CHARLES UNIVERSITY IN PRAGUE

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Euro and the Effect on Bilateral Trade: Gravity Model Analysis

Bachelor's Thesis

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Abstrakt

Cílem této práce je změřit dopad společné evropské měny na bilaterální obchod. K tomu používáme Gravitační rovnici mezinárodního obchodu aplikovanou na data o 19 zemích Evropské měnové unie a 25 ekonomicky vyspělích státech za období 1993 až 2015. Jedním z charakteristik práce je způsob, jakým přistupujeme k problémům endogeneity a chybějících dat. Na Gravitační model jsou postupně použity metody country-pair fixed-effects, OLS se specifikací popsanou v Baier and Bergstrand (2009) a Poisson Pseudo-Maximum-Likelihood estimator. Posledním krokem v empirické části práce je měření effektu diverzifikace obchodu. Naše výsledky ukazují, že Euro má malý a statisticky nesignifikantní efekt na vzájemný obchod dvou zemí. Zmeřený dopad byl ve všech případech ekonomicky nevýznamný. U metody fixed-effects a OLS byl však naměřen vliv Eura negativní, zatímco v případě PPML pozitivní. Výsledky naší práce také ukazují, že přijetí Eura nezapříčinilo diverzifikaci obchodu.

Abstract

The purpose of this thesis is to estimate the impact of common European currency on bilateral trade. Using data from 1993 to 2015, we employ structural Gravity model of trade on the sample of 19 European Monetary Union members and 25 developed countries. In our analysis, we use two different methods to account for the endogeneity, country-pair fixed-effects and Baier and Bergstrands (2009) specification of the Gravity model estimated by OLS. In order to examine the effect of missing observations, we employ Poisson Pseudo-Maximum-Likelihood estimator. Last, we focus on the adoption of the Euro as a reason behind the effect of trade diversion. The results of all three models show that the creation of the EMU had statistically insignificant effect limiting to zero. In the case of fixed-effects and OLS, the estimated effect is negative, while in the case of the PPML, we found a positive impact. In addition, the results of our analysis show that the adoption of the Euro did not cause a trade diversion

Klasifikace JEL: C33, F10, F13, F14, F 15, F33, F47, F36

Klíčová slova

Gravitační model, export, import, endogeneita, exogeneita, diverzifikace obchodu, country-pair fixed-effects, PPML, OLS, multilateral resistance, panelová data

JEL Classification: F10, F13, F14, F 15, F33, F47, F36

Keywords

Gravity mode, export, import, endogeneity, exogeneity, trade diversion, country-pair fixed-effects, PPML, OLS, multilateral resistance, panel data

Declaration of Authorship

I hereby proclaim that I wrote my bachelor thesis on my own under the leadership of my supervisor and that the references include all resources and literature I have used.

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Prague, July 12, 2017

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Prohlašuji, že jsem svou práci napsal/a samostatně a výhradně s použitím citovaných pramenů.

Souhlasím s tím, aby práce byla zpřístupněna pro studijní a výzkumné účely.

Prague, July 12, 2017

Signature

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Contents

Bachelor's Thesis Proposal

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Topic Characteristics

Since its introduction in 1960s, the Gravity model has been an essential tool in the empirical analyses of international trade. Enabling to estimate barely measurable factors e.g. common language or distance, the Gravity model became widely used to estimate the overall effects of currency unions, impacts of migration, or globalization on international trade. Being pioneers in the field of estimations of currency unions, Rose (2000) and Rose and van Wincoop (2001) were pioneers in Gravity model analysis of currency unions and as consequence they struggled early on with positive bias of the effect which appeared from unobserved exogeneity. Later, Micco et al. (2003) improved on those models as they focused on addressing the bias of omitted time-invariant variables. The partial solution to this problem was the addition of country-pair dummies. Also, Micco et al. (2003) mainly used data on developed nations as they hoped to find more credible information. Baldwin and Taglioni (2006) extend the issue of endogeneity and point out common mistakes in the implementation of the Gravity Model. Till today, the magnitude of the impact of currency unions on bilateral trade has been a subject of estimation in more than thirty papers. The list includes very optimistic suggestions of 53 % of increase in trade by Taglioni (2004) as well as analysis by Serlenga and Shin (2007) providing an estimate of no impact at all. To capture the large disparity in literature, Havránek (2009) carries out a meta-analysis in order to compare and evaluate previous work on the effect of currency union. He also performed meta-regression analysis to find the actual effect. In his paper, Havránek (2009) provides evidence of a serious literature bias and points out that the European Monetary Union (EMU) effect is insignificant after eliminating the bias. Surprisingly, he also noted that the IT skills of researchers play a significant role in the accuracy of the analysis. In this thesis we will build on previous papers, namely Micco (2003) and Baldwin and Taglioni (2006) (henceforth B-T (2006)) and carry out a Gravity model analysis estimating a potential boost of bilateral trade, related to the adoption of Euro. Specifically, we will focus on finding the most appropriate approach to the endogeneity problem in the Gravity model analysis of international trade.

Hypothesis

- The adoption of European currency has a positive and statistically significant impact on bilateral trade flow.
- The formation of the European Monetary Union does not cause a trade diversion.

Methodology

To validate my hypothesis, I will first carry out an empirical analysis of the commonly used Gravity model including 44 developed states. In order to improve on previous papers and provide more precise results, I will use the latest available data from 1993 to 2015. I will also employ and compare various methodologies common in Gravity model estimation and compare the results. Last but not least, I will try to evaluate possible trade diversion caused my the creation of European Monetary Union.

Outline

1. Introduction
2. Literature review and Data
3. Methodology
4. Empirical Results
5. Conclusion

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1 Introduction

The existence of the EMU has never been questioned more than during the debt crisis triggered in late 2009. Members of the Union had to deal with shared responsibility for the eventual breakdown of the Union as well as with inefficient co-operation among the members. Critics of the EMU often argue that this problem is caused by the conflict of a centrally governed monetary policy of the European Central Bank (ECB) and the fiscal policies of each state. Needs for monetary policy may differ among states and those who are not aligned with the rest of the EMU may suffer from an inability to use monetary policy as a tool to foster trade. This can be regarded as a disadvantage by export-oriented countries for whom floating exchange rates help them gain an advantage on the international market. More to this characteristic, De Grauwe (2014) notes that with monetary policy in the purview of ECB, countries eventually lose the opportunity to finance their budget deficits. In times of liquidity crises, national banks are able to eventually supply the government with cash to payout their bond holders. Being a member of the monetary union, however, a state is to some extent at the mercy of the powers of financial markets. This limitation of the EMU membership emerged when Greece was caught falsifying reports about the performance of its economy. Rescue scenario of resulting debt crisis had to be financed by remaining members via the ECB. In the light of recent EMU crisis, it seems that entering the Union is a step into uncertainty and towards the loss of control over the performance of national trade balance.

There are even more arguments feeding the scepticism over the adoption of the Euro, as the EMU is not the first attempt European states tried to unify their monetary systems. In 1865, countries of western Europe, including France, Italy, Belgium, agreed to create a Latin Motetary Union (LMU) - a bimetalic (gold and silver) system allowing coins to flow freely among states. Stability of the system relied on so called mint parity - ratio defining the relationship of value between gold and silver, Kee-Hong and Warren (2011). Expectations from the LMU were similar to those, members states of the EMU have today e.g. decreasing transaction costs or securing international trade flow from exchange rate shocks. Yet participating LMU countries with irresponsible fiscal policy managed to undermine the system by coining undervalued silver coins that financed their budgets. Slowly, it became impossible to hold mint parity on its guaranteed standard and countries had to turn back to the golden standard. “Although the Union survived in one form or another until 1925, it was not considered as success,” Kee-Hong and Warren (2011). EMU is now different. Monetary policy is now sheltered under the ECB and nations in the Union are significantly more politically integrated than they used to be in the 19th century. However, the example of credit crisis showed, that, the EMU is made of a fragile framework sensitive to any kind of turbulence.

It has to be said, however, that the ability of the Union to function for more than 17 years and the fact that it continues to lure new members [1] is proof of countries being motivated to overcome the struggles and adopt the common currency. As De Grauwe (2014) points out that with existing exchange rate between two currencies, firms participating in trade are facing uncertainty in terms of rate volatility. This may result in firms deciding to remain on the domestic market rather than losing money on transactions from one currency to another. Moreover, De Grauwe (2014) shows that reducing these risks may actually lead to higher growth rate of national output. As he presents with neoclassical growth model, transition to fixed exchange rate will lower the real interest rate and provide less risky environment for investors.

