(5)	(6)
	Coefficient of variation of prices					
Post99	0.001	-0.001	-0.001	0.012^a	0.009^a	0.009
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
Euro	0.036^a	0.048^a	0.048^c	0.050^a	0.056^a	0.056^c
	(0.001)	(0.001)	(0.007)	(0.001)	(0.001)	(0.007)
Euro×Post99	-0.015^a	-0.010^a	-0.010^b	-0.009^a	-0.005^a	-0.005
	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)
CV(GDP/dist)		0.035^a	0.035		0.036^a	0.036^b
		(0.001)	(0.009)		(0.001)	(0.002)
CV(GDPc)		0.017^a	0.017		-0.013^a	-0.013
		(0.004)	(0.051)		(0.002)	(0.045)
Constant	0.294^a	0.247^a	0.247^c	0.272^a	0.237^a	0.237^b
	(0.001)	(0.002)	(0.027)	(0.001)	(0.002)	(0.018)
Control	Rest of EU15					
Fixed effects	product			firm×product		
Cluster	No	No	Zone	No	No	Zone
Obs.	1,886,920	1,886,920	1,886,920	1,886,920	1,886,920	1,886,920
rho	0.182	0.181	0.181	0.572	0.572	0.572
	Relative dispersion of Euro prices					
Before 99	1.12	1.19	1.19	1.18	1.24	1.24
After 99	1.07	1.15	1.15	1.14	1.21	1.21

This table investigates the impact of the introduction of the Euro on the evolution of firms' price dispersion across countries using a difference-in-differences strategy. We consider the sample of French firms exporting between 1996 and 2005 toward at least two countries in the Eurozone and in the rest of the EU. The explained variable is the coefficient of variation of prices computed at the firm-product-year-area level. Here we consider two areas, namely the Euro countries and the rest of the EU. The main explanatory variables are three dummy variables: $Post99$ equals to one after 1999, Euro is 1 for Euro countries, and the interaction term $Euro \times Post99$. As control variables, we use the dispersion in GDP per capita $CV(GDPc)$ and GDP over distance $CV(GDP/dist)$ of countries served by the firm, within each group. We add product or firm-product fixed effects in our regressions. Robust standards errors in parenthesis. In columns (3) and (6), standard errors are clustered in the area dimension. Superscripts ^{c}, ^{b}, ^{a} indicates significance at 10%, 5% and 1% level.

Table 2: Difference in difference, intensive margin

	(1)	(2)	(3)	(4)	(5)	(6)
	Coefficient of variation of prices					
Post99	0.008^a	0.006^a	0.006^b	0.013^a	0.009^a	0.009
	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.002)
Euro	0.043^a	0.052^a	0.052	0.051^a	0.056^a	0.056^c
	(0.002)	(0.002)	(0.009)	(0.001)	(0.001)	(0.008)
Euro×Post99	-0.012^a	-0.008^a	-0.008	-0.011^a	-0.007^a	-0.007^c
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
CV(GDPc)		0.006	0.006		-0.019^a	-0.019
		(0.005)	(0.056)		(0.003)	(0.044)
CV(GDP/Dist)		0.030^a	0.030		0.038^a	0.038^c
		(0.002)	(0.012)		(0.001)	(0.004)
Cons.	0.291^a	0.253^a	0.253^c	0.281^a	0.244^a	0.244^c
	(0.001)	(0.003)	(0.033)	(0.001)	(0.002)	(0.021)
Control	Rest of EU15					
Fixed effects	product			firm×product		
Cluster	No	No	Zone	No	No	Zone
Obs.	931351	931351	931351	931351	931351	931351
rho	0.213	0.212	0.212	0.447	0.447	0.447
	Relative dispersion of Euro prices					
Before 99	1.15	1.20	1.20	1.18	1.23	1.23
After 99	1.10	1.17	1.17	1.14	1.18	1.18

This table investigates the impact of the introduction of the Euro on the evolution of firms' price dispersion across countries using a difference-in-differences strategy. We consider the "intensive" sample of French firms exporting before 1998 and after 1999, between 1996 and 2005 toward at least two countries in the Eurozone and in the rest of the EU. The explained variable is the coefficient of variation of prices computed at the firm-product-year-area level. Here we consider two areas, namely the Euro countries and the rest of the EU. The main explanatory variables are three dummy variables: $Post99$ equals to one after 1999, Euro is 1 for Euro countries, and the interaction term $Euro \times Post99$. As control variables, we use the dispersion in GDP per capita $CV(GDPc)$ and GDP over distance $CV(GDP/dist)$ of countries served by the firm, within each group. We add product or firm-product fixed effects in our regressions. Robust standards errors in parenthesis. In columns (3) and (6), standard errors are clustered in the area dimension. Superscripts ^{c}, ^{b}, ^{a} indicates significance at 10%, 5% and 1% level.

