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Faculty of Social Sciences
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BACHELOR THESIS

The Effect of Distance on International Trade: A Meta-Analysis

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Declaration of Authorship

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Prague, May 15, 2015

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Abstract

Over the time the effect of distance has became an essential component for understanding international trade flows. The main goal of my bachelor thesis is to collect specific data from each study concerning the distance effect and design meta-analysis based on this dataset. I build my work on the data published by Anne-Celia Disdier and Keith Head (The puzzling persistence of the distance effect on bilateral trade) that were relevant in 2006. I examine 1470 estimates reported in 130 studies. Since the previous meta-analysis does not include all required methods to reveal the publication bias, I focus mainly on this issue by incorporating all the appropriate tests. Finally, I disprove the argument that distance effects on bilateral trade decline over time and I explain the presence of heterogeneity among the estimates.

JEL Classification	C81, C83, F10, F15
Keywords	meta-analysis, gravity equation, distance effect, international trade

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Abstrakt

Vliv vzdálenosti se postupem času stal jednou z nejdůležitejích aspektů vedoucích k porozumění mezinárodního obchodu. Hlavním cílem mé bakalářské práce je sběr dat z jednotlivých studií zabývajících se vlivem vzdálenosti na mezinárodní obchod a vytvořit meta-analýzu založenou na těchto materiálech. Celá práce je založena na datech, které mi poskytli Anne-Celia Disdier a Keith Head, obsažených v jejich původní meta-analýze vydané v roce 2006. Celkově jsem nasbírala 1470 odhadů ze 130 různých studií. Jelikož původní meta-analýza neobsahuje vhodné testy, abychom určili publikační vychýlení, rozšířila jsem mou studii o dane testy. Na závěr se věnuji vyvrácení tvrzení, že vliv vzdálenosti na bilaterální obchod s postupem času klesá, kromě toho poskytuji vysvětlení heterogenity jednotlivých odhadů.

Klasifikace JEL C81, C83, F10, F15
Klíčová slova metaanalýza, mezinárodní obchod, gravitační zákon, vzdálenost

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Acronyms

AER American economic review

FAT Funnel asymmetry test

FDI Foreign direct investment

FTA Free trade agreement

GDP Gross domestic product

JIE Journal of international economics

MRA Meta-regression analysis

OLS Ordinary least squares

OECD Organisation for Economic Co-operation and Development

PPML Poisson pseudo-maximum likelihood

REStat The review of economics and statistics

Bachelor Thesis Proposal

Author	Anna Tlustá
Supervisor	PhDr. Tomáš Havránek, Ph.D.
Proposed topic	The Effect of Distance on International Trade: A Meta-Analysis

Meta-analysis is an econometric method that is used to summarize and evaluate the results of previous studies in order to correct these conclusions from publication selection and other distorting and deflecting effects.

The main goal of my bachelor work is to collect specific data from individual studies concerning The Effect of Distance on International Trade and design meta-analysis based on these materials. Firstly, I will introduce the main economic theories related to the issue of international trade. I will characterize the principal terms used in this area of trade and I will try to define the crucial differences among individual theoretical models, which examine the effect of distance on International trade. I will state the basic variables that I will use in my study based on this theoretical principle and available data.

After that, I will analyse particular models and processes of meta-analysis. I will primarily focus on rather progressive methods and processes of meta-analysis, publication bias, that haven't been used in previous studies.

I would also aim to highlight the questions that are closely connected with the issue such as sampling error - Distance coefficients are usually based on a sample of countries and years or heterogeneity- differences in statistical technique cause differences in estimates. I will build my work on the meta-analysis data published by Anne-Celia Disdier and Keith Head (The puzzling persistence of the distance effect on bilateral trade) that were relevant in 2008. My intention is to update the results of this study by using new methods and current data.

Outline

1. Introduction
2. Reasons for Meta-Analysis
3. The Distance Effects Data Set
4. Why distance effects differ
5. Results for the Meta-Analysis regression
6. Publication bias
7. Conclusion

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Author Supervisor

Chapter 1

Introduction

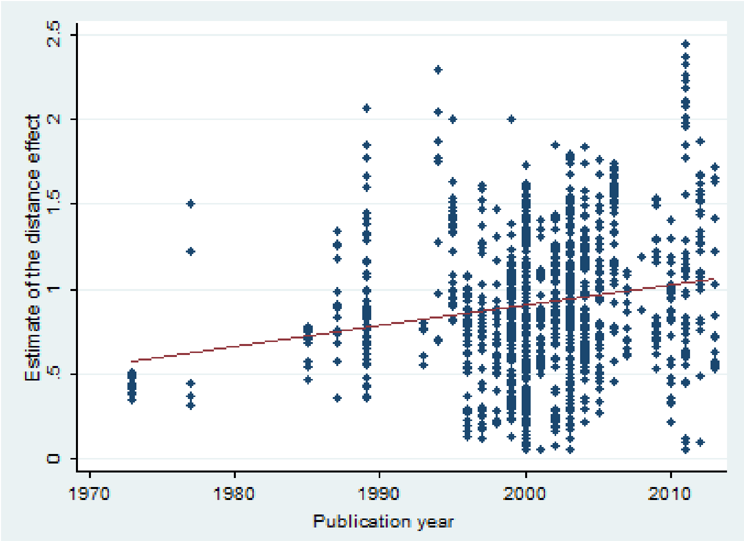
The effect of distance has become the one of the essential elements that explain the international trade flows. Recent studies that have focused on this issue have attached a big importance to define all possible factors that could clarify this connection. These various factors might be ranking from the trade cost to cultural diversity, such as different maternal language or religion. Anderson & Van Wincoop (2001), moreover, estimated that transport or trade costs have affected international trade more than production costs. For this reason these costs are increasing in distance.

In the last twenty years the finding that distance effect influence trade has grown from not being recognized by most of the economists to be regarded as the key factor explaining trade flows. This progress has been noticed also thanks to technological development that contrarily decreases the impact of trade cost. Overman *et al.* (2001) observed that goods price equalization does not raise trade costs and hence it also prevents the factor price equalization from appearing. Furthermore, countries that are remote from markets tend to have lower incomes and heavy going to entice independent manufacture.

The usual way how to estimate the effect of distance on the international trade is the application of the gravity model. The authors of particular studies prefer this model mainly due to the simple usage and its significant power to explain the flows. The gravity equation describes international trade as directly proportional to the product of the incomes and inversely proportional to the distance between two countries. Results of the gravity equation generally refer to an increase in the elasticity of trade to distance (Berthelon & Freund 2008).

Figure 1.1 presents the reported distance effect and the use of gravity equation for its determination in time. The resultant distance effects do not con-

Figure 1.1: The reported distance effects



Notes: The figure presents median estimates of the distance coefficient reported in each primary study. The horizontal axis depicts the year, when study appeared in Google Scholar. The red line presents the time trend.

verge to one value, on the contrary the value remains dispersed around the mean value represented by the red line. The dispersion of the results could be mainly caused by including new methods and data characteristics used in the gravity equation.

I apply the ”meta-analysis” to draw conclusions about the effect of distance on the international trade flows, from the initial studies until nowadays. It is a statistical analysis of a large collection of estimates from individual studies in order to integrate the findings. These statistical methods had been primarily used in the medicine. In the course of time they have been developed into economic field. Disdier & Head (2008) have already explored the distance effect on bilateral trade using meta-analysis framework. They constructed a database of 1467 estimates from 103 papers that were published until 2005.

The intention of my thesis is the widening this dataset of the studies written during the period from 2006 till 2014. I have collected 30 aspects of the studies such as data characteristics, control variables, methods used for estimation or publication characteristics. For the reason that previous meta-analysis did not include the appropriate tests for revelation of the publication bias, the main purpose is to focus my work on the above mentioned issue.

