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Trade effects of the EMU

A panel data study of the importance of exchange rate volatility

NEKM01: Master essay, one year

Spring 2011

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Abstract

This essay investigates the impact on trade flows of the formation of the European Monetary Union (EMU) and whether countries with differences in the degree of exchange rate volatility prior to the adoption of the euro have experienced such trade effects to different extents. The gravity model forms the basis for the study, which is performed using a fixed effects-method on panel data from 24 OECD-countries between 1995 and 2005.

To a large extent, the results support the hypothesis that countries with high pre-EMU exchange rate volatility have experienced larger increases in trade flows than countries with low pre-EMU exchange rate volatility. In most specifications, the study reports significant and positive coefficients for the high-volatility group. The effects of the common currency on countries with low volatility are however inconclusive.

Key words: EMU, trade effects, exchange rate volatility, gravity model, fixed effects-method.

List of abbreviations

ARCH	Autoregressive Conditional Heteroscedasticity
ARIMA	Autoregressive Integrated Moving Average
CEPII	Centre d'Etudes Prospectives et d'Informations Internationales
	(Institute for Research on the International Economy)
ECU	European Currency Unit
EMS	European Monetary System
EMU	European Monetary Union
ERM	Exchange Rate Mechanism
EU	European Union
FE	Fixed effects-method
GDP	Gross Domestic Product
IMF	International Monetary Fund
MRT	Multilateral Resistance Term
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
RTA	Regional Trade Agreement
RE	Random effects-method
SMP	Single Market Program

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1. Introduction

The formation of the European Monetary Union (EMU) and with it the adoption of the euro as the common currency in several European countries meant large changes for the political as well as the economic climate in Europe. Already the introduction of the Single Market Program (SMP) in the 1993 aimed at promoting competitiveness and efficiency by allowing goods, services and factors of production to move freely within the European Union (EU) (Badinger, 2007, p.497-398). Additionally, introducing a common currency is believed to promote trade by its contribution to the reduction of transaction and information costs as well as the removal of exchange rate volatility and uncertainty between member countries (Flam, 2008, p.9-13). With a common currency, agents can trade under conditions that are less costly and less insecure compared to the situation in which several currencies are used, and the adoption of a common currency should therefore have a trade-promoting effect.

If exchange rate volatility and uncertainty is indeed one of the main channels through which the introduction of a currency union promotes trade, it seems reasonable to argue that the effects of forming such a union should affect countries differently, depending on their exchange rate volatility prior to the introduction of the common currency. The aim of this essay is to investigate whether this proposition is supported by empirical data in the case of the EMU. Hence, its main purpose is to answer the question:

- *Have countries with high exchange rate volatility prior to the adoption of the euro experienced larger EMU-related trade effects than countries with low exchange rate volatility?*

There are several reasons for this question being of particular interest. First, the majority of the literature assessing trade effects of the EMU[1] point to the conclusion of the EMU having led to increased trade between member countries. The size of these trade effects is, however, not unanimously agreed on. It seems motivated, therefore, to try and separate low- and high-volatility countries and investigate whether trade effects differ between these. If this is the case, the result could, at least partly, explain why previous studies have obtained different estimates of the size of the EMU-related trade effects. One could also argue that ignoring the potential difference between countries when assessing trade effects of the EMU implies the risk of obtaining results that are not valid for all countries in the sample. Second, by

[1] See section 3 for a presentation of some of these studies.

acknowledging the difference between low- and high-volatility countries, one could seek an answer to the question of whether the presumed positive trade effects of the EMU have been evenly or unevenly distributed among the member countries. Third, finding an answer to this research question could have an impact and shed further light on the discussion of pros and cons of joining a currency union for countries that are candidating for such membership.

To investigate the question posted above, one needs to look at countries that are already members of the EMU and compare the volume of trade between these with the volume of trade for a control group, i.e. another group of countries with similar characteristics, but which are not EMU-members. In the existing literature within this field, one common feature of most methods used for assessing trade effects is their usage of the gravity model as the starting point for the analysis. Also in this essay, the gravity model will form the basis for the analysis of trade effects of the EMU and different degrees of exchange rate volatility. There are several methodological issues to take account of and one can take different approaches regarding the use of cross-section-, time-series- or panel data, all of which imply different possibilities as well as problems for the econometric part of the survey. This essay adopts a panel data approach for accomplishment of the analysis, using a sample including data for 24 OECD-countries and covering the time period 1995-2005.

The disposition of the essay is as follows. Section 2 presents background information of interest for this essay. Section 3 gives a brief overview of previous research, while section 4 and 5 contain a description of the method and the data, respectively. The results of the performed study are presented in section 6 and discussed in section 7. Section 8 concludes the essay.

2. Background

To provide the reader with some background information, this section presents the institutional framework surrounding the formation of the EMU and the criteria that candidate countries are required to meet before becoming official members. Additionally, the channels through which exchange rate volatility is believed to affect trade are presented.

2.1. The EMU and the convergence criteria

2.1.1. The formation of the EMU

The formation of a European currency union was a long process. In 1951, After the Second World War, (West) Germany, Belgium, France, Italy, Luxembourg and the Netherlands created the European Coal and Steel Community to promote solidarity between countries and create economic integration between countries that had suffered losses during the war (EU-upplysningen1, 2010-12-15).

At the same time, the Bretton Woods-system, under which all currencies were convertible towards the US Dollar, which in turn was convertible against gold, provided exchange rate stability. As the Bretton Woods-system started to experience difficulties, however, voices were raised in favor of the deepening of monetary cooperation and integration in Europe. Attempts to implement these wishes were made in the 1970s, including the introduction of a system called the "Snake in the Tunnel", which implied that the European currencies were allowed to fluctuate 1.125 percent against each other (the Snake) and 2.25 percent against the US dollar (the Tunnel). The system ran into problems, however, but another, more long-lasting, system followed. The European Monetary System (EMS), of which the Exchange Rate Mechanism (ERM) was part, was an attempt to foster monetary integration in Europe. The ERM, in turn, was based on two principles. The first was the introduction of the European Currency Unit (ECU), an artificial currency consisting of a weighted calculation of the currencies of the ERM member countries. The ECU was seen as a measure of the degree of convergence among the member countries. Divergence thresholds indicating when intervention measures should be used were set separately for each currency depending on its weight in the basket of the 12 currencies initially forming the ECU. The second feature of the ERM regulated the bands within which the currencies of each country were allowed to

fluctuate without intervention. This band was first set to ±2.25 percent, but was widened to ± 15 percent in 1993 (Pilbeam, 2006, p.411-415).

The ERM, therefore, was a system of partly fixed exchange rates, and despite the introduction of completely fixed exchange rates through the euro on the 1st of January 1999, it is still of interest as one of the convergence criteria for countries wanting to join the EMU and adopt the euro as their domestic currency. These convergence criteria are discussed in the next section.

2.1.2. The EMU convergence criteria

The convergence criteria for EMU membership consist of five different parts regulating important macroeconomic indicators and can be summarized as follows:

Table 2.1: The EMU convergence criteria

Goal/Indicator	**Requirement**
Price stability/Inflation	Compared to the average of the three EU countries performing best in terms of price stability, the inflation rate of the candidate country may not exceed this rate by more than 1.5 percentage points.
Interest rate convergence/Average long-term interest rate	The average long-term interest rate may not exceed the rate of the three EU countries with best inflation performance by more than 2 percentage points.
Budget deficit	The ratio of general government deficit to GDP must not exceed 3 percent.
Government debt	The ratio of general government deficit in relation to GDP may not exceed 60 percent.
Exchange rate stability	Corresponding to the regulations of ERM II[2], the currency of the candidate country may not fluctuate by more than ±15 percent of the central rate against the euro during at least two years without devaluing.

Source: Schröder, 2003, p.14.

The aim with imposing the above requirements on countries wanting to join the EMU is to ensure their ability to function under conditions similar to those that characterize the situation

[2] ERM II refers to the ERM system after original EMU members had adopted the euro in 1999 (Eu-upplysningen4, 2011-01-03). As described above, the regulation regarding the allowed fluctuations of the exchange rate of ±15 percent is, however, the same as under the original ERM system starting in the 1970s.

once they have become members of the union[3]. Further, it is interesting to note that all criteria demand the requirements to be fulfilled during one year, except the one dealing with the stability of the exchange rate of the candidate country, which has to be met during two years (Schröder, 2003, p.12). Also, it should be noted that although the convergence criteria on exchange rate volatility requires the exchange rate of an accession country not to fluctuate by more than ±15 percent, candidate countries can choose independently which exchange rate regime they want to apply to meet this criterion, with the exception of crawling pegs, freely floating without a central rate and pegging towards a currency not being the euro (Szápary, 2000, p.12)[4]. One should note that the band of ±15 percent means that the volatility of each country´s exchange rate is limited, but that the wide band also implies that currencies can experience large differences in exchange rate performance.

Another issue regards the question of which measures a country candidating for joining the EMU can undertake to improve its ability to meet the above criteria. For the fulfillment of the criterion on exchange rate volatility, one could argue that a fixed exchange rate regime should be the best choice since the exchange rate in this case cannot fluctuate without active intervention from the authorities. If these are committed to the convergence criteria, it should, therefore, not be an issue to meet the criterion on exchange rate stability.

