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Investigating the Effects of Euro on Bilateral Trade: a Kernel Matching Approach

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Abstract

The aim of this paper is to estimate the effects of the adoption of the Euro on the bilateral trade of European and OECD countries. Using the most recently available data and a more appropriate deflator of bilateral trade, this research tries to assess whether EMU countries trade more than they would have if they had not adopted the Euro. In doing so an augmented 'difference in differences' approach is used. The results obtained show that the adoption of the Euro increased trade significantly and that there is also no evidence of trade diversion effects.

- **JEL Classification:** C14, F15, F33
- **Key Words:** European Union, common currency, difference-in-differences estimation, trade creation, kernel matching

I. Introduction

It has been theoretically demonstrated that exchange rate risk and exchange rate volatility have a negative effect on international trade. However, empirical

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literature has found it difficult to provide conclusive evidence for this negative effect. This has generated concerns that a common currency may not affect bilateral trade as well. A direct empirical investigation for the effect of common currencies on trade was initiated by Rose (2000). Rose's paper is probably the most influential in this decade with more than 500 citations (Baldwin (2005)). Using an augmented version of the gravity model, Rose finds that the effect of common currencies on bilateral trade is not only positive and significant but also very large. In particular, he finds that countries with the same currency trade twice as much as countries without one.

Despite the fact that Rose's (2000) initial study and the following literature were motivated by an aspiration to, indirectly, assess the possible effect of the Euro on bilateral trade, only a very small number of studies investigate this impact directly. The main reason for this seems to be the small time period available since the introduction of the Euro. The Euro was introduced in 1999 and therefore, previous studies use data at most of three years after its introduction in order to investigate its effect on bilateral trade.[1] In this study by using a thirteen-year period (1995-2007), the effect of the Euro on bilateral trade is estimated. These eight years after adoption of the Euro is the largest period that has, so far, been available in order to determine the above effect.

In the related literature there have primarily been two questions that research has sought to answer. Glick and Rose (2002, p. 1131) state these questions and relate the effort to answer one of them to the use of fixed-effects 'within' estimators in panel-data context: "Above and beyond econometric robustness, the fixed effects estimator has one enormous advantage. Since the within estimator exploits variation over time, *it answers the policy question of interest,* namely the (time series) question 'What is the trade effect of a country joining (or leaving) a currency union?' This can be contrasted with the cross-sectional question "How much more do countries within currency union's trade than non-members?" (see also Micco *et al.* (2003, p. 327).

The present research, however, tries to answer a third question, while taking on some critical views in relation to the means used in the empirical literature that has sought to answer the aforementioned questions. Namely, the question of interest in this research is: how much has trade increased for the adopters of the Euro in comparison to the trade they would have experienced if they had not adopted it?

[1]However, the physical introduction of the Euro took place in January 2002.

The difficulty in answering this question is that it essentially requires data on unobservables. Although we have the value of trade of the Euro countries, we cannot obtain the value of trade that would have been experienced if they had continued using their previous own currencies. To answer this question and deal with the problem of constructing the aforementioned 'counterfactual', an augmented 'difference-in-differences' estimation framework was used.

This approach compares the experiences of countries affected by the introduction of the Euro with the experiences of those which are not (or, at least, are much less) affected. Difference in differences is commonly used in the examination of tax reforms and the evaluation of job training programs.[2] [3] It is appropriate in the context of the introduction of the Euro because the structure of that reform is such that there are some countries which are strongly affected by the reform and so form a natural 'treatment' group while the other countries which are largely unaffected form a natural 'control' group. However, the countries that form the control group may have systematic differences from the countries of the treatment group and these differences may be reflected in their value of trade. In order to make these two groups comparable the method of matching is applied. Then by using the 'difference-in-differences' approach we can measure the amount by which the bilateral trade increases for the treatment group and hence indirectly answer the third question.

Moreover, in this paper a different and better proxy for bilateral trade is introduced. All the previous studies (to the best of the authors' knowledge) use the value of imports and/or exports, measured in US dollars and deflated by the US GDP deflator because the researchers did not have price data for imports and exports. However, this deflator is not the bilateral trade deflator but an approximation of it and hence it can lead to biased results. In this study, apart from the traditional implicit trade deflator, an explicit bilateral trade deflator is constructed since prices and quantities of both imports and exports are available. The base period for this deflator is 1999.

In order to empirically address the question of interest an augmented version of the gravity model is used in two different samples of countries. The first panel includes the 44 (European and OECD countries) which represent most of the trade of the European Union's total trade, while the second is focused only on the trade

[2]For example Eissa (1995).
[3]Heckman *et al.* (1998).

of the EU-14 countries with the rest of the world. Both panels contain data for the years 1995-2007.[4] The reason for using the first sample is to investigate-in a better way-possible trade diversion due to the Euro. According to Midelfart-Knarvik's critique on the Micco *et al.* (2003) paper, one should use both developed and developing countries in order to get a better picture of possible trade diversion effects owing to the introduction of the Euro.[5] However, the selection of the less developed countries should be carefully performed, for if too many of them are included then a sample selection bias problem may arise. The possibility of this sort of bias has been a basic critique on Rose's (2000) pioneer paper.

The results obtained in the present research show that the Euro has a positive effect on the bilateral trade of the European countries irrespective of the methods of estimation used. However, the magnitude of this effect depends on the estimation method. Moreover, when the explicit trade deflator is used, the effect of the Euro is larger than when the bilateral trade is deflated with the GDP deflator, for both fixed effects estimation and difference in differences estimation and for both samples. On the other hand, it should be mentioned that although the effect of the euro is not negative for any individual country, there are three countries (Finland, Germany and Austria) in which this effect is statistically insignificant. More important may be that there is no trade diversion of the EMU-member countries due to the introduction of the Euro, despite the fact that both developing and developed countries are included in the sample.

