Local versus Producer Currency Pricing: Evidence from Disaggregated Data*

Alexis Antoniades
(Job Market Paper)
Jan 17, 2008

Abstract

The pricing behavior of firms is a central issue in international macroeconomics. Whether firms set prices in the currency of the producer or the consumer is critical for policy because a devaluation succeeds in increasing demand for a country’s goods when the prices are rigid in the currency of the producer, but not if the prices are rigid in the currency of the consumer. Using the introduction of the euro as a natural experiment, I find that import price volatility among Eurozone members dropped dramatically after the introduction of the euro. Additionally, I show that the magnitude of the drop is commensurate with the drop in exchange rate volatility. On the other hand, when looking at exports, I find that the introduction of the euro had no impact on export price volatility. The results support the presence of pricing in the currency of the producer. (JEL F1, F3, F4).

*I would like to thank Kyle Bagwell, Richard Baldwin, Richard Clarida, Ron Findlay, Mark Giannoni, James Harrigan, Robert Hodrick, Amit Khandelwal, Paolo Pesenti, and Michael Woodford. I am especially indebted to David Weinstein and Donald Davis for their continuous support and guidance.
1 Introduction

In recent years, one of the central issues in international macroeconomics concerns the pricing behavior of firms. This is considered in a context in which there are price rigidities over horizons relevant to policy. Specifically, the question has been whether a producer selling in a foreign market has prices that are rigid in the producer’s currency or in the local currency of the consumer. This is critical for policy because a devaluation succeeds in increasing demand for a country’s goods when the prices are rigid in the currency of the producer, but not if prices are rigid in the currency of the consumer.

Indeed the issue of producer versus consumer (local) currency pricing has been critical to a variety of policy debates. One such debate is on whether the European monetary union (EMU) has economic justifications. The strongest objection to the EMU comes from Feldstein (1993, 1997) and Obstfeld (1997), who echo the views expressed by Friedman (1953) and Mundell (1961) on the stabilizing power of exchange rates. Feldstein and Obstfeld both argue that in a flexible exchange rate regime, a country faced with an adverse demand shock may devalue its currency and thus spur an export-led recovery overnight. However, entering the EMU strips countries of their ability to use devaluation to trigger an export led recovery. As Feldstein (1997) puts it, "... a European monetary union would be an economic liability".

Implicitly, as Engel (2000), and Devereux and Engel (2003) point out, this argument assumes that prices are rigid in the producer’s currency. If, instead, prices are rigid in the consumer’s currency, they will not fluctuation much with movements in the exchange rate. In this model, exporting firms use their profits as buffers against movements in the exchange rate. Consequently, a devaluation cannot stimulate the "expenditure switching" required for the export led recovery. And so giving up this "tool" carries no cost. According to Engel (2000), "The extent of LCP\(^1\) among European countries undermines this [Feldstein’s] view. The prices that consumers pay for imported goods are not much influenced by changes in nominal exchange rates in the short run". This debate motivates an empirical investigation that is the subject of this paper.

While this discussion was specifically in the context of the introduction of the euro, the consequences are obviously much broader. There is a recent debate on whether the European Central Bank (ECB) should

---

\(^1\)LCP refers to exporting firms setting prices in the (local) currency of the consumer.
take a stronger stance on preventing the strengthening of the euro. Many believe that the weakening of the US dollar in the expense of the euro hurts the demand for European exports and European exporters feel that the ECB should be more active in maintaining a "competitive" euro. A recent article in the Wall Street Journal summarizes this view: “The euro’s steady climb against the U.S. dollar is hurting European exports, prompting politicians to lash out at the European Central Bank, the U.S. trade deficit and China’s tightly controlled currency” (Oct 6, 2007). And the American Enterprise Institute in Washington offers the following catchy title in a recent article on the issue: "Mr. Trichet Sleeps as the Dollar Sinks" (Oct 7, 2007).

What the ECB should do depends crucially on the sensitivity of prices to exchange rate movements. In the optimal monetary policy literature, flexible exchange rates is the optimal response when prices of traded goods are rigid in the producer’s currency. In contrast, a fixed exchange rate regime becomes optimal when prices are rigid in the consumer’s currency\(^2\). In other words, whether the ECB should be alarmed or not by the strengthening of the euro and whether it should try to curtail its steady climb depends on how much of the euro’s appreciation is pass-through to prices of EU exports abroad.

In this paper, I investigate how import and export prices in Europe respond to exchange rate fluctuations by looking at the periods before and after the introduction of the euro. My main hypothesis is that if prices are rigid in the (local) currency of the consumer, changes in the volatility of the nominal exchange rate should have no effect on the volatility of import prices. Therefore, there should be no change in the volatility of import prices before and after the introduction of the euro purely from the elimination of exchange rate volatility. In the case that prices are rigid in the currency of the producer however, import prices respond to changes in the exchange rates. The adoption of a common currency takes away the volatility of the nominal exchange rate. Therefore, after the introduction of the euro there should be a drop in import price volatility.

Using highly disaggregated trade data I find that import price volatility among Eurozone members dropped dramatically after the introduction of the Euro. On average, price volatility of Eurozone imports from other Eurozone exporters fell by more than 5% as a result of the common currency. The drop was present in most countries. For example, in the case of France and Spain, import price volatility from other

\[^{2}\] Some of the papers that investigate what the optimal monetary policy should be in an open economy under different pricing assumptions are Obstfeld and Rogoff (2000), Clarida, Gali and Gertler (2002), Benigno and Benigno (2001), Devereux and Engel (2003), Corsetti and Pesenti (2004)
Eurozone members dropped by 20% and 19%, respectively. Additionally, I show that the magnitude of the 
drop is commensurate with the drop in exchange rate volatility. That is, for a country that had a volatile 
trade-weighted exchange rate before, the drop in import price volatility was large, but for a country with a 
less volatile exchange rate, the drop was much smaller. On the other hand, when looking at exports, I find 
that the introduction of the euro had no impact on export price volatility. The results support the presence 
of producer currency pricing and thus strengthen the argument of Feldstein and Obstfeld. Furthermore, 
I find stronger evidence of pricing in the currency of the producer for differentiated goods and goods with 
lower elasticities of substitution, but no evidence of pricing in the currency of the producer for commodities.

The paper is organized as follows: Section 2 presents the literature review. Section 3 establishes the 
methodology used for exploring price sensitivity before and after the euro. Section 4 describes in detail the 
dataset used. Section 5 presents the results and Section 6 summarizes the findings and concludes this work.

2 Literature Review

Because of the central role of producer versus consumer currency pricing, an important empirical literature 
has arisen to examine it. This may be broken up into two groups, one of which has worked with aggregated 
data and the second of which has worked with highly disaggregated data. The former group tends to reject 
the law-of-one price (LOP) and finds evidence of pricing in the currency of the consumer. The latter group 
finds more evidence in favor of relative LOP and of pricing in the currency of the producer. Recent studies 
use more disaggregated price data than the early studies, since now such data at bilateral levels are becoming 
more available. Below I review some of the most relevant papers. The literature on the subject is vast and 
thus, the review below will attempt to be suggestive rather than exhaustive.