There are, however, other aspects that need to be considered and there is an ongoing discussion on which exchange rate regime to choose in order to make the adaption process as smooth as possible. Discussed issues are for example the appropriateness of simultaneously regulating the exchange rate and the inflation rate, the risk of the inflation target being a hinder in the catching-up process, which is likely to be associated with rising price levels due to increases in productivity and wage levels, and the impact on domestic markets of the expected appreciation of the real exchange rate[5].

The EMU convergence criteria thus put a limit on the allowed volatility of the exchange rate prior to the adoption of the euro. Still, national currencies are allowed to fluctuate with ±15 percent against the euro, and which exchange rate regime that is preferable in order to meet these criteria is a debated issue.

[3] A more detailed description of the convergence criteria as a test for the country´s ability to handle EMU-similar situations can be found in Darvas and Szápary (2008).
[4] Once having joined the ERM, however, the by the IMF officially reported exchange rate regime is the ERM. This excludes the possibility to use the officially announced exchange rate regime to classify countries in different groups, as discussed in section 5.2.1.
[5] For a discussion on these and related topics, see for example Szápary, 2000, and Darvas and Szápary, 2008.

2.2. Exchange rate volatility and trade flows

As has already been repeatedly stated, the volatility of the exchange rate is believed to have an impact on trade between countries. The direction and size of this effect are, however, not unanimously agreed on[6]. In this section, theoretical arguments regarding the impact of exchange rate volatility on trade are presented, relying on theories on the behavior of profits under exchange rate volatility, the theory on the option value of investment and the importance of uncertainty and risk aversion.

First, one should remember that the EMU with the introduction of a common currency implies totally fixed exchange rates between member countries. In general, a fixed regime is believed to promote cooperation between countries internationally, as coordination of exchange rates requires countries to agree on how to maintain such rates in practice. Furthermore, the advantages of having a fixed exchange rate regime include the reduction in transaction costs and exchange rate volatility, which is believed to encourage trade and investment across countries. On the other hand, disadvantages include the loss of the exchange rate functioning as a shock absorber and the loss of independent monetary policy (Pilbeam, 2006, p.236-240).

Of largest interest for the purpose of this essay is the discussion on how and to which extent the elimination of exchange rate volatility should affect trade within the EMU. One should note that a fixed exchange rate regime does not affect the amount of trade only through the volatility of exchange rate-aspect, but also through the reduction of transaction and administration costs. These, however, are estimated to be small (Flam, 2008, p.10) and without any large effects on trade. Therefore, for the remaining parts of this section, focus lies mainly on the effect of exchange rate volatility on trade rather than on these different kinds of costs.

The relationship between exchange rate volatility and trade flows can be analyzed from a number of aspects. One considers the impact of exchange rate volatility on firms´ profits and implies a positive relation between these. The reason is that if the profits of firms depend on the output produced and the costs of input, fluctuations in the exchange rate, which cause the price of the input goods to change, can be partly avoided by the firm changing the optimal combination of input goods used in production. This, in turn, implies larger profits if the price in foreign currency is assumed to be constant. This should act as an encouragement to

[6] For a discussion on empirical evidence, see section 3.

produce and trade more. The positive relation between exchange rate volatility and profits is hence said to promote trade (Flam, 2008, p.10).

Another fruitful approach is to apply the theory of the option value of investment on trade, which implies that the more volatile the exchange rate, the less trade will occur. The reason is that starting to trade implies costs, for example in terms of market research, and once undertaken, such costs are sunk costs which cannot be reversed even if the firm stops trading. Since a non-fixed exchange rate can fluctuate to become either more or less favorable, there is a value in postponing the investment or decision to start trading and maintaining that option for the future. The larger the volatility of the exchange rate, the more can be gained by postponing the decision of whether to start trading or not. Hence, there is an option value that is larger the larger is the exchange rate volatility. This, in turn, implies that exchange rate volatility should act as an obstacle to trade (Flam, 2008, p.10-13).

An additional aspect to consider is the importance of uncertainty regarding the value of the exchange rate for agents engaged in trading activities. A very volatile currency implies large variations in the cost of trading with countries with another currency. If producers are risk-averse and exchange rate volatility implies that the expected future profit is uncertain, trade is negatively related to exchange rate uncertainty and volatility, as shown by Either (1973). As explored by Demers (1991), this negative relationship remains even with risk-neutral producers. Exchange rate volatility affects the price of the good produced and therefore also the demand for the product. This, in turn, means that the producer is faced with uncertainty regarding the demand for the produced good, and if investment is irreversible, such uncertainty will cause a reduction in production and trade. In both cases, therefore, exchange rate volatility will act as a hinder to trade due to the uncertainty it causes for producers and consumers, respectively (McKenzie, 1999).

3. Earlier empirical studies

The following section aims at presenting previous research of relevance for this essay. First, an overview of studies investigating the impact of exchange rate volatility on trade is presented, followed by a brief overview of research assessing trade effects of the formation of the EMU. There is a vast amount of literature investigating these questions. To review all studies previously performed is not possible within the framework of this essay, and the following overview does not claim to cover all important aspects. Nevertheless, the purpose is to provide the reader with some useful background information on the methods used in and the results obtained by studies already performed within the field.

3.1. Currency policy and trade

In an influential paper using panel data on the bilateral amount of trade from five different years and 186 countries, Rose (2000) investigates the impact of a common currency on trade. Rose recognizes the frequently used argument of reduced transaction costs and exchange rate volatility as two of the main reasons for the increase in trade due to the adoption of a common currency. The observed exchange rate volatility prior to the formation of the EMU was, however, relatively low, and one should therefore, according to Rose, investigate the impact of a reduction in exchange rate volatility and the complete elimination of this uncertainty separately (Rose, 2000, p.10). The variable measuring the volatility of the exchange rate is defined as the standard deviation of the first-difference of the monthly natural logarithm of the bilateral nominal exchange rate in the five years preceding the year of interest (Rose, 2000,p.15).

The result of the study has remarkable implications for the discussion regarding trade effects of the adoption of a common currency. Apart from the mere reduction in exchange rate volatility, there is, the author argues, an additional effect, stemming from the complete elimination of exchange rate volatility. Even after controlling for other variables commonly believed to affect the extent to which two countries trade with each other, the total effect of the common currency on trade is estimated to be of size 3.35, implying that adopting a common currency increases trade by more than 300 percent (Rose, 2000, p.17-18). Controlling for omitted variables, potential endogeneity of the exchange rate volatility and allowing alternative specifications of the variables measuring exchange rate volatility and the

common currency does not change the results. These are also robust to changes regarding the choice of which countries to include in the sample[7] (Rose, 2000, p.18-31).

However, the study by Rose (2000) has been criticized in a number of aspects. These include potential biased estimates due to the omission of variables correlated with the dummy representing membership in a currency union, the problem of reversed causality, potential misspecification of the model and the fact that the countries sharing a common currency are not a representative share of the sample but dominated by small and poor countries (Baldwin and Taglioni, 2008, p.18). In relation to the last argument, Quah emphasizes in the discussion part following upon Rose´s paper the fact that only 320 observations, constituting 0.94 percent of the whole sample, represent the part of the sample with a single currency. Relying on this small sub-group for investigation of differences in trade flows due to the existence of a common currency might call for some caution when interpreting the results (Rose, 2000, p.37-38), especially since the features, in terms of for example openness and income, of these countries are often not representative for the rest of the countries (Baldwin and Taglioni, 2008,p.18-19).

Although criticized and questioned in some aspects, the importance of Rose´s work should not be understated. As Baldwin and Taglioni (2008, p.8) point out, the study by Rose gave rise to an increasing amount of studies being performed and is thereby a source of and reason for further research assessing the trade effects of exchange rate volatility in general and of currency unions in particular.

Klein and Shambaugh (2006) focus on the choice between whether or not to peg the exchange rate to the exchange rate of one of the large industrial countries, which, they argue, is the choice of most relevance for policymakers choosing between a fixed and flexible exchange rate regime. The methodology applied includes the use of the gravity model as the basis for the analysis. The model includes all basic-gravity-model variables[8] as well as dummy variables capturing the presence of a fixed exchange rate regime, currency unions and also including a measure of the volatility of the exchange rate. The authors specify the gravity model in a somewhat different way compared to previous research. A fixed rate, they argue, is qualitatively different to a pure reduction in exchange rate volatility, since a fixed rate can

[7] The exception is the alternative specification of the variable measuring exchange rate volatility using levels, which does not support the in other cases robustly negative and statistically significant coefficient of this variable. According to the author, however, one should not rely too heavily on this measure and the results relying upon it since differences in inflation and productivity might affect the result.
[8] For a more detailed discussion on the gravity model, see section 4.1.

provide greater certainty for agents participating in trading activities. Also, the starting level from which the volatility of the exchange rate is reduced matter for the implications of the reduction. To account for the effect of multilateral resistance[9], several variations of the country-fixed effects-method are used, of which the country-year-fixed-effects-method is argued to be the one most appropriate and underpinned in theory. Depending on the specific econometric technique used, a fixed exchange rate is shown to increase trade with up to 35 percent. The authors perform several robustness checks, controlling for, among other things, alternative specifications of the exchange rate regime, alternative subsamples, using instrumental variables and controlling for the appropriateness of using fixed rather than random effects. All in all, the results seem to be robust to these alternative specifications.