The remainder of the paper is organized in the following way: in section II the existing literature of the impact of currency union on trade is reviewed. Next, a description of the econometric framework and variables follows in Section III, and in Section IV the results of the EMU trade effects are presented. Conclusions finally follow in Section V.

II. The Effects of Common Currencies on Bilateral Trade

The literature examining the impact of currency unions on trade represents an extensive and active field of research in international economics. Much of the recent interest in the field was sparked by Rose (2000) who discovered a surprising cross-section result that trading partners belonging to a currency union experienced

[4]An account of the countries included in these samples is given in the Appendix.
[5]Who use as a sample of only 22 developed countries.

a three-fold[6] increase in bilateral trade compared to other trading partners. In particular, he used an augmented version of gravity model to estimate the effects of currency unions and exchange rate volatility on trade.[7] The gravity equation that he adopted has as a dependent variable the bilateral trade of each two trading partners and as independent variables: income; distance; dummies which capture the common border effect; common language; regional trade agreements; historical and political links between partners; and exchange rate volatility.

The interesting finding is that a currency union seemed to have a very large effect on trade. Members of currency unions traded over three times as much as otherwise similar pairs of countries, *ceteris paribus.* Rose does not provide a specific reason for this big effect. However, the possible explanation that he gives is that the common currency represents a serious commitment of governments adopting it which could lead to greater financial integration, and which, in turn, stimulates international trade in goods and services. However, although he uses a sample of almost all the countries of the world, only a small number of them belong to currency unions. Furthermore, these countries are small, poor or both. This fact led many researchers to question whether the result of common currency on trade could in fact be so substantial by using smaller and more concrete samples.

The basic critique on Rose's paper concerns his sample. For instance, Thom and Walsh (2002) argue that broad panel studies are irrelevant of interest since they do not provide particular information on large economies. More importantly, Persson (2001) underlines the selection bias that Rose's sample faces. He points out that the countries which are included in the Rose's sample are not randomly selected. Therefore, given that countries inside the currency unions differ from countries outside them, the large effect of common currency may be seriously biased upward due to this difference.

However, using smaller samples has been a necessity when the effect of the Economic and Monetary Union in Europe (EMU) and not of all the monetary unions is the focus of research. When the first data became available, a number of studies tried to measure the effect of the Euro on the bilateral trade of European

[2]Although after some corrections on his sample the effect is more than two-fold.

[3]According to the standard gravity model, bilateral trade is positively correlated with real GDP and negatively with distance between two countries. If other variables are introduced in the standard version, then we have an augmented version of gravity model. More details of the history and the justification of gravity model are provided in Section III.

countries (Barr *et al*. (2003), Bun and Klaassen (2002), De Nardis and Vicarelli (2002), Micco *et al.* (2003), and Bun and Klaasen (2007)).

One of the most notable attempts to measure the effects of the Euro on trade is the study by Micco *et al*. (2003). They use a sample of 22 industrial countries for the years 1992 to 2002. They find that on average, the Euro countries increased their trade compared with that of the pre-Euro period, but the overall increase was small varying between 4 to 16 percent depending on the methods applied. Moreover, Micco *et al*. are particularly interested in the timing of the Euro's impact. They find that EMU countries were already trading more among themselves than with other countries before the creation of the EMU. More importantly, the largest effect of the Euro has been observed one year before its introduction. Finally, they check whether the increase in trade comes at the expense of the other countries. They add a new dummy which takes the value of one when only one of the two countries involved in the bilateral trade uses the Euro, to check for trade diversion effects. They find no evidence of such an effect. Thus they conclude that the monetary union increases trade not just with EMU countries, but also with the rest of the world.

Bun and Klaasen (2002) investigate the impact of adopting the Euro on the commercial transactions of EMU countries by following a slightly different approach. They assume that exports are not only a function of real foreign income, the expected real exchange rate and the EMU but also of lagged exports as well. Based on a sample that includes annual data from 1965 to 2001 for the EU countries plus Canada, Japan and USA, they find that the Euro has a small positive effect on trade in the first year (around 4%). However, the cumulative effect is found to be almost 40%, half of which will be achieved by 2006.

Barr *et al.* (2003) investigate the effects of EMU on trade with Rose's (2000) standard gravity model, consisting of 17 European countries and data from the first quarter of 1978 to the first quarter of 2001. The authors are particularly concerned with an endogeneity issue. Namely, do EMU members trade more as a result of the adoption of the Euro, or did they form a monetary union as a result of intensive trade links? These authors use price and output co-movement variables as instruments to test for endogeneity. Their estimates of the currency union effect are significantly smaller than those found by Rose (29% rather than 300%. On the other hand the exchange rate volatility effect found by Barr *et al*. (2003) is larger than that found in Rose (2000).

De Nardis and Vicarelli (2003) examine if, and how much, the Euro has affected trade. Their estimation is based on an unbalanced panel data set of 11 exporter countries and 32 importer countries, for the period 1980-2000. Their short-run estimate of the Euro effect is 9% while the long-run is 16%. Their estimates are much smaller compared to the pre-EMU studies. According to the authors, one reason for this divergence is that the Euro was adopted after a long-term process of European integration and trade links had already been established because of cultural and neighboring factors.

Finally, Bun and Klaasen (2007) point out that serial correlation is an important issue when the fixed-effects estimation method is used in order to investigate the effects of the Euro on bilateral trade. This has been attributed to the fact that trade increased with time and thus the Euro dummy picks up on this increase too. In this way it was proposed that an additional independent variable, that of the product of time with each pair of countries in the sample, should be used. When the results obtained using these corrections are compared to those of earlier studies, Bun and Klaasen (2006) find that the effect of the Euro in the former case is dramatically reduced.

There is a very recent study by Chintrakarn (2008) which applies the difference in difference technique in the gravity model. In particular, by using various non-parametric techniques Chintrakarn finds that the euro increases bilateral trade from 9% to 14%. However, there are some important differences between this study and the study of Chintrakarn. The first one is the choice of the variables in order to construct the propensity scores. As Rosenbaum and Robin (1983) mention the choice of these variables determines in a large way the final treatment effect. In his paper Chintrakarn (2008) does not include as an independent variable the participation of a country in European Union. Moreover, the sample that he uses contains only developed countries and only four years of the euro period. In particular, he uses the Micco *et al*. data set which contains data for developed countries for the year 2002.