The remainder of the paper is ordered as follows. Chapter 2 describes theoretical approach to the issue. In Chapter 3 I briefly explain the rationalization of meta-analysis and some frequently repeated criticism. Chapter 4 displays the possible ways of the estimation of distance effect and basic characteristics of the data set, including its collection. Chapter 5 tests for publication bias. Chapter 6 deals with the heterogeneity in the estimates of the distance effect in order to explore contribution of particular source. Appendix A provides the list of studies covered in the meta-analysis.

Chapter 2

Theoretical background

2.1 Distance effect on international trade

The international trade presents the exchange of goods, capital or services across different borders or countries. Its role in the economic sphere has been rising in recent years. The economists have started exploring how the international effect could be the most efficient. In the past many economic theories firstly did not pay any attentions to the relevancy of the distance. Since 1991, when Krugman (1991) put back the idea that distance played significant role in the area of the international trade, researchers have started making up the model to measure the distance effect. In the course of time, economists have replaced many models such as the Adam Smith's model, Ricardian model or Heckscher-Ohlin model, however, for the most successful and employed is taken the Gravity model of trade. In this section I will describe how the researchers have come up with the idea to connect these findings with one of the most key significant models in economics, a gravity equation.

2.2 Gravity equation

Gravity has ranked among the most successful empirical models in economics (Anderson 2010). It often presented in different sources in the area of international trade. Many authors who have ever dealt with the topic of international trade have tried to build out their research on the theory of the gravity equation. It has become a phenomena in the economic area and the researchers have started seeking for more accurate results.

This theory has been progressively developing since Tinbergen (1962). The main idea is that "bilateral trade between two countries is proportional to their respective sizes, measured by their GDP, and inversely proportional to the geographic distance between them"(Chaney 2008). The following part explains how the international trade is closely connected with the physics.

2.2.1 A link between physics and economics

In 1678, Isaac Newton moved the sphere of physic ahead when he succeeded in defining the "Law of Universal Gravitation" (Head 2003).

$$F = G\frac{m_1 m_2}{d^2} \tag{2.1}$$

Where

- F is the attractive force,
- m_1 and m_2 are the masses of two objects,
- d is the distance between the two objects,
- G is a gravitational constant depending on the units of measurement for mass and force.

In early sixties Tinbergen (1962) created the alternative of this equation for the international trade flows. Since his discovery in the economic area, the gravity equation has been further widened into the field such as tourism, foreign direct investment or migration. The quantities in the international trade can be explained by the following.

In the course of time, it has been found out that the gravity equation can be used in different fields of science. Head & Mayer (2013) in their study about gravity equation provided the particularized description of findings of the main gravity features of trade data. The first of them is the idea that trade is proportional to size. They managed to show that exports grow up proportionately with the economic size of the destination and imports grow up proportionately with the economic size of the origin of economy. They showed as an example of these predictions the trade flows between the European Union and Japan. As a measure of the economic size they used GDP.

The second feature is the fact that trade is on the contrary inversely proportional to physical distance. This idea was made up by shifting contrarily GDP to the left-hand side of the chart that helps us to observe "how bilateral imports or exports as a fraction of GDP varies with distance" (Head & Mayer 2013). They described it by using export and import data from France (and the association with Francophone countries, former colonies, and other members of the EU or the Eurozone). There were visible deviations detected from the distance effect which has become the subject of additional investigations.

2.2.2 A history of entering the gravity equation to trade

The history of using the gravity equation in economic areas was more complex. In the this section I will summarize the progress of gravity equation from being ignored by economists to becoming one of the most frequent topics published in the top general interest journals. The gravity equation was one of the most famous findings that Isaac Newton ever discovered. Nevertheless, for researchers it was not easy to persuade other scientists to believe in its existence in the field of economy.

Many people did not believe that there could exist any link between the physics point of view and the economic knowledge. Tinbergen (1962) tried to convince them about contrary. In his work he described how a Newtonian discovery is connected with bilateral trade flow. As Head & Mayer (2013) already mentioned in their study about gravity equations, Tinbergen's work was unfortunately not acknowledged. The first who criticized the expansion of the gravity to the world of international trade was (Deardorff 1984, p. 503) in his Handbook series. He said that the gravity equation can be derived from another theory and its relation to Heckscher-Ohlin model is not reasonable for empirical research. Thereby all of the previous studies were currently regarded as useless. Until 1995, there were many other trials that were supposed lead to detection of the real relation.

The year 1995 brought big changes in the research of gravity equations in the area of economics. Trefler (1995) in his work made a big breakthrough in this issue when he figured out the idea of "missing trade". He found the shortages in the previous explaining of the Heckscher-Ohlin models. He accounted a missing trade to the presence of home bias[1] instead of the influence of distance. Even though the link of gravity equations in economics has been already established the economists did not recognize its position in the international trade. For this reason, in the same year Leamer & Levinsohn (1995) decided to describe

[1] Home bias - the investor put more money into home equities than to foreign ones for the reason of other issues that could happen during the investments to the foreign equities

graphically how these already existing empirical results would work in this area.

In 1995 together with Krugman (1991) in the Handbook of International Economics came the idea that apart from the dependence of the distance in bilateral trade the geographical position of both countries should be also taken into account. In addition, McCallum (1995) pointed out the importance of the border effect[2] that has made lately a contribution to other research.

Head & Mayer (2013) presented there were two other important periods in the development of the gravity equation in the international trade. Firstly, there was the period between the years 2002 and 2004. This period was represented by several economists who reached the interconnection between the fixed effect in gravity and important economic theories. Furthermore, Anderson & Van Wincoop (2001) proved that the gravity equations are generally valid among countries. Secondly, there was the year 2008. It is important to mention three studies - Chaney (2008), Helpman *et al.* (2007) and Melitz & Ottaviano (2008). They figured out the models for heterogeneous firms that are closely connected with the gravity model. The main idea was to pounder the amount of firms that export and where.

[2]"The border effect in the international trade refers to a situation in which there is higher volume of trade within a country compared with the volume of trade across the country's borders" (McCallum 1995)

Chapter 3

Meta-Analysis Methodology

3.1 Meta-Analysis Methodology

Meta-analysis comprises a range of statistical techniques for combining the results of similar studies (Pang *et al.* 1999). It could be said that it serves to widen the research. If the authors deal with the same subject using different data sets and methods, then merging their results can bring more significant explanation than mere listing of particular results. At the beginning meta-analysis take into consideration all studies including the unpublished papers, trying avoid potential biases introduced by whichever intentional selection of studies (Stanley 2001). In the following parts I present the whole progress of the meta-analysis from its early beginnings.

3.2 A brief history of meta-analysis

The review is the most important form of the economic statements (Hendl 2004). In addition to other types of the review such as, evaluations of new trends in sciences, the empirical evidence or classifications of knowledge in a research, where the conclusions are provided quantitatively with a minimum of quantitative manipulation, the meta-analysis uses the statistics purely to quantitative results of studies. On the contrary to these informal (qualitative) reviews, it is necessary to inhibit the informational losses and to take into account all variables that could influence the significant level of the results. Therefore these results are more accurate.

The term meta-analysis was firstly defined by Glass (1976) as "the statistical analysis of a large collection of analysis results from individual studies for the purpose of integrating the findings." Before Glass coined the term "meta-analysis", there had appeared many trials to achieve the quantitative integration of the results. The first attempts belong to founders of modern statistics - K. Pearson and R. A. Fisher who tried to propose a simpler form of combining p-values from the independent tests of the same hypothesis (Fisher 1925). However, these findings became practically useless. In the sixties of the twentieth century, a big progress of the empirical research in a human science brought the newly arising meta-analysis (Hendl 2004). The indigenous meta-analysis was emerged by the study of Glass and Smith Glass (1976).