In the early 90s, debate among EU states over the common currency transformed into a serious political topic. By that time Emerson et al. (1992) estimated transaction costs related to operations within the market of multiple currencies to be 1% of the GDP of a small, free-trade oriented country, such as Belgium. With fixed exchange rate and minimized transaction costs coming from exchange of currencies, the monetary union should provide firms with easier access to foreign markets and thus increase the competition. The overall impact of EMU on trade between its members has been often recognized as one of the most critical arguments behind the formation. In addition, Micco et al. (2003) noted that the Euro may actually shelter its members from exchange rate risks in transactions with nations outside the Union and thus result in trade creation with non-members.

[2]

We believe that the importance of our study lies in providing newer estimates of the EMU on the potential boost in trade. In the context of the discussion over the adoption of the Euro by the Czech Republic (a strongly export oriented country), such predictions may add valuable arguments to the debate. Even though, more than 30 papers have been published on the effect of the Eurozone since 1993, analyses are still being refined as methods of estimation are improving. We also believe that the dataset, listing up to 23 years with 18 years of existence of the EMU, will allow us to improve on previous results. The objectives of this work will be not only to predict the size and sign of the effect but also to declare whether entering the EMU increases trade with non-member countries. Previous researches done on the topic of the EMU and trade account for wide range estimates with mostly small but positive values. In his study, Havránek (2009) compared results of 28 working papers on the Eurozone effect with standard fixed effects (FE). [3]. His FE method assigns high level of importance to papers that have provided the theoretical founda-

[1] Estonia - 2011; Latvia - 2014, Lithuania - 2015

[2] Micco et al. (2003) explain this phenomenon with high liquidity of Euro that allows holders of the currency to hedge against exchange rate risks.

[3] The prediction of $\beta = 3.87\%$ with $CI = (3.36\% - 4.39\%)$ on the 95% level

tion to our work. [4] Using established methodologies that have managed to address the majority of theoretical issues in the Gravity model analysis, we expect to find the EMU has positive and significant effect on bilateral trade. In addition, we believe that positive effect of the EMU will also appear in trade with partners outside of the Union.

Our study will be conducted in the following order; In the first two sections, we will give an overview on influential studies on the effect of various monetary unions and shortly comment on data used in our analysis. The third section will offer an introduction to the Gravity model analysis and provide an explanation of the concept behind this econometric tool. We will continue with a section dedicated to some of the most discussed problems appearing in the analyses on regional trade agreements and describe our approach to these issues in the Methodology section. Here, we will also state specifics of our augmented Gravity model. In the chapter the Empirical Results, we will comment on predictions of our analysis.

[4] B-T (2006)~10.75%; Serlenga and Shin (2007)~39.75; Micco et al. (2003)~1.02%

2 Literature Review

Behind the idea of common European currency were several defining objectives. Further political integration as a necessary way to control the joint money market, stable distribution of subsidies but also promising injection to the volume of trade. Even though economic theory suggests a positive and economically relevant effect on trade, the magnitude and the significance has had yet been a subject to discussion.

Rose's (2000) initial effort to provide empirical estimate of the effect of common currency did not aim at the European Monetary Union. Given the lack of data on EMU, the author rather sampled data from 1970 to 1990 and looked for an impact of CU schemes throughout the world. In his work, Rose, similarly to De Grauwe (2016), focuses on distinguishing two features of CUs that, in his opinion, are responsible for the positive influence on trade: reduction of transaction costs and the non-presence of exchange rate volatility. In his analysis, Rose (2000) uses an augmented version of the Gravity equation from the 1960s and measures bilateral trade with unconventional explanatory variables such as Currency Union (CU), Free Trade Are (FTA), common language or contingency dummies. The results of his estimates for the CU variable were overwhelming. The coefficient of CU suggested an improvement of trade up to 300 %. The positive bias could be interpreted as insufficient explanation of time-invariant and time-variant patterns of trade as showed in B-T (2006). As suggested by Micco et al. (2003), a significant role also played the fact that Rose (2000) used the dataset which mostly included CU of small, developing nations where the effect is expected to be rather large.

At an early stage in attemps to evaluate the benefits of the Euro, Micco et al. (2003) presented a paper consisting of various modifications of the Gravity equation that brought an estimation of 4-16 %. Their main goal was to investigate not only changes in intra-euroland trade where the economic theory suggests an increase, but also trade flow with partners outside Europe. In the latter case, the authors looked for similarities with custom unions which were known for causing so called supply switching. In other words, nation included in the custom union tends to look for new suppliers of goods and services inside the Union and reduce the supply from those outside. Using 2 samples of 22 developed countries and smaller sample of EU 15 for estimation of the inner-EMU trade, the researches came to different conclusions. In fact, adopting a Euro turned out to have positive effect on both, trade with third countries and on intra-euroland trade. In the case of bilateral trade with non-member countries, the impact was estimated at 9 %. Micco et al. (2003) also paid attention to the long-term effect of the Euro on bilateral trade. To do so, they included lagged variable of trade as an explanatory variable and used its estimate to compute long-term effect. Lagged bilateral trade also helps to take care of serial correlation that may appear in the dataset. What distinguishes Micco et al. (2003) estimates from those of Rose (2000) is their raised awareness of cross-sectional variation. They treat the variation as proposed in Rose (2001), with a country-pair fixed-effects (FE) to pick up all time-invariant effects remaining in the error term.

B-T (2006) can be viewed as a cookbook to Euro-effect analysis. The authors comment on the history of the Gravity Equation of International Trade, derive its suitable form for estimating bilateral trade and finally execute the analysis in order to support their conclusions. Most importantly though, they provide an overview of mistakes, so called Medals, common in previous papers and show different approaches of correcting them. First to be mentioned, Gold Medal mistake stands for the form of endogeneity often caused, as previously recognized, by unexplained cross-sectional variation. B-T (2006) treat this problem in various ways to show the differences in estimation. At the end, they chose time-invariant country-pair dummies as the most reliable solution. Secondly, they describe a Silver Medal mistake which addresses the issue of incorrectly averaged data of bilateral trade that results in an overestimation of the volume. Lastly, Bronze Medal mistake corresponds to a spurious correlation between GDP and inflation.

A study not necessarily aiming at an estimation of the Euro effect but also enriching the theory of the Gravity model of international trade has been written by Baier and Bergstrand (2009). As they presented on US-Canadian case, their method of linear approximation of trade resistance provides a similar prediction of effects influencing bilateral trade flow as fixed-effects (FE) or non-linear least squares (NLS) do. In addition, they were able to obtain an estimate of the so called Multilateral Resistance Term (henceforth MRT) even though it is not directly observable.

Work of Serlenga and Shin's (2007) stands out in a way in which they approach the problem of unobserved Multilateral Resistance Terms, or simply trade barriers. They recognize some of the disadvantages of broadly used time-fixed effects, which usually absorb most of the country specific and country-pair variation. Such methodology, however, does not capture the effects changing over time, for instance business cycle or globalization. Authors rather provide a methodology including Hausman and Taylor instrumental variable estimation technique that allows a certain amount of cross-sectional variation but is also able to estimate time-varying effects. In their findings, Serlenga and Shin (2007) present an almost non-existing or little effect of currency unions on trade.

Relatively large differences in estimates of the Euro effect were subject to analysis in Havránek (2009), the author employs meta-analysis and meta-regression analysis to estimate the bias of the literature and then to find the statistically and economically relevant effect of European Monetary Union on trade. In his findings, Havránek presents a strong bias in existing literature and almost no true effect of the EMU. On the other hand, he estimates the true effect of other currency unions to be around 50%.