3.2. Trade effects of the EMU

Micco, Stein and Ordoñez (2003) undertake a gravity model-based panel data-analysis with country-pair fixed effects[10] to investigate the effect on trade of the EMU. The authors repeatedly stress the distinction between using a cross-sectional- and a panel data approach. The difference is also emphasized in Flam (2009), who points to the difference in the wording and meaning of the research question. Using cross-sectional data, one can investigate whether countries with the same currency, and hence no exchange rate volatility, trade more with each other than do countries with different currencies at a particular point in time. It should be noted, though, that one cannot say anything about the development of trade flows over time. However, using panel data and including countries going from applying different currencies to the adoption of a common currency and thereby eliminating exchange rate volatility, allows for assessing the development of trade flows over time, taking into account how the shift of exchange rate regime affects such flows (Flam, 2009, p.12). Hence, the latter question deals with a possible real-world-scenario and is therefore of large interest to policymakers (Micco et al.,2003,p.323-324).

The study by Micco et al. (2003) investigates trade effects of the euro using two different samples of data consisting of 22 developed countries and 15 EU-countries. The aim is not

[9] For a more detailed discussion on the multilateral-resistance-term, see section 4.3.

[10] Using country-pair fixed effects enables one "…to isolate the euro effects over time, and leave out the cross-sectional variation." (Micco et al., 2003, p. 327). This method is also appealing due to it absorbing part of the cause for endogeneity (Micco et al., 2003, p. 330). For further discussion of methods and regression techniques, see section 4.4.

only to assess trade effects of the EMU on member countries of this currency union, but also to investigate whether outside countries have been hurt by trade diversion. Depending on the exact specification of the sample and the method used, the impact on trade between euro countries is estimated to be between 4 and 26 percent (Micco et al., 2003, p. 328-329). Also, the results of a dynamic specification of the model are consistent with the previously reported results (Micco et al., 2003, p. 336-338). Taking account of the possible impact on trade between euro- and outside countries, the fear of the euro creating trade diversion against third countries does not find any support in this survey. In fact, the adoption of the euro seems to encourage trade also with third countries with up to 9 percent. This estimate comes from the developed country-sample and is statistically significant at a significance level of 1 percent. Even though the effect is smaller (1.2 percent) when using EU-countries as a benchmark, there is in neither case any sign of trade diversion taking place as a result of the adoption of the euro.

The study also investigates the effect on trade for individual countries and the results point to some differences. The largest effects are found for the Netherlands and Spain, whereas the coefficients for Greece and Portugal are negative, although only the former is statistically significant. In general, there seems to be a tendency for more advanced countries to experience larger effects of the adoption of the euro (Micco et al., 2003, p.339-342).

Several additional studies have been performed on this and/or closely-related topics. For example, Bun and Klasseen (2007) argue that one should account for the upward trend of residuals when using panel data to assess the trade effects of the introduction of the euro, and that the estimates when taking account of this issue decrease from ranging between 5 percent to 40 percent to be about 3 percent. As a dependent variable, the logarithm of the real trade flow, specified as the sum of the nominal imports and exports divided by the US producer price index, is used. According to Baldwin and Taglioni (2008) however, this implies biased estimates and the results should therefore be interpreted with some caution (Baldwin and Taglioni, 2008, p.28-29). Flam and Nordström (2007) use data between 1995 and 2005 and find that trade between members of the EMU increased by 21 and 26 percent for the period 2002-2005 compared to 1995-1999, the control groups being OECD- and EU-countries, respectively. The relatively large effects found have been questioned, one of the points of critique being the unlikelihood of the Single Market not having a significant effect on trade (Baldwin and Taglioni, 2008, p. 27).

The table below summarizes the results regarding trade effects of the studies presented above.

Table 3.1 Summary of earlier empirical studies

Estimated trade effects of earlier empirical studies		
Author(s)	**Study object**	**Estimated trade effect**
Rose (2000)	Common currency	335 %
Klein and Shambaugh (2006)	Fixed exchange rate	up to 35 %
Micco, Stein and Ordoñez (2003)	EMU	4-26 %
Bun and Klasseen (2007)	EMU	3 %
Flam and Nordström (2007)	EMU	21-26 %

Although being far from a totally comprehensive description of all studies performed within the field, it seems clear from the review of the existing literature above that the gravity model, despite its attractiveness and ability to explain observed trade flows with a relatively few explanatory variables, is far from easy to use and implement in practice. The choice of included variables, estimation method, sample of countries and many other factors are very likely to affect the results to different extents and in different directions.

4. Methodology

The following section aims at presenting the methodology used for the accomplishment of the study to be performed in this essay. The basic gravity model as well as its extensions are presented and related to the discussion of the effect of exchange rate volatility on trade and the fixed effects-method, which will be used in the statistical analysis, is discussed.

4.1. The gravity model

The basic gravity model relies on the premise that the size of and distance between two countries are crucial for the size of the bilateral trade flows between these (Greenaway and Milner, 2002, p. 578). Size is often measured as the gross domestic product (GDP) of the importer and exporter, since the GDP of the exporter can be seen as a measure of the capacity to export and the GDP of the importer symbolizes the demand for imports. Hence, size is expected to affect the amount of trade positively (Flam and Nordström, 2007, p.7).

The importance of the distance between the countries can be motivated by its appropriateness as a proxy for transport costs. Furthermore, the distance variable acts as an indicator of the size of communication and synchronization costs and of the time elapsing during the transport (Head, 2003, p.5-8). Also, it should be mentioned that it is common to account for trade costs not only by including the distance between the countries, but also adding variables capturing the existence of for example border contiguity, common language and trade policies (Flam and Nordström, 2007, p.6).

The basic gravity model has been extensively used to investigate the impact of specific variables on the amount of bilateral trade and it has been successful in explaining such trade flows using only a few explanatory variables. The validity of the model in its most basic form as described above, however, has been questioned for not being theoretically grounded, which induced a wave of research aiming at giving the gravity model a more solid theoretical foundation[11] (Greenaway and Milner, 2002, p.578-580).

The gravity model can also be extended to account for the importance of specific institutions for the amount of trade flows between countries. By including dummy variables for

[11] Both traditional Heckscher-Ohlin trade theory focusing on inter-industrial trade as well as new trade theory explaining intra-industrial trade have been used to theoretically derive the gravity model.

membership in a regional trade arrangement (RTA), it is possible to ex post investigate the actual effects of such an agreement. By including several dummies symbolizing the membership of the importer, the exporter and both, respectively, one can distinguish changes in trade flows for different countries and assess the possibility of trade creation and trade diversion taking place as a consequence of the formation of RTAs (Carrére, 2006, p. 228). Also, one could assess other type of trade effects, for example the occurrence of export diversion, i.e. decreased export volumes to third countries as a consequence of the formation of an RTA, as done in Soloaga and Winters (2000). Other contributions to the development contain the inclusion of the Armington assumption, i.e. that goods are differentiated according to their origin, and the importance of relative distance, rather than only absolute (bilateral) distance[12] (Greenaway and Milner, 2002, p. 574-580 and Baier et al., 2008, p. 466-469).

4.2. The gravity model and exchange rate volatility

The gravity model as described above forms the basis for many studies investigating trade effects. For the purpose of this essay, the main contribution of the gravity model is its implications regarding the expected impact on trade of a change in trade costs.

The arguments presented in section 2.2, which describes the channels through which exchange rate volatility affects trade, imply that the formation of a currency union has effects in terms of reduced transaction and administration costs as well as a less insecure trading environment. Hence, the formation of a currency union such as the EMU implies that the costs associated with trade are reduced, which, according to the gravity model, means that the amount of bilateral trade should increase.

If, as is further argued in section 2.2, there is an option value of trade and if exchange rate volatility implies less trade due to the uncertainty it creates, not only exchange rate volatility in itself, but also its magnitude seems to be of importance for how large the trade-impeding effects of a volatile exchange rate could be. Hence, one would expect the elimination of exchange rate volatility to have a trade-promoting effect for all countries, but that the size of this effect would differ depending on the degree of exchange rate volatility prior to the adoption of a common currency. Interpreted in the framework of the gravity model, one

[12] For a more detailed discussion on the importance of relative distance, see section 4.3.

would believe that the unequal reduction in trade costs among the member countries would imply an uneven distribution also of the expected increase in EMU-related trade flows and the gains from these.

