

# Non-tariff barriers, trade integration and the gravity model

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Master Thesis  
Economic Theory and Econometrics

Department of Economics  
University of Oslo

May 2014





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2014

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Trykk: Reprosentralen, Universitetet i Oslo

# Summary

This thesis sets out to discuss how the gravity model is used to account for the presence of non-tariff barriers (NTBs) in world trade, and how different applications have consequences for policy analysis. This is discussed through the models use in in two independent studies trying to predict the effects of a trade integration agreement between the EU and US. I also run my own gravity regression using a unique dataset to further supplement the discussion.

NTBs are complex measures which impact trade in other ways than standard ad-valorem tariffs. They can be argued to correct market failures (e.g. as sanitary measures or safety regulations), or function as protectionist tools (i.e. as substitutes and/or compliments for tariffs). Furthermore, NTBs are difficult to monitor and measure, much more so than tariffs. Therefore, NTBs pose a serious challenge for economic research, especially since it is a general consensus that the presence of NTBs has become more apparent in recent decades, as shown by e.g. World Bank (2012).

I investigate how the gravity model of trade, the most common tool for estimating trade flows, is used to account for the presence of NTBs. In particular, I look at how the model is used differently in two comprehensive studies that both try to predict the effects of the Transatlantic Trade and Investment partnership (TTIP) – a trade agreement between the EU and US currently under negotiation. NTB reduction is an explicit goal of the agreement, which makes this an important part of both studies.

The studies are performed by the Leibniz Institute for Economic Research (IFO) and the Centre for Economic Policy Research (CEPR). They reach very different conclusions on the effects of TTIP, both regarding the magnitude of the effects and sometimes also the direction of the outcome. I find that they use the gravity equation in different ways in the two studies, and argue that this is one of the reasons for their divergent results.

To further discuss the presence of NTBs, and to provide an alternative to the CEPR and IFO studies, I construct an independent dataset. I use data on tariffs, NTBs and regional trade agreements (RTAs), and run my own regressions based on a thorough discussion on both the theoretical and empirical aspects of the gravity model. My data confirms that NTBs are more important than tariffs (on average) and my regressions show that there are gains to be made from reducing both NTBs and tariffs, but that the success of TTIP, or any trade agreement for

that matter, to a large extent will hinge on NTB reductions. In this respect my data confirm similar observations in both the CEPR and IFO study. The results also imply that the effects of trade agreements seem somewhat underestimated in the CEPR study. Furthermore, my results indicate that the method used by IFO is highly sensitive to which trade agreements' that are included in their RTA dummy variable, as their method consists of simulating a TTIP scenario based on the average effect of existing trade agreements.

# Acknowledgements

This thesis is completed as part of the project “Non-tariff barriers, food safety and international food trade” at the Norwegian Institute of International Affairs (NUPI) in cooperation with the Norwegian University of Life Sciences (NMBU) and the Kiev School of Economics (KSE).

First and foremost, I wish to extend my uttermost gratitude to my supervisor and project manager, Arne Melchior at NUPI. Thank you for allowing me to partake in the project, for providing me with valuable experience presenting my work at the seminar in Kiev, and for vital guidance and comments throughout the process. I also wish to extend my gratitude to Hege Medin at NUPI for letting me contribute to the NHO-report on TTIP, and for many stimulating discussions and useful suggestions.

I would also like to thank my many co-students at the University of Oslo for providing moral support, and for sharing a seat with me on the long journey through my degree. In particular, I wish to thank Bård and Torbjørn for their advice, and for spending their time reading my drafts. I also want to extend a warm gratitude to my friends; Jonas, Frida, Anders, Thomas, Jonas H, Eirik, Adam and Dan for constantly reminding me that there is a fun world out there, beyond the economic literature.

My parents also deserve my gratitude; for making this process as easy as possible for me, and for providing a peaceful alternative workspace at the lovely house in Tønsberg.

Last, but far from least, I want to thank my utterly wonderful girlfriend, Guro Gjørven, for her unconditional love and support in seeing me through this process.

Marcus Marsilius Gjems Theie

May 2014, Oslo





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# 1 Introduction

During the last few decades the world economy has become increasingly integrated, and an important aspect of so-called “Globalization” has been to successfully reduce economic frictions between nations. In spite of this there are few countries, industries or even products where free trade truly exists, and as tariff levels have decreased, a new challenge has emerged. Non-tariff barriers (NTBs) are complex measures which impact trade in other ways than standard ad-valorem<sup>1</sup> tariffs. Ranging from technical regulations and sanitary measures to import quotas and border inspections, they can correct market failures or serve as tools of protectionism. According to the World Bank (2012), NTBs have been increasing in recent years, both in magnitude and multitude, and it is often argued that they serve as substitutes for tariffs (e.g. by Kee et al, 2009). Therefore, for anyone trying to remove trade frictions between nations, NTBs are a serious challenge. Furthermore, they pose a challenge to everyone wanting to measure and quantify them.

Unlike tariffs, NTBs are not easily observed and there is no universal consensus on how they should be accounted for in empirical research. A tool which is frequently used is the gravity model of trade. If data is available the model can be used to estimate the effect of NTBs on trade flows, but it can also be used to transform data (e.g. from surveys) into ad-valorem tariff equivalents (as in e.g. Kee et al, 2009 and ECORYS, 2009a).

In this thesis I discuss the use of gravity and how it is used in economic research to account for NTBs in an applied setting. In particular, I look at the case of the Transatlantic Trade and Investment Partnership (TTIP) – a trade integration agreement between the EU and US currently under negotiation. To reduce NTBs as well as tariffs is an explicit goal of the agreement (it is even pronounced on the TTIP homepage<sup>2</sup>). However, in spite of political will to get the agreement up and running on both sides of the Atlantic, NTB reduction is a complicated and sometimes delicate task. There is no guarantee of successful NTB removal. Therefore, there have been numerous studies trying to predict the results which look at various depths of the agreements’ ability to reduce frictions. In particular, there have been two major studies that have influenced the debate; one by the Leibniz Institute for Economic Research (IFO), the other by the Centre for Economic Policy Research (CEPR). Their results

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<sup>1</sup> Ad-valorem is Latin for “according to the value”. Thus, tariffs are ad-valorem in the sense that they are proportional, i.e. an X % ad-valorem import tariff amounts to X % of the import value.

<sup>2</sup> <http://ec.europa.eu/trade/policy/in-focus/ttip/about-ttip/>

are generally positive; TTIP will increase trade, GDP and welfare (IFO, 2013a; CEPR, 2013). But the studies vary tremendously in terms of both the magnitude of the impact, and sometimes also regarding the direction of the outcome. However, in both studies the gravity equation plays a pivotal role. In particular, both use the gravity model, in different ways, to incorporate the presence of NTBs into their models. Their different ways of using the gravity model can help to explain their divergent results. This makes the two studies the perfect backdrop for a discussion on how the gravity model can be used to account for the presence of NTBs, and how different ways of using the model have consequences for policy analysis.

