Has the Euro Shrunk the Band?
Price Convergence in a Currency Union

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Abstract

I study the effects of the European Monetary Union (EMU) on price convergence using monthly disaggregated price indices from 32 European countries from 1999 to 2016. I apply Heckscher's insight that transaction costs create bands of inaction in which price differences are not arbitraged away, and I estimate the bands of inaction using a threshold autoregressive model. My findings suggest that the EMU reduces transaction costs: the bands of inaction between countries in the EMU are 17% lower than the average band. Time series evidence from the entry in the EMU of selected countries further confirms the result.

Keywords: Currency Union, Price Convergence, Euro, Arbitrage, Threshold Autoregressive Model.

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1 Introduction

Does a currency union improve price convergence among of its members? According to the theoretical literature on optimal currency areas, the answer is yes: a common currency reduces transaction costs and, hence, facilitates price convergence (Mundell, 1961). The eighteen years of the European Monetary Union (EMU) have provided a relevant experiment to test such an intuitive theory. However, the evidence that a currency union improves price convergence is mixed. Engel and Rogers (2004) find no convergence in prices after the birth of the EMU while Allington et al. (2005) document it. However, more recent work from Cavallo et al. (2014, 2015), which incorporates the new entrants in the EMU, suggests that prices in a currency union do converge.

I study the effects of the EMU on price convergence using a comprehensive dataset of monthly disaggregated price indexes from Eurstotat. Moreover, I analyze whether the convergence in prices in the EMU can be explained by a reduction in transaction costs associated with international arbitrage[1]. Heckscher's noted in 1916 that transaction costs create scope for deviations from the law of one price (LOP) and, hence, from purchasing power parity (PPP). I formalize the insight in a simple model of international arbitrage, in which arbitrageurs must pay variable and fixed costs to exploit international price differences for profit. Frictions to international arbitrage generate "commodity points," defined by Obstfeld and Taylor (1997) as "*thresholds delineating a region of no central tendency among relative prices*," namely, bands of inaction. The model predicts that the bands of inaction between two countries increase with variable and fixed transaction costs, and decline with the size of the two countries. By reducing transaction costs, a currency union shrinks the bands of inaction and, thus, it facilitates price convergence.

I estimate the thresholds of the bands of inaction for 43 tradable baskets of goods, using disaggregated price indexes from 32 European countries. The data span from the introduction of the euro in January 1999 to April 2016. I compute the short-run deviations from PPP by demeaning and detrending the good-specific real exchange rate for each country pair, in order to control for long-run differences in prices due to pricing to market or distribution costs. I estimate the thresholds of the bands of inaction of the short-run deviations from PPP using a threshold autoregressive (TAR) model (Obstfeld and Taylor, 1997). The average band of inaction across all goods and country pairs is 6.6%: any differences between the relative price of a good and its long-run equilibrium value outside the 6.6% range would be arbitraged away.

The euro has a negative and statistically significant effect on the bands of inaction. Country pairs that share the same currency have bands of inaction that are 17% smaller than the average band: the euro shrunk the band. The result is robust to alternative empirical specifications, where I control for traditional indicators of trade costs and country size (Head et al., 2010). Moreover, controlling for the volatility of the nominal exchange rate, I find that the effect of the euro on the bands of inaction exceeds that of a fixed exchange rate regime, which confirms the results of

[1] Engel and Rogers (1996) were the first to estimate trade costs using price data.

Cavallo et al. (2014). Finally, the euro shrunk the bands of inaction for the 11 founders of the EMU as well as for the new members.

Countries that are members of the EMU are also members of the European Union (EU) and, for the most part, of the Schengen Area. Both the EU and the Schengen Area are European institutions that promote economic integration. In fact, the average band of inaction is 5.6% within the EU and 9.8% outside the EU. Similarly, country pairs in the Schengen Area have an average band of inaction of 6.2% while outside of the Schengen Area, the average band is 7.2%. To identify the effect of the EMU separately from these other European institutions, I restrict the sample of countries to members of the EU and the Schengen Area. On average, a country pair that belongs both to the EU and to the EMU has a band of inaction that is 18% lower than the average band in the EU. The euro reduces the average band within the Schengen Area by 11%, and by 17% within both the EU and the Schengen Area.

A common concern in measuring integration in the EMU is the endogeneity in the choice of joining the currency union (Alesina and Barro, 2000). If economic integration is a prerequisite for entering the EMU, estimates from the cross-section of country pairs would not capture a causal effect of the EMU on the bands of inaction. To address this issue, the ideal test requires comparing the bands of inaction before and after the entry in a currency union. Data limitations allow me to perform such a test on two cases. First, I consider the four countries that joined the EMU in the middle of the period available in the data: Cyprus, Malta, Slovenia, and Slovakia. I estimate the bands of inaction between those four countries and the others in my sample before and after their entry to the EMU. The bands of inaction for the pairs that entered the EMU fell by 22%. Second, I combine my dataset with the price indices for selected goods provided by Juvenal and Taylor (2008) from 1981 to 1998. After the creation of the EMU in 1999, the bands of inaction of country pairs that shared the same currency fell by approximately 50% relative to the country pairs that kept different currencies.

The theoretical model suggests that bands of inaction are lower within the EMU because a currency union reduces transaction costs. Although the effect of a currency union on transaction costs cannot be directly measured given the available data, additional evidence supports the model's prediction that bands of inaction are related to transaction costs. Bands of inaction are wider for more distant country pairs and for islands. On average, country pairs that share a common language and that are members of the EU have lower bands of inaction. Moreover, the evidence indicates the presence of fixed costs of international arbitrage: the larger the countries are, the lower the transaction costs between them are. There is a negative relationship between bands of inaction and the dimension of the distribution network, proxied by measures of the size of retail, wholesales and online markets. Finally, I estimate the bands of inaction for non-tradable goods: neither the euro nor bilateral distance affects the bands of inaction of non-tradable goods.

However, the model predicts that bands of inactions are an indirect measure of transaction costs. Since arbitrage usually occurs through non-traditional distribution channels, such as parallel imports (Ganslandt and Maskus, 2004), there is a certain degree of substitutability between goods sold in traditional channels and the goods sold by arbitrageurs. Such substitutability dampens the effects of transaction costs on bands of inaction: the estimated effect of the euro on the bands of inaction can be considered as a lower bound for the effect of the euro on transaction costs.

What types of transaction costs does the EMU reduce? First, the EMU eliminates the need to hedge against exchange rate risk, which is analogous to fixed exchange rate regimes. However, the results of the study imply that the effect of the EMU goes beyond that of a pegged system. Second, a common currency reduces currency exchange fees (Anderson and Wincoop, 2004). Third, a currency union reduces information frictions by facilitating the comparison of prices. In fact, experimental evidence from Mussweiler and Strack (2004) suggests that consumers find it easier to compare prices in the same currency[2].

In the last few years, the European crisis (Lane, 2012) and the recent vote on the exit of the UK from the EU cast some shadows on the European experiment. This study addresses both issues. First, critics of the EMU claim that in the presence of country-specific shocks, the lack of exchange rate flexibility limits price adjustments. However, the results of this study partially contrast this claim for tradable goods: within the EMU, bands of inaction are narrower, and prices converge faster when they are outside the bands of inaction, in line with Bergin et al. (2016). Moreover, countries that are in the EU exhibit bands of inaction that are 24% lower than the average band. The result implies that prices in the UK and the members of the EU will diverge.

The remainder of the paper is organized as follows. Section 2 surveys the related literature. Section 3 presents a simple model of arbitrage that guides the empirical analysis. Section 4 outlines the empirical strategy to estimate the bands of inaction and to quantify the effect of the EMU on the bands. Section 5 provides evidence for the negative effect of the euro on the bands of inaction. Section 6 concludes.

2 Related Literature

Several studies have examined the effects of the EMU on price convergence, finding mixed results. Engel and Rogers (2004), Parsley and Wei (2008), and Fischer (2012) are among the studies that reject the hypothesis of price convergence within the EMU[3]. By contrast, Goldberg and Verboven (2004), Lutz (2004), Allington et al. (2005), Dvir and Strasser (2013), Cavallo et al. (2014), and Cavallo et al. (2015) provide evidence for a positive effect of currency unions on price convergence[4].

[2] Boivin et al. (2012) argue that information frictions can explain the deviations from the LOP between the US and Canada, despite minimal transaction frictions. A related mechanism is that of Cavallo et al. (2014), who argue that firms tend to charge similar prices in a currency union to avoid angering their customers (Rotemberg, 2005).

[3] Goldberg and Verboven (2005), Rogers (2007), Cuaresma et al. (2007) and Faber and Stokman (2009) document price convergence within the EMU years or decades prior to the birth of the currency union.

[4] A related research question is whether a currency union promotes trade. In the context of the EMU, the currency union effect on trade flows is in the range of 4-50% (Micco et al., 2003; Baldwin, 2006; Flam and Nordström, 2006; Glick and Rose, 2016).

The dataset and the methodology used distinguish this study from the previous literature. Using price indices is highly representative, in that it covers more products than the micro studies of Parsley and Wei (2008), Fischer (2012), and Cavallo et al. (2014). Another benefit of the data used in this paper is the period covered. With the exception of Cavallo et al. (2015), in fact, most of the authors were forced to study the effect of the EMU on its original members. In this study, I consider additional eight entrants and study how the bands of inaction for some of them changed before and after the entry in the EMU. However, the use of price indices underestimates the bands of inaction because of a downward aggregation bias (Allington et al., 2005). Evidence suggests that the aggregation bias may have only mild consequences: the estimated effect of the euro on the bands of inaction is robust to using more aggregate definitions for the basket of goods.

This study introduces, in this field of literature, the TAR model (Obstfeld and Taylor, 1997) to estimate the bands of inaction of relative prices. The main benefit of this approach is that it identifies a channel - the reduction in transaction costs - through which a currency union improves price convergence among its members. I borrow the TAR model from the literature that argues that non-linearities in the time series of real exchange rates explain deviations from LOP and PPP[5]. This study is closely related to Parsley and Wei (2008) who estimate a TAR model using data on the prices of a Big Mac and its ingredients from 1993 to 2006. The authors assume that the EMU only affects the speed of price reversion, and that the bands of inaction are good specific and are constant across country pairs. In this study, the variable of interest is the band of inaction, which is assumed to be good and country pair specific. I find that the EMU reduces the bands of inaction and, furthermore, increases the speed of convergence.

The bands of inaction provide an indirect measure of transaction costs and, thus, the results of this study suggest that the euro reduces those costs. Despite deviations from the LOP and PPP imply the existence of transaction costs, the literature lacks a systematic assessment of the extent of international arbitrage and its costs. Evidence of international arbitrage is limited to particular industries and distribution channels. A popular case in the economic and public health literature is the smuggling of cigarettes. For instance, Galbraith and Kaiserman (1997) document that the presence of smuggled cigarettes limits the effect of taxes on cigarettes in Canada. Another type of arbitrage is the case of parallel imports, which are *"goods traded without the authorization of an original trademark or copyright owner"* (Maskus and Chen, 2002). A report from NERA (1999) illustrated that the share of parallel imports over industry imports ranges from less than 5% to 15%. A similar share is reported by Verboven (1996) in the automotive industry. Ganslandt and Maskus (2004) and Thompson (2008) document how prices are arbitraged through parallel imports

[5] According to the TAR model, the relative price of the same goods in two locations is a random walk within a band of no-arbitrage while outside of the band the relative price is mean-reverting (Obstfeld and Taylor, 1997). The Exponential Smooth Transition Autoregressive model instead assumes that the relative price is always mean reverting but the speed of reversion is higher the higher the distance from the mean (O'Connell and Wei, 2002). Juvenal and Taylor (2008) use a Self-Exciting Threshold Autoregressive model, whose main difference with the TAR model is that the number of lags in the AR process is chosen according to the information criterion.

in the case of pharmaceutical products and of digital cameras.