4.3. The importance of multilateral resistance

In the gravity model, exchange rate volatility, the existence of trade policies, the distance between countries and other similar circumstances affect trade through their impact on trade costs. Trade costs can hence be seen as a measure of the resistance to trade between countries. It should be stressed, though, that such resistance is of importance not only on a bilateral basis as the absolute resistance between countries. As argued in Anderson and van Wincoop (2003), it is not only the absolute resistance between the importer and the exporter in terms of for example the distance between them that matters, but also the resistance relative to the trading partner´s resistance to other potential trading partners around the world. It seems reasonable to argue that what matters for a country engaged in trade is not only the cost of trading with a partner country, but also the cost of trading with the partner country compared to the costs of trading with other countries. For example, if costs are reduced between a specific country and the rest of the world, this country will probably divert trade from the partner country towards the other countries. Hence, a high degree of towards-the-rest-of-the-world (multilateral) costs of either of the two countries engaged in bilateral trade implies large amounts of trade between these two countries. To account for the importance of such multilateral resistance, Anderson and van Wincoop (2003) include multilateral resistance-terms (MRT) to avoid the problem of the omission of these variables resulting in biased coefficients. To include variables capturing a country´s relative resistance to trade, they derive the gravity model including multilateral resistance variables as price indices. These price indices are a function of the price indices of all other countries, the trade barriers between the two countries at issue and the income share of the country of interest. In the estimation process, a non-linear least squares-method is used. Other approaches for dealing with the MRT-variables include Ordinary Least Squares-estimation (OLS) of the price-index-equations as in Baier and Bergstrand (2001), the inclusion of country-specific fixed effects as in Rose and van Wincoop (2001) (Gil et al., 2004, p.1264) and the construction of remoteness-variables as in Carrére (2006). In the study performed in this essay, the multilateral resistance-terms are taken account of by the use of the fixed effects-method, which is described in the next section.

4.4. The fixed effects-method

To account for (un)observable differences among countries, such as the multilateral resistance-varibales, not captured by the included explanatory variables of a model, one could add one dummy variable for all but one of the countries in the sample[13]. Country-specific heterogeneity not accounted for by the explanatory variables would in this case be captured by the dummy variable. With large samples, this method is, however, cumbersome to implement. An alternative method with identical implications is the fixed effects-method (FE), which allows each unit, i.e. each pair of countries in this setting, to be heterogeneous. The heterogeneity is captured in the constant term, which therefore can differ between the different units in the sample (Baum, 2006, p.219). The constant hence includes all differences among the units that are not already captured by the included explanatory variables. As opposed to the random effects-method (RE), in which the constants are assumed to be random factors that are identically distributed across individuals, the fixed effects-method does not require the constant to be independent of the included explanatory variables[14] since the constant is eliminated from the regression by the use of a within regression. In the absence of such correlation between the constants and the regressors, the random effects-model is efficient and consistent, whereas when such correlation exists, the fixed effects-model is consistent. To test which model is most appropriate, one can conduct a Hausman test[15].

Using the fixed effects-method, however, has some implications for the estimation of the coefficients for some variables. The fixed effects-method does not allow estimation of time-invariant variables (Verbeek, 2008, p.355-375), which could be both an advantage and a disadvantage depending on the specific circumstances in each situation. For the study to be performed in this essay, the disadvantage in using the fixed effects-approach is that variables such as the existence of a common language, contiguity and the distance between countries will be included in the fixed effects, which means that their coefficients will not be estimated separately. For the purpose of this essay, this drawback is of minor importance since the main question at issue regards the importance of the pre-EMU exchange rate volatility rather than the assessment of the importance of variables commonly used in gravity modeling.

[13] Setting the total number of dummy variables to one less than the total number of countries allows one to avoid the dummy variable-trap. For a discussion on this issue, see section 5.2.1 and Verbeek (2008).
[14] The choice between fixed- versus random effects as the most appropriate estimation method depends crucially on this correlation. For further details, see for example Verbeek (2008).
[15] Again, see Verbeek (2008) for further details.

The feature of the fixed effects-method to include time-invariant variables in the fixed effects on the other hand also implies a convenient way of dealing with the issue of how to take account of the multilateral resistance-terms (MRT). Since the MRTs, which illustrate a country´s resistance to trade with the rest of the world, are presumably constant across the short time period used in the study in this essay, these variables will also be included in the fixed effects, and the problem of them causing omitted variable-bias is thus avoided.

There are several versions of the fixed effects-method that can be applied to the gravity model and an on-going discussion on the pros and cons of different approaches. Klein and Shaumbagh (2006) discuss the development of the use of the fixed effects-technique to take account of the multilateral resistance-terms. The country fixed effects-method implies denoting one dummy to each country. For each country pair, there are thus two dummies that are simultaneously equal to one. Another possibility is to use country-year-fixed effects, a method that recognizes that the multilateral resistance-terms may change over time, and that separate country-fixed effects therefore should be included for each year. This method implies the creation of thousands of dummies, one for each country pair and year. One could also use country-pair-fixed-effects, which implies that a dummy variable is denoted to each pair of countries in the sample. This implies that specific country-pair characteristics are captured in the fixed effects and will not affect the results. The authors claim the country-year-fixed-effects-method to be the one best underpinned in theory and argues for the use of this method when using the gravity model (Klein and Shambaugh, 2006, p. 363-369).

Similar discussions can be found in other papers. Gil et al. (2008), who rely on Baier and Bergstrand (2007) and Baldwin and Taglioni (2006), claim that time-invariant pair dummies and time-varying country dummies are appropriate to use (Gil et al, 2008, p.1264), whereas Micco et al. (2003, p.330) argue for the use of country-pair-fixed-effects since this method reduces the scope for endogeneity.

Obviously, there are several alternative versions of the fixed effects-method available when using a gravity model-based panel data approach to assess trade effects. Opinions differ on which method one should use, but it seems reasonable to argue that each sample and the characteristics typical for each data set influence what method is most appropriate. For the statistical analysis to be performed within the framework of this essay, the country-pair-fixed-effects-method will be applied, adding also separate time dummies for each year to capture

time-fixed effects and thereby making use of information on and from the control group, as argued appropriate in Brüderl (2008)[16].

[16] Applying the country-year-fixed-effects-method would also be possible. Considering the large amount of dummy variables needed to capture the effect of each year and country, however, the risk of causing an unstable model as well as the risk of causing multicollinearity makes this approach less desirable.

5. Data and empirical specification

This section contains a description of variables that are included in the version of the gravity model that will be used in this essay, as well as a presentation of the data. The final subsection presents the empirical specification of the model that will be estimated.

5.1. Gravity variables

The dependent variable is the nominal value of bilateral imports from one country to another, measured in US Dollars. The unidirectional, one-way, trade flow of imports is chosen rather than both imports and exports. Since all countries in the sample are included as both importers and exporters, however, the dataset contains information on both imports and exports to and from all countries. Note also that the value of imports is the nominal value. No attempts are made to transform the nominal values to real values. This choice is motivated by the fact that the theoretical gravity model is derived using a demand equation with nominal values[17], by the consistent use of nominal values of other variables included in the study as well as by the difficulties in finding a price index that is appropriate for the purpose of deflating trade flows.

The variable mass consists of the product of the GDP of the two trading countries. The value of GDP is the nominal value since using real GDP would require deflation also of the value of trade, which is somewhat cumbersome[18]. Choosing nominal values instead of real ones mitigates this problem.

According to the basic gravity model, also the distance between the two countries is included in the gravity equation. As explained in section 4.4, however, variables that are time-invariant are included in the fixed effects. Hence, the impact of bilateral distance on trade will not be estimated separately in this setting.

[17] See for example Anderson and van Wincoop, 2003.
[18] See Baldwin and Taglioni (2008) for a discussion on this issue.

5.2. Exchange rate volatility

5.2.1. How to classify exchange rate volatility

Naturally, the specification and definition of the variable measuring exchange rate volatility is of large importance for the research question. Initially, the question at issue in this essay intended to focus on the importance of the pre-EMU exchange rate regime, but the institutional framework of the EMU-joining process, including the requirement on an accession country to join the ERM during at least two years prior to the official entrance into the monetary union, implies some investigational problems for this approach. The IMF Annual Report on Exchange Arrangements and Exchange Restrictions, which seemed appropriate to use as the source of the classification of the countries´ exchange rate regimes, classifies the exchange rate regimes into three main categories; fixed, intermediate and floating regimes. This classification would have been suitable also for the purpose of this essay. The convergence criteria for joining the EMU, however, imply that all countries are tied to and officially reported as belonging to the ERM prior to joining the union, which clearly limits the possibility to investigate the importance of differences in the announced exchange rate regime prior to adopting the euro. The argument behind the exchange rate regime being of importance is the presumed difference in exchange rate volatility, which is allowed to vary under the ERM, although at a maximum of ± 15 percent. For these reasons, this essay focuses on the importance of exchange rate volatility as such rather than on the importance of the exchange rate regime.

The use of the calculated volatility rather than the official classification of exchange rate regimes as reported by the IMF can also be motivated by the allowance of this method to avoid the problem of there being a difference between the officially announced, de jure, regime and the regime de facto employed in practice. What matters for agents engaged in trade is presumably the actual volatility and not the official regime announced by the authorities, and so the employed method is appropriate not only due to data availability.

Exchange rate volatility is calculated using the value of the nominal exchange rate against the US Dollar[19] for the period before the adoption of the euro, i.e. during the years 1995-1998[20], and depending on the value of the calculated volatility, countries are divided into two groups

[19] For a detailed description on these calculations, see section 5.2.2.
[20] The introduction of the euro took place in several steps. The new currency was adopted for electronic transactions on 1st of January 1999, although the introduction of the euro as a physical currency occurred on the 1st of January 2002 (EU-upplysningen3, 2011-01-03).

of equal size, illustrating countries with low and high volatility, respectively. One could base the classification of countries´ exchange rate volatility on a division into more than two groups, but considering the limit by the ERM on the fluctuations being maximum ± 15 percent, using more than two groups implies a risk of the differences between the groups being too small, thereby limiting the possibility to detect any significant differences in trade effects.