In its most simple form the gravity equation relates a country  $j$ 's expenditure on goods from country  $i$ , i.e.  $i$ 's exports to  $j$ , to the countries sizes, often measured by GDP, and any trade frictions between them. This relation has proved to be one of the most empirically successful in economic literature, but until recently it has lacked a proper theoretical footing (Head and Mayer, 2014). One of the first successful attempts to derive a theoretical version of the model was Anderson and van Wincoop (2003). The most important result emerging from their work is one that is intuitively appealing, but previously not formalized into the model; "... the more resistant to trade with all others a region is, the more it is pushed to trade with a given bilateral partner" (Anderson and van Wincoop, 2003 pp. 170). In other words, trade frictions with all trade partners of both  $i$  and  $j$  affect their bilateral trade. Previous empirical versions of the gravity equation have failed to control for this, and have thus suffered from an omitted variable bias (Anderson and van Wincoop, 2003). Anderson and van Wincoop named this concept "multilateral resistance" and nearly every theoretical gravity model since have integrated this concept one way or another (e.g. Bergstrand et al, 2013). Now, the model has a range of different theoretical microfoundations and has been shown to be very flexible to a wide range of specifications; e.g. the convergence with the heterogeneous firms literature (by Chaney (2008); Helpman et al. (2008); Melitz and Ottaviano (2008)). There have also been substantial developments regarding the econometric version of the model; with the use of fixed effects estimation (suggested by e.g. Feenstra, 2004), and the introduction of PPML estimation by Silva and Tenreyro (2006). This has made the gravity model the obvious choice for determining the impact of any variable on trade flows, which makes it a natural framework for measuring the effects of NTBs on trade.

The increased relevance of and focus on NTBs by policymakers and researchers, along with the recent developments of the gravity model and its use as a tool to predict the effects of TTIP motivates the following objective for my thesis:

*Investigate how the gravity model is used to account for the presence of NTBs in economic research, and in particular how it has been used to predict the outcome of TTIP.*

The structure of the thesis is as follows. Chapter 2 introduces the gravity model. The purpose is to establish a firm understanding of the model before going into a discussion about how it is used to account for the presence of NTBs. In chapter 3, I discuss the two studies on TTIP. I present their main results to demonstrate the divergence between them, before going into depth on their use of gravity and how they use the model to estimate the impact of NTBs. Chapter 4 contains my own estimations of the Anderson and van Wincoop gravity model. I use a comprehensive dataset on NTBs from the World Bank (constructed by Kee et al, 2009), which provides additional insight to the size of transatlantic as well as worldwide NTBs. Furthermore, my regressions provide an alternative to both the CEPR and the IFO studies and demonstrate the sensitivity of their methods. In addition to data on NTBs, I use data on existing trade agreements and discuss their ex-post effects on trade flows for both members and non-members of these agreements. Chapter 5 concludes.

# 2 The gravity equation of trade

In this chapter I introduce the gravity model. The purpose is to formally introduce and discuss the model which is commonly used to measure the effects of NTBs on trade flows. I start with a brief discussion of the evolution of the model which has gone through a substantial evolution over the last decades. However, it is not my intent to present every aspect of its evolution; I present a selective survey where I focus on what is most relevant for my thesis, namely the tools needed to discuss the effects of NTBs. In this regard, the introduction of so-called multilateral resistance by Anderson and van Wincoop (2003) is important.

First, I introduce a general version of the gravity model which is useful for capturing the modern concept of gravity in trade, before deriving the Anderson and van Wincoop (2003) gravity model in its entirety. Their model is a crucial element in both studies on the TTIP agreement which will be discussed in the next chapter. I also include a brief discussion on the limitations of the model and the assumptions it makes. Next, I discuss some of the most common estimation techniques used in the literature. The discussion is limited to what is relevant for the estimations in chapter 4.

## 2.1 The evolution of gravity in trade

The gravity model of bilateral trade flows first made its appearance in the economic literature in the 1960s. It is the Dutch economist Jan Tinbergen (1962) who is given credit for bringing the Newtonian law of universal gravitation from the late 1600s into the gravity literature (e.g. by Head and Mayer, 2014 and Feenstra, 2004). The Newtonian law of gravity stipulates that the gravitational force between two objects is proportional to the product of the two objects mass and inversely proportional to their distance. Analogous to this, the first gravity equation of international trade stipulated that trade between two countries is proportional to the product of the countries size and inversely proportional to the distance between them. Let  $X_{ij}$  be bilateral trade (exports or imports),  $Y_i$  and  $Y_j$  denote the country size (often measured by GDP),  $\phi_{ij}$  represent bilateral distance, and  $G$  be a constant:

$$(2.1) \quad X_{ij} = G Y_i^a Y_j^b \phi_{ij}^{-c}$$

Equation (2.1) is the original gravity equation used by Tinbergen (1962). In light of the recent advancements within gravity research it is named the “Naïve” gravity equation by Head and



Mayer (2014).<sup>3</sup> The generalization that  $a \neq b \neq c \neq 1$  is a feature added to the original Newtonian law of gravity which assumes that the coefficients equal unity. However, many studies have suggested that this might be the case for economic gravity as well. In a meta-analysis, Head and Mayer (2014) find that average estimates are  $a = 0.98$ ,  $b = 0.84$ ,  $c = 0.93$ , and that the unity coefficient often is included in the confidence intervals.<sup>4</sup> However, Silva and Tenreyro (2006) argue the “unity-consensus” is based upon a bias resulting from the use of OLS estimation with heteroskedastic data. This will be discussed in detail below.

While the gravity equation of Tinbergen has been used by economists since the 1960s and was proved to be of high empirical relevance, it received opposition from the research community and stayed outside the mainstream of trade research until 1995 (Head and Mayer, 2014). One of the reasons for this was the perception that the gravity equation was more an analogy of physics than a product of economic theory, despite an elaborate attempt by Anderson (1979) to provide a sound theoretical foundation. His model was deemed too complex, and did not catch on (Head and Mayer, 2014). But, while Anderson’s model did not push gravity into the limelight, it laid the groundwork for the Anderson and van Wincoop (2003) model which revolutionized the field.

Head and Mayer (2014) divide the success of gravity, and its acceptance into the mainstream research community, into three stages, which will be elaborated in the three following subsections.

### 2.1.1 Admission

The turnaround came in 1995, when the conventional trade theories were the subject of discussion. Trefler (1995) criticized the standing literature’s empirical relevance, and in particular he claimed that the Heckscher-Ohlin (H-O) theorem performs horribly. The H-O theorem states that a country will export the good which uses its relatively most abundant factor of production intensively, and import the good which uses its relatively scarce production factor intensively. In other words, factor endowments determine the trade flows in the H-O model. Trefler states that; “[f]actor endowments correctly predicts the direction of factor service trade about 50 percent of the time, a success rate that is matched by a coin toss”

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<sup>3</sup> I have added the coefficient  $-c$  to the last term of the naïve gravity equation as it is written in Head and Mayer (2014, eq. 4). This is to underline the point that since it is assumed that distance is the only trade friction the coefficient is assumed to be negative.

<sup>4</sup> In 700, 671 and 1835 gravity studies respectively (Head and Mayer, 2014).

(Trefler, 1995 pp. 1029). He argues further that when a major theory within a field performs this badly, it should serve as an incentive to develop new theories. Also in 1995, Leamer and Levinsohn argued that gravity models have an impressively high success rate regarding its ability to explain international trade flows. They go on to criticize economists for not admitting distance into their way of thinking (Leamer and Levinsohn, 1995).