The rise of online retail had a twofold effect on transaction costs. First, the ease with which price information can be gathered online reduces the costs to arbitrage a good sold online and in traditional stores[6]. Second, online stores introduce virtual barriers that limit the websites accessible to customers: a consumer from the EU cannot make purchases on the iTunes market in the US. Anecdotal evidence suggests that arbitrage is still possible even in the presence of virtual barriers. For instance, iTunes US gift cards allow access to the US market, regardless of the geographic location of the consumer. As a result, iTunes US gift card are sold on eBay above face value outside the US (Ng, 2013). In this study, I find that the extent of online purchases has a negative effect on bands of inaction. However, probably due to the only recent rise in online purchases, such an effect is of limited magnitude.

3 A Simple Model of International Arbitrage

Consider an identical good sold at different prices $\tilde{p}_i$ and $\tilde{p}_j$, expressed in the same currency, in two countries i and j. Purchasing the good in i and selling it to j is subject to frictions. First, arbitrageurs pay a variable cost τ_{ij} that captures all variable costs involved with arbitrage (for instance, shipping and tariffs). Arbitrage also involves a set of activities whose cost is independent of the quantity shipped, such as fixed fees for storage, transport or currency exchanges. Moreover, legal barriers such as property rights, safety regulations and exclusive distribution channels create additional costs to arbitrage. I summarize these frictions as a fixed cost of arbitrage f_{ij}.

International arbitrage often occurs through non-traditional distribution channels, and in order to benefit from lower prices of arbitraged goods, consumers incur in switching costs. For instance, price arbitrage of books requires consumers to switch between traditional and online retail (Alaveras et al., 2015). Moreover, parallel imports are sold through distributors other than the licensed ones (Ganslandt and Maskus, 2004). I summarize those costs with the assumption that the good sold by traditional retailers and the good sold by arbitrageurs are imperfect substitutes. Let Q_j denote the demand for the good in country j and p_{ij} denote the price charged by the arbitrageur that purchases the good in i and sells it in j. Because of the switching costs faced by consumers, the arbitrageur is only able to capture a fraction of Q_j. In particular, the arbitrageur faces a demand q_{ij} equal to:

$$q_{ij} = Q_j \left(1 - \gamma \frac{p_{ij}}{\tilde{p}_j}\right) \tag{1}$$

The parameter γ captures the degree of substitution between the two goods. For the demand to be positive, $p_{ij} \leq \frac{\tilde{p}_j}{\gamma}$. I assume that $\gamma \geq 1$ for the price charged by arbitrageurs to always be smaller than $\tilde{p}_j$. By contrast, the textbook model of international arbitrage assumes that by offering the

[6] See (Alaveras et al., 2015) for the case of books. Moreover, there is a number of websites and books that claim to explain how to exploit arbitrage opportunities through Amazon.

same good at a slightly lower price, arbitrageurs are able to capture the entire demand for a good[7].

Suppose that $\tilde{p}_i < \tilde{p}_j$. Let us consider the profits of an arbitrageur that purchases q_{ij} units of a good from i at a price $\tilde{p}_i$ and sells them in j at a price p_{ij}. Using (1), profits equal:

$$\pi_{ij} = q_{ij}(p_{ij} - \tau_{ij}\tilde{p}_i) - f_{ij} = Q_j\left(1 - \gamma\frac{p_{ij}}{\tilde{p}_j}\right)(p_{ij} - \tau_{ij}\tilde{p}_i) - f_{ij}$$

Profit maximization yields the following optimal price:

$$p_{ij} = \frac{1}{2}\left[\frac{\tilde{p}_j}{\gamma} + \tau_{ij}\tilde{p}_i\right]$$

The optimal price of the arbitrageur is a linear combination of the highest price it can charge and its marginal cost to deliver the product. The profits of the arbitrageur are then:

$$\pi_{ij} = \frac{E_j}{4\gamma}\left[1 - \gamma\tau_{ij}\frac{\tilde{p}_i}{\tilde{p}_j}\right]^2 - f_{ij} \tag{2}$$

Where $E_j = Q_j\tilde{p}_j$ denote total expenditures on the good in country j. Similarly, if $\tilde{p}_i > \tilde{p}_j$, the profits of the arbitrageur who purchases the good in j and sells it to i are given by:

$$\pi_{ji} = \frac{E_i}{4\gamma}\left[1 - \gamma\tau_{ji}\frac{\tilde{p}_j}{\tilde{p}_i}\right]^2 - f_{ji} \tag{3}$$

Setting the two profit conditions (2) and (3) to zero yields the commodity points, or thresholds for the band of inaction. In particular, for $\frac{\tilde{p}_i}{\tilde{p}_j} \in \left[\frac{1}{1+\underline{c}_{ij}}, 1 + \bar{c}_{ij}\right]$, arbitrage does not occur, as the profits of the arbitrageur are negative[8]. The lower threshold of the band of inaction $\underline{c}_{ij}$ can be obtained by setting $\pi_{ij} = 0$. In fact, for $\frac{\tilde{p}_i}{\tilde{p}_j} \leq \frac{1}{1+\underline{c}_{ij}}$ the profits from shipping the good from i to j are positive. If the price in i is small enough to cover variable and fixed costs of arbitrage, the arbitrageur will exploit the opportunity. The lower threshold of the band of inaction equals:

$$\underline{c}_{ij} = \frac{\gamma\tau_{ij} + 2\left(\frac{\gamma f_{ij}}{E_j}\right)^{\frac{1}{2}} - 1}{1 - 2\left(\frac{\gamma f_{ij}}{E_j}\right)^{\frac{1}{2}}} \tag{4}$$

Similarly, the upper threshold of the band of inaction $\bar{c}_{ij}$ can be obtained by setting $\pi_{ji} = 0$. In fact, for $\frac{\tilde{p}_i}{\tilde{p}_j} \geq 1 + \bar{c}_{ij}$ the profits from shipping the good from j to i are positive. The upper

[7]An exception is Maskus and Chen (2002), who assume that parallel importers and official retailers compete oligopolistically.

[8]The only restriction on the parameters is that $f_{ij} < \frac{E_j}{4\gamma}$, which implies that profits are positive when the price at which arbitrageurs purchase the good is zero.

threshold of the band of inaction equals:

$$\bar{c}_{ij} = \frac{\gamma\tau_{ji} + 2\left(\frac{\gamma f_{ji}}{E_i}\right)^{\frac{1}{2}} - 1}{1 - 2\left(\frac{\gamma f_{ji}}{E_i}\right)^{\frac{1}{2}}} \tag{5}$$

In logs, the width of the band of inaction is given by $\ln\bar{c}_{ij} + \ln\underline{c}_{ij}$. Absent any fixed cost of arbitrage, the width of the band of inaction is proportional to the variable cost of arbitrage τ_{ij}, which is the standard assumption in the literature (Obstfeld and Taylor, 1997; Anderson and van Wincoop, 2003). Fixed costs of arbitrage create a role for market size: the larger the size of both countries i and j, the lower the band. Moreover, the effect of variable and fixed costs on the band of inaction depends on the degree of substitution between the arbitraged good and the original good γ[9].

When two countries enter a currency union, the bands of inaction of their relative prices could shrink, because either variable costs τ_{ij} or fixed costs f_{ij} fall. There are several channels through which a common currency could facilitate international arbitrage. First, as in a fixed exchange rate regime, hedging currency risk is no longer necessary in a currency union. Second, a common currency eliminates fees and other costs related to currency exchange and settlement delays (Allington et al., 2005). Finally, there could be a psychological component related to a common currency: the results of Mussweiler and Strack (2004) suggest that a common currency increases consumers' ability to compare prices[10].

4 Empirical Strategy

Guided by the model, this section tests whether a currency union reduces the bands of inaction for the relative prices of goods. I begin by describing the sources of data. Then, I present the empirical methodology: first, I estimate the bands of inaction, and second, I estimate the effect of a currency union on the bands of inaction.

4.1 Data

I use data on the Harmonized Index of Consumer Prices (HICP) of 80 disaggregated baskets of goods for 32 European countries from January 1999 to April 2016. A basket is a four-digit good of the Classification of Individual Consumption According to Purpose (COICOP). I divide goods into tradable and non-tradable following the division proposed by Sturm et al. (2009). The main results of the study are derived from the sample of 43 tradable four-digit COICOP goods. The

[9] Without fixed costs of arbitrage, the role of γ would cancel out in a first order approximation.

[10] Because of this psychological reason, Cavallo et al. (2015) argue that firms reduce price differences of their products across countries to avoid angering their customers.

appendix reports the list of countries and the dates of their entry to the EMU, as well as the list of goods considered in the analysis.

A potential concern is that the entry in the EMU corresponds to changes in the methodology used to collect price data. However, all the countries in the sample started collecting price data according to HICP methodology before January 1999 or in the early 2000's. Moreover, Eurostat conducts regular compliance monitoring activities to verify that countries in the EU adhere to the guidelines, recommendations and methodology of HICP. All the national practices of data collections of EU countries inspected between 2006 and 2016 are deemed comparable and of adequate precision and representativity. Table 7 in the appendix summarizes the findings of the monitoring activities. Using HICP for European countries makes it possible to estimate bands of inaction for a wide set of products. It allows for general conclusions on the relationship between prices and currency unions relative to studies that focus on a single good[11] or a small set of products[12]. Another benefit of the dataset is the period covered, which includes the entry in the EMU of Greece in 2001, and of seven additional countries after 2001. With the exception of Cavallo et al. (2015), prior research on price convergence in the EMU could not include the latter seven countries — merely because they were not in the EMU yet.

The main shortcoming of HICP is the downward aggregation bias of price dispersion (Allington et al., 2005): the dispersion of prices of baskets of goods is smaller than the dispersion of prices of individual goods. To understand it, consider a basket of two goods, with the same price index in France and Germany. Suppose that one of the goods is cheaper in France and the other good is cheaper in Germany. Although consumers arbitrage away the price difference of the two goods, the price indices remain unchanged. As a result, using price indices underestimates the bands of inaction and, thus, the costs of international arbitrage. A potential concern may arise if the aggregation bias were stronger in EMU countries relative to countries that do not share the same currency. In such a case, using more aggregate price indices would magnify the effects of the euro on the bands of inaction. However, studying the effects of the euro on the bands of inaction for more aggregate price indices (three-digit COICOP) yields results that are similar to the baseline case. Such an exercise suggests that the aggregation bias may only affect the level of the bands but not the effect of the euro on the bands.

Using the dataset described, I follow a two-stage procedure. First, I estimate the bands of inaction for each country pair and each good. Second, I estimate the effect of a currency union on the bands of inaction across country pairs.