In the recent years we can notice the expansion of the meta-analytical techniques to various domains such as medicine, psychology, education, marketing, social science. Frequently, it is considered as an up-to-date trend mainly thanks to the fact that it helps to deal with the informational explosion Hendl (2004). The application in economics commenced in 1989 - 1990. The most important studies for this periods were Stanley & Jarrell (1989), Smith & Kaoru (1990), Gurevitch *et al.* (1992), Kruse (1992).

3.3 The criticism of meta-analysis

In the course of time, the amount of meta-analysis studies has raised. Unfortunately, not a meta-analysis avoided a criticism. Even though the creation of meta-analysis seems simple, the quality of its processing is often neglected (Nelson & Kennedy 2009). With the low-quality of meta-analysis, some criticism has appeared. The criticism is mainly connected with data collection, where the researchers might have made some mistakes.

The first issue can be caused by the quality level of individual studies. The researchers have to pay attention not to calculate the average of large number of low quality studies and small number of high quality studies. Sometimes we can contend with the obstacle that some of the main important studies are left out from data set. It is important, hence, for meta-analysts to pay attention just into significant studies. The so called "shoddy studies" as designated Disdier & Head (2006) should be rather ignored than weighted equally with important studies. I tried to eschew this issue by detecting the differences of the particular studies. It was nearly impossible to cover all of the incentives causing the variance of the estimated variable, therefore, I focused on the most important, such as the magnitude and the significance of different methods on results. I also observed whether the study was published in one of the high rated journal. These studies use certain systematically better methods to estimate the effect and I will able to find out if this difference and many others could have an impact on the different distance effect.

The second source of criticism comes out of merging different kinds of studies in the same analysis (Wolf 1986). The summary effect usually disregards these potential differences such as different outcomes, different explanatory variables across studies. Using the same units is also very important, so that researchers could emphasise on studies properly. To avoid this issue I ponder in my thesis only the estimates of the effect of distance on international trade. Thanks to "the near universal use of the gravity equations which estimates a unit-free elasticity" I need not be afraid of the potential differences among units (Disdier & Head 2006). As Disdier & Head (2008) pointed out, it is important to pay attention to different populations such as "countries versus provinces, old versus recent data in industries versus aggregate trade" might have also different distance parameters.

The third and simultaneously one of the most discussed weaknesses of meta-analysis is the occurrence of publication bias. Publication selection appears when editors, reviewers, or researchers prefer statistically significant results (Stanley 2005). In my thesis I decided to focus mainly on this issue, since the prior meta-analysis by Disdier & Head (2006) does not contain all required methods to reveal this weakness.

3.4 Publication bias

Publication bias or "file drawer problem" has been considered a serious weakness of meta-analysis for long time. It could easily threat the empirical economics (De Long & Lang 1992). Many researchers, for example Card & Krueger (1995), Doucouliagos & Stanley (2009), Abreu *et al.* (2005) or Rose & Stanley (2005) have made an attempt to detect the presence of publication bias in different areas of economic research Stanley (2005). They have tried using meta-regression analysis (MRA) to prove that in many studies there have been chosen mainly statistical significance results that often used to be overpresented. On the contrary the studies with small, insignificant effects would tend to be left over in the file drawer (Rosenthal 1979). Doucouliagos and Stanley (2013) in their recent studies pay attention to diversity of the spheres that have been affected by the problem of publication bias.

In my meta-analysis I have been following the order of Havranek *et al.*

(2015). In a view of the fact that the possible presence of the publication bias determines the weight that should be applied in meta-analysis. They finally test for the bias before they move to the analysis of heterogeneity. By this ordering, I can determine whether the exclusion of the standard error has the additional benefit of removing the obvious heteroskedasticity.

The problem of publication bias has been widened mainly in the medical sphere. Many pharmaceutical companies tend to overstate with significant results. This leads to indistinct bias in the published literature. In the recent years, this process has been more monitored. The rising number of the inaccurate results brought to the presence a number of established associations in different areas that take control over the published studies. The economy does not stand apart. The editors of the American Economic Review and the American Economic Journal have projected the Association institute a Registry of randomized experiments. These association is specifically responsible for the countering publication bias and the results of conducted studies (Siegfried *et al.* 2012, p. 648).

Chapter 4

The data set of the distance effects

4.1 Estimates of distance effects

Since 1962, when Tinbergen (1962) came with the original formulation, the gravity equation has been accepted in the empirical models in economics. Integrating the "Law of Universal Gravitation" into the economic practice has led more accurate estimation (Salvatici 2013). The gravity equation has been used in a whole range of what Head (2003) in his study for beginners termed as social interactions comprising tourism, migration or foreign direct investment. Generally, the equation for these social interactions can be expressed in the same way as the gravity law.

$$E[T_{ij}] = Y_i^{\alpha} Y_j^{\beta} D_{ij}^{-\theta} exp \varphi A_{ij} \tag{4.1}$$

The formula remains identical as in Equation 4.1, but the explanation of the variables has been transformed. The meaning of T_{ij} is the flow from country i to country j, T_{ij} can also denote the sum of flows - from from country i to country j and vice versa). The masses from the previous equation are replaced by the appropriate economic sizes, largely the gross domestic product (GDP). The variable D_{ij} keeps its sense from the prior equation. It also stands for the distance, but in this case between countries (the researchers commonly states the distance from centre to centre). The Greek letters α, β and θ stands for the elasticities to be estimated. Specifically, θ was defined by Disdier & Head (2006) as the distance effect.

Last term replaces the gravitational constant in the original formula. The vector Aij represents all other bilateral indicators of the accessibility characteristics between the two countries such as adjacency, common language or free trade agreement. And finally ϕ stands for a vector that denote the coefficients of the variable Aij.

The authors of particular studies assume for the standard approach the following equation $T_{ij} = E[T_{ij}]\varepsilon_{ij}$, where ε_{ij} denotes the error term Disdier & Head (2006). They usually suppose that the error term is statistically independent on the other regressors and additionally it has a conditional expectation $E(\epsilon_{ij} \mid Y_i Y_j D_{ij})$ that equals to one. Then taking logarithmic transformation of the Equation 4.1, we will obtain

$$\ln T_{ij} = \alpha \ln Y_i + \beta \ln Y_j - \theta \ln D_{ij} + \varphi A_{ij} + \ln \varepsilon_{ij} \tag{4.2}$$

Being linear in the parameters, the authors primarily select the ordinary least squares (OLS) methods to estimate the Equation 4.2. Even though this method seems to be optimal, there are some exceptions that prevent from the estimating by the OLS. I explain a possible differences that arise due to the diverse kind of estimation methods in Chapter 6.

In the following parts of my thesis I am devoted to the interpretation of the meta-analysis that deals with the gravity equation. The main goal of the carried out meta-analysis consists in the widening of the already published study "The Puzzling Persistence of the Distance Effect on Bilateral Trade" by Disdier & Head (2006). I also apply new methods to remove the gained estimates from potential publication selection. Then, I investigate whether some of the characteristics of collected studies have systemically effect on the heterogeneity among the particular studies. All of the contained and required results are realized with the aid of application statistical software STATA.