However, the most important difference is that the Chintrakam study assumes that the mean difference in unobservable characteristics between EMU countries and non-EMU countries is equal to zero. In this study, we used two versions of difference in difference approach.[8] The first one is parametric while the second one is a non-parametric technique which is the only one among the family of matching techniques which does not make the above assumption and hence gives unbiased

[8]The term “unobservable characteristics” refers to the variables that are not included in the econometric equations.

results (Heckman *et al*. (1998), in order to investigate the effects of the euro on bilateral trade.

An alternative use of the kernel matching is proposed by Baier and Bergstrand (2009). In particular, they use the Abadie and Imbens (2006) non parametric matching approach in order to investigate the effects of trade agreements on international trade flows. Their method differs from the one used in this paper by the fact that their matching is done on every variable of the gravity equation and not only on the variable of interest. This can lead to the "curse of high dimensionality" (Baier and Bergstrand) if certain assumptions are not fulfilled.

The most important assumption is that the selection of the treatment assignment is random in the sense that each treated pair is matched closely to an untreated pair in terms of all relevant covariates influencing trade. However, a country that uses a common currency should first be a member of a trade agreement and therefore the covariate of the trade agreement variable cannot be the same between members and non members. Moreover, the Abadie and Imbens (2006) technique can be used only on cross sectional data and not on panel data.

The three main limitations of the research reviewed may be those of: a) the small dataset relating to the short period after the introduction of the Euro, b) the small number of countries that they include and, c) the CPI as the price index used in order to deflate the values of trade. This study tackles the above limitations by using a larger time period, a larger country sample and a more appropriate deflator of bilateral trade.

Moreover, as Persson (2001) argues, the effect of a common currency on trade depends on which countries one compares and on the exact relationship between trade and its determinants. If the countries that form the sample are systematically different from the EMU countries and the trade equation is not linear, then the above coefficients may be biased. In order to tackle these problems this paper applies matching techniques and 'difference-in-difference' estimation along with fixed-effects estimation. Hence, it provides more up to date and perhaps more reliable results regarding the effects of EMU on trade.

III. The Model, the Variables and the Econometric Techniques

A. The Gravity Model[9]

[9]The terms "gravity model" and "gravity equation" are used synonymously.

Inspired by Isaac Newton who first proved that the gravity force of two objects increases with their size and decreases with their square distance, Anderson (1979) argues that the bilateral trade of two countries is positively related to the values of their GDP and negatively related to their distance. In the history of applied economics, there is no other model that has been used so many times[10] and provides such "good" results on the determinants of trade, besides the gravity model.

Notwithstanding its popularity, the gravity model faces a lot of critique, mainly about not being based on solid economic theoretical grounds. The large number of studies that have applied the gravity model have produced a multitude of explanatory variables. The basic critique is that these variables are not theoretically justified in the gravity equation. However, this may not be entirely justified for in recent years there have been various attempts to provide some theoretical background for this model. For example, the use of the product of two countries GDPs as an explanatory variable (of trade) was introduced by models of trade with increasing returns to scale and product differentiation, such as Helpman and Krugman's (1985) model. Helpman and Krugman also show that, in the model of increasing returns to trade, any variable that represents trade barriers (such as transportation cost) reduces trade. Moreover, Anderson and Wincoop (2002) provide theoretical grounds on the use of any variable that reduces bilateral trade such as a different currency in the equation.

The gravity model still serves as the 'workhorse' in empirical studies assessing the effect of various variables on bilateral trade. Despite the fact that it is not a fully developed theoretical model, most of the variables that are used in it have some theoretical reasoning. For these reasons the gravity equation is adopted in order to investigate the effects of the Euro on the bilateral trade of EMU member countries.

B. Variables and Data Set

The purpose of this research is to estimate the effect of European Monetary Union on international trade not only of the European countries but also of the 44 European and OECD countries. For this reason the fixed effects and the difference in differences estimation method are applied in (a) a sample of 44 OECD and European countries and (b) the EU-14 countries.[11] Both data sets cover the period

[10]The Econlit web-site yields more than 2,000 references on the phrase "gravity model".
[11]For the lists of countries see Table A1 in the appendix.

from 1995 to 2007. The full sample consists of 9536 observations, while the smaller sample of 7826. In both samples Luxembourg and Belgium are considered as one country.[12]

The variables that are used in either fixed effects and/or difference in differences estimations are the following: Real **GDP** and **Distance** which are the core variables of the gravity model and their expected signs are positive and negative respectively, since 'richer and closer' countries are expected to have larger bilateral trade. Common **Language** is used to account for cultural similarities among countries. It is expected that countries with common language and hence cultural similarities trade more than the others. There are other variables that capture cultural similarities as well, such as common religion. However, since there is a strong correlation among these variables, only common language is included. The product of the '**Area**' of the two bilateral partners is used in order to account for the fact that larger countries probably have respectively larger volumes of trade. The **Real exchange rate** for each partner (hence Real Exchange rate1 and Real Exchange rate2) is used in order to capture exchange rate risk and volatility. Following Rose's (2000) pioneer paper the real exchange rate should be included in the regression in order to isolate the effect of the common currency on bilateral trade. The omission of this variable may cause an omitting variable bias since the euro dummy will capture the effect of the volatility of exchange rate on bilateral trade. The real exchange rate for each partner firstly used by Micco *et al.* (2003) is used since is the best approximation for the effect of the exchange rate volatility on trade (Baldwin (2005). An **EU** dummy variable is also included in order to take into account the possibility that a country's participation in the European Union increases trade.