3 Data

When choosing an appropriate set of data to estimate the effect of the EMU on bilateral trade, we have taken under consideration two standpoints, the historical context of integration in Europe and the relevance of selected countries to our objective. In the former case, there are two most common approaches. First, examiners use as large span of time as possible in order to recognize the long-term trend of bilateral trade flow. Berger and Nitsch (2008) explain overall increasing tendency of trade flow in Europe as result of continuous process of political and economic integration. Using data from 1948 to 2003, they have come to a conclusion that EMU has been nothing but another step in a long-term effort to minimize trade barriers. Moreover, their analysis has led to a statistically insignificant coefficient of EMU variable. It is important to say that the number of Eurozone members has grown by more than 50 % since 2003. In addition, Flam and Nordstrom (2006) point out that the EMU effect can be distinguished from other aspects of economic integration with proper econometric analysis, for instance by including the time-varying EU dummy. Such a tool should be able to minimize the change in the impact of the EMU caused by the sample extension.

The second most popular approach accounts for datasets starting in the early 1990s. The construction of a common currency area began in 1992 by Maastricht Treaty and escalated in 1999 by introducing the Euro. In this paper, we will work with data from 1993 to 2015. By placing the base year immediately after the first legislature steps we hope to capture the impact the Euro might have on trade even before coming into force.

As previously mentioned, the relevance of included countries to different formats of our model played a significant role. Initial set-up consists of 35 countries of OECD and 11 large economies such as China, Russia, India etc. that are not members but have a strong position in international trade. Such a dataset should consist of enough information to allow for the estimation of trade diversion. This effect appears when nations change their patterns of trade from non-members of the Union to countries within the EMU after they adopt the common currency. The data on bilateral trade were taken from the IMFs Direction of Trade Statistics (DOTS). Due to Belgium and Luxemburg customs union, both states were treated as one subject with a shared output. Data on current GDP in dollars was taken from the World Bank WDI database. Information on bilateral distance were taken from CEPII's website. [5]Since our package of data contains mainly developed nations, we seek to obtain rather precise information as measurement errors should appear in minimal cases.

[5] $http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=6$

4 Methodology

4.1 Introduction to Gravity model analysis

The resemblance of Isaac Newton's Gravity equation and the Gravity model of international trade has its roots in strong economic intuition. Determinants such as size of two nations, or their mutual distance, were early on anticipated as one of the most recognizable variables in the evaluation of bilateral trade flow. However, for a respectful period of time, the Gravity equation of International Trade was lacking a theoretical foundation. Despite the crystal clear logic behind the formula, economists had trouble linking the formula to already existing economic principles. The irony of empirical analyses based on the non-physical Gravity model was that the models were actually providing efficient results in terms of goodness-of-fit. The method could also be applied to a wide range of topics from migration to trade policies. Without the proof of connection between the Gravity model and the economic theory, the veracity of results was, however, somewhat fragile.

The model was introduced as a tool to econometric analysis for the first time by Tinbergen (1962) in his seminal paper: "Shaping the World Economy". Since then, it took 17 years before Anderson (1979) managed to derive the equation from the standard Cobb-Douglas expenditure function $M_{ij} = b_i Y_j$. Here, M_{ij} represents consumption in country *j* of a good coming from country *i*; b_i is a share, or ratio of income spend on a good from country *i*; and finally *Y* stands for income in country *j*. The initial model required a number of restrictions and assumptions be imposed: constant elasticity of substitution, specialization of each country in producing its own unique good, non-existing trade costs, tradability of all goods. Assuming that the income in *country-i* is solely defined by total sales: $Y_i = s_i(\sum_j^n Y_j)$, Anderson (1979) was able to obtain the plainest version of the Gravity equation: $M_{ij} = \frac{Y_i Y_j}{\sum_j^n Y_j}$. Yet, this equation does not resemble the relationship as we know it today.

The more convenient solution brought B-T (2006). They started with a one-way expenditure share identity function:

$$p_{od} x_{od} = s_{od} E_d \tag{1}$$

where the total volume of export from country of origin-o to the country of destination-d on the left side is equal to the proportion of country-d expenditure controlled by the share variable. The last component naturally depends on relative prices and income levels. In order to explain the relationship, B-T (2006) use the Constant Elasticity of Substitution (CES) demand function and show:

$$share_{od} = (\frac{p_{od}}{p_d})^{1-\sigma} \tag{2}$$

where

$$p_d = (\sum_k^N n_k(p_{kd}^{1-\sigma}))^{1/1-\sigma} \quad \text{and} \quad \sigma > 1$$

Here p_{od}/p_d represents "real price" with a help from CES price index p_d. N stands for the number of nations and n_k for the number of types of goods. Due to poor disposability of data on prices, the authors were in need of substitution for more convenient determinants. This is the point where the formula becomes more complex from econometrical standpoint, as B-T (2006) include trade costs (θ_{od} and price-cost markup (μ) as factors defining the price of the imported good:

$$p_{od} = \mu p_o \theta \tag{3}$$

B-T (2006) then assume that all goods are traded, their variety is symmetric, and that μ is a parameter equal to one. The authors multiplied the initial expenditure share identity with n_o (the number of varieties of goods that country-o produces) and substitute (3) into (2). By applying the general equilibrium condition to equation (1) they were able to obtain following formula:

$$V_{od} = n_o(p_o\theta_{od})^{1-\sigma}\frac{E_d}{P_d^{1-\sigma}} \tag{4}$$

V_{od} denotes total bilateral trade between nations *o* and *d*. Solid data on prices of goods in the importing as well as exporting nation are the most difficult to collect. Therefore, B-T (2006) assume that p_o and wages adjust to conditions on domestic and foreign market, as all produced goods have to be sold. Total output of nation-o is then equal to sum of bilateral trade with all trading partners (domestic market included): $Y_o = \sum_{r=1}^N V_{od}$

By substituting the last relationship to the function of bilateral trade and solving it for $n_o p_o^{1-\sigma}$, B-T (2006) expressed:

$$n_o p_o^{1-\sigma} = \frac{Y_o}{\Omega_o}, \quad \text{where}$$
$$\Omega_o = \sum_{i=1}^N (\theta_{oi})^{1-\sigma}\frac{E_i}{p_d^{1-\sigma}}$$

When this expression is combined with formula (4), it is possible to obtain a Gravity equation with solid theory foundations in microeconomics:

$$V_{od} = \theta_{od}^{1-\sigma}(\frac{Y_o E_d}{\Omega_o P_d^{1-\sigma}})$$

The steps leading to the a formulation of the Gravity equation as we present it,are, of course, a major simplification of the detailed process described in B-T (2006) but for the sake of conciseness, we will mainly focus on the final formula. In order to make the resemblance with The Gravity equation in physics and their formula more obvious, B-T substitute GDPs for nation-o production output Y_o and nation-d expenditure determinant E_d. Also they present the variable *distance* as a determinant for bilateral trade costs:

$$\text{bilateral trade} = G\frac{Y_1 Y_2}{(dist_{12})^{\sigma-1}}$$

Here *G* is often called gravitational un-constant as such term as gravity is not present in trade. B-T rather explain *G* as:

$$G = \frac{1}{\Omega_i}\frac{1}{P_j^{1-\sigma}}$$

where Ω represents openness to trade.

At this point, the layout of the equation has been formulated to echo the "original" relationship from physics. From econometrical standpoint, however, more adjustments had to be made. First, the multiplicative form of the equation cannot be estimated by OLS, and therefore, the model has to be transformed into a log-log level. Second, barriers to trade nor other MRT represent more complex problem that is often troublesome. Significance of mutual distance as a main cause of high trade costs decreased while new sources were introduced. For instance, MRT in the Gravity equation take form of tariffs, permanently changing costs of transport, limited ability to communicate due to language differences or simply due to historical aversion between two nations. The elementary Gravity equation, suitable for econometric estimation could, therefore, be written:

$$ln(V_{ij}) = ln(Y_1 Y_2) + (1-\sigma)ln\Theta_{ij} + lnG + \epsilon_{ij}$$

Θ = multilateral resistance term; ϵ_{ij} = the disturbance with common properties.

4.2 Cross-section or Panel data

For econometric researchers, a decision about the character of their dataset is usually the first to come. For the Gravity model of international trade, this principle has become critical. Even though cross-sectional analysis has been used early on in studies on CUs, namely in Rose (2000), in recent years, estimation based on panel data has established as the more convenient and dominant approach. Bachetta et al. (2012) suggests that with time-series aspect in the panel data, analysts can employ tools such as Fixed Effects or Random Effects to take care of time country-pair specific variation. Panel data thus offer the possibility to solve the problem of time-fixed omitted variables on the general level.