The inclusion of only one dummy variable to capture the difference between the two groups is due to the need to avoid the dummy-variable trap of exact multicollinearity, which arises if the included number of dummy variables is equal to the total number of categories. Including only one variable does not imply that the other category is neglected, however, but rather that it functions as the reference group to which the results for the other group are compared[21].

5.2.2. How to measure exchange rate volatility

A number of methods to measure exchange rate volatility exist and have been used in the research regarding exchange rate volatility per se and the issue of the impact of exchange rate volatility on other variables. McKenzie (1999) provides an overview of the different methods used to generate a measure of the volatility of the exchange rate. Approaches include the use of ARIMA and ARCH models as well as the computation of the moving average of the standard deviation of the exchange rate and the average absolute difference between the previous forward rate and the current spot rate (McKenzie, 1999, p. 77).

The measures of exchange rate volatility employed in this essay are the average of the absolute monthly percentage change in the exchange rate and the standard deviation of the monthly percentage change in the exchange rate[22]. The choice of these measures stem mainly from their computational simplicity compared to other available measures and the choice of using more than one measure is motivated by the need to control for the sensitivity of the results to the definition of the most important explanatory variable. As reported in McKenzie (1999), both of them are employed in studies on the importance of exchange rate volatility for trade and they are also used in for example Levy-Yeyati and Sturzenegger (2003) and Belke and Gros (2001).

[21] See for example Verbeek (2008) for a further discussion on this issue.
[22] The percentage change is calculated as the difference in the logged value of the nominal exchange rate between two successive months.

Just as with the variables imports and GDP, one could use either the real or the nominal exchange rate when calculating exchange rate volatility. The nominal exchange rate is the price of one currency in terms of another, whereas the real exchange rate is the nominal exchange rate with account taken of price differences between the countries (Pilbeam, 2006, p.10). For several reasons, the variable chosen for the study in this essay is the nominal exchange rate. First, keeping in mind that both GDP and trade flows are measured in nominal terms, it seems appropriate to consistently use nominal values. Second, focus of this essay is on the volatility of the exchange rate rather than on changes in prices. As described above, volatility is calculated on the basis of monthly changes in the exchange rate. To account for changes in prices, as is the case when using the real exchange rate, would probably require the use of longer time units. Third, the choice of using the nominal rather than the real exchange rate is also a question of data availability. There is data on the real effective exchange rate index, but the use of such a weighted index of the exchange rate would probably not reveal the fluctuations of the exchange rate against each currency in the sample. Fourth, it has been shown that the choice of nominal versus real exchange rate does not affect the results of empirical studies to any larger extent (McKenzie, 1999, p. 85).

The variable used in this essay is the nominal exchange rate of each currency against the US Dollar. Volatility is, as mentioned above, for each year calculated both as the average of the absolute monthly percentage change and as the standard deviation of the monthly percentage change. A resulting question is, however, how to calculate the bilateral exchange rate volatility between two countries when one of them is not the U.S. Ready-made data on the bilateral exchange rate for each country pair does not seem to be available. For this reason, exchange rate volatility is calculated for each country as the volatility against the US Dollar, and for each country pair, volatility is calculated as the average of the volatility of those countries´ currencies against the US Dollar. Recognizing this method to be far from perfect, it still seems appropriate to use for the purpose of this study. To control for the sensitivity of the results to the use of this method, the estimation will also be performed with volatility measured separately for the importer and the exporter and including these as two explanatory variables.

In total, therefore, the study contains four different specifications, which are summarized in the table below.

Table 5.1. Specifications of the model

Version of the model	Calculation method	Volatility measure
Basic specification	Average of absolute monthly percentage change	Average of exporter and importer
	Standard deviation of monthly percentage change	Average of exporter and importer
Robustness test of separating the exchange rate volatility of the exporter and the importer	Average of absolute monthly percentage change	Exporter and importer separately
	Standard deviation of monthly percentage change	Exporter and importer separately

Naturally, depending on the calculation method used and whether volatility is calculated separately or as the average of the importer and exporter, the classification of countries as high- or low-volatility-countries differs. The complete list of which countries belong to which group as well as the volatility limits for the classification of countries as high-volatility countries can be found in Appendix 2 and Appendix 3.

5.3. Sample

The statistical analysis is performed using panel data from the 24 high-income countries that were members of the OECD throughout the whole time period of 1995-2005[23], which results in the total number of observations being 6072. The choice of panel data rather than pure time series- or cross-section data allows one to capture the effects of the EMU over time and not only comparing trade flows of different countries at a given point of time[24].

Data on the value of bilateral imports is missing for 98 of the 6072 observations in the sample. For the statistical analysis to be performed, these will be treated as having reported a value of zero. Being aware of the possibility that this might affect the result of the analysis, it can still be argued that since the number of observations with a missing value is small relative

[23] Information regarding which countries are members of the OECD during the whole sample period and which countries classify as high-income countries is retrieved from OECD1 and the World Bank (2011). The inclusion of Turkey as a high-income country can be questioned, but the long membership of this country of the OECD serves to motivate this choice.

[24] In fact, the use of cross-section versus panel data implies a difference not only for the type of data being used, but also for the wording and meaning of the research question at issue. As Flam (2008) points out, a pure cross-sectional analysis answers the question of there being a difference between countries with different exchange rate volatility at a given point in time, whereas the use of panel data allows one to address the question of whether the volume of trade changes when the degree of exchange rate volatility changes. Hence, the latter approach also includes the time dimension that is not accounted for when using pure cross-sectional data.

to the total number of observations in the sample, it is acceptable to deal with the issue in this way.

Also the existence of zero values imposes some problems and there exist several ways to handle such issues. A commonly used, and the perhaps most convenient, way to deal with the problem is to add a constant of value one to each of the reported values. This approach is employed also in the study in this essay. Since the model is in log-linear form, adding a constant of one to each of the values allows the inclusion of all observations in the estimation[25] [26].

A list of the countries included in the sample can be found in Appendix 1. The choice of countries to include in the sample can be argued appropriate from a number of aspects. First, it contains countries with similar characteristics to the EMU-countries, allowing a comparison between countries that have adopted the euro with countries that have not. One could limit the sample to include EU-countries only, but since this would result in a control group consisting of three countries only[27], it seems more appropriate to include also OECD-countries that are not members of the EU. Also, this considerably increases the number of observations forming the basis for the study and the inclusion of all high-income OECD countries therefore acts to enhance the quality of the study in several aspects. For these reasons, the essay follows Flam and Nordström (2007) and many others in including not only EU- but also OECD-countries in the sample.

The time period seems appropriate since it covers several years both prior to and following upon the introduction of the euro on the 1st of January 1999 in most member countries[28]. By choosing 1995 as the first year in the sample, one also avoids the problem of dealing with the change in the technique for data collection in 1993 and having to account for the enlargement of the EU in 1995, when, Finland, Sweden and Austria joined the union (Baldwin and

[25] If a constant is not added, the observations with a reported value of imports equal to zero will be excluded from the analysis since the value of the log of 0 is undefined.
[26] Alternative methods to deal with the problems of missing observations are for example the use of a sample selection-method, a non-linear estimation method or exclusion of the zeroes. See for example Martin and Pham (2008) for a discussion on this issue.
[27] The three EU-countries that have not adopted the euro are Sweden, Denmark and the United Kingdom. See appendix 1 for a complete list of OECD-, EU- and EMU-countries included in the sample.
[28] All EMU-countries included in the sample adopted the euro for electronic transactions on the 1st of January, 1999, although the introduction of the euro as a physical currency occurred on the 1st of January 2002.. The exception is Greece, which became member of the EMU in 2001 (EU-upplysningen3, 2011-01-03). One could, of course, exclude Greece from the sample to avoid the late entrance to affect the results, but since the variable of main interest for this essay, the volatility of the exchange rate, is calculated for the years 1995-1998 and since trade effects of the euro should have had enough time to operate also in the Greek case from 2001 to 2005, all countries listed as EMU-members in the table in Appendix 1 are included in the sample.

Taglioni, 2008, p.24 and EU-upplysningen2, 2010-12-16). Also, choosing 2005 as the last year seems appropriate for enough time having elapsed for impacts of the euro showing any effects and for data to have been collected.

The data used for the study is collected from the database "Monthly Statistics of International Trade" from the OECD Statistics, from the CEPII Gravity Dataset, which entails data on variables commonly used in gravity model-analysis, and from the website "EU-upplysningen", which provides information on issues related to the EU. The table below lists the variables of interest for the study to be performed as well as the sources of information.

Table 5.2. Data sources

Variable	**Data source**
Imports	OECD Stat: "Monthly Statistics of International Trade"
GDP of exporter and importer	CEPII Gravity Dataset
Members of the EU	EU-upplysningen2
Members of the EMU	EU-upplysningen3
Nominal exchange rate against US Dollar	OECD Stat: "Monthly Statistics of International Trade"

5.4. Empirical specification

After having discussed the variables and the data, this section aims at specifying the version of the gravity model that forms the basis for the statistical analysis to be performed as well as the expected sign of each coefficient of these variables.