[11] Fischer (2012) uses the price of washing machines and Goldberg and Verboven (2004) those of cars

[12] Cavallo et al. (2015) uses online prices and Parsley and Wei (2008) those of the Bic Mac and its ingredients

4.2 First Stage: Estimating the Band of Inaction

Let p_{it}^g be the logarithm of the harmonized index of consumer prices of commodity g in country i at month t. Let z_{ijt}^g be the good specific (log) price deviation from PPP between countries i and j, defined as

$$z_{ijt}^g = p_{it}^g - p_{jt}^g - s_{ijt} \tag{6}$$

where s_{ijt} is the logarithm of the nominal exchange rate, defined as the price of one unit of j's currency in terms of i's currency. The source of data for the monthly exchange rate is Eurostat[13]. For each country pair ij and each good g, I regress the log price deviation on a constant and on a time trend:

$$z_{ijt}^g = \alpha_{ij}^g + \beta_{ij}^g t + x_{ijt}^g \tag{7}$$

I record the error term x_{jit}^g, which is the demeaned and detrended log price deviation from PPP. Demeaning and detrending the log price deviation allows us to study short-run deviations from PPP. Hence, the empirical analysis abstracts from long-run deviations from PPP due to pricing to market (Alessandria and Kaboski, 2011), quality differences (Verhoogen, 2008), or long-run trends in prices of non-tradable inputs (Crucini et al., 2005)[14].

Let c_{ij}^g be the threshold of the band of inaction for good g between country i and j. I assume that the commodity points are symmetric, which implies that fixed and variable costs of arbitrage are symmetric too[15]. I estimate c_{ij}^g by maximum likelihood using the following TAR model (Obstfeld and Taylor, 1997)[16]:

$$\Delta x_{ijt}^g = \begin{cases} \lambda_{ij}^{g,out}(x_{ij\,t-1}^g - c_{ij}^g) + e_{ijt}^{g,out} & \text{if } x_{ij\,t-1}^g > c_{ij}^g \\ \lambda_{ij}^{g,in} x_{ij\,t-1}^g + e_{ijt}^{g,in} & \text{if } c_{ij}^g \geq x_{ij\,t-1}^g \geq -c_{ij}^g \\ \lambda_{ij}^{g,out}(x_{ij\,t-1}^g + c_{ij}^g) + e_{ijt}^{g,out} & \text{if } -c_{ij}^g > x_{ij\,t-1}^g \end{cases} \tag{8}$$

where $e_{ijt}^{g,out} \sim N(0, \sigma_{ij}^{g,out2})$, $e_{ijt}^{g,in} \sim N(0, \sigma_{ij}^{g,in2})$. I set $\lambda_{ij}^{g,in} = 0$, which implies that when the relative price is within the band of inaction ($|x_{ij\,t-1}^g| < c_{ij}^g$), the relative price is a random walk. There

[13] Since the dataset covers the period 1999:01 to 2016:04, for each good and country pair, there should be 207 observations of z_{ijt}^g. However, there are missing data and for some countries, the time series of prices start at a later date, which reduces the total number of observations. To avoid estimating the bands of inaction for goods and country pairs with few observations, I drop all good and country pairs with less than 135 observations (about 0.4% of the sample).

[14] Without detrending, the average band of inaction across tradable goods and country pairs is approximately 12% — twice as large as the baseline result. The euro reduces the bands of inaction as in the baseline case. However, the magnitude and the robustness of the results suggests that the EMU mainly improves the convergence of price around their short run equilibrium, rather than the convergence of long run prices. Details available upon request.

[15] Using the theoretical model's notation: $c_{ij}^g = \ln \bar{c}_{ij}^g = \ln \underline{c}_{ij}^g$. Waugh (2010) finds that trade costs of exporting are asymmetric across countries. In the Online Appendix, I explore this possibility by estimating asymmetric thresholds of the bands of inaction, finding similar effects of the euro.

[16] The TAR model yields a larger loglikelihood than a AR(1) in more than 99% of all goods and country pairs.

are no forces of arbitrage inside the band of inaction, and thus, the best prediction of tomorrow's relative price is today's relative price. Outside the band, when $|x^g_{ij\,t-1}| > c^g_{ij}$, the relative price is an AR(1) process, with coefficient λ^{out}. The larger the absolute value of λ^{out} is, the faster prices converge to the thresholds of the band of inaction $(+c^g_{ij}, -c^g_{ij})$.

The description of the algorithm that estimates the bands of inaction is in the appendix. The first stage, here described, generates a symmetric matrix of bands of inaction for each good[17]. In the second stage, I develop a regression model to find a systematic relationship between bands of inaction and currency union[18].

4.3 Second Stage: Estimating the Effect of the Euro on the Band

Guided by the theoretical predictions of the simple model of arbitrage, I use the following regression model in which the dependent variable is the threshold (c^g_{ij}) estimated in the first stage:

$$c^g_{ij} = \beta_0 + \beta_1 \text{Euro}_{ij} + \beta_2 \tau_{ij} + \beta_3 \sigma(s_{ij}) + \beta_4 \text{Expenditures}_{ij} + e_g + \epsilon^g_{ij} \tag{9}$$

The independent variables are

- $\text{Euro}_{ij} = 1$ if the pair ij was in the EMU at any time in my sample.
- τ_{ij} is a vector of the following proxies for trade barriers, from CEPII (Head et al., 2010):
  - $\text{Log(Distance)}_{ij}$ = log of bilateral distance between i and j;
  - $\text{Common Border}_{ij} = 1$ if i and j share a border;
  - $\text{Common Language}_{ij} = 1$ if i and j share an official common language or if a language is spoken by at least 4% of the population of i and j;
  - $\text{Island}_{ij} = 1$ if either i or j is an island;
  - $\text{Landlocked}_{ij} = 1$ if either i or j is landlocked;
  - $\text{European Union}_{ij} = 1$ if the pair i, j was in the EMU at any time in my sample.
- $\sigma(s_{ij})$ = standard deviation of the bilateral monthly nominal exchange rate s_{ijt} between i and j in the period considered, from Eurostat.
- Expenditures_{ij} = sum of the log of PPP adjusted real GDP in i and j, from the World Development Indicators.

[17] Obstfeld and Taylor (1997) assume a reference country and estimate the bands of inaction of prices relative to the prices in the reference country. Here, I estimate the bands of inaction across all country pairs. In the regression analysis, I use the upper diagonal matrix.

[18] Since missing data do not allow us to compute the bands of inaction for all goods–country pairs, in the main regression model, I restrict the sample to those goods for which I can compute the bands of inaction across all country pairs. Results are robust when I consider the unbalanced sample of all goods (table 8 in appendix)

- e_g = good fixed effect.

The geographical variables that I use are standard proxies for trade costs in the "gravity" trade literature (Head and Mayer, 2013). In the context of price dispersion, Lutz (2004) use a similar set of variables to study whether trade costs affect price dispersion. I include $\sigma(s_{ij})$ to separate the effect of a currency union on trade from that of a fixed exchange rate regime, as in Cavallo et al. (2015). Finally, the existence of fixed cost of arbitrage motivates the inclusion of the variable for the size of country pairs, proxied by Expenditures_{ij}.

5 The Euro Shrunk the Band

This section shows the main result of the study: being a member of a currency union reduces the bands of inaction of relative prices. After overviewing the descriptive statistics, I show the results from a cross-sectional analysis, in which I examine the currency union effect exploiting the variation of bands of inaction across country pairs. Then, for a few countries, I study the time variation in the bands of inaction before and after entry to the EMU.

The average threshold of the bands of inaction across tradable goods and country pairs is 6.6%. In other words, any differences between the relative price of a good and its long-run equilibrium value above 6.6% would be arbitraged away. Thresholds vary across commodities, suggesting that at least a component of costs to international arbitrage is good specific. Materials for the repair of the dwelling and fruits are the goods with the lowest thresholds (5%) while information-processing equipment and photographic equipment have the highest threshold (10%).

Previous studies estimate thresholds that are of similar magnitude. Obstfeld and Taylor (1997), using the US as a reference country and a more aggregated product classification, estimate thresholds in the range of 7–10%. On the other hand, the commodity points estimated by Juvenal and Taylor (2008) are larger than those found here: using the US as the reference, the average commodity point the authors find with the SETAR model is 17%. Finally, my estimates are larger than those of Parsley and Wei (2008), whose commodity points are common across countries and range between 0.8 and 6%.

The descriptive statistics already suggest that currency unions reduce bands of inaction. In fact, the average threshold of the band of inaction is 4.8% for country pairs that are in the EMU and 7.5% for country pairs that do not share the same currency. Moreover, at the product level, 41 out of 43 commodities exhibit a lower average band of inaction for country pairs that are in the EMU. For durables for recreation, games and household appliances, the band of inaction between countries in the EMU is half that between countries not sharing the same currency[19].

This descriptive analysis suggests that the EMU has shrunk the band of inaction between members. In the next subsection, I confirm these results using a more formal regression analysis.

[19] The appendix reports the average bands of inaction at the product level, inside and outside the EMU.

5.1 Evidence from the Cross-Section

Table 1 shows the estimated coefficient from the regression model (9) under alternative specifications. The coefficient on the euro dummy is always negative and statistically significant: the euro shrinks the band. The interpretation of the coefficient is as follows. Since the average band of inaction is 0.066 and the coefficient on the Euro dummy in the last regression is -0.011, the euro reduces the average band of inaction by $\frac{0.011}{0.066}$ =17%. The effect of the euro on the bands of inaction are quite heterogeneous across goods. Estimating (9) for each good separately yields the result that games, household appliances, and beer are the commodities with the greatest reductions in the bands (above 40%).

The reduction in the bands of inaction suggests that the EMU reduces transaction costs associated with international arbitrage. However, since arbitraged goods are sold through parallel imports or unconventional distribution channels, they can be considered substitute for the goods sold through traditional channels. Hence, the reduction in the bands of 17% cannot be interpreted as a reduction in the transaction costs of 17%. In fact, the larger the degree of substitution between goods and arbitraged goods, the smaller the reduction in the bands due to the same level of reduction in transaction costs. As a result, the reduction in the bands of inaction provides a lower bound for the reduction in transaction costs.

Table 1: The Euro Shrunk the Band

	(1)	(2)	(3)	(4)	(5)
Euro	-0.026***	-0.027***	-0.013***	-0.014***	-0.011***
	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Log(Distance)		0.018***	0.013***	0.013***	0.011***
		(0.003)	(0.002)	(0.002)	(0.002)
Common Border		0.017***	0.013***	0.014***	0.013***
		(0.004)	(0.004)	(0.004)	(0.004)
Common Language		-0.002	-0.005	-0.005	-0.007**
		(0.004)	(0.003)	(0.003)	(0.003)
Island		0.030***	0.028***	0.026***	0.026***
		(0.004)	(0.003)	(0.003)	(0.003)
Landlocked		0.002	-0.001	-0.002	-0.002
		(0.003)	(0.003)	(0.003)	(0.003)
$\sigma(s_{ij})$			0.109***	0.109***	0.085***
			(0.012)	(0.012)	(0.012)
Log(Expenditures)				-0.001**	-0.001**
				(0.001)	(0.001)
European Union					-0.016***
					(0.003)
R^2	0.10	0.20	0.25	0.25	0.26
# Observations	9424	9424	9424	9424	9424

Results from OLS of equation (9). Robust std. error in parenthesis. Cluster: country pair. ***: significant at 99%, ** at 95%, * at 90%. Product fixed effects. Sample: tradable four-digit COICOP goods.