Another important contribution was Krugman (1995) who introduced the concept of “remoteness”. This was one of the first steps on the way towards the concept of multilateral resistance, which was popularized by Anderson and van Wincoop (2003). Remoteness measures a country’s average distance from *all* its trading partners, weighted by the partner countries share of world GDP. The idea is that bilateral trade relations between countries  $i$  and  $j$  are influenced by both countries’ *other* bilateral trade relations. Krugman elegantly illustrates his point with a thought experiment where the trading countries  $i$  and  $j$  are moved from the heart of Europe to Mars. Intuitively, he argues, this would affect their trade patterns. In the context of Trefler’s call for a new major theory of trade, Krugman’s thought experiment can be understood as an argument for the need to include general equilibrium effects into this theory.

Another highly influential paper was McCallum (1995). He used the gravity equation to measure the effect of national borders on trade. He concludes that both national borders and bilateral distance are significant frictions to trade. This came at a time when the business press was claiming the “death of distance” and the “borderless world” as world trade became more integrated (Head and Mayer, 2014). In light of this, McCallum’s result was named the “Border puzzle” and his paper was an important demonstration of the explanatory power of the gravity equation.

### **2.1.2 Structural gravity – the “revolution” of multilateral resistance**

Trefler’s call for a new major theory to explain trade flows, Leamer and Levinsohn’s focus on the high empirical relevance of gravity, and Krugman’s call for including general equilibrium effects resulted in the gravity model of Anderson and van Wincoop (2003). The goal of their paper was twofold; to create a sound theoretical framework for the gravity model, and use this to solve the McCallum border puzzle. My focus will be on the former. The Anderson and van Wincoop model stipulates that trade between  $i$  and  $j$  is a function of (i) bilateral trade frictions between  $i$  and  $j$ , (ii) trade frictions between  $i$  and all its trade partners, and (iii) trade

frictions between  $j$  and all its trade partners (Anderson and van Wincoop, 2003). Effects (ii) and (iii) are what they call “multilateral resistance”, which now has become a standard concept in gravity models. The surge of gravity models following Anderson and van Wincoop has become known as structural gravity equations.

While Anderson and van Wincoop (2003) deserve to be credited for formalizing the concept of multilateral resistance, the concept precedes them. As mentioned above, Krugman’s thought experiment and his concept of remoteness reflects this. Furthermore, the necessity of controlling for multilateral effects is clearly stated by Polak (1996). He calls for including a term in the gravity equation which measures the “...total negative effect on the imports [...] resulting from all the bilateral distances” (Polak, 1996 pp. 535). Controlling for this corrects an underestimation of trade flows in the gravity equation relative to observed values which was persistent in the literature, e.g. in Frankel et al. 1994a and 1994b (Polak, 1996). Polak states that the idea of including all bilateral distances is traced all the way back to Linnemann (1966). Linnemann created a “location index” measuring each country’s average distance from its trading partners, as Krugman suggested, but he did not include this in his gravity equation.

### **2.1.3 Convergence with the heterogeneous firms literature**

The gravity models’ final step towards inclusion in the field of international economics was the unification with the literature on heterogeneous production, i.e. where productivity is assumed to vary across firms (Head and Mayer, 2014). This concept was brought into the field of international economics by Melitz (2003). In 2008, three independent papers that expanded the gravity model in this direction were published; Chaney (2008), Helpman et al. (2008), and Melitz and Ottaviano (2008). All these papers have in common that they allow for heterogeneous productivity on the supply side in the gravity model. Thus, these models were able to analyze the effects of trade shocks on the intensive and extensive production margins separately. For instance, an exogenous increase in trade costs leads to lower exports through two potential channels; (i) the least productive firms will be unable to produce, i.e. there will be a reduction in number of producers (extensive margin), and (ii) production is more expensive so each producing firm will produce (and export) less (intensive margin). As firm heterogeneity will not be a focal point of my thesis, I will not go far into this literature.

The introduction of multilateral resistance and the subsequent expansion of gravity to include firm heterogeneity shows how the gravity model has gone from being an empirical relation without a proper theoretical foundation, which met little respect in the mainstream economic literature, to become a model truly respected by theorists. The model now has a range of different theoretical microfoundations, and has been shown to be flexible to a wide range of specifications. In the next section, I go deeper into the formalities of the Anderson and van Wincoop gravity equation.

## 2.2 Microfoundations

Since the “revolution” of multilateral resistance a wide variety of theoretical microfoundations for the gravity model has been introduced. While my estimations are based on the Anderson and van Wincoop model, it is useful to start off at a more general level to demonstrate the flexibility and robustness of the gravity model across a wide range of different microeconomic assumptions and specifications.

### 2.2.1 The Basic definition

A general version of the modern gravity model can be written as in Head and Mayer (2014):

$$(2.2) \quad X_{ij} = GS_i M_j \phi_{ij} \quad , \quad \phi_{ij} \in [0,1]$$

Where  $X_{ij}$  is bilateral export from  $i$  to  $j$ <sup>5</sup>.  $S_i$  represents all “capabilities” of the exporter to all destinations while  $M_j$  captures all the characteristics of the import market in  $j$ . Note that the model is more general than the naïve version in the preceding subsection;  $Y_i$  and  $Y_j$  have been replaced by  $S_i$  and  $M_j$ , where all characteristics belonging to  $i$  and  $j$  are included.  $S_i$  and  $M_j$  are multilateral terms as they are equal across all importers (exporters) for a given exporter (importer). The term  $\phi_{ij}$  is now interpreted as bilateral *accessibility* of exporter  $i$  to importer  $j$  which now captures all concepts of friction in trade. This includes both natural frictions such as distance and geographical placement, and political frictions such as borders, tariffs and NTBs. The term  $G$  is a gravitational constant. If time subscripts were added, i.e. if the above equation is used in a panel data analysis,  $G$  would be allowed to vary over time.

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<sup>5</sup> In principle  $X_{ij}$  can also be bilateral imports.

Two important features stand out from equation (2.2). First, note that each term enters multiplicatively. This particular functional form is consistent across all specifications of the gravity model. It is a feature which is rooted in the models historical analogy to the Newtonian law of gravity. In other words, the multiplicative form has occurred somewhat unintentionally and does not necessarily reflect any features of economic theory. Nevertheless, the functional form has some theoretical justifications. In particular, Anderson (1979) demonstrates that a multiplicative form follows from a Cobb Douglas model where products are differentiated by place of origin, and Helpman and Krugman (1985) show that the multiplicative form could be generated in a model with intra-industry trade only. However, it is possible that future work will make use of other functional forms, as argued by Head and Mayer (2014).