Table 3: Difference in difference, size effect

	(1)	(2)	(3)	(4)
	Coef. of variation of prices			
Post99	0.009^a	0.010^a	0.010^a	0.007^a
	(0.001)	(0.001)	(0.001)	(0.001)
Euro	0.057^a	0.057^a	0.057^a	0.062^a
	(0.001)	(0.001)	(0.001)	(0.001)
Euro×Post99	-0.006^a	0.010^a	0.024^a	0.013^a
	(0.001)	(0.003)	(0.003)	(0.005)
Euro×Post99×log(VA)		-0.002^a		
		(0.000)		
Euro×Post99×log(Sales)			-0.003^a	
			(0.000)	
Euro×Post99×log(Exports)				-0.001^a
				(0.000)
CV(GDP/dist)	0.036^a	0.036^a	0.036^a	0.039^a
	(0.001)	(0.001)	(0.001)	(0.001)
CV(GDPc)	-0.013^a	-0.015^a	-0.015^a	-0.018^a
	(0.003)	(0.003)	(0.003)	(0.003)
	0.243^a	0.243^a	0.243^a	0.267^a
	(0.002)	(0.002)	(0.002)	(0.002)
Fixed effects	firm×product			
Observations	1,542,210	1,542,210	1,542,130	1,219,400
rho	0.563	0.564	0.565	0.540

This table investigates the impact of the introduction of the Euro on the evolution of firms' price dispersion across countries for different type of firms. We consider the sample of French firms exporting from 1996, between 1996 and 2005 toward at least two countries in the Eurozone and in the rest of the EU. The explained variable is the coefficient of variation of prices computed at the firm-product-year-area level. Here we consider two areas, namely the Euro countries and the rest of the EU. The main explanatory variables are: $Post99$ equals to one after 1999, Euro is 1 for Euro countries, the interaction term $Euro \times Post99$, and triple interaction term $Euro \times Post99 \times log(size)$. Where firms' size is measured by total sales, value added and total exports in 1996. As control variables, we use the dispersion in GDP per capita $CV(GDPc)$ and GDP over distance $CV(GDP/dist)$ of countries served by the firm, within each group. We add firm-product fixed effects in our regressions. Robust standards errors in parenthesis. Superscripts ^{c}, ^{b}, ^{a} indicates significance at 10%, 5% and 1% level.

Table 4: Ordinary versus weighted least squares

	(1)	(2)
	Coef. of variation of prices	
Post99	0.009^a	-0.031^a
	(0.001)	(0.009)
Euro	0.057^a	0.087^a
	(0.001)	(0.010)
Euro×Post99	-0.006^a	-0.028^a
	(0.001)	(0.010)
CV(GDP/dist)	0.036^a	0.041^a
	(0.001)	(0.012)
CV(GDPc)	-0.013^a	-0.032^c
	(0.003)	(0.018)
Constant	0.243^a	0.322^a
	(0.002)	(0.016)
Fixed effect	firm×product	
Method	OLS	WLS
Observations	1,219,400	1,219,400
	Rel. dispersion of Euro prices	
Before 99	1.23	1.27
After 99	1.20	1.10

Fixed effect estimates, observations are weighted by firm's share in total exports. Robust standard errors in parenthesis.

Table A.1: Difference in difference, control group: OECD

	(1)	(2)	(3)	(4)	(5)	(6)
	Coefficient of variation of prices					
Post99	0.007^a	0.009^a	0.009^c	0.020^a	0.020^a	0.020^b
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Euro	-0.047^a	-0.026^a	-0.026	-0.020^a	-0.004^a	-0.004
	(0.002)	(0.002)	(0.004)	(0.001)	(0.001)	(0.003)
Euro×Post99	-0.021^a	-0.018^a	-0.018^c	-0.017^a	-0.014^a	-0.014^c
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
CV(GDPc)		0.026^a	0.026		0.027^a	0.027
		(0.001)	(0.016)		(0.001)	(0.006)
CV(GDP/Dist)		0.099^a	0.099^c		0.097^a	0.097^a
		(0.002)	(0.016)		(0.002)	(0.000)
Cons.	0.383^a	0.317^a	0.317^b	0.353^a	0.290^a	0.290^a
	(0.001)	(0.002)	(0.007)	(0.001)	(0.001)	(0.004)
Control	OECD countries excepted Euro countries					
Fixed effects	product			firm×product		
Cluster	No	No	Zone	No	No	Zone
Obs.	2211700	2211700	2211700	2211700	2211700	2211700
rho	0.170	0.169	0.169	0.558	0.558	0.558
	Relative dispersion of Euro prices					
Before 99	0.88	0.92	0.92	0.94	0.86	0.86
After 99	0.83	0.87	0.87	0.90	0.83	0.83

This table investigates the impact of the introduction of the Euro on the evolution of firms' price dispersion across countries using a difference-in-differences strategy. We consider the sample of French firms exporting between 1996 and 2005 toward at least two countries in the Eurozone and in the rest of the OECD. The explained variable is the coefficient of variation of prices computed at the firm-product-year-area level. Here we consider two areas, namely the Euro countries and the rest of the OECD. The main explanatory variables are three dummy variables: $Post99$ equals to one after 1999, Euro is 1 for Euro countries, and the interaction term $Euro \times Post99$. As control variables, we use the dispersion in GDP per capita $CV(GDPc)$ and GDP over distance $CV(GDP/dist)$ of countries served by the firm, within each group. We add product or firm-product fixed effects in our regressions. Robust standards errors in parenthesis. In columns (3) and (6), standard errors are clustered in the area dimension. Superscripts ^{c}, ^{b}, ^{a} indicates significance at 10%, 5% and 1% level.