Finally, **EMU** and **NONEMU** are the variables of interest. The expected sign of the first variable is positive, since common currency reduces volatility and hence fosters trade. The second variable captures trade diversion effects due to the Euro. The expected sign of this variable is negative. The measurement of the effect of these variables is the very purpose of this paper. In one specification of the gavity model, the EMU dummy is replaced with the product of the EMU and a dummy of each country in order to measure the effect of the Euro on each individual country.

[12]The full sample includes the trade of the oldest EU-14 countries with the rest of the countries in our sample plus the trade of the new EU-10 countries for the years between 1999 and 2004 with the rest of the countries in our sample.

Bilateral trade[13] is obtained from the Eurostat database and is deflated using 1999 as the base year. For our sample period we have data for both values and quantities of trade. Therefore, we find the unit price of trade for the year 1999 and then we multiply the quantity of trade for each year with the unit price of 1999's trade in order to construct the trade deflator. Real GDP (measured in 1999 prices) has been taken from the United Nations database. Exchange rates are obtained from both Eurostat and IMF databases. 'Great circle distance' is used in order to measure distance between the capitals. 'Language, Area and Border' data are derived from the CIA web page.[14]

C. Methods

As the 'within' estimator has been extensively used in the related literature, it is also used here as it allows for the comparison of the results obtained with those of earlier studies employing different time dimensions and trade deflators. Thus, the fixed effects 'within' estimator has been used for estimating the following gravity equation that has incorporated suggestions put forward recently by Bun and Klaasen (2006):

$$\begin{aligned}\ln(TRADE_{ijt}) = \beta_0 + \beta_1 \ln(Y_i Y_j) + \beta_2 EU_{ijt} + \beta_3 EMU_{ijt} + \beta_4 MONEMU_{ijt} \\ + \beta_5 Real\ Exchange\ Rete1_{ijt} + \beta_6 Real\ Exchange\ Rete2_{ijt} + t^{*}\tau_{ij} + \varepsilon_{ijt}\end{aligned} \quad (1)$$

where i and j denotes countries, t denotes time, and the variables are defined as:

- $TRADE_{ijt}$ is the value of real bilateral trade deflated with the trade deflator or US GDP deflator between i and j at time t measured in Euros,,
- Y is the real GDP, measured in Euros
- EU is a dummy variable that takes the value of one if both countries are members of the European Union.
- EMU is a binary variable which is unity if both i and j use the Euro at time t,
- NONEMU is a binary variable which is unity if one of i and j uses the Euro at time t,
- Real Exchange rate is given by the product between the nominal exchange rate of each country vis-à-vis the US dollar and the USA GDP deflator divided by

[13]For each sample, bilateral trade is deflated with the use of both the US GDP deflator and the explicit bilateral trade deflator.

[14]http://www.odci.gov/cia/publications/factbook/

the country's GDP deflator,[15]
- β is a vector of nuisance coefficients,
- $t^*\tau$ is the product of time with each pair and captures the country- pair dependence of the fixed effects
- ε represents other influences of bilateral trade which are assumed well-behaved.

A country-pair fixed effects estimator of the above gravity model has been suggested in the literature as having the advantage of exploring the time variation of the data and thus answering the more interesting time-series question as to whether the adoption of the common currency has increased trade for those countries adopting it (Glick and Rose (2002), Micco *et al*. (2003)).

In a next step the 'difference in differences' estimation framework is used. This compares the behavior of two groups of bilateral trade flows. The treatment group includes those countries whose bilateral trade flows should have been boosted by the adoption of the Euro. These countries are those which adopted the Euro as their currency. The control group is made up of the countries whose bilateral trade flows should not have been affected by the Euro. In essence, the procedure is to compare the change in the treatment group's trade flows due to the adoption of the Euro (first difference) to the change in flows for the control group (the second difference).[16] Given the fact that the introduction of the Euro was not the only thing that changed between the pre-1999 and post-1999 periods, in the first specification of the gravity model using the difference in differences approach we include all the explanatory variables to control for factors which reflect these changes.

However, one may argue that there may be other variables that influence trade apart from those used in the gravity model and hence the two groups of countries cannot be compared. More importantly, the relationship of these variables with bilateral trade may not be linear. In order to address these problems the matching technique is employed. The purpose is to form two groups of countries which are similar in all aspects apart from their behavior towards the Euro adoption and then compare their trade using the "difference in differences" approach. Persson (2001) uses a similar strategy in order to challenge Rose's (2000) empirical findings. The present research differs from Persson's in that it uses a nonparametric conditional

[15]For reasons of comparison with the existing literature the exchange rates for each partner are deflated with the US GDP deflator instead of the trade deflator. However, when the exchange rates are deflated with the explicit deflator, the regression's results are almost identical.

[16]Hence the term difference in differences.

difference-in-differences extension to the method of matching firstly introduced by Heckman *et al*. (1998). This procedure is based on kernel matching technique and difference-in-differences estimation instead of the nearest matching technique and stratification which Persson (2001) used. Heckman *et al*. (1998) proved that this non parametric technique is more appropriate, since the estimators derived from the nearest matching and stratification are biased.[17]

IV. Results[18]

A. Country-pair Fixed Effects

Despite the reservations expressed in the previous section with regards to the interpretation of the currency-union dummy variable (EMU in the present context) coefficient, country-pair fixed-effects estimator results are presented in this section primarily for reasons of comparability.

The results of applying the 'within' estimator for the full sample are presented in Table 1, while those for the restricted sample in Table 2.[19] In the first column for each table the bilateral trade is deflated by the US GDP deflator while in the second column the bilateral trade is deflated by trade deflator.[20]

The effects of the Euro on trade are insignificant for both samples when the bilateral trade is deflated with the traditional US GDP deflator. On the other hand, when the trade deflator is used, the EMU dummy is positive and statistically significant at the 1% level. Moreover, GDP, EU and NonEMU have the appropriate sign and are statistically significant at the 1% level for the full sample. The increase in trade due to the Euro is 9% for the whole sample and 13% for the restricted sample. These effects are larger compared to those of Bun and Klaasen (2006) who take into account the omitted trend variable bias (also in this study) and use the US GDP deflator for the deflation of bilateral trade. A possible explanation for this result is the large depreciation of the euro in the year 1999.