The empirical specification of the model is in log-linear form, which implies that the obtained coefficients are estimates of the elasticity, i.e. the percentage change in the amount of imports due to a one-percent-increase in the explanatory variables. The dummy variables, however, are not logged an hence, the obtained coefficients in this case are semi-elasticities and measure the percentage change in the dependent variable imports due to an absolute change in the dummy variable[29].

The basic specification of the gravity equation includes exchange rate volatility measured as the average of the exporter and the importer and can be written as

[29] For a more detailed discussion on this topic, see for example Chapter 3: Interpreting and Comparing Regression models in Verbeek (2008).

$$\ln Imp_{ij} = \ln \beta_0 + \beta_1 \ln Mass_{ij} + \beta_2 (BothEMU * EMUyears) + \beta_3 (BothEMU * EMUyears * highvolatility) + \beta_4 (ImpEMU * EMUyears) + \beta_5 (ExpEMU * EMUyears) + \sum_{t=1996}^{2005} \beta_{6-15} year_{dummy} + \mu_{ij} + u_{ijt}$$

(Equation 5.1)

$\ln Imp_{ij}$ is the log of the nominal value of bilateral imports and $\ln Mass$ is the log of the product of the nominal GDPs of the two countries. $(BothEMU * EMUyears)$ is a dummy variable equal to one during the EMU-years of 1999-2005 if both the importer and the exporter are EMU-members. This variable also serves as the reference category including countries that do not belong to the high-volatility group. The variable named $(BothEMU * EMUyears * highvolatility)$ is the dummy capturing high-volatility-countries and is equal to one during the EMU-years of 1999-2005 if both the importer and the exporter are EMU-members and if the average volatility of these countries falls in the high-volatility group. $(ImpEMU * EMUyears)$ and $(ExpEMU * EMUyears)$ are dummy variables equal to one during the EMU-years of 1999-2005 if the importer or exporter, respectively, is a EMU-member. The constant term, β_0, captures the country-pair fixed effects and $\sum_{t=1996}^{2005} \beta_{6-15} year_{dummy}\, \varepsilon_{ij}$ are time dummies included in the estimation to capture time-fixed-effects. Finally, u_{ijt} is the error term.

Note, again, that the impact of time-invariant variables such as common language, contiguity and distance are not estimated separately but captured by the fixed effects and included in the value of the constant. Also the effect of the EMU countries´ higher propensity to trade with each other before the formation of the EMU, which in the specification of the model is illustrated by these countries belonging to the EMU group during the whole time period studied, is captured by the constant and does therefore not affect the result of the study.

One might first think that it would be appropriate to include versions of the $(EMUyears * highvolatility)$-dummy for the importer and exporter, respectively. This would, however, illustrate trade effects between a high-volatility EMU-country and an outside country, and since the purpose of this essay is to investigate the importance of exchange rate volatility for

countries that are members of the EMU and which have eliminated mutual exchange rate volatility by both adopting the common currency, it seems clear that including such variables is not meaningful.

In the robustness test in section 6.2.2, the gravity equation is slightly changed. The version estimated in that section can be written as

$$\begin{aligned}\ln Imp_{ij} = {} & \ln \beta_0 + \beta_1 \ln Mass_{ij} + \beta_2 (BothEMU * EMUyears) \\ & + \beta_3 (BothEMU * EMUyears * highvolatility\ of\ exporter) \\ & + \beta_4 (BothEMU * EMUyears * highvolatility\ of\ importer) \\ & + \beta_5 (ImpEMU * EMUyears) + \beta_6 (ExpEMU * EMUyears) \\ & + \sum_{t=1996}^{2005} \beta_{7-16} year_{dummy} + \mu_{ij} + u_{ijt}\end{aligned}$$

(Equation 5.2)

The definitions of the variables are equal to the definitions of the variables in the basic specification in equation 5.1. The exception is the variables named $(BothEMU * EMUyears * highvolatility\ of\ exporter)$ and $(BothEMU * EMUyears * highvolatility\ of\ importer)$, which are dummy variables that are equal to one during the EMU-years of 1999-2005 if the exporter or the importer, respectively, classify as a high-volatility country.

The expected signs of the variables are presented in the table below.

Table 5.3. Expected signs of the estimated coefficients

Expected signs of the estimated coefficients	
Variable	**Expected sign**
$\ln Mass_{ij}$	+
$(BothEMU * EMUyears)$	+
$(BothEMU * EMUyears * highvolatility)$	+ (larger than for $(BothEMU * EMUyears)$)
$(BothEMU * EMUyears * highvolatility\ of\ exporter)$	+ (larger than for $(BothEMU * EMUyears)$)
$(BothEMU * EMUyears * highvolatility\ of\ importer)$	+ (larger than for $(BothEMU * EMUyears)$)
$(ImpEMU * EMUyears)$	+/-
$(ExpEMU * EMUyears)$	+/-

According to theory, $\ln Mass_{ij}$, is believed to have a positive impact on the amount of bilateral trade flows. Both the reference group, $(BothEMU * EMUyears)$, and the three specifications of the high-volatility group, $(BothEMU * EMUyears * highvolatility)$, $(BothEMU * EMUyears * highvolatility\ of\ exporter)and(BothEMU * EMUyears * highvolatility\ of\ importer)$, are believed to have a positive impact on trade. According to the hypothesis presented in the beginning, however, the latter three are expected to have larger estimated coefficients than the reference group. The expected signs of the variables $(ImpEMU * EMUyears)$ and the $(ExpEMU * EMUyears)$ can be both positive and negative, depending on if the EMU is believed to result in trade creation (+) with or trade diversion (-) against outside countries.

6. Results

The results of the estimated gravity model as specified above are presented below. First, the results of the basic specification are reported, followed be a section aiming at controlling the robustness of the results with respect to the origin of exchange rate volatility and the appropriateness of using the fixed- versus the random effects-method.

6.1. Basic specification

The basic specification of the gravity model includes exchange rate volatility measured both as the average of the absolute monthly percentage change of the nominal exchange rate and as the standard deviation of the monthly percentage change of the nominal exchange rate. The exchange rate volatility of the two countries engaged in bilateral trade is calculated as the average of the two country-specific volatilities. The estimation is performed using the fixed effects-method described in section 4.4 and the results are presented in table 6.1 below.

Table 6.1. Basic specification

Basic specification		
Fixed effects-method		
	Measure of volatility = average	**Measure of volatility = standard deviation**
Variable	**Estimated coefficient**	
ln Mass	1.259***	1.298***
BothEMU*EMuyears	0.150	-0.303
BothEMU*EMuyears*highvolatility	1.090	1.455**
ImpEMU*EMUyears	0.032	0.032
ExpEMU*EMUyears	0.625***	0.625***
Year 1996	-0.060	-0.063
Year 1997	0.052	0.052
Year 1998	0.060*	0.060*
Year 1999	-0.142**	-0.144**
Year 2000	0.006	0.007
Year 2001	0.059	0.060
Year 2002	-0.095*	-0.101*
Year 2003	-0.439***	-0.460***
Year 2004	-0.617***	-0.649***
Year 2005	-0.703***	-0.741***
Constant	-14.335**	-15.311**
Overall R^2	0.471	0.474
Mean VIF	2.24	2.39
*significant at 10 % **significant at 5 % ***significant at 1 %		

A look at the table above shows that the log of the mass of the two countries, $\ln Mass$, is highly significant and of expected sign in both specifications. It is also close to one, which is predicted by theory. In the specification using the average of the absolute monthly percentage change to measure volatility, the coefficients of $(BothEMU * EMUyears)$ and $(BothEMU * EMUyears * highvolatility)$ are both of expected sign, although not significant. When the standard deviation of the monthly percentage change is used, the coefficient for $(BothEMU * EMUyears * highvolatility)$ is positive and significant at a significance level of five percent. The coefficient for the reference group,$(BothEMU * EMUyears)$, is, however, still insignificant.

In both specifications, the coefficients for $(ImpEMU * EMUyears)$ and $(ExpEMU * EMUyears)$ are interestingly both positive, although only the latter is significant, and there is hence no indication of trade diversion towards non-EMU-members taking place. Also the time dummies explore significance only to a limited extent, but these are included to capture

time-fixed-effects and are therefore of minor interest. Finally, the coefficient of determination, R^2, of 0.471 and 0.474, respectively, is fairly high considering the small number of explanatory variables included in the model.

The results reported above are inconclusive when it comes to the hypothesis of high-volatility-countries experiencing larger trade effects than low-volatility countries as a consequence of the formation of the EMU. As with all models and surveys, the results are dependent on the assumptions and specifications made. To control for the appropriateness of these, the next section will be devoted to various forms of robustness tests.

6.2. Robustness tests

This section presents the tests performed and the countermeasures undertaken to take account of potential econometric problems in the estimation process. Moreover, to control for the robustness of the results, the sensitivity of these to the definition of the variables and to the choice of method are tested from two different aspects; the separation of exchange rate volatility and the use of the fixed effects- versus the random effects-method.

6.2.1. Econometric problems and countermeasures

Several measures are taken to mitigate and remedy undesired complications due to the characteristics of the data and/or potential econometric problems.

To account for potential heteroscedasticity and autocorrelation, robust standard errors are used and to detect any multicollinerarity between the explanatory variables, the variance inflation factor (VIF) is calculated. The value of the variance inflation factor ranges between 2.24 and 2.50 and multicollinearity should thus not be a reason for concern[30].