4.2 The collection of distance effect data

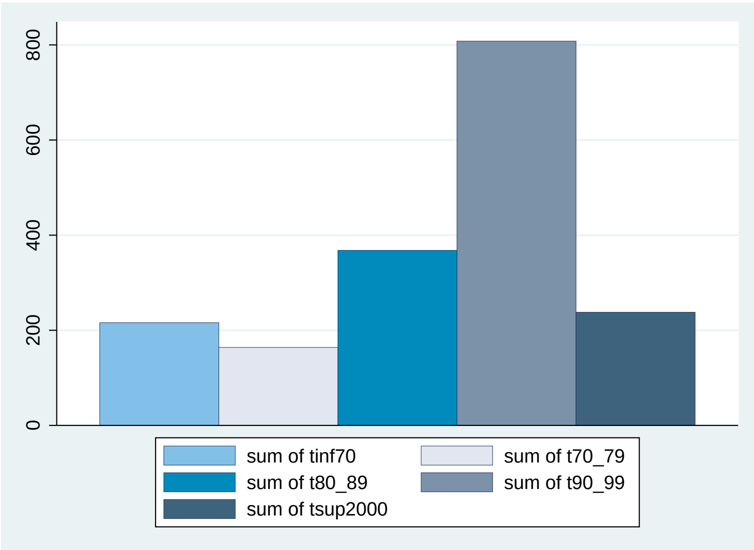
The collection of data ranks among the important parts of the very meta-analysis. Since this work is based on already published Meta-analysis by Disdier & Head (2006), I contacted Keith Head who was so nice and provided me their data from 2005. Form that time the economists have detected the connection between the gravity equations and the international trade, the interest about its examination has rapidly increased. It means that from 2005 till 2014 I find plenty of papers that focus on this topic. For this reason I decide to move ahead in the same manner as Disdier & Head (2006) did, in order to keep the indigenous structure of the matrix.

The first step of the meta-analysis is to create a database of estimated coefficient θ for bilateral flows of trade in goods (Disdier & Head 2008). As I already mentioned in the Chapter 2, there is a huge amount of empirical papers whose bases are constituted by gravity equations. It was impossible to cover all papers that were published on this topic. Disdier & Head (2006) used for their searching the Econlit database. For the extension their base sample I preferred a database RePEc, because it closely co-operates with the American Economic Association's EconLit database and it was more synoptic for me. Their final sample based on Econlit keywords comprises 78 papers - 68 published papers in academic journals, 4 chapters in books and 14 working papers. I have found additional papers that were published in time period ranking between January 1, 2006 and January 1, 2014 and were listed in the RePEc database. For maintaining a consistency in the search for other sources of data, I took over the searching criteria that were used by Disdier & Head (2006) and Disdier & Head (2008) during the data collection in their studies:

- In the keywords or in the title where are used "gravity equation", "gravity and distance and trade" and "gravity and history and trade",
- In the keywords where are used "border and distance and trade" and "home bias and trade", by reason that the gravity equations are occurred in the empirical papers on border effects.

This clarification of the way how to create a good sample is necessary for maximization the replicability and objectivity of the meta-analysis. For this reason I apply the following inclusion criteria. Firstly, I include just these studies that provides the standard errors for the estimates. Without standard errors I could not test for publication bias in the literature that is the main intention of my thesis. Since the prior meta-analysis by Disdier & Head (2006) included some studies that do not provide standard errors (for example Brown & Anderson (2002) or Tamirisa (1999)), I removed them from my dataset. Secondly, apart from the quantity, there was also the language barrier that defended me to include all of them. That is why I chose only English language papers. Next inclusion criteria is an excluding these studies, which do not measure "distance effect" in the gravity equation, otherwise they deal with observing measure the border effect or effect of FDI. I suppose studies concerning with regions of only one country use such different manners that will require other meta-analysis. Finally, I exclude all studies that are focused on trade between a large country and its small territories, because these studies involve the distance effect only within the framework of one country. My thesis conversely is based on the trade between two different countries.

Figure 4.1: Distance effetcs accros time periods



I have collected 130 primary studies and 1470 observations corresponding with my inclusion criteria and recorded them in Appendix A. They span a very large time period from 1870 to 2010. Figure 4.1 provides a quantity of distance effect measured in a corresponding decade. We can observe that most of the sample estimates are measured in time period 1990-1999.

The resulting data set includes the estimated distance effect range from 0.57 to 2.44. All of these estimates have negative effect on bilateral trade flow. The mean number of elasticity of the distance effect is 0.92 and the median is 0.91. We can observe that distance effect has increased over time, since the mean estimate of the elasticity reported in the prior meta-analysis by Disdier & Head (2008) was 0.91 and the median was 0.87. The fact that the distance effect is a very indispensable part for research in international economic imply a number of received citations of collected studies. Together they have counted almost 44,000 citations in Google Scholar, or about 150 on average per year. This number is reduced by recent studies that have not frequently been cited yet.

The distance effect sample is shown in Figure 4.2. This boxplot is used to graphically depict groups of distance effect data through their quartiles. The

Figure 4.2: Boxplot of individual estimates of distance coefficient

second quartile of the data set, the median, is indicated by the vertical line that goes through the centre of the box. Other components of the boxplot determines the ranges of the estimated data. From the first range we are able to find out the whole scale of the estimated variables. The second range, known also as interquartile range, demarcates the estimated variable by the first and the third quartiles. This range is exactly represented by the width of the box. If the estimates of a study include the outliers, they are depicted separately as points on the chart. Thanks to the boxplot we can easily observe heterogeneity of particular studies.

Additionally, boxplots show that the estimated data have usually different skewness pattern. They can be skewed left if the data are concentrated on the high end of the scale and on the contrary skewed right if the data lies on the low end. The most of studies presents at least some estimates around 0.9 that is very close to the mean number of distance effect.

From Figure 4.2 we can notice, nevertheless, that the distance effect estimates differ across particular studies. This heterogeneity can be caused by several reasons, where the most significant difference is a diversity of country-pairs for which the distance effect is assessed.

Table 4.1: Distance effects across countries

Unweighted	No. of estimates	Mean	95% conf. interval	
Industrial	580	0.98	0.86	1.14
Developing	44	1.37	0.87	1.87
Mixed	845	0.85	0.73	0.96
Weighted	**No. of estimates**	**Mean**	**95% conf. interval**	
Industrial	580	0.89	0.79	0.99
Developing	44	1.3	0.78	1.83
Mixed	845	0.9	0.82	0.98

Table 4.1 documents the mean estimates for three groups explored in the primary studies. We can observe whether the distance effect vary among developed or developing countries. The estimates for group of both, developed and developing countries, are included in the overall mean reported in the third row of the table. The upper-part of the table presents unweighted estimates, contrary to the second part that presents the estimates weighted by the inverse number of the sample utilized in a particular study. These weights make the importance of each variables equal, hence, we are able to easily compare the

estimates of each group. The confidence intervals in both sides of the table are made using clustered standard errors. Havranek *et al.* (2015) in their meta-analysis pointed out that many meta-analysis cluster standard errors, since the distance effect estimated in the same study have higher probability to be dependent.

The table presents the difference of the estimated effect across these above mentioned groups. The group of industrial countries does not considerably differ from the mean number of the estimated distance coefficient. The group of developing countries, however, shows higher mean of estimated distance coefficient with the value of 1.3, when the estimates by the inverse of the number of observations reported in each study are weighted. The possible explanation for the difference between industrial and developing countries might be caused by the proportional connection between trade costs and distance. The last group covers the mix of developed and developing countries, nevertheless, the proportion of developing countries is lower, for example the international trade among European countries and China or some of African countries. The mean weighted estimate of distance coefficient of this group is just slightly higher (1%) than that in the group of developed countries. Interestingly, the unweighted averaged coefficient is even lower than the one of industrial countries. Meaning that there are many estimates of distance coefficient in the studies, where the coefficient has lower value.