[17]The paper of Heckman *et al*. (1998) provides an excellent survey of all methods of matching and treatment effects.

[18]The results are obtained with the use of the STATA 8.2 econometric software.

[19]The standard errors are corrected for both heteroscedasticity and serial correlation with the use of the Newey and West (1987) alrgorithm with the Newey and West (1998) optimal lag selection rule.

[20]As a second step the residuals of the fixed- effects regression are regressed with the time invariant variables (distance, common border, common language, exchange rates of the two countries). Since the focus of this study is an investigation of the effect of the Euro on trade and not of the determinants of trade and, because the difference in differences estimation of the effect of these variables is obtained explicitly, the results of this regression are not presented but are available upon request.

Table 1. Fixed Effects Estimation: Full Sample

Dependent Variable: Bilateral Trade		
Variables	US GDP Deflator	Bilateral Trade Deflator
Gdp	0.06***	0.08***
	(0.01)	(0.01)
EMU	0.004	0.09***
	(0.03)	(0.02)
EU	0.03	0.10***
	(0.03)	(0.03)
NonEMU	0.17***	0.21***
	(0.02)	(0.03)
Real Exchange rate country1	-0.00001	-0.00001
	(0.0001)	(0.0001)
Real Exchange rate country2	-0.0001	0.00003
	(0.0002)	(0.0002)
No. Observations	9536	9536
R^2 (overall)	0.14	0.16
F test that all u_i=0	70.64	72.12

Note: Newey-West standard errors in parentheses. *** Asterisks denote that the variable is significant at 1%. Constant term and time*pair are not reported in the table.

Table 2. Fixed Effects Estimation Restricted Sample

Dependent Variable: Bilateral Trade		
Variables	US GDP Deflator	Bilateral Trade Deflator
Gdp	0.07***	0.11***
	(0.01)	(0.01)
EMU	0.05**	0.12***
	(0.02)	(0.03)
EU	0.04	0.06
	(0.04)	(0.04)
NonEMU	0.25***	0.13***
	(0.04)	(0.03)
Real Exchange rate country1	-0.00004	-0.00001
	(0.00004)	(0.0001)
Real Exchange rate country2	-0.0001	-0.00013
	(0.0002)	(0.00011)
No. Observations	7826	7826
R^2 (overall)	0.19	0.21
F test that all u_i=0	61.63	64.33

Note: Newey-West standard errors in parentheses. *** Asterisks denote that the variable is significant at 1%. Constant term and time*pair are not reported in the table.

Therefore, when the bilateral trade is measured in Euros and deflated by the explicit trade deflator this effect is taken into account.[21] Moreover, not only there is no trade diversion due to the Euro, but the Euro is also found to boost the trade of the countries of the Eurozone with the rest of the OECD and European countries. Moreover, the effect of the exchanges rates on bilateral trade are insignificant in both samples and despite the use of the deflator. This result is similar with the results of most of the previous studies and confirm the Rose (2000) argument that the reduction of exchange rate volatility has a minor effect on trade, when a country is a member of a currency union.

Surprisingly, the effect of the NONEMU dummy is larger than that of the EMU. A tentative explanation for this is that most of the countries that adopted the Euro faced - before its introduction - large exchange rate volatility in their currencies. Therefore, by adopting a less volatile and less vulnerable to shocks currency, they increased their trade not only with the Euro countries but also with the rest.

Finally, when the effect of the Euro in each country is estimated separately (using appropriate interaction terms), the results show that there is a positive and statistically significant impact in nine out of twelve members of the Eurozone. The only countries that the euro seems to have no statistically significant impact on trade are Finland, Germany and Austria. In this exercise all other explanatory variables of the gravity model have the expected sign and are statistically significant.

The largest effect of the Euro concerns countries which suffered large currency volatility prior to its introduction like Italy (16.5%) and Portugal (15%).[22] Furthermore, the smallest effect of the Euro has been found in the case of Belgium, a mere 0.5%. These said, two rough conclusions may be brought about from the analysis of the country-specific Euro effects. The first is that the effect is positive for all member countries. The second is that the strength of the country-specific Euro effect is related to a country’s exchange rate volatility prior to the Euro. A tentative conclusion that follows may be that future members that are likely to benefit most are that currently exhibiting greater currency volatility.

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[21]Micco *et al.* (2002) also mention that in order to take into account the depreciation of the euro in the year 1999, the bilateral trade should be measured in euros instead of dollars and an explicit trade deflator should be used.

[22]The results of this estimation are not presented separately but are available from the authors upon request.

B. Difference-in -differences Approach

Having estimated the effect of the Euro on bilateral trade with the use of the conventional country-pair fixed effects estimator, the analysis proceeds to empirically investigate an equally important and yet unexplored issue namely: how much does trade increase for the adopters of the Euro compared to the trade that they would have experienced had they not adopted it? For this reason the 'difference-in-differences' approach is used.

Formally, the analysis involves regression of the form:

$$\begin{aligned}\ln(TRADE_{ijt}) &= \beta_0 + \beta_1 X_{ijt} + \beta_2 \ln DIST_{ij} + \beta_3 LANG_{ij} + \beta_4 \ln(Area_i Area_j) \\ &+ \beta_5 Border_{ij} + \gamma_1 EMU2_{ij} + \gamma_2 P_2 + \gamma_3 (EMU2_{ij} \times P_t) + \varepsilon_{ijt}\end{aligned} \tag{2}$$

where:

- $TRADE_{ijt}$ is the value of real bilateral trade deflated with the trade deflator or US GDP deflator between *i* and *j* at time *t* measured in Euros,
- *X* is the vector or previous explaneid variables apart from EMU an NonEMU
- Dist is the distance between *i* and *j* measured in kilometers
- Lang is a binary variable which takes the value of one if *i* and *j* have a common language,
- Area is the land mass of the country measured in square kilometers,
- Border is a binary variable which takes the value of one if *i* and *j* have common border,
- EMU2 is the dummy taking the value of one for the treatment group and
- *P* is a dummy indicating the post-EMU period.