In the camp of using aggregated data, Engel (2000) finds that the law of one price (LOP) fails in a sample 
of 22 goods categories from 9 European countries. He concludes that the results support the presence of 
pricing in the currency of the consumer (LCP). Looking at five aggregate import bundles, namely food, 
manufacturing, energy, raw materials and nonmanufacturing, Campa and Goldberg (2004) find that there 
is partial exchange rate pass-through to import prices in the short-run and so reject both hypothesis that 
prices are set in the currency of the producer (PCP) or the consumer (LCP).
In the camp of using disaggregated data, Goldberg and Verboven (2005) examine auto prices in five European countries from 1970 to 2000 and find strong convergence towards both the absolute and the relative versions of the LOP. They also find high degrees of pass-through suggesting that pricing in the currency of the producer is a common practise for automakers selling in Europe. Using price data on 270 goods across 71 countries collected by the Economist Intelligence Unit, Crucini and Shintani (2006) find that the time it takes for price differentials of similar goods across two locations to fall in half (half-life) is about 1 year. Then, they introduce aggregation bias and small sample bias in their estimations and show that half-lives increase from 1 year to 3-5 years, the range found in earlier studies that used aggregated data. They conclude that the LOP seems to hold and that aggregation bias and small sample bias result in over-rejection of the LOP.

The literature above has made important advances in our understanding of the question of producer versus consumer currency pricing. At the same time, it is clear that there are some limitations. Using aggregated data introduces aggregation bias that results in over-rejection of the LOP. The bias is especially large when non-traded goods are included in the aggregates. Imbs et al. (2002, 2005) and Crucini and Shintani (2006) are some of the studies that discuss the importance of aggregation bias. In the appendix of this paper, I show how after controlling for the aggregation bias introduced by the non-traded goods included in the price indexes, we can view the evidence from Engel’s (2000) correlation test in favor of the LOP and not against it. The results in the studies above are also influenced by measurement error and small sample bias which tends to be important as Crucini and Shintani (2006) and Chen and Engel (2004) show.

From the point of view of a policy maker that is interested in the stabilizing power of exchange rates, whether deviations from the LOP occur or not is not very informative. What the policy makes cares about is what percentage of these deviations can be attributed to movements in the exchange rates. To understand this, consider the work of Parsley and Wei (1996). The authors look at deviations from relative LOP using data on goods prices within the US and find half-lives of about five quarters. Since there are no exchange rate surprises or trade barriers involved in their study, their findings imply that there are other shocks that have transitory effects on the gap between prices of identical goods across locations. Furthermore, it is invalid to view the rejection of the LOP as evidence in favor of pricing in the currency of the consumer.
As Giovannini (1988) points out, deviations from LOP can occur both when pricing in the currency of the producer or the consumer takes place, as long as there is price discrimination.

The Goldberg and Verboven (2005) study avoids the limitations above. The authors carefully collect data on car prices in order to ensure that they examine prices of identical goods, so that they can minimize aggregation bias and measurement error. Their evidence suggest that import prices are sensitive to exchange rate movements. However, they only look at one industry. It would be nice to know whether their findings generalize to other industries as well.

This paper presents a new methodology for examining the sensitivity of prices to exchange rate movements. By using the introduction of the euro as a natural experiment, I can examine whether import and export prices volatility changed as the result of the introduction of the euro in a cross-sectional framework. This enables me to see whether prices are set more according to PCP or LCP. I use highly disaggregated price data on traded goods and not price-indexes. Because the exercise is performed in a cross-sectional rather a time-series framework, each regression has 30,000 observations on average (300,000 for the pooled specifications). Consequently, I minimize aggregation and small sample bias. In the data section I also discuss how I minimize measurement error. Unlike Goldberg and Verboven (2005) that focus on the auto industry, the data in this paper comes from several industries. This enables me to examine pass-through not only by country, but also by industry characteristic. As Dornbush (1987) pointed out, the choice of firms to set prices in their own currency or in the currency of the consumer depends on the market structure, the market integration and on the substitutability of their good. I will be able to apply my methodology and examine this in more detail. I will now proceed with a formal presentation of the methodology.

3 Methodology

On January 1st 1999, the EMU members participating in the Eurozone pegged their local currencies to the euro and on January 1st 2002, the euro was officially adopted. Denmark, Sweden, and the United Kingdom, although members of the EMU, chose not to participate in the Eurozone. The move to a common currency consisted of three stages and followed the roadmap set out by the 1989 Delors Report to establish a monetary union. Stage One increased financial integration and coordinated central bank policy, Stage Two created
the ECB, and Stage Three fixed the exchange rates and transferred monetary policy responsibilities to the ECB.

Based on the behavior of import and export prices before and after the introduction of the euro, I develop a framework that enables us to examine the sensitivity of prices to exchange rate movements using cross-sectional data. First, I introduce the intuition behind the methodology using a simple thought experiment. Consider two countries (Home and Foreign) trading with each other. For simplicity, assume that each country exports only one good and no transportation or transaction costs exist. There are two regimes (Flexible and Fixed) in this setting and each regime lasts two periods (Period 1 and Period 2). As the names suggest, under the Flexible regime, the two countries have a flexible exchange rate, but under the Fixed regime, the exchange rate is fixed.

The objective of the thought experiment is to see how import and export prices change from Period 1 to Period 2 under each regime and each pricing rule. Without loss of generality, let us focus on prices in the Home country (e.g. Spanish pesetas). This yields a total of four combinations to investigate since there are two trade directions and two pricing rules to consider. Start first the Flexible regime and consider import prices. Define price volatility to be the squared change in log price of the good from Period 1 to Period 2. Under the PCP hypothesis the import price of the Foreign good (in pesetas) will change from Period 1 to Period 2 as a result of a movement in the exchange rate between the two periods. Under the LCP hypothesis the import price of the Foreign good will not change despite a move in the exchange rate as the Foreign exporter prices in the Home currency (in pesetas). Under the Fixed regime, there is no exchange rate volatility. Hence, both PCP and LCP impose that there will be no change in the import price of the Foreign good from Period 1 to Period 2. Compare now what happens as we move from the Flexible to the Fixed regime. Under the PCP hypothesis there will be a drop in import price volatility (going from a positive number to 0) and under the LCP hypothesis there will be no change in import price volatility (it is 0 under both regimes).

A similar prediction is obtained under the PCP and LCP hypotheses if we look at exports. In the Flexible regime, under the PCP hypothesis there should be no change in the export price of the Home good

\[ \text{Price Volatility} = (\ln P_{2} - \ln P_{1})^2 \]

This is a measure of volatility in a cross-section and not in a time-series.
between Period 1 and Period 2. In contrast, under the LCP hypothesis the export price will change from Period 1 to Period 2 as a result of a move in the exchange rate. This is because the Home exporter needs to adjust the price of the good (in pesetas) in order to maintain its price constant in the foreign currency.

In the Fixed Regime, there is no exchange rate volatility. Hence, both PCP and LCP impose again that there will be no change in the export price of the Foreign good from Period 1 to Period 2. Comparing the two regimes, under the PCP hypothesis there will be no change in export price volatility as we move from Flexible to Fixed (it is 0 under both regimes) and under the LCP hypothesis there will be a drop in export price volatility (it goes from a positive number to a negative). Notice that the predictions under the PCP and LCP hypotheses for exports are diametrically opposite from the predictions for imports.

Therefore, to test whether PCP or LCP occurs in this simplified environment, it suffices to measure the price volatility of the good under the Flexible and the Fixed regimes. If we observe that import price volatility drops, then PCP in present. In contrast, if there is no change in import price volatility between the two regimes, then LCP is present. Similarly, if we study the export price, a drop in price volatility signals that LCP is present, whereas no change signals that PCP is present.

It becomes obvious now how a formal test of the nature above is developed. Set Periods 1 and 2 of the Flexible regime to be 1994 and 1995, respectively and set Periods 1 and 2 of the Fixed regime to be the years 2002 and 2003, respectively. Flexible corresponds to the period prior to the euro that is characterized by exchange rate fluctuations. I will refer to this period as the period BEFORE. Fixed corresponds to the period after the euro. I will refer to this period as the period AFTER. The years are selected with two specific criteria in mind: first, to stay close to the introduction of the euro, and second, to allow for a few years of transition to minimize noise. Alternative year specifications are tested for robustness.