The second, and most important feature in (2.2) is the fact that all third country effects must come through the multilateral terms  $S_i$  or  $M_j$ . To extrapolate this point, Head and Mayer expand the above definition of the gravity model:

$$(2.3) \quad X_{ij} = \underbrace{\frac{Y_i}{\Omega_i}}_{S_i} \underbrace{\frac{X_j}{\Phi_j}}_{M_j} \phi_{ij}$$

Equation (2.3) is called the *Structural Gravity Equation*. Here, country  $i$ 's value of production,  $Y_i = \sum_j X_{ij}$ , is defined as the sum of its exports to all regions, and the value of country  $j$ 's expenditure,  $X_j = \sum_i X_{ij}$ , is defined as the sum of its imports across all exporters. In practice GDP is often used as a proxy for  $Y_i$  and  $X_j$ . The terms  $\Omega_i$  and  $\Phi_j$  are the multilateral resistance terms which are defined as:

$$(2.4) \quad \Phi_j = \sum_l \frac{\phi_{jl} Y_l}{\Omega_l} \text{ and } \Omega_i = \sum_l \frac{\phi_{li} X_l}{\Phi_l}$$

The important feature of the multilateral resistance terms is that they include trade friction terms between all trading partners for both  $i$  and  $j$ . It is intuitively appealing that the friction between  $j$  and its other trading partners, i.e. all  $l \neq i$ , will affect its demand for goods from  $i$ . For example, if a bilateral trade agreement were initiated between importer  $j$  and some other country  $l \neq i$ , this would decrease trade costs between  $j$  and  $l$  relative to those between  $j$  and  $i$ . Hence, country  $j$ 's demand would shift towards  $l$  and away from  $i$ , and exports from country  $i$  to country  $j$  would decrease.

The structural gravity model, as described in equation (2.3) and (2.4) above, identifies the core features of modern gravity theory. It relates bilateral exports multiplicatively to bilateral trade frictions, the exporter's value of production, importer's value of expenditures, and controls for multilateral resistance. However, beyond this the model in (2.3) and (2.4) is of little use. To obtain a gravity equation to be used for estimation, a more elaborate theoretical framework is needed. As mentioned above there are many possible approaches. Both conditional- and unconditional general equilibrium frameworks can be used. In the next section, I derive the model based on the conditional general equilibrium framework from Anderson and van Wincoop (2003). Their model is relevant for discussing both the IFO and CEPR studies on the TTIP agreement as both use extensions of this model to account for NTBs and tariffs. I will also briefly present alternative specifications such as the unconditional general equilibrium approach, based on monopolistic competition and increasing returns to scale in production, as in Bergstrand et al (2013).

## 2.3 The Anderson and van Wincoop gravity model

### 2.3.1 Assumptions

There are two main underlying assumptions in the Anderson and van Wincoop model. The first assumption is that *goods are differentiated by place of origin*. This is the so called Armington assumption, after Armington (1969), who assumed that two goods of the same kind originating from different regions were imperfect substitutes. The Armington assumption implies trade separability. This means that the allocation of trade across countries is separable from the allocation of production and spending within countries (Anderson and van Wincoop, 2004). This assumption ensures that the model is a conditional general equilibrium model where supply of and expenditure on goods can be taken as a given in the analysis of bilateral trade patterns (ECORYS, 2009b). A related assumption is that each country specializes in production of only one good and regards the supply of each good as fixed. Hence, their model does not include firm's decisions. The second assumption is that *consumers have identical and homothetic preferences*<sup>6</sup>. This motivates the use of a constant elasticity of substitution (CES) utility function (Anderson and van Wincoop, 2003).

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<sup>6</sup> I.e. described by a homothetic utility function, defined such that if the consumer is indifferent between  $A$  and  $B$  he is also indifferent between  $zA$  and  $zB$  for any  $z > 0$ . The CES utility function is homothetic.

### 2.3.2 Deriving the gravity equation

The CES utility function of consumers in country  $j$  is given by

$$(2.5) \quad U_j = \left[ \sum_{i=1}^N \beta_i^{(1-\sigma)/\sigma} \cdot c_{ij}^{(\sigma-1)/\sigma} \right]^{\sigma/(\sigma-1)}$$

Where  $c_{ij}$  is consumption of goods from  $i$  by consumers in  $j$ ,  $\sigma$  is the elasticity of substitution and  $N$  is the number of countries.  $\beta_i$  is an arbitrary parameter of preference towards goods from country  $i$ , which can be thought of as an *inverse* measure of quality. It might be more useful to consider  $\beta_i = 1/\alpha_i$ , where  $\alpha_i$  can be thought of as the attractiveness of country  $i$ 's good (Head and Mayer, 2014). This is more intuitively appealing and it would be a simple matter to replace  $\beta_i^{(1-\sigma)/\sigma}$  with  $\alpha_i^{(\sigma-1)/\sigma}$  in equation (2.5). However, I continue with the above specification as this is the one used by Anderson and van Wincoop (2003).

The consumers maximize utility subject to the budget constraint:

$$(2.6) \quad Y_j = \sum_{i=1}^N p_{ij} c_{ij}$$

where  $p_{ij}$  is the price on goods from  $i$  faced by consumers in  $j$ . Due to trade costs, the price of country  $i$ 's goods differ depending on the importer  $j$ . Trade costs are modeled according to the “iceberg”-structure where it is assumed that a fraction  $t_{ij}$  of the good “melts” away during transportation from  $i$  to  $j$ <sup>7</sup>. How large this fraction is will depend on the individual characteristics of each bilateral relation. Formally, the price of  $i$  goods in  $j$  can be written as  $p_{ij} = \tau_{ij} p_i$ , where  $\tau_{ij} = (1 + t_{ij})$  and  $p_i$  is the supply price of the firm in  $i$ . The nominal value of exports from  $i$  to  $j$  is then  $X_{ij} = p_{ij} c_{ij} = \tau_{ij} p_i c_{ij}$ . Note that the trade cost term  $\tau_{ij}$  is analogous to the accessibility term,  $\phi_{ij}$ , from the previous section. Furthermore, it is assumed that total (nominal) income in country  $i$  is given by  $Y_i = \sum_j X_{ij}$ , as was also discussed in the previous section. This assumption can be thought of as a market clearing condition.

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<sup>7</sup> Anderson and van Wincoop use a slightly different specification of the trade costs in their 2003 paper. They assume that for each unit of the good shipped, the exporter incurs an export cost equal to  $t_{ij} - 1$  which is passed onto the importer. The qualitative and quantitative implications are the same. I use the iceberg analogy since this is a more common specification in the literature.

Combining the above assumptions with the budget constraint, we get the following Lagrange function for utility maximization with respect to  $c_{ij}$

$$(2.7) \quad L = \left[ \sum_{i=1}^N \beta_i^{(1-\sigma)/\sigma} \cdot c_{ij}^{(\sigma-1)/\sigma} \right]^{\sigma/(\sigma-1)} - \lambda \left[ \sum_{i=1}^N \tau_{ij} p_i c_{ij} - Y_j \right]$$

where  $\lambda$  is the Lagrange Multiplier. Maximization yields the following first order condition:

$$(2.8) \quad \frac{\partial L}{\partial c_{ij}} = \left[ \sum_{i=1}^N \beta_i^{(1-\sigma)/\sigma} \cdot c_{ij}^{(\sigma-1)/\sigma} \right]^{1/(\sigma-1)} \beta_i^{(1-\sigma)/\sigma} c_{ij}^{-1/\sigma} - \lambda \tau_{ij} p_i = 0$$

Along with the budget constraint this yields the following demand function (for full derivation see appendix A1):

$$(2.9) \quad X_{ij} = \frac{(\tau_{ij} p_i \beta_i)^{1-\sigma}}{P_j^{1-\sigma}} Y_j$$

Where  $P_j = \left[ \sum_{i=1}^N (\tau_{ij} p_i \beta_i)^{1-\sigma} \right]^{1/(1-\sigma)}$  is the CES price index of country  $j$ . Note that a higher  $\beta_i$  implies a lower demand for  $i$ 's product in  $j$ . This is consistent with the interpretation of  $\beta_i$  as an inverse measure of quality. If I were to follow Head and Mayer (2014) the term  $\alpha_i^{\sigma-1}$  would replace  $\beta_i^{1-\sigma}$  in the numerator and demand would increase with  $\alpha_i$  making the interpretation as a measure of attractiveness of  $i$ 's goods clear.