Moreover, Serlenga and Shin (2007) argue that models based on cross-sectional datasets actually ignore patterns of trade related to time which ultimately leads to the biased estimate. In the exact words: "A country would export different amounts of the same product to two different countries, even if their GDPs are identical and they are equidistant from the exporter." In addition, Glick and Rose (2001) point out that policy makers and economists are rather interested in an effect that the adoption of the Euro has over time. The cross-sectional approach, therefore, may result in a misleading assumption of increased or decreased volume of trade among estimated countries. Meanwhile, this effect could have been caused by the time variant determinants such as political integration, globalization or business cycle.

4.3 Dependent Variable

Another catch that is hidden in the estimation of bilateral trade flow comes from the dependent variable. As common sense might suggest, the measure of trade would consists of volume of export and import. Unfortunately, living in an imperfect world, we have to address the discrepancies in the information collected. Given the fact that either participants of the trade deal are often motivated to manipulate reports of their shipments goods or mistakes in measurement appear, trade data contains information on four different measurements: export from country i to country j, import from i to j and vice versa.

Normally, averaging those four trade observations would create sufficient product, legitimate for estimation. As B-T (2006) imply, in the case of log-linear specification of the Gravity model, incorrect averaging of trade data may lead to its overestimation.

The problem is caused by σ, ratio of bilateral trade flow i.e. $V_{ij} = \sigma V_{ji}$ where *V* represents reported import and export from country *i* to country j and vice versa. Here, σ represents a coefficient which adjusts both variables to be equal. If the bilateral trade flow is averaged before taking the logarithm:

$ln[(V_{ij}V_{ji})/2]$ where this equal to: $lnV_{ij} + ln(1 - \sigma) - ln2$

What B-T (2006) suggest is to rather average the product after we take the logarithm:

$$\frac{1}{2}ln(V_{ij}V_{ji}) = \frac{1}{2}[lnV_{ij} + ln\sigma]$$

Taking the difference those two approaches, we obtain the error caused by wrong averaging:

$$error = ln(1 + \sigma) + \frac{ln\sigma}{2} - ln2 \qquad \sigma > 1$$

B-T(2006) refer to this error as a Silver Medal Mistake. The discrepancy becomes larger for a pair of countries with unbalanced trade flow i.e. one is dominantly importing country, while the other is export oriented. The error is always positive, hence the overall trade flow suffers from overestimation.

Alternative to using all four statistics of trade, is to include only one-way trade flow data e.g. export. This would eventually double the size of dataset, as every country pair would now appear twice. B-T (2006) write that since 1993, EU states are actually motivated via tax rebate to give correct reports on volume of export.

4.4 Zero Observation of Trade

It is a one of econometric principles that selecting the wrong sample of the data or ignoring certain patterns in the sample, i.e. outliers, missing observations etc., may result in inconsistent estimates. Since negative values are unlikely to be recorded in the dataset on trade, the issue comes with the zero trade observations. Complications caused by missing or non-existing values of trade could be summed up in two dimensions. 'First, it is the logarithmic character of the Gravity equation which would eventually drop out zero observations as the logarithm of zero is not defined. The second dimension is represented by the fact that observation could have been left out due to an error. When data is collected monthly, missing observations are more frequent and are less impactful. When data is collected annually, missing trade observation are more of an issue as they affect predictions of the model. On this topic, Bachetta et al. (2012) mention several occasions on which the wrong recording of trade may lead to incorrect estimates. Here, the authors propose three possible treatments. The reasons behind non-existing bilateral trade flow in the data may vary. Firms in two countries are simply not willing to trade with each other mainly because of long distances, high costs of transport or other bilateral barriers to trade. Second, there might be difficulties in recording data in less developed countries. This may eventually lead to imprecise measurements of traded good. Last, the volume of trade is simply too low and therefore was not recorded or was rounded down to zero. The last two effects are often eliminated by selecting of developed economies.

As stated above, Bachetta et al. (2012) offer three possible solutions to this problem with eventual limitations:

- adding a small constant (i.e. 1 dollar) to the zero observation
- dropping all observations with zeros
- using OLS estimation on levels

None of the three methodologies is universal and an econometrical intuition is needed in order to choose the most suitable approach. Adding the constant to the observation would be help in the case of small, but present trade flow. However there is no way how to clarify this assumption. Being wrong about those observations would inevitably lead to inconsistent predictions. On the other hand, dropping zero observations is not justifiable and standard econometric approach. If there is not other way around, those zeros have to be randomly distributed in the dataset, otherwise by deleting them, the truncated model would suffer from inconsistency. Last suggestion, the use of OLS on levels is not supported by theoretically founded gravity model estimation, as it is present in a multiplicative form. (Bachetta et al. 2012).

4.5 Poisson Pseudo-Maximum-Likelihood Estimator

Another popular method of estimation offering a solution to problem of zero observations is a Poisson pseudo-maximum-likelihood estimator. Santos Silva and Tenreyro (2006) add to the discussion on why is log-linear specification of Gravity equation often troublesome. Specifically, they show that error term defined as: $\epsilon_i = y_i - E[y_i|x]$ is source of heteroskedasticity, as conditional variance $V[y_i|x]$ often records large deviations, Santos Silva and Tenreyro (2006). [6] The authors then propose to use a the a PPML estimator that can be executed regardless of the distribution of data. They go even further and note that the PPML estimator could produce heteroskedastic-robust results given the fact that it puts less weight on outlying observations. To be able to follow this assumption, however, the models conditional variance needs be proportional to the conditional mean: $V[y_i|x] \propto E[y_i|x]$. Since this is unlikely to happen in trade data, robust standard errors should be reported along with PPML estimates. When it comes down to estimation, PPML method for Gravity equation is applied as any other standard Poisson regression, its employment thus mainly requires knowledge of a statistical software.

In addition, recent papers, focusing on the problem of zero observation, suggest the use of zero-inflated negative binomial estimator, (Burger et al. (2009). In many cases, distribution of data on bilateral trade shows an excessive appearance of zeros over other values. Hence, employing ZI-NB estimator, designed for this purpose, would produce more efficient estimates than PPML. Unfortunately, to the best of our knowledge, theoretical support for panel estimation of ZI-NB regression does not exist at appropriate specification for panel data in statistical softwares Stata, nor R.

[6] Santos Silva and Tenreyro (2006) argue that for $E[y_i|x]$ approaching zero, probability of y_i having positive values also limits to 0, hence also $V[y_i|x]$ takes proportionaly small value. The same analogy works for large values of y_i

4.6 Endogeneity and Multilateral Resistance

4.6.1 EMU and the reverse causality

In this chapter, we will address one of the most challenging problems in the Gravity model analysis - endogeneity. Countries forming trade and monetary unions are typically seeking to foster already existing partnership with its economic ally. Intuitively, bilateral economic agreements are conducted with an intention to build on existing, significant exchange of goods with a motivation to reduce its barriers and consequently to increase the trade. In other words, it is likely that nations form currency union in order to improve the trade line, not to create a new one. Bachetta et al. (2012) noted that this motivation behind currency unions is important as it carries information on why these countries started to be trade partners in the first place. Intense economic connection among two nations may be a result of a spectrum of reasons. To mention one, we might look at the long-existing cultural sympathy between Canada and European nations, such as France. This bond has most likely its roots in the colonisation time and has been recently affirmed by The Comprehensive Economic and Trade Agreement. On the other hand, economic isolation of Israel in the Middle East is an example of cultural-political aversion that led the nation into the trade vacuum with its neighbours. These variables form a composite structure of trade determinants that are however often difficult to capture with standard economic tools. On the other hand, ignoring the historical context of trade would necessarily lead to the omitted variable bias and subsequently to the faulty estimates of the unions.