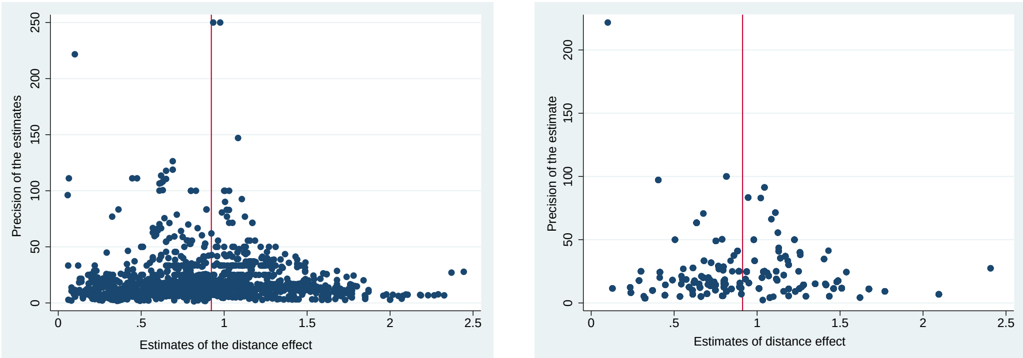
Chapter 5

Testing for publication bias

5.1 Funnel plot

The existence of publication bias can be found out using several methods. The one of the most popular is the funnel plot. It is a scatter plot showing the scale of estimated effects (horizontal axis) and the precision or the inverse of the standard error (vertical axis). The name of the chart is created from its shape that should reach funnel plot in optimal case. The optimal case comes to pass when the largest studies are plotted close to the average, while the smaller ones are spread uniformly on both sides of the average. On the contrary, the deviation from the "funnel shape" warn us about the publication bias. If the plot is asymmetrical it can be concluded that the researchers eliminated some estimation of unexpected sign or magnitude. The smaller, less precise studies are more likely to be positive than the larger ones (Reade *et al.* 2008). The other case of the deviation of the accurate shape is that the funnel plot becomes hollow. In this situation the researchers remove the studies with statistically insignificant estimates.

The funnel plot for my data set is shown in Figure 5.1. Figure 5.1(a) depicts the funnel plot for the effect of distance of the all coefficient estimates reported in the primary studies, while Figure 5.1(b) depicts the funnel plot for the median number of the estimates reported in the primary studies. Both funnel plots are relative symmetrical, even left-side is little bit heavier. The most of the estimates are close to the mean number. Additionally, funnel plots are not hollow, even though the results that yields small coefficients with very little precision are reported. Finally, the funnel plot in Figure 5.1 has several peaks that suggest heterogeneity on the estimated distance effect (Havranek



(a) All estimates (b) Median estimates reported in studies

Figure 5.1: Funnel plots

et al. 2015). The funnel shapes might seem to be inaccurate, however, many other studies dealing with the meta-analysis signify the clearer evidence of publication bias, such as Valickova *et al.* (2014) or Havranek & Kokes (2015).

5.2 Funnel assymetry test

As the other methods, the funnel plot has also shortcomings that lead to indistinct argument for shape deviation. For this reason I enhance the previous result, gained from the funnel plot, by the explicit regression test. The FAT (funnel asymmetry test) pursues the same idea as the already mentioned funnel plot. In fact, the FAT is an inverse version of the funnel plot, but it shows on the horizontal axis the standard errors instead of precision.

The basic idea has been created by Card & Krueger (1995), who developed the relationship between the estimates of the elasticity and their standard errors. They claimed that correlation between the estimated size of the coefficient and its standard errors leads to presence of the publication bias. The authors of smaller studies have a tendency to concentrate the searches on findings of larger estimated effects in order to offset their related larger standard errors Doucouliagos & Stanley (2009).

At some time, the estimates are chosen for publication because of their significance or an intuitive sign. Then the relationship will be significant (Havranek *et al.* 2015). The publication selection can be therefore revealed by the relationship between the size of the estimate and its standard error. (Stanley, 2008) It can be tested by the following regression model:

$$Effect_{ij} = Effect_0 + \beta_0 \cdot SE(Effect_{ij}) + \varepsilon_{ij} \qquad (5.1)$$

where $Effect_{ij}$ denotes i-th estimates of the elasticity recorded, $SE(Effect_{ij})$ is the standard errors of the estimates, $Effect_0$ denotes the average elasticity corrected for potential publication bias, β_{ij} measures the magnitude of publication bias and ϵ_{ij} denotes for a normal disturbance term. In case that the data are not influenced by the publication selection, the estimated effects will vary randomly around the "true" effect, $Effect_0$ Stanley (2005). If the "true" effect was zero (signifying no distance effect) but all researchers determined the 5% of the estimates that are positive and statistically significant, the estimated β_0 would be close to two; meaning that the researchers Effect *SE(Effect)*, to equal at least two Havranek *et al.* (2015).

Table 5.1: Funnel asymmetry test

A: Unweighted regressions	1	2	3	4
Estimated standard error of Distance	-0.270	-0.636	1.169***	-3.356**
	(0.737)	(0.748)	(0.424)	(1.563)
Constant	0.946***	0.998***	0.821***	1.197***
	(0.0599)	(0.0662)	(0.0369)	(0.123)
Observations	1469	1041	1469	1349
B: Weighted regressions	**1**	**2**	**3**	**4**
Estimated standard error of Distance	0.602	1.518	-0.434	-0.887
	(0.894)	(1.226)	(1.057)	(1.201)
Constant	0.870***	0.794***	0.905***	1.016***
	(0.0559)	(0.0986)	(0.0791)	(0.0807)
Observations	1469	1469	1412	1393

Standard errors in parentheses
Standard errors are clustered at the study level.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The results from the funnel asymmetry tests are presented in Table 2. The table is divided into two parts, part A shows the unweighted regressions, while part B shows, on the contrary, the regressions weighted by their precision. The part A is divided into four columns:

1. All estimates in my sample (1469 observations),

2. estimates of published journals (1041 observations),

3. I include the fixed effects for each study (1469 observations),

4. I include the logarithm of the number of observations in the gravity model as an instrument for the standard error of the estimates.

The results of the part A of the funnel asymmetry test can be summarized as follows. The estimations in the first and the second columns yield insignificant estimates of β_0 of regression from Equation 5.1 that signify the publication bias. And on the contrary, they yield significant estimates of Effect_0 of regression at the 1% level (Equation 5.1) that signify the underlying mean elasticity of distance effect corrected for publication bias. The estimations lie around 0.9, which is close to the mean of the elasticity of distance effect and median reported in Chapter 4. The third and the fourth columns presents only significant results at the 1% level. The significant results of estimated standard error of distance imply the presence of the publication bias. By estimating the regression with the fixed effects and standard errors clustered at study level, I control for method or other quality characteristics specific to each study. The positive publication bias might be caused by leaving out the larger estimates.

In meta-analysis it is necessary to control for endogeneity of the standard errors. As Havranek *et al.* (2015) pointed out, sometimes the meta-analyst is not able to collect all relevant information on the methodology used in each study. If he or she omits an important point of methodology that affect both the reported coefficients and their standard errors in the same direction, he or she will get deviated estimates of the magnitude of the publication bias. The results of the part A of the Table 5.1 suggest that since the effect beyond bias are still significant at 1% level, it is not an important issue. The part B of the table, moreover, widen the test for publication bias on the level of weighted regressions.

In the panel B Table 5.1 is divided into 4 columns:

1. All my estimates weighted by their precision,

2. weighting by the inverse of the number of estimates reported in studies is added to the previous one,

3. I add the weighting by the discounted recursive RePEc impact factor,

4. in the last column, the estimates are weighted by the number of citations per year in Google Scholar

From the first panel it is clearly visible that precision weights do not change the results. Additionally, the mean elasticities do not change significantly from column to column and the results lie around the sample mean, which is 0.91 (note the difference is in all cases in 10% interval around the sample mean). When each study gets the same weight, the mean elasticity slightly decreases. However, when weighted by Google Scholar citations, the elasticity is increasing by around 10%, meaning when we give more weight to highly cited papers we increase the estimate of distance effect.

Chapter 6

Why distance effect differ

6.1 Explanatory variables

The fact that distance effects vary across particular studies is already well known. This difference could be related with different specifications within studies. In this chapter I will present a number of explanatory variables as sources of heterogeneity in estimated distance effect. Disdier & Head (2006) divided the variables into three groups, however, I use different division methods according to Havranek *et al.* (2015) to make the occurrence of used variables in my dataset more understandable.