Inserting (2.9) into the market clearing condition  $Y_i = \sum_j X_{ij}$  and solving for  $(\beta_i p_i)^{1-\sigma}$  yield

$$(2.10) \quad (\beta_i p_i)^{1-\sigma} = \frac{Y_i}{\sum_{j=1}^N \left( \frac{\tau_{ij}}{P_j} \right)^{1-\sigma} Y_j}$$

Now, define world nominal GDP as  $Y^w = \sum_{j=1}^N Y_j$ . Expanding the right hand side of equation (2.10) by  $(1/Y^w) \cdot (1/Y^w)^{-1}$ , and inserting the resulting expression back into the demand equation (2.9) yields:

$$(2.11) \quad X_{ij} = \left( \frac{\tau_{ij}}{P_j} \right)^{1-\sigma} \frac{Y_j Y_i}{Y^w} \left[ \sum_{j=1}^N \left( \frac{\tau_{ij}}{P_j} \right)^{1-\sigma} \frac{Y_j}{Y^w} \right]^{-1}$$

Rearranging equation (2.11) yields the Anderson and van Wincoop gravity model:



$$(2.12) \quad X_{ij} = \frac{Y_j Y_i}{Y^w} \left( \frac{\tau_{ij}}{\Pi_i P_j} \right)^{1-\sigma}$$

Where  $P_j^{1-\sigma}$  and  $\Pi_i^{1-\sigma}$  are multilateral resistance terms. They are defined as:

$$(2.13) \quad \Pi_i^{1-\sigma} = \sum_{j=1}^N \left( \frac{\tau_{ij}}{P_j} \right)^{1-\sigma} \frac{Y_j}{Y^w}$$

$$(2.14)^8 \quad P_j^{1-\sigma} = \sum_{i=1}^N \left( \frac{\tau_{ij}}{\Pi_i} \right)^{1-\sigma} \frac{Y_i}{Y^w}$$

The Anderson and van Wincoop gravity model is groundbreaking in the sense that it was the first to formally incorporate the concept of multilateral resistance into the gravity model. Failure to control for multilateral resistance has been labeled the “gold medal mistake” of gravity research by Baldwin and Taglioni (2006). According to Head and Mayer (2014), almost every paper preceding Anderson and van Wincoop (2003) is awarded this gold medal.

### 2.3.3 Trade costs

Unfortunately, the trade cost term in (2.12) is not directly observable. Anderson and van Wincoop use the following proxy for trade costs:

$$(2.15) \quad \tau_{ij} = d_{ij}^\rho e^{\gamma B_{ij}}$$

In (2.15)  $d_{ij}$  is bilateral distance,  $B_{ij}$  is a dummy variable that equals one if the two regions  $i$  and  $j$  are separated by a border. The particular proxies used by Anderson and van Wincoop are specific to their problem as they are trying to solve the “McCallum border puzzle”. I will not discuss the reasons for their exact specification, but it is useful to specify their trade cost function here as the functional form used is crucial for my own estimations in chapter 4. Their way of specifying the trade costs has become standard in the gravity literature (see e.g. Egger and Larch, 2011; Shepard, 2013 and Baier and Bergstrand, 2009).

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<sup>8</sup> The expression in (2.14) is obtained by expanding the right hand side of equation (2.10) by  $(1/Y^w) \cdot (1/Y^w)^{-1}$ , inserting the resulting expression into the price index term  $P_j = \left[ \sum_{i=1}^N (\tau_{ij} p_i \beta_i)^{1-\sigma} \right]^{1/(1-\sigma)}$  and inserting for  $\Pi_i^{1-\sigma}$ .

### 2.3.4 Limitations of the Anderson and van Wincoop model

Although the inclusion of multilateral resistance is a pivotal contribution in the field, the Anderson and van Wincoop model has its limitations. Many of these have been corrected for by others, and I will introduce some in the next subsection. But there are also some problems with the model where the literature is limited, and where there is scope for future research.

An obvious problem with the model is that it analyzes trade at the aggregated level only. The assumption that each country produces only one good suppresses the fact that trade frictions affect different sectors differently. Anderson and van Wincoop admit to this limitation in their paper (Anderson and van Wincoop, 2003 footnote 8).

In light of the preceding literature on distance in trade, the success of Anderson and van Wincoop is to formally include the ideas of Polak (1996) and Krugman (1995) that distances to *all* trading partners matter. A next step would be to include the insight from the field of economic geography (as in e.g. Fujita et al, 1999). In this field the location of economic activity is assumed endogenous to the firms. Hence income becomes a function of geographical location as production is clustered spatially. In terms of the gravity equation (2.12) this would mean that GDP would be a function of distance. Research in this field is limited.

Another issue with the model is the possible reversed causal relation between GDP and trade flows. High income will lead to more trade, but it is also quite clear that more trade can lead to higher income. This issue has to my knowledge not been sufficiently addressed in the gravity literature, even though it is well-established empirically (e.g by Irwin and Terviö, 2002).

### 2.3.5 Alternative specifications of the gravity equation

Head and Mayer (2014) underline the flexibility of the structural gravity equation (2.3) in terms of the different microeconomic frameworks it can be adapted to.

#### *Demand side specifications*

Bergstrand et al. (2013) derive an alternative gravity equation based on a general equilibrium model where the supply side is modeled specifically and the assumption of trade separability is lifted. The model utilizes a Dixit-Stiglitz-Krugman framework where consumer's

preferences are determined by a “love for variety” and firms operate under monopolistic competition with increasing returns to scale (Bergstrand et al. 2013; Head and Mayer, 2014). This model is also relevant for the preceding discussion as it is used along with the Anderson and van Wincoop model in the ECORYS study on transatlantic non-tariff barriers (NTBs) which will be discussed in detail in the next chapter (ECORYS, 2009a).

The main contribution of Bergstrand et al. (2013) is the development of a gravity model that allows for asymmetric trade costs and proper estimation of the elasticity of substitution. The elasticity of substitution is needed to conduct comparative statics analysis. Anderson and van Wincoop have to make an educated guess on the value of the elasticity of substitution based on previous estimations in their paper. Bergstrand et al. (2013) criticize this and show through various Monte Carlo exercises that this can lead to significant biases of the comparative statics results. I have included a formal derivation of the Bergstrand et al. (2013) gravity model in appendix A2. The model is not directly relevant as I will focus the Anderson and van Wincoop in the following chapters, but the framework is used by many (e.g. by Feenstra, 2004). The derivation in the appendix also demonstrates that the fixed effects regression version of the Bergstrand et al. model similar to the Anderson and van Wincoop fixed effects regression model which I discuss below.