The only non-dummy explanatory variable included in the regressions is the log of the product of the GDP of the two countries. Keeping the relative short time period covered in the sample in mind, non-stationarity of imports and/or GDP should not be an issue.

As argued in Micco et al. (2003), the use of country-pair-fixed-effects and the relatively short time period used in the study imply that endogeneity is not a reason for concern. The

[30] See for example O´Brien (2007) for a discussion of VIF as a tool for detecting multicollinearity.

possibility to test for endogeneity is also limited by the difficulty in finding appropriate instruments for the variables included in the gravity model.

Neither potential omitted variables should be a problem in this setting since heterogeneity among the units, which would otherwise have been captured by the additional variables, is captured by the fixed effects.

Finally, the question of the fixed- versus the random effects-method as the most appropriate estimation method is dealt with in section 6.2.3.

6.2.2. Separation of exchange rate volatility

As described in section 5.5.2, the restricted availability of data on the bilateral exchange rate implies the need for some modification of the data for the measure of volatility to take account of the volatilities of the currencies of both countries engaged in trade. In the basic specifications above, the average of the country-specific volatilities is used. To control for the sensitivity of the results to this definition, the gravity equation is also estimated including the volatility of the exporter and importer separately as specified in equation 5.2. Table 6.2 below reports the estimated coefficients for this specification. The estimations are performed using both employed measures of exchange rate volatility.

Table 6.2. Robustness test of the measure of exchange rate volatility

Sensitivity analysis with respect to the measure of exchange rate volatility: separation of exporter and importer		
Fixed effects-method		
	Measure of volatility=average	**Measure of volatility =standard deviation**
Variable	**Estimated coefficient**	**Estimated coefficient**
ln Mass	1.305***	1.476***
BothEMU*EMuyears	-0.593*	-0.829**
BothEMU*EMuyears*highvolatility of exporter	2.147***	2.048**
BothEMU*EMUyears*highvolatility of importer	0.010	0.511
ImpEMU*EMUyears	0.032	0.023
ExpEMU*EMUyears	0.625***	0.604**
Year 1996	-0.063*	-0.073*
Year 1997	0.052	0.060
Year 1998	0.060*	0.065*
Year 1999	-0.145**	-0.140**
Year 2000	0.007	0.033
Year 2001	0.060	0.097*
Year 2002	-0.102*	-0.095
Year 2003	-0.464***	-0.530***
Year 2004	-0.655***	-0.775***
Year 2005	-0.748***	-0.890***
Constant	-15.481**	-19.722**
Overall R^2	0.463	0.459
Mean VIF	2.35	2.50
*significant at 10 % **significant at 5 % ***significant at 1 %		

Table 6.2 above presents the results when exchange rate volatility is measured and included in the regression for the exporter and the importer separately. Again, the coefficient for $\ln Mass$ is significant at the one-percent level, although somewhat larger when the standard deviation is used to measure volatility. Just as in the basic specifications, $(ExpEMU * EMUyears)$is positive and significant in both specifications, whereas $(ImpEMU * EMUyears)$ is insignificant.

In both specifications, the $(BothEMU * EMUyears * highvolatility\ of\ exporter)$-variable has a relatively large reported coefficient[31] of 2.147 and 2.048 with statistical significance at

[31] Note, again, that the reported coefficients are elasticities and semi-elasticities.

the one- and five-percent level, respectively. The coefficient for $(BothEMU * EMUyears * highvolatility\ of\ importer)$, however, is insignificant in both specifications.

The coefficient for $(BothEMU * EMUyears)$, the reference group including countries with low pre-EMU volatility, is significant at the ten- and five-percent-level, respectively, but the coefficient is negative in both specifications, indicating that countries in this group have actually experienced a decrease in within-EMU-trade flows during the EMU-years of 1999-2005.

6.2.3. The fixed effects- versus the random effects-method

As described in section 4.4., one can perform a Hausman test to determine if the fixed effects- or the random effects-method is most appropriate to use. Both methods are consistent, but in the case of no correlation between the constants and the regressors, the random effects-method is more efficient and delivers more precise estimates than the fixed effects-method.

Since the possibility to use the random effects-method can vary between the different specifications of the model, the reported coefficients above are for consistency the coefficients estimated using the fixed effects-method. The result of the Hausman test indicates that the random effects-method can be used for the two versions of the basic specification, i.e. when volatility is measured as the average volatility of the exporter and the importer. The results of these estimations are presented in table 6.3 below. For the specifications in section 6.2.2 above, however, which includes the volatility of the exporter and the importer separately, the random effects-method is not appropriate[32].

[32] The p-value of the Hausman test is in these cases are 0.0000 and 0.0005, respectively. Hence, one can reject the null hypothesis that the random effects-method can be used at the one-percent level. The obtained p-values in the other specifications are presented in the table below.

Table 6.3. Robustness test of the choice of method

Sensitivity analysis with respect to the choice of method Origin of volatility: average of importer and exporter		
Random-effects-method		
	Measure of volatility=average	**Measure of volatility =standard deviation**
Variable	**Estimated coefficient**	**Estimated coefficient**
ln Mass	0.987***	0.985***
BothEMU*EMuyears	0.306**	-0.122
BothEMU*EMuyears*highvolatility	0.919***	1.293***
ImpEMU*EMUyears	0.014	0.014
ExpEMU*EMUyears	0.545***	0.545***
Year 1996	-0.046	-0.045
Year 1997	0.045	0.045
Year 1998	0.060	0.060
Year 1999	-0.096	-0.096
Year 2000	0.032	0.032
Year 2001	0.076	0.076
Year 2002	-0.027	-0.026
Year 2003	-0.261***	-0.260***
Year 2004	-0.360***	-0.358***
Year 2005	-0.410***	-0.407***
Constant	-7.461***	-7.403***
Overall R^2	0.472	0.475
Mean VIF	2.24	2.39
p-value of Hausman test H_0: use RE H_1: use FE	0.265	0.384
*significant at 10 % **significant at 5 % ***significant at 1 %		

As mentioned above, both specifications of the model using the average of the volatility of the importer and the exporter for measuring the exchange rate volatility can be estimated using the random effects-method. The p-values of the Hausman test are 0.265 and 0.384, respectively. The coefficient for $\ln Mass$ is in both cases close to unity and hence somewhat lower than in the previous specifications using the fixed effects-method in sections 6.1 and 6.2.2 above. For the specification using the average of the volatility of the exporter and importer, the random effects-method gives significant coefficients for $(BothEMU * EMUyears)$ and $(BothEMU * EMUyears * highvolatility)$ to a larger extent. Both of them are of the expected positive sign and statistically significant at the five- and one-percent level, respectively. Also, the coefficient for $(BothEMU * EMUyears * highvolatility)$ is

higher than the coefficient for$(BothEMU * EMUyears)$, which implies that the hypothesis of high-volatility countries experiencing increased trade flows to a larger extent than low-volatility-countries is supported in this specification.

For the specification using the standard deviation, the coefficient for $(BothEMU * EMUyears * highvolatility)$ is also positive, although smaller than in the same specification estimated with the fixed effects-method. For the reference group, however, statistical significance is not obtained.

It is noteworthy that the estimated coefficients for $(ImpEMU * EMUyears)$ and $(ExpEMU * EMUyears)$ are positive in all specifications in the study although continuously, only the coefficient for $(ExpEMU * EMUyears)$ is significant. Hence, there is no sign of the formation of the EMU resulting in trade diversion against third countries. Also, the estimated coefficients for these two variables seem to be the most stable throughout all specifications when comparing with other variables of interest.

Finally, note also that the overall R^2-value remains stable at a level around 47 percent regardless of the change in model specification. This is, however, not surprising since the difference between the specifications lies mainly in the way of measuring exchange rate volatility rather than in changing the number and characteristics of the explanatory variables.

7. Discussion

The results reported above seem to support the hypothesis presented in the introduction of high-volatility-countries experiencing EMU-related trade-enhancing effects to a larger extent than countries with low exchange rate volatility prior to the adoption of the euro. Using the random effects-method when the situation allows and the fixed effects-method in other cases, the estimated coefficients for countries classifying as high-volatility countries are significant at the one- and five-percent level. The exception is the coefficient for high-volatility import countries in the robustness test in section 6.2.2, which is insignificant both when using the average of the absolute monthly percentage change and the standard deviation of the monthly percentage change as measure of exchange rate volatility. This implies that in the case of high pre-EMU volatility on behalf of the exporter, trade effects have been larger for high-volatility- than for low-volatility countries. For the volatility of the importer, however, there is no statistically significant tendency. A potential explanation may be that since the price of a tradable good is set by the exporter, it is mainly the volatility of the exporter rather than the volatility of the importer that matters. The insignificance of the latter, therefore, is not as contradicting with theory as one might first think. Also, exchange rate volatility being measured towards the US Dollar and not directly towards the currency of the trading partner could have some impact on the obtained results.