Including geographical proxies for trade costs does not alter the euro coefficient, and bands of inaction reflect differences in trade costs across countries. With the exception of the dummy for a shared border, which appears to increase the band of inaction[20], the other geographical variables have the expected signs. More distant country pairs have wider bands of inaction, in line with the findings of Obstfeld and Taylor (1997). Bands of inaction decline if two countries share a common language while they increase if one of the countries is an island. The results are in line with the findings of Lutz (2004), who document that price dispersion across countries increases with distance and falls with commonality of language.

The currency union effect on the bands of inaction is more than that arising from a simple fixed exchange rate. In fact, the coefficient on the euro dummy variable is negative and statistically significant when I control for the standard deviation of the bilateral exchange rate, despite declining somewhat in magnitude. This result is consistent with the findings of Cavallo et al. (2014), who find that price deviations from the LOP are smaller in currency unions relative to countries that have pegged currencies.

The coefficient on Expenditures is negative and statistically significant at the 95% level. The larger the size of the country pair is, the smaller are the bands of inaction for prices. From the simple theoretical model, such a result supports the hypothesis that arbitrageurs must pay the fixed costs, not only the variable costs of arbitrage[21].

Finally, the EU dummy is negative and statistically significant. Relative to the average, the band of inaction is 24% lower when two countries are part of the EU. The magnitude of the coefficient suggests that the EU successfully reduced transaction costs.

5.2 EMU, European Union and Schengen Area

Other agreements and institutions — the EU and the Schengen Area — that promote economic integration could potentially bias the results of the previous subsection. In fact, all EMU countries are part of the EU, and Ireland and Cyprus are the only countries in the EMU that do not belong to the Schengen Area. The appendix provides the entry dates in these institutions for the countries in the sample. The average threshold c^g_{ij} for tradable goods is 5.6% inside and 9.8% outside the EU; 6.2% inside and 7.2% outside the Schengen Area, and 5.2% inside and 7.9% outside both the EU and the Schengen Area. Hence, the coefficient on the euro could then capture the integration emerging from those three agreements and it is only partially controlled with the EU dummy.

To address this issue, I restrict the sample of country pairs used in regression (9), conditioning on those pairs that belong to the EU, the Schengen Area, or both. Table (2) shows the estimated coefficient on the euro dummy.

By eliminating country pairs outside of the EU or of the Schengen Area, I isolate the effect of the currency union from the effects of other integration policies. The effect of the EMU persists: the coefficient on the euro is negative and statistically significant in all specifications. Conditional

[20] This result is due to a non-linear relationship between the thresholds and $log(distance)$. The coefficient on the shared border is, in fact, negative if I drop the distance variable.

[21] Lutz (2004) finds the opposite result: price dispersion increases with market size.

Table 2: The Euro Effect in the EU and Schengen Area

	(EU)	(Sch.)	(EU+Sch.)
Euro	-0.010***	-0.007***	-0.009**
	(0.002)	(0.002)	(0.002)
R^2	0.15	0.38	0.15
# Observations	7182	5700	4389

Results from OLS of equation (9). Robust std. error in parenthesis. Cluster: country pair. ***: significant at 99%, ** at 95%, * at 90%. Product fixed effects. Sample: tradable four-digit COICOP goods. The coefficients on the control variables are reported in the appendix. (EU): only countries in the European Union. (Sch.): only countries in the Schengen Area. (EU+Sch.): only country pairs both in the European Union and Schengen Area.

on the country pairs belonging to the EU, sharing the same currency reduces the bands of inaction by 18% relative to the average band in the EU.

The effect of the euro is robust to restricting the sample to country pairs that abolish border controls. The coefficient has a slightly smaller magnitude than the previous case: country pairs in the Schengen Area and EMU have bands of inaction that are 11% smaller than the average band in the Schengen Area. Moreover, conditioning the country pairs on being both members of the Schengen Area and of the EU does not alter the economic and statistical significance of the currency union dummy[22]. In fact, countries in the EMU have bands of inaction that are 17% smaller than the average band in the EU and Schengen Area combined. To summarize, being a member of the EMU reduces the bands of inaction, and this effect is not generated by other agreements that facilitate international transactions.

5.2.1 Robustness

The 11 founders of the EMU have been part of a long process of economic integration that fostered convergence of prices for 50 years (Faber and Stokman, 2009). The currency union effect could then be driven simply by such stronger integration between the founders of the EMU. However, the results are robust to dropping all country pairs in which both countries are founders of the euro: in fact, the effect of the euro becomes slightly larger.

Moreover, the results are robust to changes in the variable capturing the common currency. Since I estimate the bands of inaction using data from 1999 to 2016, and some countries entered the EMU only after 2007, we might expect that the euro effect varies with time. I count the number of years in which a given country pair share the same currency, and then repeat (9) using the number of years as the explanatory variable. I find a negative and statistically significant

[22]An even stronger test is to condition on countries that are members of the EU, that are members of the Schengen Area, and that share a common border. An example is to compare the bands of inaction between Austria, Czech Republic, and Slovakia. Even in this case, the coefficient on the euro is negative and statistically significant. Details in appendix.

coefficient: the longer the pair has been in the common currency, the stronger is the reduction in the band of inaction.

Another way to capture the different effects of the currency union across countries that entered the EMU at different times is as follows. I create three new dummy variables to capture three possible relationships: 1) a pair formed by founders of the euro, 2) a pair formed by new members of the EMU, and 3) a pair formed by a founder and a new member. The estimated coefficients on the three dummies are negative and statistically significant. The euro reduces the bands of inactions regardless of when a country joined the area. Moreover, stronger reduction occurs when a country pair comprises a founder and a new member. Hence, the EMU facilitates integration between new entrants and the original members[23].

Results are robust to using alternative measures of exchange rate volatility. I create a dummy variable which equals one if the country pair is in a fixed exchange rate regime or in the EMU, and zero if the country pair is in a flexible exchange rate regime. Following Reinhart and Rogoff (2004), I divide country pairs into fixed and flexible regimes according to the median deviation of the bilateral exchange rate from its average in the sample. If the median deviation is below 5%, the dummy takes a value of one[24]. Table (9) in the appendix shows that the euro reduces the bands of inaction controlling for the exchange rate regimes. Moreover, results are robust to restricting the sample to country pairs in a fixed regime and in the EU.

Variable and Fixed Costs

The currency union effect is robust to alternative measures of trade costs. In the appendix, I run regression (9) using a non linear function of the log of distance (Simonovska, 2015) and the indicators of distance region from Eaton and Kortum (2002).

Although the empirical specification does not allow for a distinction between fixed and variable costs of arbitrage, I examine the presence of fixed costs of arbitrage following two strategies. First, the easier it is to create a business aimed at exploiting arbitrage opportunities, the lower the fixed transaction costs associated with arbitrage. Thus, I control for the minimum value of the ease of doing business in the country pair ij from the World Bank. The variable is a proxy for all frictions that may be correlated with the fixed cost of arbitrage. I find that the easier it is to do business, the smaller the bands of inaction.

Second, the presence of fixed costs of arbitrage creates a negative relationship between the size of the market and the bands of inaction. Such a negative relationship is robust to changes in the measures of expenditures used in the regression, such as total household consumption and GDP weighted by consumption shares. Moreover, not only the size of the market reduces the bands of inaction, but also the size of the distribution network improves price convergence. Using data from

[23]The result is similar to the findings of Lindenblatt and Feuerstein (2014). The authors document price convergence in the EU after the enlargement to Eastern European countries. The strongest convergence is recorded between old members of the EU and new entrants.

[24]The threshold of 5% is the largest crawling band allowed in Reinhart and Rogoff (2004).

Eurostat, I find that the larger the turnover of retailers and wholesalers, the smaller the bands of inaction. Finally, the rise in Internet use facilitates arbitrage opportunities between traditional retailers and online stores. Using Eurostat data on the share of individuals in one country having made an online purchase in the previous three months, I find that online stores reduce the bands of inaction.

Non-Tradable Goods

A test for the sensibility of the empirical model is to examine whether transaction costs and a common currency affect the bands of inaction for non-tradable goods. I follow the same procedure described for tradable goods and estimate the bands of inaction for 36 non-tradable four-digit COICOP goods. The average threshold for the bands of inaction is 8.3%, which is larger than the average across tradable goods[25]. Moreover, the results from the regression (9) on the sample of non-tradable goods are as expected: the euro has an insignificant impact on their bands of inaction. In addition, other variables that play a role in explaining the bands for tradable goods, such as distance and the EU, do not have a significant effect for non-tradable goods.

The bands of inaction of non-tradable goods decrease with the size of the two countries. Moreover, the bands are lower when a country pair shares a common language while they are higher when one of the countries in the pair is an island. We can interpret the result in light of the findings of Engel and Rogers (2004), who document that in European countries, price dispersion of both tradable and non-tradable goods fell in the 1990s. The authors argue that the integration of factors' markets drives the price convergence in the non-tradable sector. The results shown here suggest that the size of the country pair, the commonality of language, and the country's isolation (captured by the island dummy) are contributing factors to the integration in the market for factors of production.

Speed of Convergence and Price Dispersion

Does the euro increase the speed of convergence of relative prices? To answer this question, I test whether the euro affects the estimated $\lambda_{ij}^{g,out}$, the autoregressive coefficient outside the band of inaction (8). In fact, the larger the absolute value of $\lambda_{ij}^{g,out}$ is, the faster is the convergence of relative prices toward the band. I regress $\lambda_{ij}^{g,out}$ on the euro dummy variable and the controls used in the empirical model (9). The regression results indicate that the euro increases the magnitude of $\lambda_{ij}^{g,out}$. The common currency reduces the band of inaction and it increases the speed of convergence when prices are outside the band. The result is in line with Bergin et al. (2016), who find that the speed of convergence to PPP is higher in the EMU.

[25]The result is consistent with Crucini et al. (2005), who document that price dispersion across destinations declines with the tradability of a good. The relative small difference of the average band between tradable and non-tradable goods is surprising. Such a result may suggest the presence of a particularly strong aggregation bias that underestimates the bands of inaction for non-tradable good. Alternatively, a possible concern may be that the classification of goods by Sturm et al. (2009) is not appropriate. As robustness, I consider the effects of the euro on the bands of inaction for all goods, both tradable and non-tradable. The effect of the euro is robust to this change in the sample of goods (Table 16 in the Appendix.).

Another related question is whether the euro reduces the volatility of the demeaned and detrended log price deviations x^g_{ijt} (7). To examine the relationship between the volatility of prices over time and a common currency, I regress the standard deviation of x^g_{ijt} on the same controls used in (1), finding a negative and statistically significant coefficient on the euro dummy. The result is similar in spirit to the findings of Cavallo et al. (2015), who document a reduction in the price dispersion across goods between members of a currency union[26].

This result is not surprising. If the euro reduces the bands of inaction, the volatility of prices must fall. However, a possible concern is that the causality is reversed. In particular, prices in a currency union could converge for other reasons I have not considered, such as a common monetary policy or firms' pricing to market strategies. Under this scenario, the bands of inaction that I estimate are shrinking in the EMU simply because the variance of prices has fallen. To control for this possibility, I add to the main empirical specification (1) the standard deviation of the log price deviation x^g_{ijt}. The coefficient on the euro is still negative and significant, although its magnitude declines.