### *Supply side specifications*

On the supply side, the most relevant derivations of the structural gravity model are the ones allowing for heterogeneity of firms’ productivity, as discussed above. This makes it is possible to analyze how trade costs affect the production structure. If a trade frictions increase marginal costs, trade will be reduced via the extensive margin, i.e. through reducing the production within each firm. If fixed costs are increased, trade will decrease as a result of fewer firms being able to produce. This kind of model is used in the paper by Egger and Larch (2011) which is used in the IFO study on the effects of the TTIP agreement.

## **2.4 Gravity estimation**

Unfortunately, the multilateral resistance terms in (2.13) and (2.14) are not observable. This poses a problem for estimation. Another problem stems from the multiplicative nature of the gravity model. In this section I will discuss the reasons for, the consequences of and some of the solutions to these problems.

### 2.4.1 Estimation in Anderson and van Wincoop

The pivotal role played by Anderson and van Wincoop in terms of their impact on the theory of gravity is not the case when it comes to estimation. To be able to solve the model in terms of observed variables, Anderson and van Wincoop make additional assumptions. Looking back at the general specification of the structural gravity model in (2.3) and (2.4), note that the model in (2.12) – (2.14) assumes that  $j$ 's expenditure,  $X_j = \sum_i X_{ij}$ , is equal to its nominal income  $Y_j$ . In their paper they also assume symmetrical trade costs,  $\tau_{ij} = \tau_{ji}$ . Together, these assumptions imply  $\Pi_i = P_i$  and make it possible to solve the equation system in (2.13) and (2.14) implicitly as a function of observables, i.e. GDPs and proxies for trade costs. Anderson and van Wincoop then suggest using nonlinear least squares estimation (NLS) for empirical estimation. The assumption of symmetrical trade cost is quite strong and has received criticism in the literature, e.g. by Bergstrand et al. (2013). Their model allows for asymmetrical trade costs. The use of NLS estimation has also been criticized (see Silva and Tenreyro, 2006).

### 2.4.2 Fixed effects OLS estimation

A popular way to control for multilateral resistance, which does not require assuming symmetrical trade costs, is fixed effects estimation. By effectively creating a dummy variable for every exporter and importer included in the estimation, all country specific effects are taken into account. Formally, by taking the logs of equation (2.12) we get

$$(2.16) \quad \ln X_{ij} = -\ln Y_w + \ln Y_i + \ln Y_j + (1 - \sigma) \ln \tau_{ij} - (1 - \sigma) \ln \Pi_i - (1 - \sigma) \ln P_j + \varepsilon_{ij}$$

where  $\varepsilon_{ij}$  is an added stochastic error term. By putting the terms together we can write this as:

$$(2.17) \quad \ln X_{ij} = C + F_i + F_j + (1 - \sigma) \ln \tau_{ij} + \varepsilon_{ij}$$

$$(2.18) \quad C = -\ln Y_w$$

$$(2.19) \quad F_i = \ln Y_i - (1 - \sigma) \ln \Pi_i$$

$$(2.20) \quad F_j = \ln Y_j - (1 - \sigma) \ln P_j$$

Equation (2.17) is the standard gravity equation used for fixed effects estimation, where  $F_i$  and  $F_j$  are the exporter and importer fixed effects, defined by (2.19 and (2.20). It captures all the information inherited in the multilateral resistance terms, and allows for OLS estimation. This is much less cumbersome than NLS estimation and has become very common in the literature (Head and Mayer, 2014). Note that since world GDP is constant across all country pairs it becomes the regression constant  $C$ .

Unfortunately, fixed effects estimation does not come without limitations. All information in the single country dimension is inherited in the fixed effects of equation (2.19) and (2.20). This estimation method is therefore unable to single out any information on variables inherited in the fixed effects, i.e. any variables which are constant across all exporters (importers) for a given importer (exporter), such as GDP. Another weakness when using fixed effects estimation method with OLS compared to NLS is that zero-observations in trade matrices are discarded due to the fact that the natural logarithm of zero is undefined.

### 2.4.3 Poisson Pseudo Maximum Likelihood estimation

Along with zero-observations, the problem of heteroskedasticity often occurs in trade data. Silva and Tenreyro (2006) present an elegant and simple solution that fixes both these problems. They argue that the Poisson Pseudo Maximum Likelihood (PPML) estimator should be the workhorse estimator for gravity research, as it solves both these problems and can still be used with country fixed effects estimation.

#### *Heteroskedasticity*

Technically, the error term  $\varepsilon_{ij}$  in (2.16) is defined as  $\varepsilon_{ij} = \ln \eta_{ij}$  where  $\eta_{ij}$  is the stochastic element in a regression version of equation (2.12):

$$(2.21) \quad X_{ij} = \frac{Y_i Y_j}{Y_w} \left[ \frac{\tau_{ij}}{\Pi_i P_j} \right]^{1-\sigma} \eta_{ij}$$

where the  $\eta_{ij}$ 's are assumed to be independently and identically distributed. Another important assumption for OLS consistency is that the error term does not depend on any of the regressors, i.e.  $E(\varepsilon_{ij} | Y_i, Y_j, \tau_{ij}, \Pi_i, P_j) = E(\ln \eta_{ij} | Y_i, Y_j, \tau_{ij}, \Pi_i, P_j) = 0$ . In other words, the validity of the process of log-linearizing (2.21) depends critically on the assumption that  $\ln \eta_{ij}$ , and therefore also  $\eta_{ij}$ , is independent of the regressors. However, when taking the

expected value of the natural logarithm of a random variable, like  $E(\ln \eta_{ij})$ , the result will depend on both the mean and the higher moments of  $\eta_{ij}$  (Silva and Tenreyro, 2006).

Therefore, if the dataset suffers from heteroskedasticity, i.e. the variance of  $\eta_{ij}$  depends on one of the regressors, then  $E(\ln \eta_{ij} | Y_i, Y_j, \tau_{ij}, \Pi_i, P_j) \neq 0$ , and the conditions for consistency of the OLS estimator is violated, which will lead to biased estimates. Silva and Tenreyro (2006) argue that heteroskedasticity often is the case with trade data, and therefore suggest using a non-linear estimator, i.e. one which does not require log-linearization.

Through thorough Monte Carlo experimentation, Silva and Tenreyro (2006) show that using log-linearization and OLS estimation achieves greatly biased estimates. They also test the PPML estimator against the OLS, NLS and Gamma Pseudo-Maximum Likelihood estimators. Four different specifications of heteroskedasticity are used during the tests. They conclude that the workhorse estimator for gravity models, and indeed any model with a constant-elasticity framework, should be the PPML estimator. It outperforms the other estimators and is relatively more robust across a wide range of heteroskedastic specifications and measurement errors in the data (Silva and Tenreyro, 2006). Furthermore it is far less cumbersome in terms of calculation, as opposed to e.g. nonlinear least squares which is used by Anderson and Van Wincoop (2003). Based on this I use the PPML estimator for the estimations in chapter 4.