In order to control for other factors that affect price volatility beyond fluctuations in the exchange rate I create a control and an experimental group. Let the set of OECD countries outside the Eurozone be the NonEZ group (control group), and let the set of all OECD countries in the Eurozone be the EZ group (experimental). I focus on OECD countries to reduce heteroskedasticity. That might arise by comparing

---

4The two groups are: OECD - EZ (Austria, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, and Spain) and OECD Non-EZ (Australia, Canada, Denmark, Japan, New Zealand, Norway, Sweden, Switzerland, UK, USA). Turkey and Mexico are dropped from the Non-EMU group since both countries experienced high inflation for part of the period
developed countries with developing ones. Since most trade takes place among OECD members, the sample covers a high percentage of all trade\(^5\).

To see what happens to the volatility of prices before and after the euro, a Differences-in-Differences (DIDs) framework is employed. In the DIDs framework, any change in price volatility not captured by the time dummy or the group dummy is the result of the introduction of the euro. In the case that we are looking at imports of Eurozone members the regression will be

\[
(\ln P_{cgit} - \ln P_{cgit-1})^2 = a_0 + \alpha_1\text{AFTER}_t + \sum_c \sum_i \beta_{ci} \text{D}_{ci} + \alpha_3\text{EZ}_i\cdot\text{AFTER}_t + u_{cgit} \tag{1}
\]

where \(c\) denotes the reporting country (the importer) and it includes only OECD/EZ members. The set of partners (exporting countries) is indexed by \(i\) and it includes all OECD members. \(\text{D}_{ci}\) is a dummy variable that captures reporter-partner (importer-exporter) fixed effects, \(g\) denotes the product (a 6-digit HS code) and \(t\) denotes the time (\(t = 1995, 2003\)). \(\text{AFTER}_t\) is a dummy variable that takes the value 1 if the year is 2003 and 0 otherwise. It captures aggregate factors that affect price volatility over time in the same way for both groups. Finally, \(\text{EZ}_i\cdot\text{AFTER}_t\) is a dummy that takes the value of 1 if the observation corresponds to an import from an OECD/EZ country (origin) after the introduction of the euro. Any changes in the dependent variable not captured by the other regressors will be captured by \(\alpha_3\), the coefficient of interest (usually called the DIDs coefficient). I also estimate equation (1) using exports data. In this case, the subscripts will be the same, but the reporting country, \(c\), with denote to the exporter and the partner, \(i\), will denote to the importer.

The sign of the \(\alpha_3\) reveals if prices are set more according to PCP or LCP. In the case that we run (1) using imports, a negative coefficient implies that prices are set in the currency of the producer (PCP), whereas a zero coefficient implies that prices are set in the currency of the consumer (LCP). When we run the regression using exports data, the sign of the \(\alpha_3\) will have the exact opposite implications. That is, if it is negative, it will now point to pricing in the currency of the consumer (LCP) and if it is zero, it will point to pricing in the currency of the producer (PCP). The relation between the sign of \(\alpha_3\) and the two contrasting pricing theories is summarized in Table 1.

\(^5\)We find that 70% of a country’s trade is with other OECD countries.
By setting the dependent variable as \((\ln P_{cgit} - \ln P_{cgit-1})^2\) I can directly interpret \(\alpha_3\) as the percentage change in (import or export) price volatility that is caused by the introduction of the euro. An alternative measure would be to calculate the price variance of each variety before and after the euro and then use that as the dependent variable in a time-series framework. However, at the moment, there are not sufficient periods after the euro’s introduction to do this. Another decision made in the choice of the dependent variable was not to control for product in the baseline regression\(^6\). There are three main reasons behind this. First, I consider each variety to be different. Wine in Germany imported from Italy is not the same as wine in Germany imported from France. By assuming that these two varieties are the same, I explicitly assume that the markups of French and Italian wineries are the same and so are the marginal costs, two very strong assumptions. Second, it has been shown by Engel (1993) that prices of a good relative to a different good in the same country are less volatile than prices of that good relative to a similar good in another country. This border effects shows that country effects are more important to production than product effects. Third, when good dummies are included in the regressions, they did not appear statistically significant. For robustness check, product dummies were included but the results did not change. I will present these results in the next section. Finally, notice that country as well as variety fixed effects are captured in the regressions. The former is captured by including country dummies and the latter by taking annual differences of varieties’ prices.

4 Data Description

I use imports and exports data at the 6-digit harmonized system (HS) for the period from 1994 to 2004 to obtain unit prices. The data come from the United Nations Commodity Trade Statistics Database, which is commonly known as COMTRADE. I use data from 1994/95 and 2002/03 for the baseline regressions. To check robustness of the results the regressions are re-estimated using alternative dates. All value data are

\(^6\)Following Broda and Weinstein (2006), I define a product to be an HS6 code for Comtrade data and HS10 code for Feenstra’s US Exports data. For example, "wild blueberries canned" is a product. I define a variety to be a product per destination per origin. For example, "Italian wild blueberries canned exported to France" is a different variety than "Italian wild blueberries canned exported to Germany". I restrict the sample to contain varieties that exist for all years between years 1994 and 2003.
converted from US dollars to local currencies using the conversion rates reported by COMTRADE.

Before proceeding with a formal testing of the behavior of prices with respect to exchange rate movements, let me point out to the following stylized fact: the value of a traded variety appears to be inversely related to its price volatility. Graph 1 depicts this relation. On the x-axis, exports are allocated in bins based on (log) trade value. The y-axis depicts the mean price volatility for all varieties within the same value bin. The data are pooled together across time and partners. The graph shows that low export trade values experience higher price volatility on average. As the value of traded goods increases, price volatility decreases. Identical distributions were obtained when I considered only EZ or NonEZ countries and I looked at the periods BEFORE or AFTER. This shows that the pattern is persistent across time and exporter group.

A possible explanation of the high price volatility observed at low trade values is measurement error. Consider "wild blueberries canned". It is hard to imagine the quality of "wild blueberries canned" exported to Italy changing from year to year. Therefore, on average, I expect the price to be constant. Now, consider a different product: "Industrial Robots for Lifting, Hand, Load, or Unload". The US exported two units to New Zealand in 1996 at a price of USD 44,338 per unit, and 5 units in 1997 at a price of USD 6,180. Just from the description of the HS code I expect these robots to be customized for the specific needs of a plant. Even at this high level of disaggregation, we unfortunately have highly differentiated products sharing the same HS code. Broda and Weinstein (2006) discuss such measurement errors in their work. They propose a way of accounting for these errors by applying a weighting scheme based on the trading value of each variety. Following their advice I value-weight the data. I also clean the data to reduce noise. Nevertheless, one may still criticize the accuracy of unit-value data. To the extent that the errors in the data are non systematic and do not bias my results in a certain direction - and we have no reason to suspect that they are systematic, the results in this paper will be robust. With this note on using unit-value data, we now proceed to the presentation of the main results.

\[ w_{gijt} = \left( \frac{1}{V_{gijt}} + \frac{1}{V_{gijt-1}} \right)^{-2} \]

where \( V_{gijt} \) is the value of good \( g \) exporter (imported) to (from) country \( i \) by country \( j \) at time \( t \).