The coefficient γ_1 indicates how much the post-EMU trade is higher for treatment group, γ_2 by how much trade changes during the reform and γ_3 is the difference in differences estimator measuring the treatment effect and indicating by how much more trade increases for the treatment group. The estimation results using the difference in difference approach for the full sample are reported in Table 3, while those of the restricted sample are found in Table 4. As before, in the first column for each table bilateral trade is deflated by the US GDP deflator while in the second column bilateral trade is deflated by a trade deflator.[23]

Again when bilateral trade is deflated with the bilateral trade deflator, the

[23]It is important to note that, according to Bertrand *et al.* (2004), serial correlation is an important issue in difference in differences estimation, since the standard errors obtained by the traditional OLS regression are biased. As suggested by Bertrand *et al*, blocked bootstrap has been used to compute standard errors.

Table 3. Difference in Differences: Full sample

Dependent Variable: Bilateral Trade		
Variables	US GDP Deflator	Trade Deflator
Gdp	0.56*** (0.01)	0.68*** (0.01)
Distance	-0.88*** (0.01)	-1.63*** (0.01)
Border	1.51*** (0.05)	0.83*** (0.03)
Language	0.39*** (0.05)	0.22*** (0.01)
Area	0.32*** (0.01)	0.12*** (0.01)
EMU2	-0.53*** (0.08)	0.22 (0.19)
EU	1.26*** (0.03)	1.15*** (0.03)
P	-0.39*** (0.05)	-0.44*** (0.04)
EMU2*P	0.58*** (0.13)	0.54*** (0.08)
Real Exchange rate country1	0.0002*** (0.00003)	0.0002*** (0.0001)
Real Exchange rate country2	0.0001*** (0.00005)	0.0001*** (0.00005)
No. Observations	9,536	9,536
R^2	0.57	0.65

Note: OLS estimation; Bootstrap standard errors in parentheses. Constant term (and year controls for pooled regression) not reported *** Asterisks denote that the variable is significant at 1%.

specification of the gravity model fits the data better than when it is deflated by the US GDP deflator. All the variables of the gravity model have the expected sign and are statistical significant. The two basic results for the restricted sample are that: a) EMU countries, which form the treatment group, are trading 25% (γ_1) more after the reform,[24] and b), and more importantly, these countries trade 0.71 times more (γ_3) than the control group. In the full sample, however, the only significant coefficient is γ_3 indicating that EMU countries trade 0.64 times more than the control group.[25]

[24]Although, this coefficient is not statistically significant.

[25]The γ_1 coefficient is negative and statistically significant for both samples when the bilateral trade is deflated with the US GDP deflator.

Table 4. Difference in Differences: Restricted Sample

	Dependent Variable: Bilateral Trade	
Variables	US GDP Deflator	Trade Deflator
Gdp	0.56***	0.70***
	(0.01)	(0.01)
Distance	-0.05***	-0.24***
	(0.01)	(0.01)
Border	2.34***	1.64***
	(0.05)	(0.05)
Language	0.23***	0.44***
	(0.04)	(0.01)
Area	0.12***	0.06***
	(0.01)	(0.01)
EMU2	-0.23***	0.14
	(0.08)	(0.09)
EU	1.32***	1.17***
	(0.04)	(0.04)
P	-0.21	-0.21**
	(0.06)	(0.04)
EMU2*P	0.31**	0.50***
	(0.13)	(0.12)
Real Exchange Rate Country1	0.0002***	0.0002***
	(0.00003)	(0.00003)
Real Exchange Rate Country2	0.0001***	0.0001***
	(0.00005)	(0.00001)
No. Observations	7,826	7,826
R^2	0.55	0.66

C. The Propensity Scores and Treatment Effect

Up to now it has been assumed that the samples used are randomly selected and the relation between the variables used in the gravity model and bilateral trade is linear. However, the only variable that is theoretically justified to enter in gravity equation in linear form is only the GDP (Deardoff 1998). Moreover, Anderson and van Wincoop (2004) maintain that if the functional form of the gravity equation is misspecified, then the trade barriers estimates are biased. These two assumptions are made in every paper measuring the effect of a common currency on trade with the exception of Persson (2001).[26] Persson argues that there is theoretical as well as

[26]There are also two further papers that question the appropriateness of the linear form of gravity equation: Sanso *et al.* (1993) find evidence of deviation of the linear form, while Ranjan and Tobias (2005) suggest a piecewise linear form as more appropriate.

empirical reason for suspecting the linearity of the gravity equation. By challenging these two assumptions Persson reduces considerably the effect of common currency on trade.[27]

In this section, the matching approach is used for estimating the treatment effect. This may been as an effort to further elaborate on the results obtained in the previous section. The basic idea of the matching approach is that for every country in the treatment group, a matching country is identified among the countries of the control group. The choice of match is dictated by observable characteristics, for example GDP. However, finding observations among the control group that are exactly similar with those of the treatment group is impossible when a large number of observable characteristics is included. This obstacle can be overcome according to Rosenbaum and Rubin (1983) who proved that matching on a single index reflecting the probability of participation could lead to consistent estimates of the treatment effect in the same way as matching in all variables. This index is called the propensity score and can be obtained by using a logit regression. The

Table 5. Probit Model Parameters Estimates

	Dependent Variable: EMU	
Variables	Full Sample	Restricted Sample
EU	2.48***	2.01***
	(0.21)	(0.19)
Gdp	0.19***	0.16***
	(0.03)	(0.03)
Distance	-0.02***	-0.02***
	(0.11)	(0.01)
Border	0.35***	0.37***
	(0.12)	(0.14)
Language	0.002	-0.001
	(0.10)	(0.17)
Real Exchange rate	-0.0001	-0.001
country1	(0.001)	(0.001)
Real Exchange rate	-0.006***	-0.005***
country2	(0.001)	(0.001)
No. Observations	9,536	9,536
Pseudo R^2	0.48	0.39

Note: *** Asterisks denote that the variable is significant at 1%.