4.6.2 Time-Invariant Bias

This brings us to the problem of time-invariant effects. As already mentioned, time-fixed exogeneity may take a form of country-specific determinant as well as patterns common between pairs of countries. Some relationships can be expressed by standard economic determinants or be substituted with proxies. Others, however, remain to difficult to observe. Because of this complexity, methods of estimation have changed from attempts including as many variables as possible (i.e. mutual distance, shared border, landlock dummy etc.) to more general approaches. Yet, correct specification of the Gravity model is still subject to theoretical disputes and researches use various methods to eliminate cross-sectional endogeneity. Glick and Rose (2001) as well as Micco et al. (2003) used a method of two-way country-pair fixed effects that diminish part of the cross-sectional relations between the pair of nations. B-T (2006) suggest introduction of country-pair dummies to standard pooled OLS regression. These dummies are taking the value of one for a pair of countries throughout the whole time series of observation e.g. the case of Germany and France, the dummies would form a column of ones for all observed years. Beside the option of country-pair dummies, B-T (2006) also propose to estimate only unilateral flow of trade. This step would allow to use nation-specific dummies which equal one for any observation concerning particular nation. B-T (2006) refer to time-invariant bias as Golden Medal Bias that has been main reason of inaccurate predictions made by Gravity model analysis. In the cross-sectional estimation, both nation and country-pair dummies have the same ability to correct significant portion of the bias. However, the advantage of country-pair approach lies in compatibility with the panel data, as method of country-pair fixed-effects can be used to eliminate the bias.

4.6.3 Time-Variant Bias

Having an EMU dummy as a variable of interest introduces necessarily an issue of time-dependent variation. The economic integration of Europe has been an ongoing process that can be traced back to the Marshall Plan in 1948. Ignoring the growth in the volume of intra-EU trade during the pre-Euro era might result in a serious bias of the model. Berger and Nitsch (2008) pay attention to this phenomenon in the paper on the effect of the Euro in a historical context. The authors extend their dataset backwards to the late 40s and take three different approaches: Pooled OLS, fixed-effect estimation with annual EMU dummies and an approach of separate estimation for each year.

According to their results, both methods provided similar results of the EMU determinant. Another, more general and basic way of treating continuous integration is to a include linear time trend. Here we assume that integration and trade had a linear tendency which should be captured by the trend. Berger and Nitsch (2008) went further and constructed an index of European integration starting in 1948 ending in 2003. In a computation of the index, the authors combine two computational methods to obtain the final index. The first method involves a percentage of intra-European trade from which they obtain the index for the third quarter of the 20th century. The second approach is linked to the Ben-David's (1993) tariff index. As a result, Berger and Nitsch (2008) obtained evolution of European economic integration which approximately followed a linear trend. The only exception appears to be during the 1980s when the index remained constant.

Bachetta et al. (2014) argue however, that such a trend does not recognize a year-specific events that might influence the trade flow. An economic crisis, monetary interventions and other effects will not be accounted for when using the Time trend variable. Here, the authors suggest using time specific dummies that are equal to one for each year and zero otherwise. Authors, however, do not provide a hint as to which approach is more convenient and effective.

4.7 Linear Approximation of MRT

Previous subsections break down the challenges of trade flow analysis into separated tasks of time variant and time-invariant exogeneity. From there, convenient and standard econometric methods can be used to address the issues of omitted variable bias. Baier and Bergstrand (2009) show, however, that different less conformed method of managing MRT can be employed in order to minimize endogeneity. The authors first point out theoretical drawbacks of fixed effects (FE) and non-linear least squares (NLS) [7] estimation. That is, the difficulty to estimate size of MRT and the fact that the bilateral trade flow of two nations is related to the mutual MRT of those nations relative to MRT with other potential partners. In other words, countries choose to trade if their MRT are lower than MRT with other countries. To address this issue, Baier and Bergstrand (2009) propose first-order log-linear Taylor-series expansion of the MRT in the Anderson and van Wincoop (2003) system of price equations. As stated above, the prices of domestic and foreign goods are on important determinant of a bilateral trade flow and also source of endogeneity in the Gravity equation. The relationship of prices with other trade variable could be summed up as following:

$$P_i = [\sum_{j=1}^{N}(\Theta_j/t_{ij}^{\sigma-1}P_j^{1-\sigma}]^{1/(1-\sigma)}$$
$$P_j = [\sum_{i=1}^{N}(\Theta_i/t_{ij}^{\sigma-1}P_i^{1-\sigma}]^{1/(1-\sigma)}$$

Both terms are resemblant to the B-T (2006) price equations described above, as they have also been derived from CES price index. Here, t_{ij} represents bilateral trade barriers, Θ is a product of countries *j* and *i* outputs: Y_iY_j/Y^T where Y^T is a total output of all countries. Again, the general term of bilateral trade barriers is difficult to obtain in econometric analysis, hence, in existing literature, researchers tend to substitute with bilateral distance (DIS_{ij}) and membership in a trade-liberalizing union (EIA), Baier and Bergstrand (2009). With the help of the Gravity equation from Anderson and van Wincoop (2003), we can better understand the problem of omitted prices from the model:

$$ln[X_{ij}/(GDP_iGDP_j)] = a_0 + a_jlnDIS_{ij} + a_2lnEIA_{ij} - lnP_i^{1-\sigma} - lnP_j^{1-\sigma} + \epsilon_{ij}$$

[7] method described in Anderson and van Wincoop (2003)

Ignoring the prices in the equation, predictions of other variables would lead to biased results. On the other hand, Taylor expansion of the first order of equations (1) and (2) offers not only the opportunity to include logarithmic form of prices in the model but also embodies exogenous MRT in relative terms, as we described above.

After performing the log-linear Taylor expansion to the price equations, Baier and Bergstrand (2003) manage to obtain:

$$lnP_i^{1-\sigma} = -lnP_i^{1-\sigma} = (\sigma - 1)[\sum_{i=1}^{N} \Theta_j lnt_{ij} - (1/2)\sum_{i=1}^{N}\sum_{j=1}^{N} \Theta_i\Theta_j lnt_{ij}]$$
$$lnP_j^{1-\sigma} = -lnP_j^{1-\sigma} = (\sigma - 1)[\sum_{j=1}^{N} \Theta_i lnt_{ji} - (1/2)\sum_{i=1}^{N}\sum_{j=1}^{N} \Theta_i\Theta_j lnt_{ij}]$$

Equations are analogous to each other and therefore the logic is the same for both. The first expression on the right-hand side is GDP-share-weighted average of gross trade costs that country-j has to face when trading with all partners. If this component is large, country-j has high MRT relative to bilateral trade costs with country-i and the trade flow between *i* and *j* will be also high. The second expression denotes so called "world resistance". This component captures the evolvement of international market as a whole i.e. if technological progress or other aspects lowering the world trade costs, it will be projected in its size. Hence, as Baier and Berstrand (2009) noted, the Taylor series expansion helps to express bilateral trade flow relative to multilateral and world trade costs.

In econometrical practice, a few adjustments have to be made to the price terms expanded by Taylor series, before they can be estimated in the standard Gravity equation. Baier and Berstrand (2009) explain that rather than GDP-share weights ($\Theta_j\Theta_i$) equal weights (1/N) should be used for centering the Taylor-series. In addition, they replace theoretically founded variable of bilateral trade costs t_{ij} with DIS_{ij} and dummy $BORDER_{ij}$ which is in a contradictory relationship to variable EIA_{ij} as $BORDER_{ij} = 1 - EIA_{ij}$. This is done to unify signs of coefficients of $DIST_{ij}$ and $BORDER_{ij}$ as authors both want them to be negative. When all inserted into the equation (3), Baier and Bergstrand (2009) describe the final Gravity equation with linearly approximated MRT in a form:

$$lnX_{ij} = \beta_o + lnGDP_i + lnGDP_j - \rho(\sigma-1)lnDIS_{ij} - \rho(\sigma-1)BORDER_{ij}$$
$$+\rho(\sigma-1)MWRDISij + \rho(\sigma-1)MWRBORDERij + \epsilon_{ij}$$

where

$$MWRDIST_{ij} = [\frac{1}{N}\sum_{i=1}^{N} lnDIST_{ij} + \frac{1}{N}\sum_{j=1}^{N} lnDIST_{ij} - \frac{1}{N^2}\sum_{i=1}^{N}\sum_{j=1}^{N} lnDIST_{ij}]$$

and

$$MWRBORDER_{ij} =$$
$$[\frac{1}{N}\sum_{i=1}^{N} BORDER_{ij} + \frac{1}{N}\sum_{j=1}^{N} BORDER_{ij} - \frac{1}{N^2}\sum_{i=1}^{N}\sum_{j=1}^{N} BORDER_{ij}]$$