\(^7\text{Varieties with less than 100 units traded in a given period and varieties that experienced extraordinary change in quantity from one year to the next are eliminated. Any change in absolute log quantity greater than 1 is considered to be extraordinary (i.e. 170% change). Finally, to correct for the measurement error I follow Broda and Weinstein (2005) and weight the data. For a given variety, the weight } w_{gijt} \text{ used is given by } w_{gijt} = \left( \frac{1}{V_{gijt}} + \frac{1}{V_{gijt-1}} \right)^{-2} \text{ where } V_{gijt} \text{ is the value of good } g \text{ exporter (imported) to (from) country } i \text{ by country } j \text{ at time } t. \]
5 Results

First, I present descriptive statistics on price movements before and after the euro. For each group, I calculate the average and median price volatility for 1995 and 2003. These results are shown in Table 2. The rows note whether the reporter is an EZ or a NonEZ member and the columns state whether the partner is an EZ or a NonEZ member. Panel A presents the mean price volatility and Panel B presents the median. Each panel reports estimates first using import prices and then using export prices. For example, looking at the upper left cell, we see that in the EZ group, the average price volatility of imports from NonEZ members between 1994 and 1995 was 23%. Similarly, looking at the cell below we observe that for NonEZ countries, the average price volatility of imports from NonEZ countries was 20% between 1994 and 1995.

Although these numbers represent simple averages across several countries and products, Table 2 does provide some interesting insights. First, notice that in 1995 the price volatility in the two groups is very similar across averages and medians as well as imports and exports. This finding is welcomed as it further shows evidence of homogeneity between the two groups. Second, notice that price volatility for EZ imports from EZ countries dropped between 1995 and 2003. Specifically, in 1995, the average price volatility was 19% but in 2003 it fell to 17%. In contrast, price volatility for EZ imports from NonEZ countries did not fall. This finding favors producer currency pricing over consumer (local) currency pricing. Finally, on the export side, we observe a reduction in price volatility when looking at EZ exports, but this reduction occurs across both destination groups. Therefore, from the descriptive statistics alone, we cannot say that the euro had a different impact on export price volatility across the two groups.

5.1 Pooled Regression:

The regression results from the pooled specification are presented next. First, the regression (1) is estimated using imports data for all EZ countries. The regression estimates are shown in Column 1 of Table 3. The coefficient of the $EZ_i AFTER_t$, i.e. $\alpha_3$, appears to be negative and statistically significant. There is a 5.4% drop in import price volatility of EZ imports from other EZ members that is attributed to the introduction of the euro. A negative coefficient provides evidence of producer currency pricing.

Next I turn to exports. Specification (1) is estimated using exports data of all EZ exports to both
OECD-EZ and OECD-NonEZ destinations. The estimation results are shown in column (2). The coefficient of interest, $\alpha_3$, is now 0. EZ export prices to other EZ members did not become less volatile as a result of the introduction of the euro. This also supports the presence of producer currency pricing.

I replicate the exercise using product dummies for robustness. I allocate all HS6 digit codes into bins based on HS2 and create a dummy for each HS2 category. This yields 94 product dummies. I then re-estimate an augmented version of (1) that includes product dummies. The results using imports and using exports are reported in columns (3) and (4) of Table 3, respectively. You can see that the $\alpha_3$ coefficient hardly changes when product dummies are included. In fact, more than 80% of the product dummies appear to be statistically insignificant\textsuperscript{8}. This further support supports the argument expressed in the previous section on why product dummies can be excluded from the baseline regression.

Summarizing the results using pooled data, I find that introduction of the euro brought about a more than 5% drop in EZ import prices volatility from other EZ members. However, it had no effect on export price volatility. This can be explained by prices set in the currency of the producer (PCP).

5.2 Country-Specific Regression:

One may worry that the results above are driven by just one country. To check this, I repeat the exercise for each EZ country. That is, specification (1) is estimated again, but this time $c$ is restricted to just one value each time. Each value corresponds to a different EZ country. Table 4 presents the results. Each column presents a different regression.

The results in the country-specific regressions further support PCP and show that the drop in import price volatility observed in the pooled data is not driven by just one country. In all but two EZ countries, I find strong evidence that import price volatility from other EZ countries dropped after the introduction of the euro. For example, the DID coefficient $\alpha_3$ ($\text{EZ}_i \text{AFTER}_t$) obtained from the regression using Austrian imports prices implies that there is a 4.4% reduction in the volatility of import prices from other EZ members that is attributed purely to the policy change (i.e. the introduction of the euro). The drop in import price volatility varies from as low as 2% for Italy to as high as 20% for France. Overall, the results provide strong

\textsuperscript{8}Although not shown to preserve space.
support for the presence of PCP. A possible explanation for the range observed in the drop is that EZ countries had various degrees of exchange rate fluctuations before adopting the euro. As a result, the euro’s ability to act as an insulating mechanism on import prices varies by country. I explore this hypothesis in detail later on and find that indeed, the magnitude of the drop is directly related to the level of the exchange rate fluctuation before the introduction of the euro.

Germany is one of the two countries where I fail to see a drop in import price volatility from other EZ countries (the other country is Portugal, the smallest economy in the group). This suggests that when exporting to Germany, firms tend to choose LCP over PCP. This finding agrees with our understanding of how firms choose to price. Germany had the most stable currency in the group and a currency that was seen as the precursor of the euro. Furthermore, the Deutch mark tended to appreciate versus the other currencies in the mid-nineties. Therefore, it seems more likely that prior to the euro, a bigger share of firms exporting to Germany would have chosen to price in Deutsche marks than in their own currencies.

I then estimate the by-country regressions using exports data. Table 5 presents the results. For several countries, there seems to be a small drop in export price volatility, although this drop is around 2% (with the exception of Ireland). This implies that some pricing at the currency of the consumer (LCP) occurs. This is expected since for many varieties in the sample (commodities) we do not expect to find evidence of PCP. I come back to this point later on. Since there are some firms choosing to price in local currency, then we should expect to find a drop in export price volatility. This is because for the share of firms choosing PCP over LCP, export price volatility does not change, but for the share that chooses LCP export price volatility drops. Aggregating the two effects together results in a drop in export price volatility. However, since the magnitude of the drop in import price volatility is much larger than the drop in export price volatility (9% over 2.5% on average for the countries that did experience a drop), the results suggest that PCP pricing in Europe dominates LCP.

Again, Germany is an exception to the rule. Export price volatility did not drop after the introduction of the euro. The interpretation of this finding is that prior to the euro, most German exporters chose to price in Deutscher mark. As discussed above, given the stability of the Deutscher mark, we should expect this to be the case.
The evidence from the country-specific regressions reinforce my previous findings; PCP prevails in the data. Furthermore, we see that setting prices at the currency of the producer is widespread among the EZ economies, and is not driven by only a few countries. Including product dummies in the regressions changes slightly the coefficients but not the direction of the results. Since the introduction of the euro eliminated nominal exchange rate fluctuations between EZ members, and I did find that EZ import price volatility from other EZ members dropped, I conclude that pricing in the currency of the producer dominates pricing in the currency of the consumer.

A concern one may have is that the results in this paper are driven by selection bias. That is, if the choice to adopt the euro and the timing did not come from political reasons but came from economic, then there is selection bias. If that is the case, the selection would tell us that a country with a low cost of adopting the euro would enter and a country with a high cost would stay out. The country with the low cost is the country with firms setting prices in the currency of the consumer. This is because in the presence pricing in the currency of the consumer exchange rates do not have a stabilizing power, so giving up the local currency comes at a low cost. But this implies that it would make it even harder for me to find evidence of pricing in the currency of the producer for the Eurozone countries as the direction of the bias goes against me.