Aggregate Price Indices

Finally, the results are robust to changing the set of goods employed for the analysis. I repeat the empirical exercise using three-digit COICOP goods, finding that the euro reduces the bands of inaction relative to the average by 20%. The descriptive results and the coefficients on the other controls employed are remarkably similar to the baseline case. The finding suggests that aggregation bias does not drive the result. The online appendix shows the detailed results.

5.3 Evidence from the Time Series

A potential problem I tackle in this subsection is endogeneity in the choice of entering the EMU. If countries that decide to enter the EMU are already more integrated than those that decide to opt out or are preparing to enter the EMU, the currency union effect documented in the previous subsection might simply reflect the already existing lower transaction costs. Although anecdotal evidence by Rose (2001) suggests that the choice to join a currency union is not driven by a trade cost motive, the concerns are reasonable. In fact, Engel and Rogers (2004) and Goldberg and Verboven (2005) document that price convergence in the EMU occurred long before the EMU was established[27]. However, recent evidence by Cavallo et al. (2014) shows that prices in Latvia converged to the EMU values right after the introduction of the euro.

The following test is required to establish whether the euro reduces the bands of inaction, or whether bands of inaction are already low when countries join the euro. For each country that enters the EMU, I need to estimate the bands of inaction before and after the entry. A comparison

[26] The volatility of Δx^g_{ijt} is not affected by the euro.

[27] Rather than endogeneity, this could reflect the forward-looking behavior of agents, who anticipate the greater integration that occurs in a currency union (Bergin and Lin, 2012).

of how the thresholds of the bands vary before and after the entry to the EMU, using as a control group the country pairs whose currency did not change, would give a definite answer on whether entry to the euro reduces transaction costs. Because of data limitations, I can implement the test for two samples of data. First, using the main dataset, I can apply the procedure for four countries only. In fact, since the period covered by the dataset is from 1999 to 2016, only countries that entered the EMU in the middle of the period provide enough observations to estimate the bands of inaction before and after the currency regime switch. Those countries are Cyprus, Malta, Slovakia, and Slovenia. Second, using data from Juvenal and Taylor (2008) for a selected number of countries and products, I can test the time series effect of the EMU on its founding members.

5.3.1 The Effects of Entry in the EMU

Let c^g_{ijt} be the threshold of the band of inaction for good g between countries i and j in period t, where i = Cyprus, Malta, Slovakia, and Slovenia, and $t = 0$ if prior to the euro and $t = 1$ after the entry to the EMU. Slovenia entered the EMU in January 2007, Cyprus and Malta in January 2008, and Slovakia in January 2009. For each period, I compute the detrended, demeaned log price deviations and, then, estimate the thresholds[28]. For each country i, I compute the log difference in the bands of inaction $\Delta c^g_{ij} = \ln c^g_{ij1} - \ln c^g_{ij0}$ for each country j. I then estimate the following regression:

$$\Delta c^g_{ij} = f_g + f_i + \beta \text{Euro}_{ij} + \epsilon^g_{ij} \tag{10}$$

where $\text{Euro}_{ij} = 1$ if the country pair ij shares the same currency after the entry to the eurozone of i. f_g is a good fixed effect, f_i is a country fixed effect that captures the different entry of each country, and ϵ^g_{ij} is the error term. Table 3 shows the results.

Table 3: The Euro Shrunk the Band

	(1)	(2)	(3)
Euro	-0.215*	-0.215*	-0.229*
	(0.115)	(0.115)	(0.123)
Good FE	Yes	Yes	Yes
Country i FE	No	Yes	Yes
Pair in EU and Schengen	No	No	Yes
R^2	0.07	0.12	0.17
# Observations	1632	1632	896

Results from OLS of equation (9). Robust std. error in parenthesis. Cluster: country pair. ***: significant at 99%, ** at 95%, * at 90%. Sample: tradable four-digit COICOP goods.

The coefficient on the euro dummy is negative and statistically significant at the 90% level. The coefficient is similar to what I found in the cross section: entering the EMU reduces the bands

[28] The thresholds are less precisely estimated than in the cross section analysis, since I use about half the observations. To maximize the accuracy of the estimate, I use the longest series available before and after the entry to the EMU. I use relative prices, which have 107 observations before and 98 after entry to the EMU for Cyprus and Malta, 84 before and 110 after for Slovenia, and 119 before and 86 after for Slovenia.

of inaction by 21%. Since entering the EMU overlaps, for the i countries considered, with entry to the EU and Schengen Area, I condition the regression on the country pairs being both in the EU and Schengen Area, finding similar results[29]. Consistent with the findings of Cavallo et al. (2014), the introduction of a currency union reduces the bands.

5.3.2 The Effects of EMU Creation

To study the effects of the creation of the EMU, I use the dataset provided by Juvenal and Taylor (2008), which spans from 1981:01 to 1998:12. The dataset covers the following nine countries: Belgium, Denmark, Germany, France, Italy, Netherlands, Portugal, Spain, United Kingdom. It provides price indices for fourteen baskets of tradable goods: Alchohol, Books, Bread, Clothing, Communication, Dairy, Domestic Appliances, Footwear, Fruit, Fuels and Energy, Furniture, Meat, Sound and Photographic Equipment, Tobacco and Vehicles. I match each good with the corresponding HICP category: some goods corresponds to four-digit COICOP goods, others to three-digit COICOP goods[30].

Let c^g_{ijt} be the threshold of the band of inaction for good g between country i and j in period t. Let $t = 0$ denote the pre-EMU period, from 1981:01 to 1998:12. For robustness, I also consider the period from 1986:01 to 1998:12, in which all countries in the sample are members of the European Economic Community. Let $t = 1$ denote the post-EMU period, from 1999:01 to 2016:04. I estimate c^g_{ij0} using the data from Juvenal and Taylor (2008) and use the baseline estimates of the bands of inaction for c^g_{ij1}. I compute the log difference in the bands of inaction $\Delta c^g_{ij} = \ln c^g_{ij1} - \ln c^g_{ij0}$ for each country pair ij. I then estimate the following regression:

$$\Delta c^g_{ij} = f_g + \beta \text{Euro}_{ij} + \epsilon^g_{ij} \tag{11}$$

where $\text{Euro}_{ij} = 1$ if the country pair ij share the same currency after the entry in the eurozone of i and f_g is a good fixed effect.

There are a few concerns in the interpretation of the results. First, there is a change in the methodology used to collect price data. During the nineties, all countries in the EU updated their price collection methodologies to the HICP guidelines. Thus, although the price indices in the two periods are not directly comparable, the change in methodology involves all countries in the sample and its effects are captured by the good fixed effect. Second, the sample of countries and goods is significantly smaller than the cross-section analysis previously discussed. In fact, only two

[29] This last regression drops Cyprus by construction.

[30] In particular, I matched the Juvenal and Taylor (2008) basket *Alcohol* to *Alcoholic beverages* (COICOP 021), *Books* to *Books* (0951), *Bread* to *Bread and cereals* (0111), *Clothing* to *Clothing* (031), *Communication* to *Telephone and telefax equipment* (082), *Dairy* to *Milk, cheese and eggs* (0114), *Domestic Appliances* to *Household appliances* (053), *Footwear* to *Footwear including repair* (032), *Fruit* to *Fruit* (0116), *Fuels and Energy* to *Electricity, gas and other fuels* (045), *Furniture* to *Furniture and furnishings, carpets and other floor coverings* (051), *Meat* to *Meat* (0112), *Sound and Photographic Equipment* to *Audio-visual, photographic and information processing equipment* (091), *Tobacco* to *Tobacco* (022), and *Vehicles* to *Purchase of vehicles* (071).

countries in the sample, Denmark and the United Kingdom, did not join the EMU.

Table 4: The Euro Shrunk the Band

	1981-2016			1986-2016		
	(All)	(3 Digit)	(4 Digit)	(All)	(3 Digit)	(4 Digit)
Euro	-0.605***	-0.621***	-0.575**	-0.618***	-0.702***	-0.452*
	(0.173)	(0.181)	(0.241)	(0.199)	(0.210)	(0.243)
R^2	0.109	0.115	0.075	0.108	0.142	0.039
# Observations	532	352	180	532	352	180

Results from OLS of equation (11). Robust std. error in parenthesis. Cluster: country pair. ***: significant at 99%, ** at 95%, * at 90%. Product fixed effects. All= all matched goods. 3 Digit= matched COICOP three-digit goods. 4 Digit= matched COICOP four-digit goods.

Table 4 shows the result. When a country pair started sharing the euro, their bands of inaction fell by approximately 50%. The magnitude of the effect is larger than the reduction of the bands of inaction experienced by Cyprus, Malta, Slovakia and Slovenia. The results are robust to changes in the sample of goods. Using the sample of three-digit COICOP goods, the euro effects is above 60%, while in the sample of four-digit COICOP goods, the entry in the EMU reduces bands of inaction by 50%.

6 Conclusions

I have argued that a currency union reduces the bands of inaction of relative prices via a drop in transaction costs. The results are in line with those of Lutz (2004), Allington et al. (2005), Cavallo et al. (2015), and Cavallo et al. (2014), who document that price dispersion declines within a currency union. Rather than focusing on deviations of prices from the LOP to assess the integration arising in the EMU, this study used a TAR model (Obstfeld and Taylor, 1997) to estimate the bands of inaction. The EMU reduces the bands of inaction by approximately 17% and the results are robust to several indicators of economic integration. The result is supported by additional time series evidence from the entry of selected countries in the EMU. The EMU eliminates costs associated with exchange rate risk hedging and with currency exchange (Anderson and van Wincoop, 2003). Moreover, the EMU reduces information frictions (Boivin et al., 2012), as it improves the ease with which consumers compare prices across locations (Mussweiler and Strack, 2004).

Although the study focused on one particular channel — transaction costs — for why prices in a currency union tend to converge, it does not exclude other possible mechanisms. In particular, Cavallo et al. (2014) document that the price of a good at its introduction is a major component of the good-specific real exchange rate. This suggests that firms could internalize arbitrage possibilities and thereby set prices within a smaller range to prevent arbitrage. Other channels are worth investigating, such as pricing to currency area or, as argued by (Cavallo et al., 2014), charging the same prices so as not to anger firms' customers (Rotemberg, 2005).

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7 Appendix

7.1 Goods and Country Details

This section provides additional details on the sample of goods and countries used in section 5. Table 5 divides the four-digit COICOP baskets of goods used in the empirical analysis in tradable and non-tradable according to Sturm et al. (2009). Table 6 shows the list of countries and the date of entry in European Institutions. More than half of the countries considered are currently in the EMU: 11 countries joined the EMU in January 1999 while 8 countries entered the monetary union in the following years. Of the sample, 26 countries are members of the Schengen area, which eliminates border controls among members[31], and 28 countries are members of the EU, and, thus, are part of a customs union and comply with a series of laws referred to as community acquis to demolish barriers to an internal market.

Iceland, Norway, and Switzerland belong to the European Free Trade Association (EFTA)[32]. In addition, Iceland and Norway belong to the European Economic Area which enables them to participate in the EU's internal market[33]. Switzerland has a free trade agreement with the EU signed in 1972, extended in 1999 to trade in agricultural products, and again extended in 2004 to processed agricultural products[34]. Finally, Turkey has been in a customs union with the EU since 1996 for all goods but agricultural products, coal, and steel[35].