4.8 Method of Estimation

In the empirical analysis, we will use an unbalanced panel dataset of a maximum of 43,516 observations. Our intention will be to obtain an estimate on how EMU membership has impacted inner-EMU trade flow and trade with countries outside the Union. Four different specifications of the augmented Gravity model will be estimated in order to gain the strongest explanation power of the effect. The first set-up will be estimated with standard method of fixed-effects (FE). For this purpose, general version of the Gravity equation will take a form:

$$ln(X_{ijt}) = \beta_0 + \beta_1 \sum_{s=1}^{k} C_{ijst} + \beta_2 EMU_t + \beta_3 EU + \gamma_{ij} + \theta_t + \epsilon_{ijt}$$

Here, $ln(X_{ijt}$ is a dependent variable denoting bilateral trade. As it is a common practice, we will include only measures of export from country-i to country-j. With this approach, we hope to avoid committing Silver Medal Mistake, as it is described in B-T (2006). C_ijt is a group of k country-specific determinants. We will include the logarithms of current GDPs of both nations in dollars. This variable is used as a standard proxy for the sizes of both countries.EMU_t is our desired variable indicating whether both nations are members of a currency union; EU stands for membership of both countries in the EU; γ_{ij} is a country-pair specific component representing any determinants influencing bilateral trade of two countries that does not change over time. θ is a time specific effect. We will address this effect by employing either Year dummies or linear time Trend; ϵ_{ijt} denotes the error terms that we assume to be i.i.d with zero mean and constant variance across all dimensions.

The second specification of the Gravity equation will be conducted as proposed by Baier and Bersgtrand (2009) with further notation BB-OLS. A more universal approach of linear approximation will be taken to the problem of ednogeneity in the estimation of MRT. Here, the Gravity equation will look as following:

$$\begin{aligned} lnX_{ijt} = \beta_o + lnGDP_{it} + lnGDP_{jt} - \beta_1 lnDIS_{ij} - \beta_2 nonEMU_{ij} \\ + \beta_3 MWRDISij + \beta_4 MWRnonEMUij + \epsilon_{ijt} \end{aligned}$$

Once again, $ln(X_{ijt})$ will be a variable denoting the value of export. Part of the MR term from the original Baier and Bergstrand's (2009) equation - $BORDER_{ij}$ will be replaced with $nonEMU_t$ in order to adjust the equation to fit our setting. In addition, original setting of the trade world modeled by Baier and Bergstrand (2009) was consisting of $n \geq 2$ countries and *N/2* regions where *N* was used as a weight of the MRT. In our estimate, we used disaggregated data on country-country level, we will take *N* as a number of countries and as our weight of MR term. Different from our first estimation that uses fixed-effects (FE), Baier and Bergstrand (2009) suggest to carry out standard pooled OLS.

The third composition of our model will be focused on the issue of zero values of trade. In previous analyses, we have truncated models from all observations recorded with zero or missing value. As already mentioned, even such observations may carry a valuable information about the trade flow between two countries e.g. zero trade and missing value do not necessarily mean the same, as the latter may be a product of measurement error while the former might be a case of non-existing trade. Another problem arises when the distribution of nulls follows a certain pattern, truncated regression then would suffer from inconsistency in its predictions. Hence, we will employ Poisson pseudo-maximum-likelihood (PPML) estimator as it is explained in Santos Silva and Tenreyro (2006). Even though PPML estimator is, in common practice, used for count data, authors explain that this assumption is not necessary in the case of the Gravity equation taking following form:

$$X_{ijt} = lnGDP_{it} + lnGDP_{jt} + EMU_t + EU_t + \gamma_t + \epsilon_{ijt}$$

This set-up is almost identical to the first one except of non-logarithmic variable of export X_{ijt}. γ_t stands again for the time effect which will be covered with a *Year dummy*.

Last but not least, we will repeat the PPML and FE estimation to find out whether Eurozone affects trade diversion. *EMU1* will be an additional dummy included in the Gravity equation that equals 1 if one of the pair of countries is a member of the Monetary Union. Depending on the sign and significance of *EMU1* , we will be able to distinguish whether EMU creates trade diversion or not. Having a positive sign, this variable would indicate that the Union has been promoting trade flow between its members and the rest of the world.

5 Empirical Results

5.1 Eurozone

Before we start interpreting results, we take a closer look at the trade patterns appearing in the data. **Figure 1.** depicts total nominal value[8] of world trade flow (EMU countries included) over the years 1993 to 2015. Since 1993, volume of trade recorder overall positive change. The increase was the most notable between 2000 and 2008 when the trade volume rose sharply and more than doubled the initial value up to approximately 9 trillion dollars. In 2009, international market went through major negative shocks as a consequence of financial crisis. Volume of trade, however, managed to recover to its original value within 2 years.
Patterns of trade flow look quite different when we extract intra-Eurozone trade. **Figure 2.** shows progression of strictly inner EMU trade and the development of trade among rest of the world. In contrasts to how world markets rose, EMU countries experienced gradual increase in a trade until 2008 and then continued to fluctuate through 2015. Even though nominal value of goods exchanged among EMU nations doubled, the market's performance was rather poor in comparison to the expansion of trade outside the EMU.

Whether this outcome was somehow related to the adoption of a common currency was subject to our estimation with several specifications of the Gravity model. **Table 1.** contains the results of standard FE method, OLS regression with linear approximation of MRT as proposed by Baier and Bergstrand (2009) and conditional fixed-effects Poisson regression. All three models used 43,516 observations, FE and BB-OLS then eventually dropped 1048 zero values. While the explanatory power of the PPML cannot be tested alone, FE and OLS offer goodness-of-fit: 0.640 and 0.824, respectively.[9]

The coefficient of EMU, variable of our interest, differs for each regression. Fixed-effects produced negative, insignificant coefficient of -0,042, [10] PPLM estimator of EMU coefficient was estimated to be positive and significant at 5% level with value of 0,099. Given the non-logarithmic character of Poisson regression and the fact that it is maximum-likelihood estimator, the coefficient cannot be translated directly to elasticity. However, opposite sign to FE estimator and the

[8]recorded numbers are in millions of dollars

[9]We find such explanatory power acceptable, given the context of other Gravity model analyses: Micco et al. (2003)=0.45; Berger and Nitsch (2008)= 0.49 but also Baldwin and Taglioni (2006)=1. Authors obtained such explanatory model after including both Pair and Year dummies. This results seems to be fairly optimistic given the recent discussion about significance of time variant exogeneity, rather than time invariant, Berger and Nitsch (2008), Serlenga and Shin (2007)

[10]log-linear character of the Gravity model implies that elasticities cannot be interpreted directly but have to be transformed as showed in Micco et al. (2003): $elasticity = exp(coefficient) - 1)$

statistical significants are notable characteristics. In the case of BB-OLS, variable *nonEMU*, formed in an inverse relationship to *EMU*, has a positive, insignificant coefficient of 0.058. The effect of Eurozone estimated by OLS and FE is, therefore, different by only 1.6 percentage points. Unorthodox, negative effect of EMU on bilateral trade can be found in two existing studies. Serlenga and Shin (2007) used OLS common correlated effect pooled Hausman-Taylor (CCEP-HT) method to obtain insignificant prediction of EMU accounting for -0.0003. Their method allowed more careful treatment time-changing effects which eventually resulted in the negative sign and insignificance of the EMU variable. B-T (2006) also presented non-positive results of Eurozone effect. Similarly to Serlenga and Shin (2007) that happened when B-T (2006) better accounted for time effects with time-varying Nation dummies. As a result, the magnitude of the EMU coefficient dropped from 0.09 to -0.09. To understand why the results of FE and OLS methods are different from the results in the Poisson regression in the sign and magnitude, we look at the dispersion of zero values of trade in our data.

Figure 3. shows distribution of zero observation by years. Here, we can see that nulls appear with highest frequency in the early 90s and slowly become scarce towards the beginning of the millennium. Since country-pairs with zero trade observations opened bilateral exchange of goods approximately at the same time the Euro was introduced, such trend might have positive impact on the coefficient of the EMU.