[27]Rose (2001) responds to Persson (2001) by applying the same techniques as Persson in an updated dataset. The large effect of common currency on trade is persists. The point here is not to investigate if Rose's finding is large but to mention that there is evidence that both random selection and linearity are very strong assumptions.

dependent variable which we use in this regression is the EMU dummy while the explanatory ones are the GDP, EU[28], common language and border, area and the real exchange rates. The results of this estimation for both samples are given in Table 5.[29]

It is important to note that the objective here is not to build an economic model that explains membership in the European Monetary Union, but rather to find the propensity scores for each pair of countries. Moreover, the inclusion of a variable that perfectly predicts the membership in the European Monetary Union does not allow for the estimation of the propensity scores (Persson 2001). Such a potent variable, in our case, is the NonEMU dummy and for this reason it is excluded from the regression. For the first sample, among 8511 observations in the control group 5980 have lower propensity score than the lowest propensity score in the treatment group. For the second sample, among 6621 observations in the control group 4203 have lower propensity score than the lowest propensity score in the treatment group. Since these observations cannot be compared to those of the treatment group they have been discarded.

Having constructed the treatment and the control group for each sample, the next step is to measure the effect of EMU on bilateral trade. The estimation of the treatment effect of a common currency is based on a nonparametric conditional difference in differences extension of the method of matching first proposed by Heckman *et al.* (1998). This nonparametric conditional difference in difference extension is based on local linear weights which is a transformation of kernel matching instead of nearest-matching and stratification that Persson used.

The previous studies which use the ‘difference-in-differences’ method (including the study of Persson, 2001) implicitly assume that the mean difference in unobservable characteristics between those participants who receive the treatment and those who do not is equal to zero. In the Euro context, the assumption that is made is that the unobservable characteristics of countries that adopt the Euro are on average equal to those that do not. The unobservable characteristics refer to every variable that is not included in the gravity equation.

In particular, the assumption that is made in previous studies can be expressed

[28]This dummy is not included in the study of Chintrakarn (2008), however, the omission of this variable may lead to a bias in treatment effect.

[29]We do not provide the results by using the US GDP deflator as the deflator of the bilateral trade since previous analyses indicate the superiority of explicit trade deflator. Moreover, the results are not very different from those presented in this section and are available from authors upon request.

as[30]:

$$B(X) = E(U_0|X, EMU = 1) - E(U_0|X, EMU = 0) = 0, \tag{3}$$

where, X are the observable characteristics of the countries (in plain words the variables that are included in gravity equation), U are the unobservable characteristics and B(X) is bias which arises if the average value of the unobservable characteristics between the two group of countries is not the same.

Following Heckman *et al.*(1998), a less restrictive assumption is made here. Conditional on X, the biases are on average equal before and after the period of the Euro adoption so that differencing the differences between the Euro members and non-Euro members eliminates the bias. In particular, the assumption that is made is:

$$B_{t1}(X) - B_{t0}(X) = 0 \text{, for some t0, t1,} \tag{4}$$

where t1 is the after EMU period and t0 is the pre-EMU period.

The results of the effect of EMU on bilateral trade using the nonparametric difference in differences extension of matching are presented in Table 6.[31]

The local linear weight estimator of the treatment effect of a common currency is 0.4 for the whole sample and 0.37 for the restricted sample. These point estimates indicate that the percentage of expansion of trade due to participation in the EMU is approximately 49% for the first sample and 45% for the restricted sample. These effects of the Euro on bilateral trade are larger compared to those

Table 6. Non-parametric Estimates of Treatment Effects

	Dependent Variable Bilateral Trade	
Variables	Full Sample	Restricted Sample
EMU	0.40***	0.37***
	(0.05)	(0.04)
Percentage of trade expansion	49	45
No. Observations	3134	3021
Treated	603	603
Control	2531	2418

Note: Standard errors derived by bootstrapping in parentheses. *** Asterisks denote that the variable is significant at 1%.

[30]This assumption refers to any linear gravity model. Heckman (1998) provides evidence that this assumption can lead to biased estimators.This assumption refers to any linear gravity model. Heckman (1998) provides evidence that this assumption can lead to biased estimators.

[31]The estimation of the effects of EMU on bilateral trade is performed using STATA 9.2 with code produced by Becker and Ichino.

derived from the fixed effects estimation. However, these two effects are not directly comparable for two reasons. Firstly, the two methods (the difference in differences and the fixed estimation) are used in order to answer two different questions, as already explained in the text. More importantly, the 'difference-in-difference' estimation in this section is not based on the two restrictive assumptions which are made in the fixed effects regression. Here, the two groups of countries are more comparable and the relation between trade and its explanatory variables does not have a particular form.

V. Conclusions

The Euro was introduced in 1999, although physically in 2002. This study uses data from 1995 to 2007 in order to measure the effect of this currency on the bilateral trade of its adopters. The nine year period since the introduction of the Euro is the largest that has, so far, been used in order to measure the effect of this currency. Moreover, since unit prices for both imports and exports are available, a different and perhaps more appropriate deflator is used in order to deflate bilateral trade. The results obtained from this deflation are compared with those obtained with the use of the conventional US GDP deflator.

In a first step, the effects of the Euro on bilateral trade of the European and OECD countries were analyzed with the use of conventional country-pair fixed effects. The effect of the Euro estimated in this manner was found to be considerably large. However, some reservations have been expressed regarding the appropriateness of this method when answering interesting questions that have been put forward in the literature, namely whether the trade of adopters has increased in post adoption (when compared to the pre-adoption) era. The present research seeks to provide an answer to the question of how much trade increases for the adopters of the Euro compared to the trade that they would have experienced if they had not adopted it. Answering this question was attempted by using 'difference-in-differences' estimation combined with matching techniques.