In Table 6.1 present all the variables that were collected from primary studies, figures summary statistics and describes their meanings in detail. Summary statistics of regression variables includes in addition to mean and standard deviation also mean weighted by the inverse number of the estimates recorded in particular studies. The variables are divided into seven groups:

- Data characteristics
- Countries examined
- Specification characteristics
- Estimation characteristics
- Treatment of zero trade flows
- Control variables
- Publication characteristics

Apart from these groups that are described below, it is important to point out the possible structural heterogeneity of distance effect. Generally, we can consider the distance effect as the product of two elasticities. At first, it is the elasticity of trade costs with respect to distance and the second one is the elasticity of trade with respect to trade costs. Disdier & Head (2006) concludes that we should expect the different distance effect on trade whenever the gravity equation is estimated on data with different degrees of substitutability between goods, different productivity dispersion or different responsiveness of trade costs to distance.

Data characteristics

The age of the data is one of the most important characteristics in my dataset. I control them identically as Disdier & Head (2008). They created a new variable to define a midpoint of the sample. I create the variable in the same manner in order to observe whether the distance effect will change in time. I also include the number of observations of each study and I use their logarithm. I do it in the same way also with the number of observations used in the gravity equations per year.

The other characteristic that is used in my dataset is the level of aggregation in the equation. The dummy that equals one is added if the data of the study are disaggregated in particular industry or sector. Almost half of primary studies of my dataset use some kind of separations of industries. Thanks to results of the coefficient on disaggregated data we can observe that the estimations managed by the aggregate data lead to lower distance effect. On the contrary to the estimations on the basis of the particular sectors that have higher distance effect. By adding the dummy variable "panel" I am able to observe whether cross-sectional and panel cause systematic deviations in distance effect.

Countries examined

My dataset includes studies that cover the distance effect between country pairs all over the world. Some of them are separated from each other by oceans and on the contrary, some of them occur in the same continent. For this reason I include a dummy variable "single continent" to detect the differences in the elasticity of trade costs with respect to distance between land and ocean. In international trade, the dataset consists of many developed and developing countries or trade regions, therefore I introduce dummy variables to divide them into main three groups. First, developed countries, where I examine 33% of studies. Second group is comprised by developing and transition countries. Finally, the mixed area covers industrial and also developing and transition countries.

Publication characteristics

In the previous part I explained the selecting process of the data. Even though the prior Meta-Analysis by Disdier & Head (2006) includes all papers in the Econlit database, I use for collecting data a RePEc database. I leave out the variable "Combes and Linnemer's rating" that was used only just for ranking journals in EconLit. Instead of that, I take account of the RePEc discounted impact factor, where each citation is split by its age in years. It compares different quality of the publication output. The other way to control the quality of the publication is including dummy that equals one if the study is published in a peer-reviewed journal. These journals are â€" the American Economic Review, the Journal of the International Economics and the Review of Economics and Statistics. As Disdier & Head (2006) present in their study, the norm for methodological rigour could be more significant at these journals and this could be the reason for correcting biases present in other estimates.

I add other variables that characterize particular studies. One of them is the year of the first placement of such a study in the Google Scholar. In addition, I record also the logarithm of the mean of Google Scholar citations obtained per year plus one. The logarithm form is used due to the fact that many studies published in more recent year have dissimilar amount of citations than older ones.

Control variables

I include several dummy variables to control for the distance effect: adjacency, common language, remoteness, home trade, and membership in a free trade agreement. I follow the strategy by Havranek *et al.* (2015) and code all of these variables that are omitted of the regression as zero even though they could be included.

Sometimes it could happen that a dummy variable has the same value for all of the trading pairs. The best example are studies by Helliwell (1995) that describes the bilateral trade flowing from US states to some of Canadian provinces.

Specification characteristics

The authors of the searched studies agreed with using the gravity equation framework for measuring the trede flows and the distance. To distinguish studies the researchers apply different methods and variables. On one hand many authors connect imports and exports for given trade pairs as single variable. They sum them and classify them as trade flow. On the other hand, some studies concentrate on directional trade. I take this fact into consideration and as Head did, I also divide the international trade into three categories. These three dummy variables determine whether the dependent variable is bilateral export or import flows or contrarily total bilateral trade flows. The last one can be affected by "silver medal mistake", as described by Baldwin & Taglioni (2007). Authors of different studies use wrong average trade, since they calculate the arithmetic average corresponding to the log of the sums, rather than the geometric average corresponding to the sum of the logs.

I code a dummy variable to discover whether authors calculate distance effect applying the great-circle formula. This formula measures the shortest distance between two places, only what they need are the longitude and latitude of principal cities for each country. The negative effect of this method is that cargo routes vary from these great-circle route (especially, how already Disdier & Head (2006) pointed out, when the routes cross over the poles). Then using the great-circle formula tends to an upward bias in the estimated distance effect.

I also include a dummy to control whether researchers control for the potential endogeneity of the GDP terms. The problem of endogeneity can happen when the GDP is correlated with the error term in gravity equation. This might arise as a result of simultaneity bias that will influence a bias in distance effects. Some researchers, hence, include the instruments to detect the possible occurrence of endogeneity.

Estimation characteristics

I consider several dummy variables according to methods that authors of primary studies apply for the problem. As Anderson & Van Wincoop (2001) emphasized, the gravity literature includes a theoretical remoteness terms or does not consider multilateral resistance completely that are connected to distance to all bilateral partners. But the first trials that engage remoteness term already came before this study (30% of the studies).

I code a dummy that controls whether authors apply the non-linear estimation method described by Anderson & Van Wincoop (2001). About 3% of studies of my dataset do so. The most forthright attitude is the applying of the fixed effects for each importer and exporter. The definition of dummy variable for countries fixed effect helps to avoid "gold medal mistake" - the fail to consider relative prices (Baldwin, 2005).

Treatment of zero trade flows

In contrast to Newtonian gravity, trade between countries can be really zero. These zeros appear easily because the countries did not trade in a given time (Silva and Tenreyro, 2006). Many authors who choose this approach should count to challenge with its predisposition to heteroscedasticity. They have to deal with this problem since the using of log linear transformation is out of question.

The easiest way how to solve this situation is estimating the new model. They usually add one to each observations and then use the log-linear model. Then, they estimate their gravity equation applying Tobit model or as Silva and Tenreyro suggest - the Poisson psuedo maximum likelihood. Silva and Tenreyro proved that PPML works well even if the authors integrate the zero trade flows. I code a dummy variable PPML to control whether the authors use exactly this method.

Finally, there are many countries with zero trade flows between them. If the authors ignore this fact, it might have impact on selection bias that could again negatively influence distance effects. I code a dummy variable that equals to 1 if the estimation incorporates zero trade flows using different method than was depicted above. Last group introduces studies that do not include zero flows (for example, aggregate trade flows between OECD pairs of countries). I include an additional dummy that takes a value 1 if zero trade flows do not appear in the data and therefore any method for incorporating them is not required.