Another concern may be that the drop I observe in import price volatility comes from a drop in inflation or a reduction in supply shocks. This however, cannot be an explanation either. Let us suppose that inflation in Austria was high in the period before the introduction of the euro but came down in the period after. In such case, import price volatility from Austria would be lower in the period after and we would observe a drop. The drop, however, would occur regardless of whether we look at French imports from Austria or US imports from Austria and it would be captured by the time dummy and not the difference-in-difference coefficient. Or suppose that supply shocks dropped in the period after for some reason. Again, we would expect this to be captured by the time dummy as it affects both export destinations (EZ, NonEZ). If you think that it should affects EZ destinations more due to the fact that EZ countries trade more with each other, then you should expect this to show up as a drop in export price volatility to other EZ destinations that is not captured by the time dummy. But as we saw earlier, export price volatility did not change.
5.3 Drop in Import Prices Volatility and Exchange Rate Fluctuation

I interpreted the drop in import prices volatility as evidence in favor of PCP. But why is the drop larger in some countries (e.g. France and Spain) than others (e.g. Italy)? Can the level of the exchange rate fluctuation before the introduction of the euro help explain the magnitude of the drop in import price volatility? The hypothesis is that the effect of the euro on reducing price volatility would be greater for countries that had volatile exchange rates in the past. For countries with stable exchange rates, the euro should have less of an impact. To investigate this I plot the drop in import price volatility (DIDs coefficient from Table 4) against the absolute change in the trade weighted exchange rate between 1994 and 1995. The weights are based on each country’s imports from the other EZ countries. The result is presented in Graph 2. The plot shows a positive correlation between a country’s exchange rate fluctuation before the euro and the magnitude of drop in import price volatility after the introduction of the euro. France and Spain seem to have experienced a much larger drop in import price volatility than most countries.

I can also capture the positive relation between the drop in import price volatility and the level of the exchange rate volatility before the euro in a regression. Below I report estimates from regressing the DIDs coefficient on the (abs) log change of the exchange rate between 1994 and 1995. The estimated equation is

$$\alpha_3 = -0.93 \Delta s_t, \quad R^2 = 0.31$$

with the t-statistics in parenthesis. The coefficient in this regression shows that for the countries that experienced a drop in import price volatility, the magnitude of the drop is commensurate with the drop in exchange rate volatility as predicted by the LOP.

5.4 Product Differentiation and Invoicing Choice

There is one additional and important empirical question I can answer by utilizing the Difference-in-Difference approach developed in this paper. Recent evidence suggests that market structure is a determinant of the
pricing choice\textsuperscript{9}. The degree of good heterogeneity determines whether a firm chooses to price in local (LCP) or producer (PCP) currency (or to price in USD even if the trade does not involve the US). By allocating goods into three broad categories as suggested by Rauch\textsuperscript{10}, Goldberg and Tille (2006), Colacelli (2007), and Gopinath et al. (2007) find a higher percentage of non-dollar pricing in differentiated goods sectors than in reference priced or commodity sectors. As a consequence of the pricing choice, these studies find that the degree of pass-through is the highest in the differentiated goods sectors.

This evidence poses the following testable hypothesis: focusing on imports among EZ members, there should be a larger drop in import price volatility after the introduction of the euro for differentiated goods than for reference priced goods or commodities. If, as suggested, pricing in dollars is more common for commodities, then the introduction of the euro should not have a large impact on import price volatility. By contrast, if non-dollar pricing is higher in differentiated goods, then import price volatility between EZ members should fall after the introduction of the euro.

To test the hypothesis above I allocate all EZ imports data into the following three groups: commodity, reference priced goods, and differentiated goods. The groups are based on the Rauch classification system at the 4-digit SITC code. To check the effect of the euro on import price volatility for each group, I pool all EZ imports together and estimate equation (1) for each product group.

Table 6 reports the DIDs coefficient ($\alpha_3$) from the three regressions with t-statistics in parenthesis. Rauch provides a "conservative" and a "liberal" classification. The results shown are based on the liberal classification. Using the conservative classification yielded identical results and was therefore, omitted. For each regression I report the coefficient of $EZ_i \text{AFTER}_t$, the $R^2$ and the number of observation. I see that among EZ members, import price volatility in differentiated goods from other EZ destinations dropped by 16\% after the introduction of the euro. By contrast, when looking at commodities I see no drop in import price volatility (there is a 2\% drop in the case of reference priced goods). In other words, I find strong

\textsuperscript{9}Simple models of market structure and pricing choice can be found in Dornbush (1987), Krugman (1987), Marston (1990), Goldberg and Tille (2006) and Hodrick and Bekaert (2008).

\textsuperscript{10}According to Rauch [1999], “Organized Exchange” traded goods cover products that have an overt market (i.e. precious metals). “Reference Price” goods are homogeneous goods that do not have a substantial enough volume to have an "official" market (e.g. obscure chemical products), but are homogeneous enough to have "reference" prices that are published in trade magazines.
evidence of PCP for heterogeneous goods but no evidence for commodities. The findings here match those of Goldberg and Tille (2006), Colacelli (2007), and Gopinath et al. (2007), and provide a robustness check to the methodology suggested in this paper.

An alternative way to examine how the market structure plays a role in the pricing choice of firms is to allocate all varieties in bins based on their elasticity of substitutions. Elasticity data are taken from Broda and Weinstein (2005). The hypothesis here is that as the elasticity of substitution increases, more firms will choose LCP over PCP. At the same time, as the elasticity of substitution falls, I should expect to find more evidence of PCP. The reason is simple. For highly elastic products, firms face a higher competition. Therefore, they will tend to set prices in the currency of the consumer in order to avoid substantial drops in demand when the exchange rate moves against them. Regression (1) is now estimated for each of the three elasticity bins. The results are in Table 7. For products with high elasticities, there is no drop in import price volatility. However, for products with low elasticities of substitution, the drop in import price volatility is substantial. There is a 16% drop in the volatility of inelastic EZ imports from other EZ members as a result of the euro. The results are not surprising since most commodities fall in the high elasticity bin ($\sigma > 5$) and most of the differentiated products fall in the low elasticity bin ($1 < \sigma < 3$).

6 Conclusion

The pricing behavior of firms is a central issue in international macroeconomics. When the producers selling in a foreign market have prices that are rigid in the producer’s currency, an exchange rate devaluation makes export goods cheaper abroad. Therefore, manipulation of the exchange rate can have a stabilizing effect in the face of an adverse demand shock. Given this, optimal monetary policy favors flexible exchange rates. In contrast, when prices are rigid in the currency of the consumer, an exchange rate devaluation does not have much of a stabilizing power as it fails to change the terms-of-trade. In this case, the optimal monetary policy favors fixed exchange rates.

Whether prices are rigid in the currency of the producer or the consumer is a key to several recent economic policy debate. One such debate is on whether the introduction of the euro came at a high cost as it stripped countries of their right to use devaluations as a stabilizing tool against adverse demand shocks.
Another debate is on whether the steady appreciation of the euro has a big negative effect on the demand for EU exports and on whether the ECB should have a more active role in controlling its climb.

In this paper I use the introduction of the euro as a natural experiment in order to see how prices are set. By examining import and export price volatility before and after the introduction of the euro, I find that for the EZ countries, import price volatility from other EZ members dropped as the result of the euro, whereas export price volatility did not change. Furthermore, I show that the magnitude of the drop in import price volatility is commensurate with the drop in exchange rate volatility as predicted by the LOP. These findings support the presence of producer currency pricing and imply that the concerns expressed by Feldstein and Obstfeld on the benefits of the euro have merit. I also show that pricing in the currency of the producer is more common for differentiated products and products with lower elasticities of substitution.