#### *Zero trade flows*

Since PPML is a nonlinear estimator it is also able to tackle the problem of zero trade flows in the dataset. As mentioned above, the gravity equation has its roots in the Newtonian Law of Gravity, which is a multiplicative formula. A problem with this analogy is that while gravitational force never can be zero (only infinitely small), zero trade flows are often observed. Thus, by log linearizing the gravity equation, we are effectively neglecting all zero trade flows and potentially creating a sample bias. Since the PPML estimator does not require use of the log of exports this bias is eliminated.

# 3 Studies on TTIP

Before proceeding to estimation of the gravity model, I demonstrate how it is used differently in two comprehensive studies trying to predict the effects of the Transatlantic Trade and Investment Partnership (TTIP) – a trade integration agreement between the EU and US currently under negotiation. The first study is performed by the Leibniz Institute for Economic Research at the University of Munich (IFO), and was completed in January 2013 on behalf of the German Federal Ministry of Economics and Technology. Although the primary concern is effects of TTIP on the German economy, the study also examines the effects on the rest of the EU and the US as well as the rest of the world. The second study is performed by Centre for Economic Policy Research (CEPR) for the European Commission, and was published in March 2013.

In both studies the gravity equation plays a key role. However, their conclusions are quite different, both in terms of the magnitude of the effects and sometimes also regarding the direction of the outcome. The latter case is especially true for the effects on TTIP's non-members. This has to do with the methods used. In particular, the two studies differ in how the gravity equation is utilized and how they account for the presence of NTBs. Both studies agree that NTBs will be the biggest challenge for the TTIP agreement, and they have very different ways of implementing this in their models. My goal in this chapter is to demonstrate how these underlying methodological differences can explain the divergent results. I first present and compare some of the main results of the studies, then I briefly discuss the overall approach before going into an in-depth discussion of the use of gravity modelling in each study.

## 3.1 Main results

As mentioned above, the studies are done separately and with different objectives. The CEPR study has a broader perspective and includes effects on trade in services and investments in addition to goods trade. It also includes environmental and sustainability impacts. The IFO study considers trade in goods only. Therefore, since my goal is to compare the studies, I only focus on the results regarding trade in goods in the CEPR study. Furthermore, since the overall focus is on the gravity equation and how it is used differently in the two studies, I only

discuss results on GDP and trade flows as these are more directly linked to the use of the gravity model.

### 3.1.1 Scenarios

Both studies look at different scenarios where the TTIP agreement is more or less effective at reducing trade barriers. The scenarios are summarized in table 3.1. The IFO study has two scenarios; a limited scenario where tariffs are eliminated and a comprehensive scenario where NTBs are reduced as well. CEPR follow the same pattern, but they also distinguish between a less ambitious and an ambitious comprehensive scenario. Although the scenarios differ somewhat, the basic idea is the same in the two studies: a limited scenario mimicking an agreement that only covers tariffs and a deeper one which successfully eliminates NTBs as well. As pointed out earlier, both studies agree that NTB removal is crucial for the success of the agreement, and the results confirm this in both studies. One of the reasons that CEPR looks at different levels of NTB reductions while IFO does not is that IFO's methodology restricts them in this area. They are also unable to be explicit about the percentage reduction. I get back to the reasons for this below.

Table 3.1 TTIP scenarios in CEPR and IFO		
	IFO	CEPR
Limited scenario	Tariffs eliminated	98% tariff reduction
Comprehensive scenario(s)	Both tariffs and NTBs reduced	<i>Less ambitious</i>
		98 % tariff reduction 10% NTB reduction on goods
		<i>Ambitious</i>
		100 % tariff reduction 25% NTB reduction on goods
Sources: CEPR 2013, table 4 and IFO 2013b, pp. 6-8		



### 3.1.2 GDP results

Table 3.2 summarizes the predicted GDP effects in the two studies. Overall, the directions of the effects are similar. In the limited scenario, IFO estimates that GDP will increase by 0.75 percent for the US and 0.24 percent for Germany. Unfortunately, they do not report an EU average. The average effect on TTIP members in the IFO study is positive, but they stress that the degree of heterogeneity is high, and that it will lead to negative effects for some member countries. Although they do not report an average for the rest of the world, they also report that GDP will decrease for countries that are attached to the EU and US through existing trade agreements, e.g. NAFTA and the EEA (IFO 2013b). CEPR predict that tariff elimination (limited scenario) will have positive GDP effects for EU countries as well as the US. Their estimated GDP effect is much lower than the IFO estimates. They also report an expected 0.01 percent decrease in the rest of the world's GDP.

Table 3.2 GDP effects in IFO and CEPR		
	IFO	CEPR
Limited scenario	US: 0.75% Germany: 0.24% (EU avg. not reported)  Row.: not reported	EU: 0.1% US: 0.04% Row.: -0.01%
Comprehensive scenario(s)	EU: 4.95% US: 13.38% Row.: decrease	<i>Less ambitious</i>
		EU: 0.27% US: 0.21% Row: 0.07%
		<i>Ambitious</i>
		EU: 0.48% US: 0.39% Row: 0.14%
Sources: CEPR 2013: table 6 , 16 and 41. IFO 2013b, figure 4 and 5. Medin and Melchior 2013		

The comprehensive scenarios are more interesting. There are two particular points that stand out. First, the GDP effects on EU and USA are much larger in the IFO study compared to the CEPR. For the US the estimated GDP increase is 13.38 percent, almost 13 percentage points higher (i.e. 34 times) than the most optimistic scenario in CEPR. Second, the IFO study

predicts a decrease in GDP for the rest of the world, while CEPR expects an increase. One reason for this is that CEPR includes what they call spillover effects for third countries.

If TTIP is successful in reducing NTBs as well as tariffs, it is important to consider these spillover effects since, contrary to tariffs, NTBs are not discriminatory by nature. When two countries agree on lower tariffs, third countries are automatically faced with higher tariffs and are therefore discriminated against. On the other hand, if the two countries agree on e.g. a new hygiene standard on import on certain agricultural goods, it is less likely that they are able to discriminate against third countries in the same way. This is the motivation for CEPR to include the spillover effects. It also serves an example of how NTBs work differently than tariffs.

CEPR distinguish between two types of such spillover effects. Countries exporting to the EU and the US will to some extent benefit from the improved regulatory conditions negotiated in the agreement. This will grant third countries easier access to both the EU and US markets, instead of having to adjust their products differently for the two markets. This is what they call the *direct spillover effect* as it involves a direct cut in trade costs for countries exporting to both the EU and US (CEPR, 2013). Also, since the TTIP trading block would be very large in terms of trade volume, it is likely that third countries will get incentives to adapt to the same harmonization of product standards and regulations as TTIP. A global convergence toward common regulations is called the *indirect spillover effect* (CEPR, 2013). IFO does not include these spillover effects, which might contribute to explaining why the results for third countries are negative (and sometimes large in magnitude) in their study.

In addition to the estimates in table 3.2, the CEPR study includes a breakdown of the estimates. They report that (in the ambitious case) 54 percent of the EU GDP increase is due to NTB reductions, and that 22 percent is from tariff reduction. For the US, only 10 percent of the increase is due to tariff elimination, and 59 percent comes from NTB reduction.<sup>9</sup> This again highlights the importance of NTB reduction for any trade agreement. The pattern of larger effects due to NTBs relative to tariffs occurs in nearly all their results and will not be stated for the remainder of the chapter.