Table 6.1: Description of used variables

Variable	Description	Mean	SD	WM
d	"The estimate of distance effect of international trade."	0.91	0.42	0.91
se	estimated standard error of distance	0.08	0.07	0.07
avyear	midyear of the sample on which the gravity equation is estimated	115.17	21.70	115.00
panel	=1 if panel data are used in the gravity equation	0.52	0.50	0.53
contin	=1 if the international trade flow is measured within single continent	0.27	0.44	0.25
rsdist	=1 if the actual road/sea distance is used instead of great-circle formula	0.32	0.47	0.31
industried	=1 if the distance effect is estimated for industrial countries	0.34	0.47	0.34
developing	1 if the distance effect is estimated for developing and transition countries	0.03	0.16	0.02
mixed	=1 if the distance effect is estimated for industrial, developing and transition countries	0.63	0.48	0.64
disagg	=1 if data are disaggregated at the sector level	0.20	0.40	0.19
nointflow	=1 if international trade flows are not present but estimated using production data	0.45	0.50	0.46
cadja	=1 if gravity equation controls for adjacency	0.42	0.49	0.43
clang	1 if gravity equation controls for shared language	0.56	0.50	0.56
cfta	=1 if gravity equation controls for free trade agreements	0.55	0.50	0.55
remote	=1 if remoteness terms are included	0.13	0.34	0.13
cendog	=1 if the instruments are used to correct for the endogeneity of GDP	0.20	0.40	0.20
countryfe	=1 if destination and origin fixed effects are included	0.04	0.19	0.04
nonzeros	=1 if observations of zero trade flows are omitted	0.45	0.50	0.46
export	=1 if the study measures only import flows	0.38	0.49	0.37
import	=1 if the study measures only export flows	0.19	0.39	0.19
trade	=1 if the researchers sum export and import trade flows before taking logarithm form	0.42	0.49	0.43
plusone	=1 if the researchers add one to observations of zero trade flows	0.04	0.19	0.04
ppml	=1 if gravity equation is estimated by the Pseudo Poisson Maximum Likelihood estimator	0.01	0.11	0.01
tobit	=1 if gravity equation is estimated by the Tobit model	0.04	0.21	0.05
avw	=1 if the nonlienear estimation method developed by Anderson and van Wincoop is used	0.03	0.17	0.03
tinf70	=1 if average year $\leq$ 1969	0.12	0.33	0.13
t70_79	=1 if 1970 $\leq$ average year $\leq$ 1979	0.11	0.32	0.12
t80_89	=1 if 1980 $\leq$ average year $\leq$ 1989	0.32	0.47	0.32
t90_99	=1 if 1990 $\leq$ average year $\leq$ 1999	0.54	0.50	0.55
tsup2000	=1 if average year $\geq$ 2000	0.25	0.43	0.25
firstpub	Year when the study first appeared in Google Scholar	0.64	0.48	29.25
impact	Recursive discounted RePEc impact factor of the outlet (collected April 2015)	0.50	0.54	0.52
published	=1 if the study is published in AER/JIE or REStat journals	29.37	6.82	0.65
lncsunits	log of the number of observations per year included in the gravity equation	6.45	1.86	6.45
lnyears	log of the number of years	1.19	1.28	1.21
lnyearcits	Log of the mean number of Google Scholar citations (collected April 2015)	2.14	1.45	2.18

6.2 Meta-regressions results

In this part, I report the empirical results for meta-regression analysis. The goal of this chapter is to explain the diversity of the results and to find the potential dependence among the variables of each study. Since the different observations from the same study are most likely dependent, as also confirms the results for publication bias, I will use cluster for individual study as I already did in Chapter 4. Disdier & Head (2006) were against the reducing the sample to a single observations per paper. Even though I partly agree with their decision, I suppose that the estimates from the same study are so much similar that will caused a distortion of the results to detect heterogeneity. I apply sampling weights equal to the inverse of the number of estimates as Havranek *et al.* (2015). He kept in mind that some studies report more estimates than other, therefore, the result are not likely to be accurate without this weight. To keep all information included in the estimates, I will apply the following equation:

$$Effect_{ij} = Effect_0 + \beta_0 \cdot SE(Effect_{ij}) + \delta X_{ij} + e_{ij} \tag{6.1}$$

where X_{ij} is a vector of the meta-independent variables contained to explain the variation of the estimates. Even if the constant in the meta-regression represents the underlying Effect corrected for reporting bias, now the constant must be interpreted along with X (Havranek *et al.* 2015).

Table 6.2: Meta-regression for sample periods

A	Coef.	SE	p-value
Average year	0.003	0.001	0.001
Constant	0.546	0.105	0.000

B	Coef.	SE	p-value
1970 $\leq$ average year $\leq$ 1979	0.161	0.081	0.046
1980 $\leq$ average year $\leq$ 1989	0.242	0.082	0.003
1990 $\leq$ average year $\leq$ 1999	0.261	0.061	0.000
2000 $\leq$ average year	0.263	0.088	0.003
Constant	0.685	0.046	0.000

The first control to detect why distance effect differ is shown in Table 6.2. The first part of the table presents a specification regresses the distance estimates only on the midyear of each sample that is reduced by 1870. This adjustment of the variable used also Disdier & Head (2006) in their meta-analysis. Then the constant can be explained as the distance effect for the earliest observation of my data sample. We can observe the positive and significant (at the 1% level) coefficient, which means that the effect of distance on international trade gives the impression to be increasing over time.

The second part of the table confirm whether the prior observation of part A would is confirmed. This part provides the regression of the distance estimates on four dummy variables that determines the range where is categorized the average year variable. We can noticed the evident growth of the distance effect after 1970. Part B provides the all results significant at least at 5% level of significance. The greatest increase has evidently begun since 1980. Since 2000, moreover, the distance effect has almost 39% higher negative impact than it had before 1969.

A still unexplained issue is the reason for this heterogeneity that has arisen across time periods. In recent time periods the deviates of the estimates might be also caused by different applied methods or different characteristic that are used in each study.

The results of OLS regression of all "estimation method" and "characteristic" variables are reported in Table 6.3. Some of the variables that were expected to raise heterogeneity, have contrarily no discernible impact on distance effect, such as control for a common language, control for FTA, distinction between import and export trade flow or remoteness control. On the other hand, there are some obvious variables that influence the effect of distance. The application of methods that replace by using estimation of production data seems to raise the distance estimate. This result is significant even at the 1% level. From the results we can also observe that methods, which the researchers used for the estimations hardly affected the distance coefficient. Tobit methods lead to larger elaticities of distance effect, on average about 0.25. On the contrary, use of the PPML method tends to obtain smaller distance coefficient (by about 0.24). By using PPML method, the researchers obtained relatively low estimates of distance coefficients, mostly around 0.7. Anyway this method has not been so popular for estimation of trade flow, since there are very few studies in my dataset that use it.

Another significant variable is number of observations per year. It is not unexpected as larger number of estimates per year must logically have bigger influence on total distance effect than smaller number. Nevertheless, from the result we can observe that this impact is very small.

Surprisingly, the published studies do not significantly influence the effect of distance. By this fact we can conclude that the unpublished studies have almost the same quality of the estimates as studies that are published in some of high ranking journal. Other publication characteristics have also any significant impact on the distance estimate.

Table 6.3: OLS - regression

OLS regression			
Variable	Coef.	SE	p-value
Midyear of data - 1870	0.001	0.001	0.098
Panel data	-0.103	0.126	0.418
Disaggregated data	0.024	0.081	0.766
Observations per year	0.058	0.022	0.008
Number of years	0.063	0.055	0.258
Developed countries only	0.014	0.064	0.821
Developing countries	0.107	0.177	0.548
No international trade	0.160	0.037	0.013
Road/Sea Distance	0.073	0.039	0.284
Single continent	0.102	0.053	0.206
Export	0.247	0.354	0.485
Import	0.133	0.359	0.712
Total trade	0.122	0.349	0.726
Remotness	-0.001	0.084	0.994
Country fixed effects	0.023	0.106	0.831
AvW's estimation	-0.037	0.104	0.722
Zero plus one	0.057	0.094	0.539
Tobit model	0.246	0.067	0.055
PPML	-0.236	0.101	0.020
Adjacency control	-0.064	0.059	0.281
Common language control	-0.018	0.060	0.281
Trade agreements control	-0.016	0.054	0.763
Published	0.023	0.065	0.731
Impact	-0.019	0.058	0.743
Number of citations per year	0.010	0.019	0.458
Publication year	0.003	0.005	0.465
Constant	-0.037	0.379	0.925

Even if many characteristics variables are not significant, they still might be jointly significant. Since I exclude all jointly insignificant variables, I obtain a restricted model that can be more useful in predicting distance effect on trade flows $\left[F_{(10,124)} = 8.30, p \leq 0.01\right]$.