Using the introduction of the euro as a natural experiment has several advantages. It enables me to work in a cross-sectional framework with highly disaggregated unit-prices trade data. As a result, I am able to minimize both the aggregation and the small sample bias. And since I have data on trade volumes I can apply the weighting scheme suggested by Broda and Weinstein (2005) in order to reduce measurement error. Furthermore, I can examine how import and export prices change by country, by market organization and by the number of substitutes a product has.

My investigation on whether the introduction of the euro is economically justified is done in a very myopic framework set forward by the debate between Feldstein and Obstfeld and Devereux and Engel. In this framework, the presence of PCP implies that there are concerns associated with a country’s choice to give up its own currency. However, in a different framework, lower import price volatility may be beneficial. A possible extension of this work is to generate welfare gains associated with the introduction of the euro by using my estimates on the change in import price volatility to calibrate models. This can be done in two ways. Devereux, Engel, and Tille (1999, 2003) show that the reduction in price volatility implies a reduction in real money shocks that can be translated to welfare gains. Alternatively, welfare gains can be modeled directly through consumer preferences. Using a Taylor series expansion of the utility function around the steady state, one can associate welfare with changes in prices. A model that incorporates this is presented in Benigno and Benigno (2006). They develop a two-country trade model and show that the welfare function...
depends on both domestic and foreign inflation. Although they are interested in optimal targeting policies under cooperation, the same model can be calibrated using the results in this paper and yield estimates on the level of welfare gains after the euro.
References


1 Appendix

The Law of One Price (LOP) states that after controlling for exchange rates, prices of identical goods across locations should be the same. Similarly, the Purchasing Power Parity (PPP) states that prices of identical bundles should be the same across locations. Empirical evidence shows that prices –after adjusting for exchange rates– are not the same across locations and that these price gaps are persistent across time. This is the celebrated PPP puzzle in Rogoff’s (1996) seminal paper.

The PPP puzzle has two main alternative interpretations. Some economists argue that the differences in international prices are evidence in favor of local currency pricing (LCP). Others argue that apparent failure of the PPP is purely an econometric artifact caused by aggregations bias, measurement errors, and small sample bias (see Imbs et al [02, 05], Chen and Engel [05]).

In this section I show how the results presented by Engel (2000) as evidence in favor of rejecting the LOP can actually be evidence in favor of the LOP. The two assumptions I will make in order to obtain this result is that the price indexes include non-traded goods (which is the case) and the prices of the non-traded goods do not fluctuate much with movements in the exchange rate. I summarize below Engel’s findings and proceed to illustrate how important aggregation bias can be.

Engel (2000) finds that the law of one price (LOP) fails in a sample of 22 goods categories from 9 European countries. He attributes part of this failure to the presence of LCP. The evidence comes from correlating the annual changes in the exchange rate with annual changes in the real exchange rate for the categories investigated. If the LOP holds, annual changes in the exchange rate should not be correlated with annual changes in the real exchange rate. This is because any change in the exchange rate should be exactly offset by changes in prices, rendering the real exchange rate unaffected. However, when Engel correlates the nominal and real exchange rates he finds that the correlations are positive and for the majority, close to 1. He also reports estimates from an error correction model that is based on the LOP but allows price differentials to be eliminated over time through price adjustments. Allowing for time adjustments does not change the findings above. Price differentials do not seem to respond to exchange rate movements. This will occur when price indexes are used to test the LOP instead of individual good prices, and when these price indexes include non-traded goods.
Next, I show explicitly how based on the correlation test above one can erroneously reject the LOP, even though the LOP actually holds. This happens because price indexes introduce aggregation bias, and this bias can be especially large when non-traded goods are included in these indexes. I will build the exercise in two incremental steps. First, the price indexes will not have non-traded goods, but the countries will have different preferences. I will then assume that the countries are identical in every respect, but the price indexes include non-traded goods.

1.1 Traded Goods

Consider two economies and one good (traded) produced in each country. Let $P_{TR}$ be the price in the home country of a basket of traded goods and $P^*_{TR}$ be the price in the foreign currency of a basket of traded goods. Let $H$ be the home-produced traded good and $F$ be the foreign-produced traded good. Furthermore, assume that the LOP holds for each of the two traded goods. We use lower case letters to denote logarithms.

Suppose that the preferences are such that allows us to express $P_{TR}$ and $P^*_{TR}$ as

\[ P_{TR} = P^*_H P^{1-\alpha}_F \]  
\[ P^*_{TR} = P^*_H P^{\beta}_F P^{1-\beta} \]

Suppose now that an econometrician cannot observe individual good prices but rather she can observe the price indexes $P_{TR}$ and $P^*_{TR}$ of the tradable baskets.

**Proposition 1** \( \text{Corr}(\Delta p^*_{TR,t} + \Delta e_t - \Delta p_{TR,t}, \Delta e_t) = \text{Corr}((\beta - \alpha) \Delta p, \Delta e_t) \neq 0 \)

where $P$ is the terms-of-trade for the home country ($P = P_{x_H}/P_{x_F}$) and $e_t$ is the exchange rate expressed as units of the home currency per unit of the foreign currency.

**Proof.** To see this

\[ P_{TR} = P^*_H P^{1-\alpha}_F = P_H P^{\alpha-1} \]  
\[ P^*_{TR} = P^*_H P^{\beta}_F P^{1-\beta} \]
where \( P = P_H/P_F \) and \( P^* = P^*_F/P^*_H \). Time subscripts are omitted for simplicity. Lower case letters denote logarithms. If the LOP holds then,

\[
P_H = EP_H^* \\
P_F = EP_F^*
\]

therefore

\[
P = \frac{1}{P^*} \tag{1f}
\]

\[
P^*_{TR} = P_F^*P^{\beta} \tag{1g}
\]

Then,

\[
P_{TR} = P_H P^{\alpha-1}
\]

\[
= P_H P^{-1} P^\alpha
\]

\[
= P_H P \left( \frac{P^*_{TR}}{P^*_F} \right)^{\frac{\beta}{\alpha-1}}
\]

\[
= P_H P^{-1} P^*_H \left( \frac{P^*_{TR}}{P^*_F} \right)^{\frac{\beta}{\alpha-1}}
\]

\[
= EP^*_H P^{-1} P^*_{TR} \left( \frac{P^*_{TR}}{P^*_F} \right)^{\frac{\beta}{\alpha-1}} \tag{1h}
\]

\[
= EP^*_H Q \tag{1i}
\]

where \( Q \) is the departure from absolute PPP, namely \( Q = (P^*_F/P^*_H)^{\frac{\beta}{\alpha-1}} = P^{\alpha-\beta} \).

Implementing the correlation test using price indexes of traded goods, we obtain

\[
Corr(\Delta p^*_{TR} + \Delta e - \Delta p_{TR}, \Delta e_t) = Corr(\Delta q, \Delta e_t)
\]

\[
= Corr((\beta - \alpha)\Delta p, \Delta e_t)
\]

\[
\neq 0
\]
Proposition 1 states that in the absence of non-traded goods, annual changes in the exchange rate will not be correlated with annual changes in the terms-of-trade when looking at price indexes if and only if the two countries have the same basket of goods (i.e. $\alpha = \beta$). Otherwise, the LOP predicts that there will be some correlation.

### 1.2 Non-Traded and Traded Goods

Let the variables be defined as above. In addition, let $N_H$ and $N_F$ be the home and foreign produced non-traded good. We will assume that the prices of the non-traded goods do not move much with changes in the nominal exchange rate. Define the CPI and CPI* as

$$
\begin{align*}
CPI &= P^\gamma_{TR} P^{1-\gamma}_{N_H} \\
CPI^* &= P^\delta_{TR} P^{1-\delta}_{N_F}
\end{align*}
$$

(10)

(11)

To make the algebra simpler and the intuition clearer let us assume that countries have identical baskets ($\alpha = \beta$) and weights ($\gamma = \delta$). We are interested in testing for the LOP but again, assume that the econometrician can only observe the two price indexes.