Eurostat conducts regular compliance monitoring activities on the ways price data is collected and combined to produce national HICP statistics for EU countries. For virtually all countries in the sample, the data pass all standard HICP validation tests: they are internally consistent and aggregate correctly[36]. Table 7 summarizes the results of the compliance evaluation, as well as the initial date of release of HICP statistics. The table focuses on two aspects of HICP. First, its representativity, in terms of accuracy and reliability, which is deemed generally adequate, adequate or appropriate. Second, it focuses on the comparability of a country's HICP to other countries HICP's, which is deemed broadly comparable, comparable or assured. The monitoring recognizes constant improvements in methodology made by all countries. Moreover, when found, instances of non-compliance are unlikely to have major impacts.

[31] Felbermayr et al. (2016) find that the Schengen Area has boosted trade by 3%.

[32] http://www.efta.int. Iceland was a candidate to join the EU from 2010 but negotiations froze in 2013. Sweden, Austria, and Finland were in the EFTA until 1995, when they joined the EU.

[33] http://www.efta.int/eea/eea-agreement

[34] http://eeas.europa.eu/switzerland/index_en.htm

[35] http://ec.europa.eu/taxation_customs/customs/customs_duties/rules_origin/customs_unions/article_414_en.htm

[36] Source: http://ec.europa.eu/eurostat/web/hicp/methodology/compliance-monitoring. The exceptions are Denmark, because of the use of surveys, and Italy in 2007.

Table 5: Tradable and Non-Tradable Four-Digit COICOP

Tradable		Non tradable	
Code	Description	Code	Description
CP0111	Bread and cereals	CP0314	Cleaning of clothing
CP0112	Meat	CP0432	Services for repair of dwelling
CP0113	Fish	CP0441	Water supply
CP0114	Dairy products	CP0442	Refuse collection
CP0115	Oils and fats	CP0443	Sewerage
CP0116	Fruit	CP0444	Services to dwelling
CP0117	Vegerables	CP0451	Electricity
CP0118	Sugar	CP0452	Gas
CP0119	Food n.e.c.	CP0455	Heat energy
CP0121	Coffe and tea	CP0513	Repair of furniture
CP0122	Soft drinks	CP0533	Repair of household appliances
CP0211	Spirits	CP0562	Household services
CP0212	Wine	CP0621-0623	Medical services
CP0213	Beer	CP0622	Dental services
CP0311	Clothing materials	CP0723	Maintenance of transport
CP0312	Garments	CP0724	Services to transport
CP0313	Clothing n.e.c.	CP0731	Transport by railway
CP0431	Materials for repair of dwelling	CP0732	Transport by road
CP0453	Liquid fuels	CP0733	Transport by air
CP0454	Solid fuels	CP0734	Transport by sea
CP0511	Furniture	CP0735	Combined transport
CP0512	Carpets	CP0736	Other transport services
CP0531-0532	Household appliances	CP0830	Telephone services
CP0561	Non-durable household goods	CP0915	Repair of equipment
CP0611	Pharmaceutical	CP0923	Maintenance of durables for recreation
CP0612-0613	Medical products	CP0941	Recreational services
CP0711	Cars	CP0942	Cultural services
CP0712-0714	Motor cycles	CP0951	Books
CP0721	Accessories for transport	CP0952	Newspapers
CP0722	Fuels for transport	CP1111	Restaurants
CP0911	Equipment for sound recording	CP1112	Canteens
CP0912	Photographic equipment	CP1211	Hairdressing
CP0913	Information processing eq.	CP1252	Insurance for dwelling
CP0914	Recording media	CP1253	Insurance for health
CP0921-0922	Durables for recreation	CP1254	Insurance for transport
CP0931	Games	CP1255	Other insurance
CP0932	Equipment for sport		
CP0933	Plants and flowers		
CP0934-0935	Pets		
CP0953-0954	Printed matter		
CP1212-1213	Electrical appliances		
CP1231	Jewellery		
CP1232	Personal effects		

There are 36 non-tradable goods. Telephone and telefax equipment (COICOP 08.20) is dropped because it contains both a tradable (purchases) and a non-tradable (repair) component.

Table 6: List of Countries and Date of Access to EU, EMU, and Schengen Area

	EU (or EEC)	EMU	Schengen Area
Austria	Jan 1995	Jan 1999	Dec 1997
Belgium	Founder	Jan 1999	March 1995
Bulgaria	Jan 2007		
Croatia	Jul 2013		
Cyprus	May 2004	Jan 2008	
Czech Republic	May 2004		Dec 2007
Denmark	Jan 1973		Mar 2001
Estonia	May 2004	Jan 2011	Dec 2007
Finland	Jan 1995	Jan 1999	Mar 2001
France	Founder	Jan 1999	Mar 1995
Germany	Founder	Jan 1999	Mar 1995
Greece	Jan 1981	Jan 2001	Jan 2000
Hungary	May 2004		Dec 2007
Iceland			Mar 2001
Ireland	Jan 1973	Jan 1999	
Italy	Founder	Jan 1999	Oct 1997
Latvia	May 2004	Jan 2014	Dec 2007
Lithuania	May 2004		Dec 2007
Luxembourg	Founder	Jan 1999	Mar 1995
Malta	May 2004	Jan 2008	Dec 2007
Netherlands	Founder	Jan 1999	Mar 1995
Norway			Mar 2001
Poland	May 2004		Dec 2007
Portugal	Jan 1986	Jan 1999	Mar 1995
Romania	Jan 2007		
Slovakia	May 2004	Jan 2009	Dec 2007
Slovenia	May 2004	Jan 2007	Dec 2007
Spain	Jan 1986	Jan 1999	Mar 1995
Sweden	Jan 1995		Mar 2001
Switzerland			Dec 2008
Turkey			
United Kingdom	Jan 1973		

Table 7: HICP monitorning

Country	First Release	Compliance Monitoring
Belgium	1995	2010 - Generally adequate; comparable 2014 - Good standard, comparability assured
Bulgaria	1997	2007 - Generally adequate; broadly comparable 2015 - Generally appropriate, comparable
Czech Republic	2000	2009 - Generally adequate, broadly comparable
Denmark	1995	2010 - Generally adequate, broadly comparable
Germany	1995	2009 and 2010 - Generally adequate, comparable 2015 - Good standard, comparable
Estonia	1996	2006 - Generally adequate, comparable 2010 - Generally adequate, comparable
Ireland	1997	2010 - Generally adequate, broadly comparable
Greece	1996	2013 - Generally adequate, broadly comparable
Spain	1997	2010 - Generally adequate, comparable
France	1995	2009 - Generally adequate, comparable 2015 - Appropriate, comparable
Croatia	1998	2015 - Good standard, comparability assured
Italy	1997	2007 - Generally adequate 2014 - Generally adequate, broadly comparable
Cyprus	1997	2006 - Adequate, comparable
Latvia	2002	2007 - Generally adequate, comparable 2013 - Adequate, comparable
Lithuania	1996	2006 - Generally appropriate, comparable
Luxemburg	1996	2012 - Generally adequate, broadly comparable
Hungary	2001	2009 - Generally adequate, broadly comparable
Malta	1996	2006 - Generally adequate, broadly comparable 2007 - Generally adequate, broadly comparable
Netherlands	1996	2012 - Adequate, Broadly comparable
Austria	1995	
Poland	1999	2008 - Generally adequate, broadly comparable 2016 - Good standard, comparability assured
Portugal	1995	2010 - Adequate, broadly comparable
Romania	2001	2007 - Generally adequate, comparable
Slovenia	2001	2006 - Adequate, broadly comparable 2016 - Good standard, comparability assured
Slovakia	1996	2008 - Generally adequate, broadly comparable 2016
Finland	1994	2012 -Generally adequate, comparable
Sweden	1995	2013 - Generally adequate, comparable
United Kingdom	1996	2009 - Generally adequate, comparable 2015 - Good standard, comparability assured
Turkey	2004	
Iceland	1997	
Norway	1997	
Switzerland	1997	

7.2 Estimating the Bands of Inaction

This section describes in more detail the algorithm used to estimate the thresholds of the bands of inaction. I follow Obstfeld and Taylor (1997) and estimate the parameters of the TAR model using maximum likelihood (8). I employ a grid search to maximize the likelihood of the TAR model against a null AR(1) model. Let $L_n(\lambda, \sigma)$ be the log likelihood function of the null AR(1) model, defined as follows:

$$\Delta x^g_{ijt} = \lambda^g_{ij} x^g_{ji\ t-1} + e^g_{ijt} \tag{12}$$

where $e^g_{jit} \sim N(0, \sigma^{2g})$. The likelihood of the null model is given by

$$L^g_{n,ij}(\lambda^g_{ij}, \sigma^g_{ij}) = -\sum_t \frac{1}{2}\left(\log(2\pi) + \log(\sigma^{g2}_{ij}) + \frac{e^{g2}_{ijt}}{\sigma^{g2}_{ij}}\right)$$

Similarly, let $L^g_{TAR,ij}(\lambda^{g,out}_{ij}, \sigma^{g,out}_{ij}, \sigma^{g,in}, c^g_{ij})$ be the log likelihood function of the alternative TAR model (8):

$$\begin{aligned} L^g_{TAR,ij}(\lambda^{g,out}_{ij}, \sigma^{g,out}_{ij}, \sigma^{g,in}_{ij}, c^g_{ij}) = &- \sum_{I_{in}(x^g_{ij\ t-1})=1} \frac{1}{2}\left(\log(2\pi) + \log(\sigma^{g,in2}_{ij}) + \frac{e^{g,in2}_{ijt}}{\sigma^{g,in2}_{ij}}\right) \\ &- \sum_{I_{out}(x^g_{ij\ t-1})=1} \frac{1}{2}\left(\log(2\pi) + \log(\sigma^{g,out2}_{ij})) + \frac{e^{g,out2}_{ijt}}{\sigma^{g,out2}_{ij}}\right) \end{aligned} \tag{13}$$

where $I_{in}(x^g_{ij\ t-1}) = 1(|x^g_{ij\ t-1}| \leq c^g_{ji})$ and $I_{out}(x^g_{ij\ t-1}) = 1(|x^g_{ij\ t-1}| > c^g_{ji})$ are indicator functions.

I estimate the parameters of the model by a grid search on c_{ji}, which maximizes the log likelihood ratio $LLR^g_{ij} = 2(L^g_{TAR,ij} - L^g_{n,ij})$. The procedure is as follows. First, I find the 10^{th} and 90^{th} percentiles of $|x_{jit}|$ and then divide the interval in steps of 0.001 width. Such steps are the candidate solutions for c^g_{ji}. For each possible c^g_{ji}, I partition the sample of $x^g_{ij\ t-1}$ into observations within or outside the band. Then, I use ordinary least squares to compute the log likelihood previously described. Finally, I pick the c^g_{ji} that maximizes the log likelihood ratio.

7.3 Descriptive Statistics

Figure 1 reports the average commodity point by good across all country pairs. In table 2, I consider the average commodity point across country pairs that share the euro, and country pairs with different currencies. I run regression (9) by type of good and report the coefficient on the euro β^g_1 normalized by the average commodity point per good c^g in figure 3.