The results obtained indicate that trade increases considerably for its adopters in comparison to that of the other countries of our sample and in comparison to the trade that adopters would have faced, had they not entered the European Monetary Union. On the other hand, the increase in their trade compared to their trade during the years prior to the Euro-while positive and statistically significant—is found to be small. Moreover, the effect is larger for the countries in which their currency has a larger exchange rate volatitlity. Finally, our findings suggest that the Euro not only does not cause trade diversion but it also increases the trade of the EMU countries with the rest of the world.

It should be mentioned that the Euro estimates are possibly not only a result of the introduction of the Euro, but a combination of the effect of the Euro along with other factors of trade integration. However, such factors may not play an important role since our sample consisted primarily of developed countries and for the years 1995 to 2007. During these years the only significant factor of trade integration was the introduction of the Euro. Other factors such as tariff reduction are eliminated in years prior to those used in this sample. Therefore, these 'other' factors of trade integration should not be anticipated to have affected the coefficients of the Euro derived in this study by any sizeable manner.

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Appendix

Countries: Austria, Australia, Bosnia and Herzegovina, Belgium, Bulgaria, Canada, Switzerland, Cyprus, Czech Republic, Germany, Denmark, Estonia, Spain, Finland, France, United Kingdom, Georgia, Greece, Croatia, Hungary, Ireland, Israel, Iceland, Italy, Japan, Kazakhstan, Lithuania, Latvia, Former Republic of Macedonia, Malta, Netherlands, Norway, New Zealand, Poland, Portugal, Romania, Sweden, Slovenia, Slovakia, Turkey, Ukraine, United States, China, Russia

References

Abadie A. and Imbens G. (2006), "Large Sample Properties of Matching Estimators for Average Treatment Effects", *Econometrica*, 74(1), pp. 235-267.

Anderson J, (1979), "The Theoretical Foundation of the Gravity Equation", *American Economic Review*, 69, pp. 106-116.

Anderson J. and van Wincoïp E. (2002), "Gravity with Gravitas: a Review of Theory and Evidence", *American Economic Review*, 93, pp. 170-192.

Anderson J. and van Wincoïp E. (2004), "Trade Costs", *Journal of Economic Literature*, 42, pp. 691-751.

Baier S. and Bergstrand J. (2009), "Estimating the Effects of Free Trade Agreements on International Trade Flows Using Matching Econometrics", *Journal of International Economics*, 77, pp. 63-76.

Baldwin R. (2005), The Euro's Trade Effects, ECB workshop, Frankfurt

Barr D. Breedon F. and Miles D. (2003), "Life on the Outside", *Economic Policy,* 37, pp. 573-613.

Bertrand M. Duflo E. and Mullainathan S. (2004), "How Much Should We Trust Differences-in-differences Estimates?", *Quarterly Journal of Economics,* 119, pp. 249-275.

Bun M. and Klaassen F. (2002), "Has the Euro Increased Trade?", *Tinbergen Institute Discussion Paper,* TI 2002-108/2

Bun M. and Klaassen F. (2007), "The Euro Effect on Trade is Not as Large as Commonly Thought", *Oxford Bulletin of Economics and Statistics* ,69(4), pp. 473-496.

Chintrakarn P. (2008), "Estimating the Euro Effect on Trade with Propensity Score Matching", *Review of International Economics,* 16, (1), pp. 186-198.

Deardoff A. (1998), Determinants of Bilateral Trade: Does Gravity Work in a Neoclassical World?, in Frankel J. (ed.) *The Regionalisation of World Economy.* University of Chicago Press.

De Nardis S. and Vicarelli C. (2003), "Currency Unions and Trade: the Special Case of EMU", *Review of World Economic*s, 139, pp. 625-649.

Eissa N. (1995), "Taxation and Labour Supply of Married Women: the Tax Reform Act of 1986 as a Natural Experiment", *NBER Working Paper* No.5023.

Glick R. and Rose A. (2002), "Does a Currency Union Affect Trade? The Time Series Evidence", *European Economic Review,* 46, pp. 1125-1151.

Heckman J. Ichimura H. Smith J. and Todd P. (1998), "Characterizing Selection Bias Using Experimental Data", *Econometrica,* 66, pp. 1017-1098.

Helpman E. and Krugman P. (1985), *Market Structure and Foreign Trade,* Cambridge, Mass: M.I.T. Press.

Micco A. Stein E. and Ordonez G. (2003), "The Currency Union Effect on Trade: Early Evidence from EMU", *Economic Policy,* 37, pp. 316-356.

Newey W. and West K. (1987), "A Simple, Positive Semi-definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix", *Econometrica,* 55, p. 703-708.

Newey W. and West K. (1994), "Automatic Lag Selection in Covariance Matrix Estimation", *Review of Economic Studies,* 61, pp. 631-653.

Persson T. (2001), "Currency Unions and Trade: How Large is the Treatment Effect?", *Economic Policy*, 33, pp. 435-448.

Ranjan P. and Tobias(2007), "J. Bayesian Inference in the Gravity Model", *Journal of Applied Econometrics*, 22(4), pp. 817-838.

Rose A. (2000), "One Money, One Market: the Effect of Common Currencies on Trade", *Economic Policy,* 30, pp. 9-45.

Rose A. (2001), "Currency Unions and Trade: the Effect is Large", *Economic Policy,* 33, pp. 449-461.

Rosenbaum P. and Rubin D. (1983), "The Central Role of Propensity Score in Observational Studies for Causal Effects", *Biometrica,* 70, pp. 41-55.

Thom R. and Walsh B. (2002), "The Effect of a Common Currency on Trade: Ireland Before and After the Sterling Link", *European Economic Review*, 46, pp. 1111-1124.