**Proposition 2** \(\text{Corr}(\Delta cpi^*_t + \Delta e_t - \Delta cpi_t, \Delta e_t) = 1 - \gamma\)

\[\text{where } 1 - \gamma \text{ is the share of non-traded goods in the basket of traded and non-traded.}\]

**Proof.**

$$
\begin{align*}
CPI &= P^\gamma_{TR} P^{1-\gamma}_{N_H} = P_{TR} \left( \frac{P_{N_H}}{P_{TR}} \right)^{1-\gamma} \\
CPI^* &= P^\gamma_{TR} P^{1-\gamma}_{N_H} = P_{TR} \left( \frac{P_{N_H}}{P_{TR}} \right)^{1-\gamma}
\end{align*}
$$

(12a)

(12b)

With LOP,

$$
\frac{CPI}{ECPI*} = \frac{P_{TR} \left( \frac{P_{N_H}}{P_{TR}} \right)^{1-\gamma}}{EP_{TR} \left( \frac{P_{N_F}}{P_{TR}} \right)^{1-\gamma}}
$$

$$
= \frac{\left( \frac{P_{N_H}}{P_{TR}} \right)^{1-\gamma}}{Q}
$$

(13)
therefore,

\[
E = \frac{\text{CPI}}{\text{CPI}^*} \left( \frac{p_{N_F}^*}{p_{N_H}^*} \right)^{1-\gamma} Q
\]

\[
= \frac{\text{CPI}}{\text{CPI}^* (n)^{1-\gamma} Q}
\] (14)

where \( n = P_{N_H}/P_{TR} \) and \( n^* = P_{N_F}^*/P_{TR}^* \). The departure from PPP is now given by \( \frac{(n^*)^{1-\gamma}}{(n)^{1-\gamma} Q} \).

The correlation test with CPI price indexes is now

\[
\text{Corr}(\Delta cpi_t + \Delta e_t - \Delta cpi_{t,TR}, \Delta e_t) = \text{Corr} \{(1-\gamma)\Delta n^* - (1-\gamma)\Delta n - \Delta q, \Delta e\}
\]

\[
= \text{Corr} \{(1-\gamma)(\Delta n^* - \Delta n) - \Delta q, \Delta e\}
\]

\[
= \text{Corr} \{(1-\gamma)(\Delta p_{N_F}^* - \Delta p_{N_H}) - (1-\gamma)(\Delta p_{TR}^* - \Delta p_{TR}) - \Delta q, \Delta e\}
\]

\[
= \text{Corr} \{(1-\gamma)(\Delta e - \Delta q) - \Delta q, \Delta e\}
\]

\[
= \text{Corr} \{(1-\gamma)\Delta e, \Delta e\}
\]

\[
= (1-\gamma)\text{Corr} \{\Delta e, \Delta e\}
\]

\[
= (1-\gamma)
\] (15)

The fourth equality comes from the assumption that the prices of the non-traded goods are not affected by changes in the nominal exchange rates, i.e. \( \Delta (p_{N_F}^* - p_{N_H}) = 0 \). As long as the non-traded sector does not rely heavily on foreign intermediate inputs, the assumption above will be a realistic one. The fifth equality comes from the fact that the traded baskets are the same across countries and therefore \( Q \) is 0.

Proposition 2 states that in the presence of traded and non-traded goods, annual changes in the exchange rate will always be positively correlated with annual changes in the real exchange rate if the LOP holds when looking at price indexes. This is true even when the countries have identical baskets and preferences. Furthermore, the correlation will be directly related to the weight of the non-traded goods included in the basket.

The implication of the proposition above is that the evidence presented in Engel (2000) may actually be
in favor of the LOP. This is because the price indexes in Engel contain non-traded goods. We know that import penetration for OECD countries is roughly 20% so in an average basket the share of non-traded goods is 80%. Therefore, Proposition 2 implies that the correlation between the nominal and the real exchange rate when price indexes are used should be closer to 0.8 than 0 if the LOP holds. Engel (2000) did find large and positive correlations (larger than 0.7) but concluded that this was clear evidence against the LOP.
Table 1 - Theory Predictions for the Sign of $\alpha_3$

<table>
<thead>
<tr>
<th></th>
<th>PCP</th>
<th>LCP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imports</td>
<td>$&lt;0$</td>
<td>0</td>
</tr>
<tr>
<td>Exports</td>
<td>0</td>
<td>$&lt;0$</td>
</tr>
</tbody>
</table>

*Notes:* The table summarizes predictions under PCP and LCP for EMU import and export price volatility after the introduction of the euro (sign of $\alpha_3$).
Table 2 - Summary Statistics

<table>
<thead>
<tr>
<th></th>
<th>Panel A: Mean Price Volatility by Group</th>
<th>Panel B: Median Price Volatility by Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>i. IMPORTS</td>
<td>ii. EXPORTS</td>
</tr>
<tr>
<td></td>
<td>Partner (Origin)</td>
<td>Partner (Destination)</td>
</tr>
<tr>
<td>Reporter</td>
<td></td>
<td>Reporter</td>
</tr>
<tr>
<td>EZ</td>
<td>0.23 0.25 0.19 0.17</td>
<td>0.18 0.16 0.16 0.12</td>
</tr>
<tr>
<td>NonEZ</td>
<td>0.20 0.22 0.18 0.17</td>
<td>0.19 0.23 0.19 0.20</td>
</tr>
</tbody>
</table>

|                  | i. IMPORTS                             | ii. EXPORTS                              |
|                  | Partner (Origin)                        | Partner (Destination)                     |
| Reporter         |                                        | Reporter                                 |
| EZ               | 0.04 0.04 0.03 0.02                     | 0.03 0.02 0.03 0.02                      |
| NonEZ            | 0.03 0.03 0.03 0.03                     | 0.03 0.03 0.03 0.03                      |
Table 3 - Pooled Regression

<table>
<thead>
<tr>
<th></th>
<th>IMPORTS (1)</th>
<th>EXPORTS (2)</th>
<th>IMPORTS (3)</th>
<th>EXPORTS (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFTER</td>
<td>0.060</td>
<td>0.001</td>
<td>0.059</td>
<td>-0.001</td>
</tr>
<tr>
<td></td>
<td>(62.63)</td>
<td>(1.08)</td>
<td>(62.38)**</td>
<td>(-1.54)</td>
</tr>
<tr>
<td>EZ&lt;sub&gt;_AFTER&lt;/sub&gt;</td>
<td>-0.054</td>
<td>0.001</td>
<td>-0.056</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(43.58)**</td>
<td>(1.02)</td>
<td>(45.42)**</td>
<td>(1.38)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.021</td>
<td>0.022</td>
<td>-0.0113</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(43.05)**</td>
<td>(72.89)**</td>
<td>(-2.42)**</td>
<td>(1.38)</td>
</tr>
<tr>
<td>Includes Product Dummies</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>302,990</td>
<td>329,465</td>
<td>302,990</td>
<td>329,465</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.18</td>
<td>0.12</td>
<td>0.21</td>
<td>0.17</td>
</tr>
</tbody>
</table>

*Notes:* Reporter-Partner Interactions omitted from the Table. T-statistics in parenthesis. * significant at 5%; ** significant at 1%. Columns (1) and (2) do not include product dummies. Columns (3) and (4) include product dummies at the 2-digit HS code. This yields 94 product dummies.
### Table 4 - Country-Specific Regressions: Imports