Figure 1: Average Commodity Point ($100 * c^g$) by Four-Digit Tradable COICOP Good

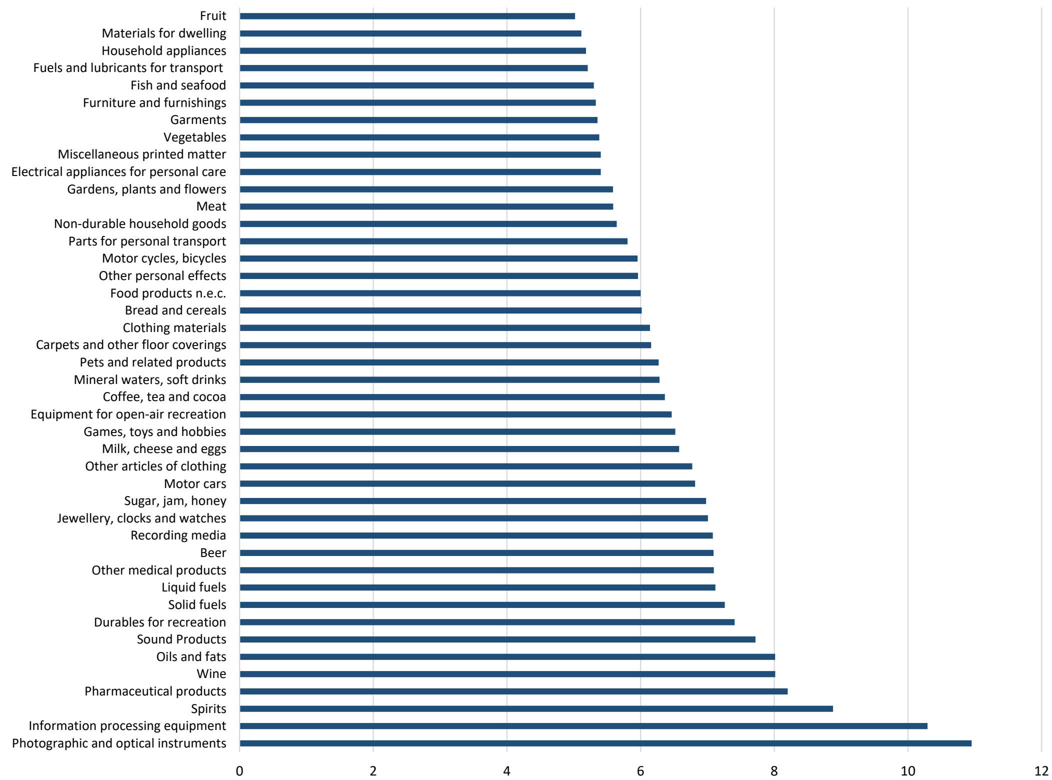

Figure 2: Average Commodity Point ($100 * c^g$) by Four-Digit Tradable COICOP Good

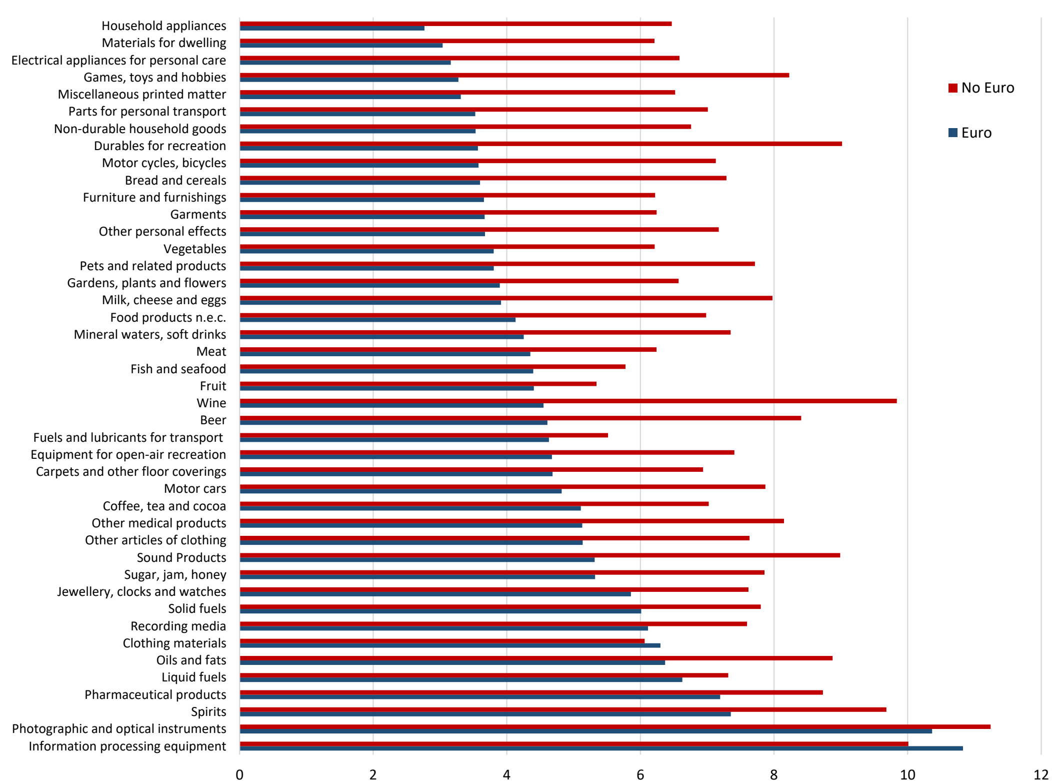

Figure 3: % Effect of Euro $\left(\frac{\beta_1^g}{c^g}\right)$ by Four-Digit Tradable COICOP Good

7.4 Robustness Tables

Table 8 presents the results of the baseline regression (9) using the unbalanced panel of goods, that is not dropping those goods for which I was not able to estimate the bands of inaction for all country pairs. Table 9 illustrates the effects of fixed exchange rate regimes. Table 10 shows the full list of coefficients used in table 2. Table 11 shows the results using alternative EMU measures, table 12 using alternative measures of distance, and table 13 of expenditures. In table 14, I explore the effects of ease of doing business and distribution channels on the bands of inaction. Table 15 presents the results of the regression using the sample of non-tradable goods and table 16 uses both tradables and non-tradables pooled together. Table 17 shows the effect of the euro on other variables of interest. Finally, Table 18 shows the results of the baseline regression controlling for the volatility of the demeaned and detrended log price deviations and of its change.

Table 8: The Euro Shrunk the Band

	(1)	(2)	(3)	(4)	(5)
Euro	-0.027***	-0.028***	-0.012***	-0.013***	-0.010***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Log(Distance)		0.016***	0.010***	0.010***	0.008***
		(0.003)	(0.002)	(0.002)	(0.002)
Common Border		0.015***	0.011***	0.012***	0.011***
		(0.004)	(0.003)	(0.003)	(0.003)
Common Language		-0.002	-0.005*	-0.005	-0.007**
		(0.003)	(0.003)	(0.003)	(0.003)
Island		0.029***	0.027***	0.025***	0.025***
		(0.003)	(0.003)	(0.003)	(0.003)
Landlocked		0.003	-0.001	-0.002	-0.002
		(0.003)	(0.002)	(0.002)	(0.002)
$\sigma(s_{ij})$			0.125***	0.125***	0.101***
			(0.011)	(0.011)	(0.011)
Log(Expenditures)				-0.002***	-0.001***
				(0.001)	(0.001)
European Union					-0.016***
					(0.003)
R^2	0.10	0.19	0.26	0.27	0.27
# Observations	20472	20472	20472	20472	20472

Results from OLS of equation (9). Robust std. error in parenthesis. Cluster: country pair. ***: significant at 99%, ** at 95%, * at 90%. Product fixed effects. Sample: tradable four-digit COICOP goods. Unbalanced panel.

Table 9: The Effect of Exchange Rate Regimes

	(1)	(Fixed)	(EU)	(Fixed+EU)
Euro	-0.010***	-0.007***	-0.008***	-0.006**
	(0.003)	(0.002)	(0.002)	(0.002)
Log(Distance)	0.016***	0.009***	0.006***	0.008***
	(0.002)	(0.002)	(0.002)	(0.002)
Common Border	0.015***	0.001	0.001	0.000
	(0.004)	(0.003)	(0.003)	(0.004)
Common Language	-0.002	-0.004	-0.003	-0.004
	(0.004)	(0.004)	(0.004)	(0.004)
Island	0.021***	0.003	0.016***	0.004
	(0.003)	(0.003)	(0.003)	(0.003)
Landlocked	-0.007**	-0.001	-0.001	-0.001
	(0.003)	(0.002)	(0.002)	(0.002)
Fixed ERR	-0.027***		-0.009***	
	(0.003)		(0.003)	
Log(Expenditures)	-0.003***	-0.001*	0.001**	-0.001*
	(0.001)	(0.000)	(0.000)	(0.000)
R^2	0.23	0.17	0.15	0.18
# Observations	9424	5244	7182	4807

Results from OLS of equation (9). Robust std. error in parenthesis. Cluster: country pair. ***: significant at 99%, ** at 95%, * at 90%. Product Fixed Effects. Sample: tradable four-digits COICOP goods. Fixed ERR=1 if the country pair is in a fixed exchange rate regime or if they are in the EMU. (Fixed) restricts the sample to country pairs in a fixed ERR. (EU) restricts the sample to country pairs in the EU. (Fixed+EU) restricts the sample to country pairs that are in a fixed ERR and are in the EU.

Table 10: EMU, EU and Schengen Area

	(UE)	(Sch.)	(UE+Sch.)	(UE+Sch.+Border)
Euro	-0.010***	-0.007***	-0.009***	-0.011**
	(0.002)	(0.002)	(0.002)	(0.005)
Log(Distance)	0.006***	0.014***	0.010***	0.007**
	(0.002)	(0.002)	(0.002)	(0.003)
Common Border	0.002	0.011***	0.007**	
	(0.003)	(0.003)	(0.003)	
Common Language	-0.004	-0.001	-0.006**	-0.010*
	(0.004)	(0.003)	(0.003)	(0.005)
Island	0.017***	0.010**	-0.002	
	(0.003)	(0.004)	(0.003)	
Landlocked	-0.000	-0.012***	-0.006***	-0.002
	(0.002)	(0.002)	(0.002)	(0.003)
$\sigma(s_{ij})$	0.061***	0.280***	0.147***	0.115*
	(0.016)	(0.023)	(0.019)	(0.064)
Log(Expenditures)	0.002***	-0.001	-0.001*	-0.002**
	(0.000)	(0.001)	(0.000)	(0.001)
R^2	0.15	0.38	0.15	0.28
# Observations	7182	5700	4389	570

Results from OLS of equation (9). Robust std. error in parenthesis. Cluster: country pair. ***: significant at 99%, ** at 95%, * at 90%. Product fixed effects. Sample: tradable four-digit COICOP goods. (EU): only pairs in the EU. (Sch.): only pairs in the Schengen Area. (EU+Sch.): only pairs both in the EU and Schengen Area. (EU+Sch.+Border): only pairs in the EU and Schengen Area that share a common border.