Results of this regression are reported in Table 6.4. This model presents more significant variables than the previous OLS regression. The estimates that

Table 6.4: Restricted model

Variable	Coef.	SE	p-value
Midyear of data - 1870	0.002	0.001	0.154
Observations per year	0.053	0.021	0.014
No international trade	0.153	0.065	0.018
Road/Sea Distance	0.064	0.061	0.295
Single continent	0.126	0.065	0.054
Total trade	-0.085	0.054	0.115
Zero plus one	0.061	0.095	0.524
Tobit model	0.255	0.125	0.041
PPML	-0.184	0.091	0.044
Adjacency control	-0.081	0.049	0.100
Publication year	0.003	0.004	0.484
constant	0.241	0.133	0.070

were measured by actual distance does not play the significant role. It can be unexpected since great-circle formula distorts the actual distance route. This finding shows that measuring of actual distance is not necessary to determine the effect of distance. By applying the method that determines whether the distance is measured within one continent, the researchers report elasticities about 0.12 higher. The variable that control for adjacency has contrarily small negative impact on the estimated elasticites. Nevertheless, the results of these these two variables are significant only at the 10% level.

Chapter 7

Conclusion

The effect of distance on international trade has became the important part of the gravity model, that belongs to the most robust empirical findings in economic sphere. In this model the bilateral trade depends proportionally on economic size of both countries and is inversely proportional to the distance between them. The role of the size that is usually measured by GDP is well known, the role of distance remains a mystery (Chaney 2013).

Meta-analysis is an econometric method that is used to summarize and evaluate the results of previous studies in order to correct these conclusions from publication selection and other distorting and deflecting effects. This thesis is based on the prior meta-analysis data reported by Disdier & Head (2006). I also follow their conviction that the effect of distance has larger impact on the international trade than the researchers have previously thought. I finally collect 1470 estimates of the distance effect in 130 individual studies with a mean elasticity of 0.92 that indicates almost inverse proportionality between the distance effect and international trade.

I test for publication selection bias in my sample in order to determine whether sample of estimates were adjusted to obtain statistically significant results. The first method, the funnel plots, graphically shows no evidence of the publication bias, since the shape of the plot reminds a funnel. I confirm this findings by the other method - funnel asymmetry test. In spite of the fact that the significant results of estimated standard error of distance might imply the occurrence of publication bias, the constant is still close to the mean. Even if few researchers might miss large estimates, we should not interpret it as strong signs of the publication bias.

Moreover, I clarify the differences in the estimates by diverse data, control variables, methods of estimation, and publication characteristics. After examination of why distance effects differ it is important to highlight several points. I prove from the results of meta-regression that the estimated distance effects are not diminishing over time. On the contrary the effects since 1970 tend to have a rising trend. The findings confirm the hypothesis that the application of new methods and new tools for estimation of distance effects increases the dispersion of the results. The researchers have tried to synchronize technology that allow to reduce trade costs and the effect of distance.

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Appendix A

Studies included in Dataset

Table A.1 contains a list of 130 primary studies used for meta-analysis. 39 of them is collected by myself, the rest is obtained from former meta-analysis carried out by Disdier & Head (2006). Online appendix of their studies is accessible on-line at: `http://strategy.sauder.ubc.ca/head/papers/meta_papers.pdf`

Table A.1: List of primary studies used

Aitken (1973)	Anderson & Van Wincoop (2001)	Combes *et al.* (2005)
Pelzman (1977)	Matyas *et al.* (1997)	Lopez-Cordova and Meissner (2005)
Bergstrand (1985)	Helliwell & Verdier (2001)	Olper & Raimondi (2005)
Brada & Méndez (1985)	Rose & Van Wincoop (2001)	Portes & Rey (2005)
Thursby & Thursby (1987)	Sapir (2001)	Blanes & Milgram Baleix (2006)
Bergstrand (1989)	Smarzynska (2001)	Dalgin *et al.* (2004)
Summary (1989)	Smith (2001)	Kang & Fratianni (2006)
Thoumi (1989)	Anderson & Marcouiller (2002)	Linders & De Groot (2006)
Sanso *et al.* (1993)	Djankov & Freund (2002)	Santos et al. (2006)
De Ménil & Maurel (1994)	Feenstra (2002)	Bas & Ledezma (2009)
Christerson (1994)	Freund & Weinhold (2002)	Fratianni (2007)
Helliwell (1995)	Head (2003)	Siliverstovs & Schumacher (2007)
McCallum (1995)	Irwin & Terviö (2002)	Faustino & Leitão (2008)
Xing (1995)	Loungani *et al.* (2002)	Alecke et al.(2009)
Eichengreen & Irwin (1998)	Rauch & Trindade (2002)	Berman (2009)
Wei (1996)	Thornton & Goglio (2002)	Bosquet & Boulhol (2009)
Abraham *et al.* (1997)	Amiti & Wakelin (2003)	Cieślik & Hagemejer (2009)
Helliwell (1997)	Egger & Pfaffermayr (2003)	Lennon (2007)
Matyas *et al.* (1997)	Estevadeordal *et al.* (2002)	Campbell (2010)
Nagy (1997)	Evans (2003)	Clever & Martínez-Zarzoso (2010)
Wolf (1997)	Fidrmuc & Fidrmuc (2003)	Crozet & Koenig (2010)
Frankel *et al.* (1998)	Hillberry & Hummels (2003)	Disdier & Marette (2010)
Frankel & Romer (1999)	Ritschl & Wolf (2003)	Felbermayr & Toubal (2010)
Head & Ries (1998)	Chen (2004)	Marimoutou *et al.* (2009)
Portes & Rey (1998)	Izquierdo *et al.* (2003)	Rudolph (2010)
Bougheas *et al.* (1999)	Koukhartchouk & Maurel (2003)	Cieślik & Hagemejer (2011)
Dunlevy & Hutchinson (1999)	Martinez-Zarzoso (2003)	Egger & Pfaffermayr (2011)
Feenstra *et al.* (1998)	Martínez-Zarzoso & Nowak-Lehmann (2003)	Garman *et al.* (2011)
Fitzsimons *et al.* (1999)	Raballand (2003)	Kleinert & Neugebauer (2012)
Frankel & Romer (1999)	Babetskaia-Kukharchuk & Maurel (2004)	Kurmanalieva & Vinokurov (2011)
Mumenthaler (1999)	De Groot *et al.* (2004)	Martinez-Zarzoso & Vollmer (2011)
Rauch (1999)	Elliott & Ikemoto (2004)	Martínez-Zarzoso *et al.* (2011)
Al-Atrash & Yousef (2000)	Fidrmuc (2004)	Parlow (2011)
Ceglowski (2000a)	Fontagné *et al.* (2005)	Vancauteren *et al.* (2005)
Ceglowski (2000b)	Freund & Weinhold (2004)	Xiong & Beghin (2011)
Egger (2000)	Imbs (2004)	Alakbarov (2012)
Hashai (2000)	Jansen & Nordås (2004)	Grant (2013)
Jakab *et al.* (2001)	Ghosh & Yamarik (2004)	Minondo & Requena (2012)
López-Córdova & Meissner (2003)	Mann & Otsuki (2003)	Sandberg & Seale Jr (2012)
Mathur (2000)	Nitsch (2002)	Behncke (2013)
Nitsch (2000)	Redding & Venables (2004)	Duenas & Fagiolo (2013)
Stone and Joen (2000)	Rose (2002)	Minondo & Requena (2013)
Wolf (2000)	Wanjala Musila (2004)	
Wolf (2000)	Wong (2004)	