The statistically significant coefficients for high-volatility countries range from 0.919 to 2.147, implying that high-volatility countries have experienced trade effects of between 2.5 to 8.6 times[33] the trade effects of low-volatility countries. Relying on these results, one can conclude that trade effects of the EMU have been unevenly distributed among the member countries. Not only have high-volatility countries experienced larger gains than low-volatility countries, but the results for the reference group, with the coefficient being significant in three of four specifications, and significantly negative in two of these, suggest that low-volatility countries might even have experienced declining trade flows.

One could think of several possible explanations to the peculiar behavior of this coefficient. As described in section 3.2, several performed studies reveal a positive impact on trade of the formation of the EMU. That the study in this essay in some cases results in a significant, negative coefficient for the reference group is therefore noticeable, but not necessarily

[33] Since the gravity equation is estimated in log-linear form, the coefficients of 0.919 and 2.147 are transformed with the natural logarithm as the base.

contradictory. One could imagine this negative coefficient to affect the results also in other studies performed, although being counterbalanced by the positive impact for high-volatility countries. Studies assessing the impact of the EMU on trade flows in general, without taking into account that exchange rate volatility and its effect might differ between countries, might therefore in some sense disregard that existing differences between countries can lead to the obtained results not being equally valid for all countries in the sample. This, in turn, might be a partial explanation to why previous studies have obtained different indications on the size of the trade effects of the EMU.

The implication of a negative and statistically significant coefficient for the $(BothEMU * EMUyears)$-variable might also have another intuitively plausible explanation. Countries not qualifying for the high-volatility group are countries experiencing relatively low pre-EMU exchange rate volatility. As the formation of the EMU, however, implies an elimination of exchange rate volatility for all member countries, there is a possibility that the increased trade for high-volatility countries takes place at the expense of low-volatility countries, for which the elimination of volatility is not as remarkable. The negative coefficient for the reference group might therefore indicate some kind of trade diversion taking place within the EMU, redirecting trade from previous low- to previous high-volatility countries.

Also, the results have interesting implications for the ongoing discussion on pros and cons of forming a currency union, in that the often used trade-promoting argument in favor of the EMU might not be as general as is often stated. Rather, the results of the performed study imply that advantages and disadvantages of membership might be even more country-specific than previously thought, with large expected gains for countries experiencing heavily fluctuating exchange rates and modest, or even adverse, effects for countries with more stable rates.

Naturally, further research is needed before one can draw any general conclusions. A number of issues imply interesting questions to be assessed by future studies. Classifying the groups of low- and high-volatility countries on the basis of the EMU-members only rather than on the whole sample might be an alternative, and investigating the importance of different types of volatility by trying to distinguish between anticipated and unanticipated movements of the exchange rate is another approach. To further investigate the validity of the results, future research could also address the importance of exchange rate volatility by applying the approach of separating countries into groups depending on their pre-currency union volatility

on other currency unions than the EMU. Already prior to forming the EMU, member countries were integrated within the framework of the EU, and the existence of the ERM as one of the convergence criteria for membership in the EMU clearly puts a limit on the potential difference in exchange rate volatility between member countries. To investigate to what extent the results change when exchange rate volatility is not limited in this way already prior to the formation of a currency union might therefore be a fruitful approach to be employed by future research.

8. Conclusion

The aim of this essay is to assess whether the decision of countries to join the EMU and adopt the euro as their official currency have had an impact on the bilateral trade flows of these countries to different extents.

The results of the panel data study using data for 24 OECD-countries between 1995 and 2005 seem to support the expectation presented in the introductory section, which states that countries with a high degree of pre-EMU exchange rate volatility should experience increased trade flows to a larger extent than countries with an initially relatively low degree of exchange rate volatility.

The estimated impact on trade of the formation of the EMU for high-volatility countries is significant in two of the three different definitions of exchange rate volatility and, when significant, continuously larger than the coefficient for the reference group. The results are, however, inconclusive when it comes to the impact of the EMU on trade flows for countries in this reference group, which includes countries not classifying as high-volatility countries.

The obtained results indicate that the trade-promoting effect of the EMU differ substantially between member countries, with high-volatility countries experiencing effects of up to 8.6 times the effects for low-volatility countries. Recognizing that further research is needed to verify the validity of the results, these still do suggest that the scope for large positive trade effects for countries candidating to join the EMU might be true only in some cases. The results of the performed study suggest that considering the country-specific exchange rate volatility is of importance both when prognosticating potential gains from joining the EMU and for further research aiming at investigating trade effects of such a currency union.

As with all modeling, the specification of the model, the availability, quality and characteristics of the data and the method used for the statistical analysis are decisive for the results obtained. It is likely that choosing another sample of countries and employing another version of the fixed-effects method would have some impact on the results. Nevertheless, the chosen method for assessing trade effects of the EMU is a method acknowledged and commonly used by researchers within the field, and the significance of the coefficients for the most important variable representing high-volatility countries should not be neglected.

9. References

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10. Appendix

9.1 Appendix 1

Table A1. Countries included in the sample

High-income OECD countries	**EU-members**	**EMU-members**
Australia	Austria	Austria
Austria	Belgium	Belgium
Belgium	Denmark	Finland
Canada	Finland	France
Denmark	France	Germany
Finland	Germany	Greece
France	Greece	Ireland
Germany	Ireland	Italy
Greece	Italy	Luxembourg
Iceland	Luxembourg	Netherlands
Ireland	Netherlands	Portugal
Italy	Portugal	Spain
Japan	Spain	
Luxembourg	Sweden	
Netherlands	United Kingdom	
New Zealand		
Norway		
Portugal		
Spain		
Sweden		
Switzerland		
Turkey		
United Kingdom		
United States		

9.2. Appendix 2

Table A2. EMU-countries in the high-volatility group

EMU-countries in the high-volatility group							
Measure of exchange rate volatility (according to table 4.1)							
Average-average		Standard deviation-average		Average-separate	Standard deviation-separate	Average-separate	Standard deviation-separate
Country pairs		Country pairs		Exporter	Exporter	Importer	Importer
Exporter	Importer	Exporter	Importer				
Austria	Belgium	Austria	Belgium	Austria	Austria	Austria	Austria
	Germany		Germany	Belgium	Belgium	Belgium	Belgium
	Spain		Spain	Germany	Germany	Germany	Germany
	Finland		Finland	Finland	Finland	Spain	Spain
	France		France	Greece	France	Finland	Finland
	Greece		Ireland	Luxem-bourg	Luxem-bourg	France	France
	Luxem-bourg		Italy	Nether-lands	Nether-lands	Greece	Ireland
	Nether-lands		Luxem-bourg			Luxem-bourg	Italy
Belgium	Austria		Nether-lands			Nether-lands	Luxem-bourg
	Germany	Belgium	Austria				Nether-lands
	Spain		Germany				Portugal
	Finland		Spain				
	France		Finland				
	Greece		France				
	Luxem-bourg		Ireland				
	Nether-lands		Nether-lands				
Germany	Austria		Italy				
	Belgium		Luxem-bourg				
	Spain		Portugal				
	Finland	Germany	Austria				
	France		Belgium				
	Greece		Spain				
	Luxem-bourg		Finland				
Spain	Austria		France				
	Belgium		Ireland				

	Germany		Italy				
	Finland		Luxem-bourg				
	Luxem-bourg		Nether-lands				
	Nether-lands		Portugal				
Finland	Austria	Spain	Austria				
	Belgium		Belgium				
	Germany		Germany				
	Spain		Finland				
	France		France				
	Greece		Luxem-bourg				
	Luxem-bourg		Nether-lands				
	Nether-lands	Finland	Austria				
France	Austria		Belgium				
	Belgium		Germany				
	Germany		Spain				
	Finland		France				
	Greece		Italy				
	Luxem-bourg		Luxem-bourg				
	Nether-lands		Nether-lands				
Greece	Austria		Portugal				
	Belgium	France	Austria				
	Germany		Belgium				
	Finland		Germany				
	France		Spain				
	Luxem-bourg		Finland				
	Nether-lands		Italy				
Luxem-bourg	Austria		Luxem-bourg				
	Belgium		Nether-lands				
	Germany		Portugal				
	Spain	Ireland	Austria				
	Finland		Belgium				
	France		Germany				
	Greece		Luxem-bourg				
	Nether-lands	Italy	Austria				
Nether-	Austria		Belgium				

lands							
	Belgium		Germany				
	Germany		Finland				
	Spain		France				
	Finland		Luxem-bourg				
	France		Nether-lands				
	Greece	Luxem-bourg	Austria				
	Luxem-bourg		Belgium				
			Germany				
			Spain				
			Finland				
			France				
			Ireland				
			Italy				
			Nether-lands				
			Portugal				
		Nether-lands	Austria				
			Belgium				
			Germany				
			Spain				
			Finland				
			France				
			Italy				
			Luxem-bourg				
			Portugal				
		Portugal	Austria				
			Belgium				
			Germany				
			Finland France				
			Luxem-bourg				
			Nether-lands				

9.3. Appendix 3

Table A3. Volatility limits for the classification of countries

Limits for classification in the high-volatility-group					
Average of exporter and importer volatility		**Exporter volatility**		**Importer volatility**	
Average of absolute monthly percentage change	Standard deviation of monthly percentage change	Average of absolute monthly percentage change	Standard deviation of monthly percentage change	Average of absolute monthly percentage change	Standard deviation of monthly percentage change
0.015808	0.019535	0.016035	0.019509	0.015808	0.019535