Table 11: Alternative EMU Variables

	(1)	(2)	(3)
Euro	-0.013***	-0.001***	
	(0.002)	(0.000)	
Log(Distance)	0.011***	0.011***	0.011***
	(0.002)	(0.002)	(0.002)
Common Border	0.014***	0.013***	0.013***
	(0.004)	(0.004)	(0.004)
Common Language	-0.009*	-0.006*	-0.008**
	(0.005)	(0.004)	(0.004)
Island	0.026***	0.027***	0.026***
	(0.003)	(0.003)	(0.003)
Landlocked	-0.003	-0.002	-0.003
	(0.003)	(0.003)	(0.003)
$\sigma(s_{ij})$	0.087***	0.085***	0.088***
	(0.012)	(0.013)	(0.013)
Log(Expenditures)	-0.002**	-0.001	-0.002**
	(0.001)	(0.001)	(0.001)
European Union	-0.015***	-0.017***	-0.015***
	(0.003)	(0.003)	(0.003)
Orig./Orig.			-0.007**
			(0.003)
Orig./New.			-0.016***
			(0.004)
New/New			-0.011***
			(0.002)
R^2	0.25	0.26	0.26
# Observations	8569	9424	9424

Results from OLS of equation (9). Robust std. error in parenthesis. Cluster: country pair. ***: significant at 99%, ** at 95%, * at 90%. Product fixed rffects. Sample: tradable four-digit COICOP goods. (1) drops all country pairs formed by founders of the EMU. (2) uses the number of years in the EMU. (3) uses the three dummies described in subsection 5.2.1.

Table 12: Alternative Measures of Distance

	(1)	(2)
Euro	-0.011***	-0.012***
	(0.002)	(0.002)
Region 1	-0.024***	
	(0.005)	
Region 2	-0.018***	
	(0.005)	
Common Language	-0.006*	-0.008**
	(0.003)	(0.004)
Island	0.025***	0.024***
	(0.003)	(0.003)
Landlocked	-0.002	-0.000
	(0.002)	(0.003)
$\sigma(s_{ij})$	0.083***	0.082***
	(0.012)	(0.012)
Log(Expenditures)	-0.001	-0.001
	(0.001)	(0.001)
European Union	-0.015***	-0.014***
	(0.003)	(0.003)
Log(Distance)		0.544***
		(0.187)
$(Distance)^2$		-0.091***
		(0.030)
$(Distance)^3$		0.005***
		(0.002)
Common Border		0.003
		(0.003)
R^2	0.26	0.27
# Observations	9424	9424

Results from OLS of equation (9). Robust std. error in parenthesis. Cluster: country pair. ***: significant at 99%, ** at 95%, * at 90%. Product fixed effects. Sample: tradable four-digit COICOP goods. Region 1 and 2 equal 1 when the bilateral distance (in miles) is [0,750) and [750,1500) and 0 otherwise.

Table 13: Alternative Measures of Expenditures

	(Baseline)	(Household Cons.)	(GDP shares)
Euro	-0.011***	-0.011***	-0.011***
	(0.002)	(0.002)	(0.002)
Log(Distance)	0.011***	0.011***	0.011***
	(0.002)	(0.002)	(0.002)
Common Border	0.013***	0.012***	0.013***
	(0.004)	(0.004)	(0.004)
Common Language	-0.007**	-0.007**	-0.007**
	(0.003)	(0.003)	(0.004)
Island	0.026***	0.027***	0.027***
	(0.003)	(0.003)	(0.003)
Landlocked	-0.002	-0.002	-0.002
	(0.003)	(0.003)	(0.003)
$\sigma(s_{ij})$	0.085***	0.084***	0.085***
	(0.012)	(0.012)	(0.012)
Log(Expenditures)	-0.001**	-0.001*	-0.001**
	(0.001)	(0.001)	(0.001)
European Union	-0.016***	-0.016***	-0.015***
	(0.003)	(0.003)	(0.003)
R^2	0.26	0.26	0.26
# Observations	9424	9424	9424

Results from OLS of equation (9). Robust std. error in parenthesis. Cluster: country pair. ***: significant at 99%, ** at 95%, * at 90%. Product fixed effects. Sample: tradable four-digit COICOP goods. Household Cons. uses the log of Household consumption from WDI. In GDP shares, for each good g, $Expenditure_i^g = GDP_i * share_i^g$, where $share_i^g$ is the share of g in the HICP index, from Eurostat.

Table 14: Fixed Costs and Type of Retail

	(GDP)	(Ret. & Whole.)	(Wholesale)	(Retail)	(Online)
Euro	-0.010***	-0.010***	-0.010***	-0.010***	-0.010***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Log(Distance)	0.012***	0.012***	0.012***	0.012***	0.012***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Common Border	0.015***	0.014***	0.014***	0.014***	0.013***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Common Language	-0.003	-0.002	-0.002	-0.003	-0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Island	0.025***	0.026***	0.026***	0.026***	0.029***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Landlocked	0.000	0.001	0.001	0.000	0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$\sigma(s_{ij})$	0.122***	0.121***	0.121***	0.121***	0.118***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Doing Business	-0.061***	-0.062***	-0.062***	-0.062***	-0.069***
	(0.008)	(0.009)	(0.009)	(0.008)	(0.010)
Size	-0.002***	-0.001***	-0.001**	-0.002***	-0.017*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.010)
R^2	0.26	0.26	0.26	0.26	0.26
# Observations	9424	9424	9424	9424	9424

Results from OLS of equation (9). Robust std. error in parenthesis. Cluster: country pair. ***: significant at 99%, ** at 95%, * at 90%. Product Fixed Effects. Sample: tradable four-digit COICOP goods. Doing Business: average (2015-2016) index of Ease of doing business index (1=most business-friendly regulations), divided by 100. The column titles describe the variable Size. *Ret. & Whole.*: average (2002-2016) total turnover in Retail and Wholesale in countries i and j, from Eurostat. *Wholesale*: average (2002-2016) total Wholesale turnover in countries i and j. *Retail*: average (2002-2016) total turnover in Retail in countries i and j, from Eurostat. *Online* average (2002-2016) share of the population that made an online purchase in the previous three months, weighted by average country population.

Table 15: The Euro Did Not Shrink the Band of Non-Tradable Goods

	(All)	(EU)
Euro	-0.004	-0.003
	(0.003)	(0.003)
Log(Distance)	0.005*	0.003
	(0.003)	(0.002)
Common Border	0.002	-0.001
	(0.005)	(0.005)
Common Language	-0.007	-0.003
	(0.006)	(0.007)
Island	0.014***	0.017***
	(0.003)	(0.003)
Landlocked	0.004	0.010***
	(0.003)	(0.003)
$\sigma(s_{ij})$	0.149***	0.150***
	(0.012)	(0.020)
Log(Expenditures)	-0.002***	-0.001**
	(0.001)	(0.001)
European Union	-0.000	
	(0.004)	
R^2	0.23	0.19
# Observations	4960	3780

Results from OLS of equation (9). Robust std. error in parenthesis. Cluster: country pair. ***: significant at 99%, ** at 95%, * at 90%. Product fixed effects. Sample: non-tradable four-digit COICOP goods.

Table 16: The Euro Shrunk the Band for all Goods

	(1)	(2)	(3)	(4)	(5)
Euro	-0.024***	-0.025***	-0.010***	-0.010***	-0.009***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Log(Distance)		0.016***	0.011***	0.010***	0.009***
		(0.003)	(0.002)	(0.002)	(0.002)
Common Border		0.013***	0.009**	0.010***	0.009***
		(0.004)	(0.004)	(0.003)	(0.003)
Common Language		-0.002	-0.006*	-0.005	-0.007**
		(0.004)	(0.003)	(0.003)	(0.003)
Island		0.026***	0.025***	0.022***	0.022***
		(0.003)	(0.003)	(0.003)	(0.003)
Landlocked		0.004	0.001	0.000	-0.000
		(0.003)	(0.002)	(0.002)	(0.002)
$\sigma(s_{ij})$			0.123***	0.123***	0.107***
			(0.011)	(0.010)	(0.011)
Log(Expenditures)				-0.002***	-0.002***
				(0.001)	(0.001)
European Union					-0.010***
					(0.003)
R^2	0.11	0.18	0.24	0.24	0.25
# Observations	14384	14384	14384	14384	14384

Results from OLS of equation (9). Robust std. error in parenthesis. Cluster: country pair. ***: significant at 99%, ** at 95%, * at 90%. Product Fixed Effects. Sample: tradable and non-tradable four-digits COICOP goods.

Table 17: The Euro Shrunk Other Variables Too

	$\lambda_{ij}^{g,out}$	$\sigma(x_{ijt}^{g})$	$\sigma(\Delta x_{ijt}^{g})$
Euro	-0.036***	-0.002***	0.008
	(0.009)	(0.000)	(0.008)
Log(Distance)	-0.021***	0.002***	0.045***
	(0.007)	(0.000)	(0.007)
Common Border	-0.019	0.002***	0.040***
	(0.016)	(0.001)	(0.014)
Common Language	-0.078***	-0.001**	0.007
	(0.022)	(0.001)	(0.020)
Island	0.004	0.004***	0.061***
	(0.008)	(0.000)	(0.010)
Landlocked	-0.038***	-0.001***	-0.024***
	(0.008)	(0.000)	(0.009)
$\sigma(s_{ij})$	0.257***	0.027***	0.489***
	(0.038)	(0.002)	(0.041)
Log(Expenditures)	0.001	-0.000***	-0.016***
	(0.002)	(0.000)	(0.002)
European Union	0.148***	-0.001***	-0.091***
	(0.014)	(0.001)	(0.014)
R^2	0.21	0.44	0.52
# Observations	9424	9424	9424

Results from OLS of equation (9). Robust std. error in parenthesis. Cluster: country pair. ***: significant at 99%, ** at 95%, * at 90%. Product fixed effects. Sample: tradable four-digit COICOP goods. Dependent variable in the header.

Table 18: The Euro Shrunk the Band

	Tradable		Non Tradable	
	(1)	(2)	(1)	(2)
Euro	-0.005***	-0.011***	-0.001	-0.003
	(0.001)	(0.002)	(0.002)	(0.003)
Log(Distance)	0.004***	0.010***	0.000	0.005*
	(0.001)	(0.002)	(0.002)	(0.003)
Common Border	0.005*	0.012***	-0.005	0.002
	(0.003)	(0.003)	(0.004)	(0.005)
Common Language	-0.002	-0.007**	0.001	-0.006
	(0.002)	(0.003)	(0.005)	(0.006)
Island	0.009***	0.024***	0.000	0.012***
	(0.002)	(0.003)	(0.002)	(0.003)
Landlocked	0.002	-0.002	0.005**	0.004
	(0.002)	(0.002)	(0.002)	(0.003)
$\sigma(s_{ij})$	-0.019**	0.070***	0.050***	0.146***
	(0.008)	(0.011)	(0.010)	(0.012)
Log(Expenditures)	0.000	-0.001	0.001	-0.002***
	(0.000)	(0.001)	(0.000)	(0.001)
European Union	-0.010***	-0.013***	0.007*	0.001
	(0.002)	(0.003)	(0.004)	(0.004)
$\sigma(x^g_{ijt})$	3.878***		2.893***	
	(0.146)		(0.155)	
$\sigma(\Delta x^g_{ijt})$		3.066***		1.315***
		(0.427)		(0.428)
R^2	0.49	0.27	0.39	0.23
# Observations	9424	9424	4960	4960

Results from OLS of equation (9). Robust std. error in parenthesis. Cluster: country pair. ***: significant at 99%, ** at 95%, * at 90%. Product fixed effects. Sample: tradable four-digit COICOP goods. Unbalanced panel.