<table>
<thead>
<tr>
<th></th>
<th>Austria</th>
<th>Finland</th>
<th>France</th>
<th>Germany</th>
<th>Greece</th>
<th>Ireland</th>
<th>Italy</th>
<th>Netherlands</th>
<th>Portugal</th>
<th>Spain</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AFTER</strong></td>
<td>0.031</td>
<td>0.074</td>
<td>0.199</td>
<td>0.01</td>
<td>0.048</td>
<td>0.073</td>
<td>0</td>
<td>0.141</td>
<td>0.003</td>
<td>0.173</td>
</tr>
<tr>
<td></td>
<td>(9.21)**</td>
<td>(22.90)**</td>
<td>(44.37)**</td>
<td>(9.01)**</td>
<td>(4.16)**</td>
<td>(15.57)**</td>
<td>-0.07</td>
<td>(42.02)**</td>
<td>-0.63</td>
<td>(37.41)**</td>
</tr>
<tr>
<td><strong>E_4AFTER_t</strong></td>
<td>-0.044</td>
<td>-0.097</td>
<td>-0.2</td>
<td>0.015</td>
<td>-0.017</td>
<td>-0.084</td>
<td>-0.016</td>
<td>-0.074</td>
<td>0.033</td>
<td>-0.192</td>
</tr>
<tr>
<td>Constant</td>
<td>0.024</td>
<td>0.018</td>
<td>0.007</td>
<td>0.021</td>
<td>0.069</td>
<td>0.107</td>
<td>0.026</td>
<td>0.046</td>
<td>0.016</td>
<td>0.026</td>
</tr>
<tr>
<td></td>
<td>(35.66)**</td>
<td>(9.03)**</td>
<td>(3.15)**</td>
<td>(33.29)**</td>
<td>(15.48)**</td>
<td>(23.37)**</td>
<td>(72.42)**</td>
<td>(27.62)**</td>
<td>(9.48)**</td>
<td>(16.50)**</td>
</tr>
<tr>
<td>Observations</td>
<td>28392</td>
<td>23962</td>
<td>46526</td>
<td>50667</td>
<td>16629</td>
<td>13780</td>
<td>40332</td>
<td>27392</td>
<td>23144</td>
<td>32166</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.05</td>
<td>0.17</td>
<td>0.2</td>
<td>0.07</td>
<td>0.1</td>
<td>0.17</td>
<td>0.28</td>
<td>0.32</td>
<td>0.09</td>
<td>0.13</td>
</tr>
</tbody>
</table>

**Notes:** Each column represents a different regression. Partner Dummies omitted from the Table. T-statistics in parenthesis. * significant at 5%; ** significant at 1%
Table 5 - Country-Specific Regressions: Exports

<table>
<thead>
<tr>
<th></th>
<th>Austria</th>
<th>Finland</th>
<th>France</th>
<th>Germany</th>
<th>Greece</th>
<th>Ireland</th>
<th>Italy</th>
<th>Netherlands</th>
<th>Portugal</th>
<th>Spain</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AFTER</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.044</td>
<td>-0.004</td>
<td>0.013</td>
<td>-0.004</td>
<td>0.018</td>
<td>0.046</td>
<td>-0.019</td>
<td>0.073</td>
<td>0.062</td>
<td>0.015</td>
</tr>
<tr>
<td></td>
<td>(7.59)**</td>
<td>(2.97)**</td>
<td>(9.62)**</td>
<td>(11.10)**</td>
<td>-1.83</td>
<td>(2.53)*</td>
<td>(13.98)**</td>
<td>(16.90)**</td>
<td>(7.97)**</td>
<td>(6.46)**</td>
</tr>
<tr>
<td><strong>EZ_AFTER_t</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.052</td>
<td>-0.017</td>
<td>-0.023</td>
<td>0.004</td>
<td>-0.009</td>
<td>-0.064</td>
<td>0.005</td>
<td>-0.026</td>
<td>-0.027</td>
<td>-0.013</td>
</tr>
<tr>
<td></td>
<td>(8.83)**</td>
<td>(8.14)**</td>
<td>(13.80)**</td>
<td>(6.79)**</td>
<td>-0.85</td>
<td>(2.52)*</td>
<td>(2.92)**</td>
<td>(5.39)**</td>
<td>(3.19)**</td>
<td>(5.52)**</td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>0.026</td>
<td>0.032</td>
<td>0.032</td>
<td>0.013</td>
<td>0.019</td>
<td>0.069</td>
<td>0.043</td>
<td>0.031</td>
<td>0.031</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>(25.65)**</td>
<td>(36.70)**</td>
<td>(47.29)**</td>
<td>(50.69)**</td>
<td>(10.20)**</td>
<td>(4.72)**</td>
<td>(76.55)**</td>
<td>(20.09)**</td>
<td>(12.06)**</td>
<td>(12.30)**</td>
</tr>
<tr>
<td>Observations</td>
<td>22086</td>
<td>11771</td>
<td>63056</td>
<td>85758</td>
<td>2740</td>
<td>4465</td>
<td>65382</td>
<td>37490</td>
<td>7745</td>
<td>28972</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.02</td>
<td>0.2</td>
<td>0.04</td>
<td>0.02</td>
<td>0.05</td>
<td>0.06</td>
<td>0.09</td>
<td>0.05</td>
<td>0.19</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Notes: Each column represents a different regression. Partner Dummies omitted from the Table. T-statistics in parenthesis. * significant at 5%; ** significant at 1%
### Table 6 - Change in Import Price Volatility by Rauch Classification

<table>
<thead>
<tr>
<th></th>
<th>Commodity</th>
<th>Reference Priced</th>
<th>Differentiated</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EMUi_AFTER</strong></td>
<td>-0.00</td>
<td>-0.02</td>
<td>-0.16</td>
</tr>
<tr>
<td></td>
<td>(-4.42)**</td>
<td>(-9.52)**</td>
<td>(-87.28)**</td>
</tr>
<tr>
<td><strong>R-Square</strong></td>
<td>0.54</td>
<td>0.16</td>
<td>0.37</td>
</tr>
<tr>
<td><strong>Observations</strong></td>
<td>18,560</td>
<td>79,811</td>
<td>202,256</td>
</tr>
</tbody>
</table>

Notes: We classify all imported goods into Commodity, Reference Priced, and Differentiated following the Rauch (1999) classification system. We then estimate the pooled regression for each category and report the DIDs coefficient. *significant at 5%; **significant at 1%.
Table 7 - Change in Import Price Volatility by Product Elasticity

<table>
<thead>
<tr>
<th>Elasticity of Substitution (σ)</th>
<th>5+</th>
<th>3-5</th>
<th>1-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMUi_AFTER</td>
<td>0.02</td>
<td>-0.03</td>
<td>-0.11</td>
</tr>
<tr>
<td></td>
<td>(10.08)**</td>
<td>(-23.34)**</td>
<td>(-47.99)**</td>
</tr>
<tr>
<td>R-Square</td>
<td>0.72</td>
<td>0.18</td>
<td>0.24</td>
</tr>
<tr>
<td>Observations</td>
<td>25,416</td>
<td>73,158</td>
<td>243,512</td>
</tr>
</tbody>
</table>

Notes: We allocate all imported goods into three bins based on the elasticity of substitution of the particular good. The elasticity data comes from Broda and Weinstein. We then estimate the pooled regression for each category and report the DIDs coefficient. T-statistics in parenthesis. * significant at 5%; ** significant at 1%.