Given the fact that EU dummy in BB-OLS specification of the Gravity equation is included in the approximated MRT, the coefficient of the variable denoting membership in the European Union can be directly estimated only by FE and PPML. Similarly to the EMU, the EU has a larger coefficient in the case of PPML estimation: 0.271 and 0.176 in the case of FE (both strongly significant). Even though the majority of nations have already been members of the EU in 1993, the Union also significantly grew in size after 2000. Hence, we may see the same effect of zero trade observations in interaction with EU dummy, as we did with EMU. Similarly to previous literature, FE and BB-OLS estimated the variable denoting membership in the European community with relatively large coefficient in comparison to the one of EMU. This might be given by the fact that EU itself reduces significant portion of trade barriers e.g. tariffs, restrictions on movement of goods, money and labour.

Elasticities of GDPs of exporting and importing countries are the most influential determinants in our analyses. FE regression estimated the coefficient of GDP of an importer to be 0.927 with significance level at 1%, coefficient of the exporting country was estimated to 0.891, also strongly significant. Similar relationship can be seen in the case of PPML estimation where exporter's and importer's GDPs are predicted as; 0.727 and 0.729, respectively. However, we found opposite relationship in BB-OLS estimation. Here, exporter's GDP affects trade flow slightly more with coefficient of 1.022 comparing to 0.837 of the importer's GDP.

The approach to time-changing effects in FE and PPML models is similar in both estimated models. Each time, we have included year specific effects and linear time trend. The former variable consists of a set of dummies (not reported in our summary) for each measured year. Such tool is meant to pick up any year-specific shocks. Variable *Trend*, on the other hand, was included to take care of long-lasting, continuous effects such as globalization or natural convergence of european market. *Trend* was estimated by standard FE as strongly significant with coefficient 0.101, PPML made smaller prediction of 0.013 with significance level of 6%. Variable trend was not part of BB-OLS estimation.

5.2 Trade Diversion

As previously mentioned, the world market has recorded sharp overall increase in the last 23 years. It would be quite surprising if EMU countries did not participate in this success. **Figure 4.** describes development of intra-Eurozone trade versus trade of EMU countries with nations outside of the Union. Starting with a higher nominal value, trade flow leaving the EMU rapidly expanded soon after 2000 and tripled the initial margin. To what extent Euro helped to this improvement was subject to estimation in **Table 2**. Here, the dummy *EMU1* takes value 1 when either one of two trading partners is a member of the currency union. FE estimated EMU1 at 2% of significance level and with the size of the effect being 0.050. The coefficient suggests that formation of the monetary union did have a positive impact of 5% on the bilateral trade flow of EMU nations and rest of the world. This result is in line with estimations of Micco et al. (2003) who found strongly significant effect of 0.086. After adding EMU1 in the Gravity equation, the coefficient of the EMU recorded moderate increase to -0.003, but remaind statistically irrelevant. Even though, the effect rose by 4 percentage points and is now almost zero, the negative sign of the variable remained. Similar growth was measured with PPML estimator. Here, the dummy EMU1 increased up to 0.159 with a strong statistical significance. As well as FE, PPML regression measured an effect of trade creation to be positive and significant with coefficient of 0.113.

Clearly both models found evidence of trade creation where adoption of the Euro played a positive and statistically significant part. The economic relevance of the effect is, however, different for each method. FE estimator reported a coefficient with a moderate economic meaning of 5% while the PPML regression estimated the effect to be economically more relevant. Given the distribution of zeros in the data, we suspect the PPML coefficient to be slightly exaggerated.

6 Conclusion

The aim of this thesis was to deliver the latest and relevant estimate of the Euro effect on bilateral trade. The theoretical section of the thesis was dedicated to the introduction of the Gravity model analysis. Here, we described a theoretical background of the model and gave an overview on the history. In this section, we also presented the most common obstacles that appear in the estimation of bilateral trade and provided various solutions to them. Further, we explained the method of the PPML estimator and the Baier and Bergstrand's (2009) specification of OLS (BB-OLS) that were later used in the analysis.
The empirical part of the paper consists of detailed description of applied Gravity equation. We used 6 years of pre-Euro period and 16 years of the Euro period on the sample of 44 matured economies. In the empirical analysis, we constructed a structural Gravity equation in three different modifications to solve the problem of unobserved effects and zero values of trade. The FE method and the BB-OLS were included mainly for their different approach to the estimation of the Multilateral Resistance Term, while the PPML estimator was used to account for missing observations in the dataset. Finally, by including additional variable EMU1, denoting trade with non-EMU countries, we adjusted the model to measure the effect of the trade diversion.

The results of FE and BB-OLS provided evidence of statistically insignificant, negative effect of common European currency on trade. Both models predicted coefficients ranging between -0.06 to -0.04. Under the same data conditions, PPML estimator produced significant and positive EMU estimate of 0.09. However, after inspecting presence of zero values of trade, we found that their distribution was leaning heavily toward the beginning of the examination period and hence might have an impact on the size of the EMU coefficient. In all three cases, we found the economic relevance of the effect to be negligible. The last method of estimation evaluating the trade diversion, we observed no evidence of supply switching among EMU members and rest of the world. In addition, the adoption of the Euro had positive and statistically significant impact of 0.05-0.10 on bilateral trade with non-EMU countries. Hence, we cannot reject our second hypothesis. Even though the results of the model do not confirm the hypothesis of positive and statistically significant effect of the Eurozone, similar predictions could be found in other literature.

Last but not least, we found limitations of our methodology in the treatment of time-varying effects appearing in the analysis. Using and coutry-pair fixed effects, year specific dummies as well as time trend, we believe, that we have accounted for majority of unobserved effects. Yet, recent study of Serlenga and Shin (2013) shows that more advanced approach might be needed to account for time-changing exogeneity.

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Tables and Figures

Figure 1.

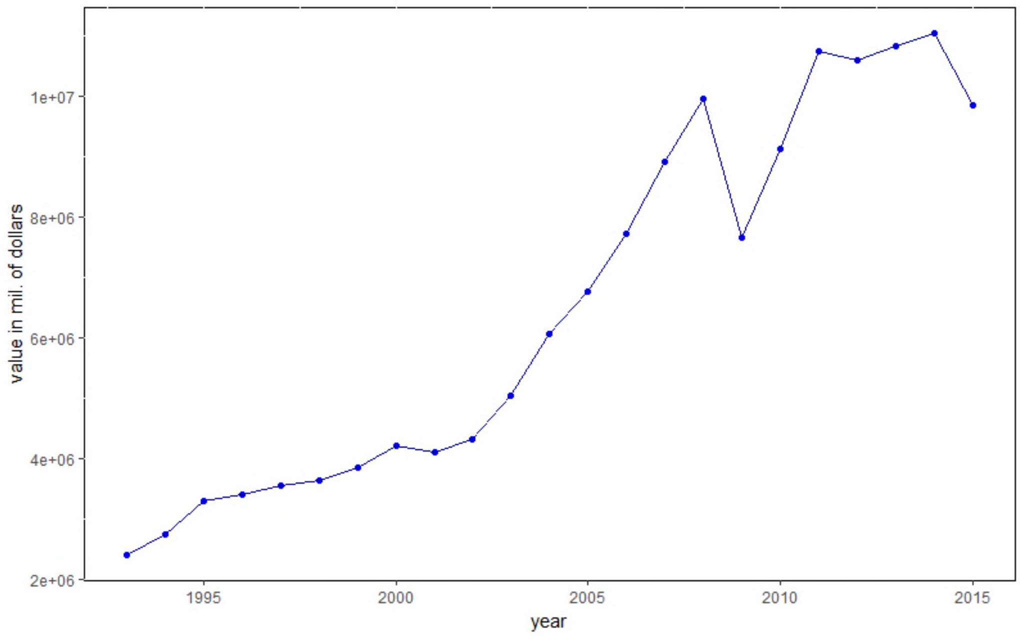

Figure 1: **Total World Trade Flow**

Figure 2.

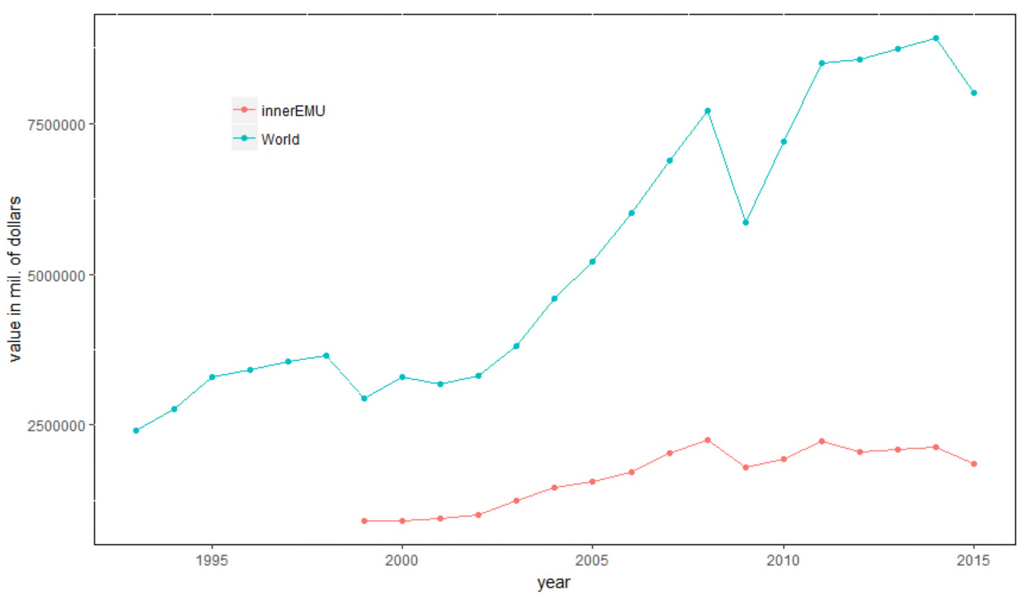

Figure 2: **Inner-EMU trade flow versus rest of the world**

Table 1.

	FE	Baier & Bergstrand - OLS	PPLM
Regressand:	log(export)	log(export)	export
EMU	-0.042		0.099*
EU	0.174***		0.271**
$Trend$	0.101*		
$logGDPi$	0.895***	1.046***	0.727***
$logGDPj$	0.927***	0.862***	0.729***
$nonEUROZONE$		0.059	
$logDISij$		-1.440***	
$MWRDISij$		0.0001***	
$MWRnonEUROZONEij$		-0.501***	
Constant		-6.877***	
Time dummies	Yes	Yes	Yes
Country-pairs	Yes	No	Yes
Observations	43,516	43,516	42,474
R^2	0.643	0.824	
Adjusted R^2	0.626	0.824	
F Statistic	411.03^{***}	688.11^{***}	

Table 1: **Euro Effect**

Summary of standard fixed-effects (FE), Poisson Pseudo-Maximum-Likelihood estimator and OLS estimation of Baier and Bergstrand (2009) specification of the Gravity equation. Statistical significance was calculated with robust standard errors. Statistics are as following: $^{\bullet}$ 0.1; * 0.5; ** 0.01; *** 0.001

Figure 3.

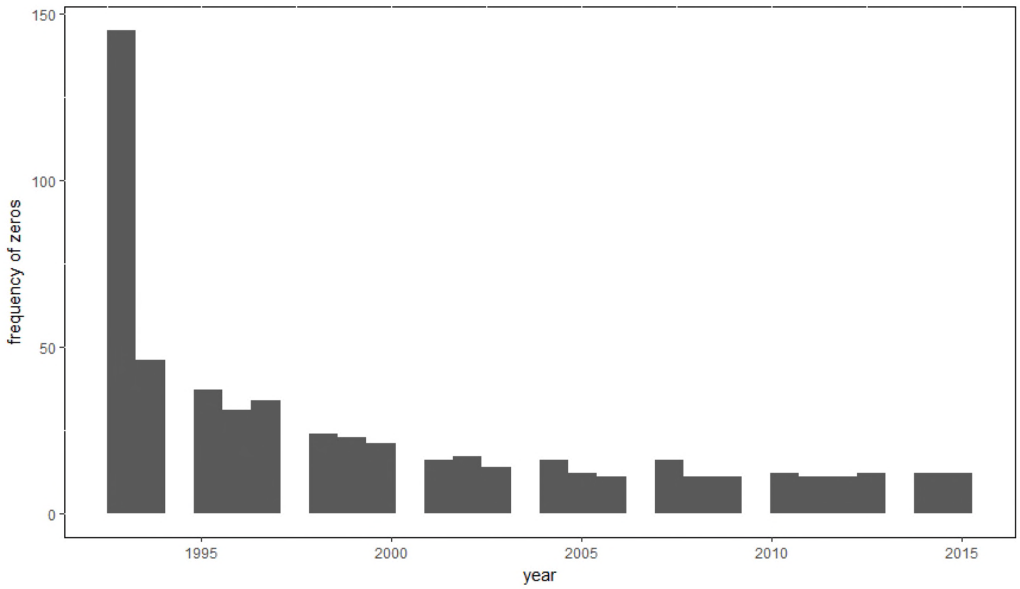

Figure 3: **Distribution of Zero Observations in the Data**

Figure 4.

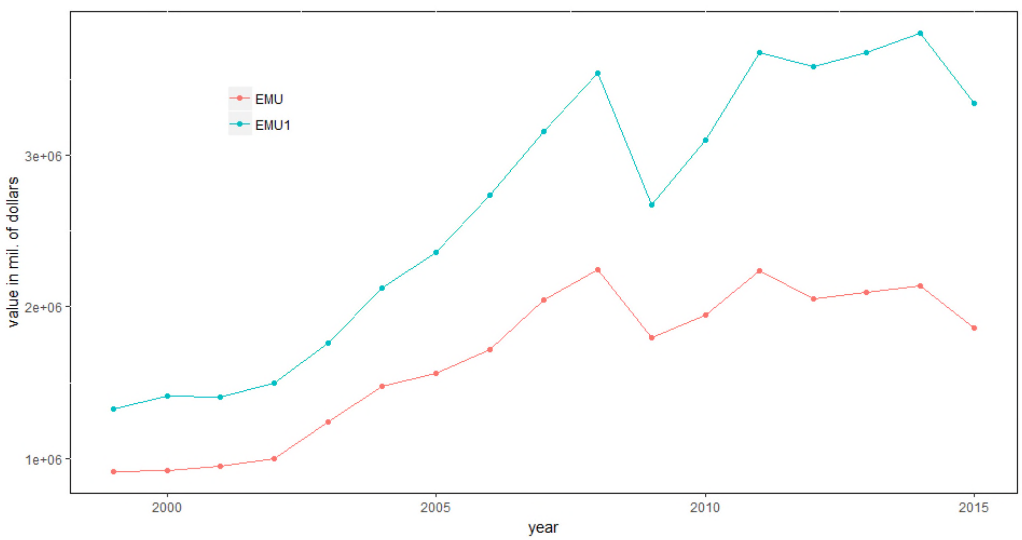

Figure 4: **EMU versus EMU1**

Table 2.

	FE	PPLM
Regressand:	log(export)	export
$Eurozone$	-0.003	0.159*
EU	0.166***	0.257 ***
$Eurozone1$	0.050*	0.113**
$logGDPi$	0.900***	0.734***
$logGDPj$	0.932***	0.736***
$Trend$	0.101	0.015*
Time dummies	Yes	Yes
Country-pairs	Yes	Yes
Observations	43,516	43,516
R^2	0.640	
Adjusted R^2	0.623	
F Statistic	401.73^{***}	

Table 2: **Trade Diversion**

Summary of standard fixed-effects (FE) regression and Poisson pseudo-maximum-likelihood estimator.

Statistical significance was calculated with robust standard errors.

Statistics are as following: $^{\bullet}$ 0.1; * 0.5; ** 0.01; *** 0.001

Appendix

List of Countries

1. Australia
2. Austria
3. Benelux
4. Brazil
5. Bulgaria
6. Canada
7. Croatia
8. Cyprus
9. Czech Republic
10. Denmark
11. Estonia
12. Finland
13. France
14. Germany
15. Greece
16. Hungary
17. China
18. Chile
19. Iceland
20. India
21. Ireland
22. Italy
23. Israel
24. Japan
25. Republic of Korea
26. Latvia
27. Lithuania
28. Malta
29. Mexico
30. Netherland
31. Norway
32. New Zealand
33. Poland
34. Portugal
35. Romania
36. Russian Federation
37. Slovak Republic
38. Slovenia
39. Spain
40. Sweden
41. Switzerland
42. Turkey
43. United Kingdom
44. United States of America