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<sup>9</sup> The remaining increases come from the direct and indirect spillover effects, reduction in NTBs on services and procurement. I have chosen not to report these here to save space. The full effects can be found in CEPR 2013, chapter 5.

### 3.1.3 Trade flow results

Table 3.3 shows the average effects on trade flows in the two studies. Note that the IFO study only shows effects on exports while CEPR shows effects on both imports and exports. Also, CEPR does not include trade flow effects for the rest of the world.

Table 3.3 Trade flow effects in IFO and CEPR			
	IFO	CEPR	
	Exports	Imports	Exports
Limited scenario	Within TTIP: 5.8 %		
	Between	EU: 1%	EU: 1.18%
	non-members: -0.5%	US: 1.13%	US: 1.91
<i>Less ambitious</i>			
Comprehensive scenario(s)	Within TTIP: 92.8%	EU: 2,91%	EU: 3,37%
		US: 3.81%	US: 4.75%
	Between TTIP members and non-members: 78.8 %		
		<i>Ambitious</i>	
	Between non-members: 3.4 %	EU: 5.11%	EU: 5.91%
		US: 4.74	US: 8,02 %
Sources: CEPR 2013: table 20 and table 21 IFO 2013a: table II.4 IFO 2013b, pp. 7			

As with the GDP estimates, the IFO study predicts much larger effects on trade than CEPR. It estimates that exports within TTIP will increase by an astonishing 92.8 percent in the comprehensive scenario. In contrast, the most ambitious scenario in the CEPR study shows an increase of 5.9 and 8 percent increases in exports for the EU and the US respectively. In this area, the CEPR study seems somewhat conservative. In a meta-analysis performed by Head and Mayer (2014) based on 257 independent gravity studies they find that the average increase in trade flows between fellow members of a trade agreement is 59 percent higher relative to trade between countries that are not in a trade agreement. My own estimations in the next chapter confirm this finding.

### 3.1.4 Note on sector level results

So far only aggregated effects are presented, but both studies include predictions on disaggregated levels. An in-depth discussion of differences and similarities between the studies on sector level is beyond the scope of my thesis. However, there are a few points worth mentioning regarding the sector level results in the two studies.

From the CEPR study it seems that industrial and manufacturing goods will experience the biggest trade flow increase between the EU and US. The US motor vehicle exports to the EU is expected to be the winner. Also, CEPR estimate large increases in processed foods and chemical trade within TTIP. Interestingly, the results show that for many sectors exports will increase in both countries, i.e. we will likely see an increase in intra-industry trade as a result of the agreement according to CEPR. This is in line with the “new trade theory” pioneered by Krugman (1980).

Contrary to CEPR, the IFO study concludes that it is the agricultural sector that will experience the largest trade increase, albeit from a very low level. They also expect large increases for the industrial sector.

### 3.1.5 Discussion of the main results

The most striking difference between the two studies is the *magnitude* of the predicted effects of TTIP. Throughout, the IFO study predicts larger effects, often many times that of CEPR. I argue that there is little chance that both studies are “correct”. By this I mean that it is unlikely that the results would converge, due to the law of large numbers, if the studies were repeated again and again, while the methods were left unchanged. On the contrary, it is my opinion that there are fundamental methodical differences between the two studies, and that this is the cause of the divergent results. At the very least this serves as motivation to dig into the underlying methodologies, which is the goal in the next two sections. However, an in-depth discussion of the entire model framework in both studies is beyond the scope of my thesis. Therefore, the discussion is limited to their implementation of NTBs through gravity models.

## 3.2 IFO methodology

The IFO methodology involves comparative statics analysis of gravity estimations, based on Egger and Larch<sup>10</sup> (2011). They compare a factual base scenario with a counter-factual scenario where the TTIP agreement is simulated based on an estimated average effect of existing trade agreements. The average effect is obtained by running a gravity estimation using a bilateral dummy variable for existing agreements. An advantage when using this method is that it does not require explicit data on NTBs and tariffs, as all trade barrier reductions are argued to be accounted for by the RTA dummy. Thus, the problem of NTB measurement is overcome. Further, IFO relies on the insight from Egger et al. (2011), where they account for the possible endogeneity of trade agreements in the gravity model. To elaborate on the methodology, each of these papers is discussed in turn in the following subsections.

### 3.2.1 Comparative statics in Egger and Larch (2011)

The core methodology used by IFO is based on Egger and Larch 2011. In this paper the authors give an assessment of the effects of the “Europe agreement” between the EU and 10 central and eastern European countries in the 1990s. The goal of the paper is to study the ex-post effects of the agreement. However, the methodology can also be used to predict ex-ante effects of potential trade agreements, which is what they do in the IFO study.

The basic idea in Egger and Larch (2011) is to run two separate gravity estimations and compare them. In the first case they estimate a factual base scenario where they include all relevant variables for gravity estimation. In the paper this includes a bilateral dummy variable for membership in the Europe agreement. In the second case, they construct a counterfactual scenario where the relevant policy variables are changed. Egger and Larch (2011) set the Europe agreement variable to zero for all observations. To get the trade effect of the agreement they compare the base scenario to the counterfactual scenario, i.e. the estimated base scenario trade flows minus the counterfactual scenario trade flows relative to the counterfactual trade flows in percent.

To further clarify this methodology, consider again the Anderson and van Wincoop gravity equation:

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<sup>10</sup> Mario Larch is one of the writers of the IFO study.

$$(3.1) \quad \frac{X_{ij}Y_w}{Y_iY_j} = \left[ \frac{\tau_{ij}}{\Pi_i P_j} \right]^{1-\sigma} \equiv x_{ij}$$

As the GDP terms are moved to the left hand side, the equation now measures GDP-normalized aggregate exports from  $i$  to  $j$  which I refer to as  $x_{ij}$ . Equation (3.1) is similar to equation (8) in Egger and Larch (2011). The main difference is that I have dropped the indicator variable that distinguishes between firms ability to produce given the current costs, i.e. the assumption of heterogeneous firm productivity is relaxed. This is done for simplicity and since it does not change the understanding of the methodology. Nonetheless, I wish to stress that the inclusion of firm heterogeneity adds strength to the IFO method as it allows them to analyze the effects of trade agreements on the extensive and intensive production margins. This is not taken into account in the gravity model used by CEPR.

Let the subscript  $c$  denote the counterfactual scenario where the relevant policy variable is altered, i.e where the Europe Agreement dummy variable inherited in the trade costs  $\tau_{ij}$  is set to zero for all observations. Then, following the logic described above, the percentage change in trade flows due to the Europe Agreement,  $\Delta x_{ij}$ , is given by

$$(3.2) \quad \Delta x_{ij} \equiv \frac{(\tau_{ij}^{1-\sigma} \Pi_i^{\sigma-1} P_j^{\sigma-1}) - (\tau_{c,ij}^{1-\sigma} \Pi_{c,i}^{\sigma-1} P_{c,j}^{\sigma-1})}{\tau_{c,ij}^{1-\sigma} \Pi_{c,i}^{\sigma-1} P_{c,j}^{\sigma-1}} \cdot 100$$

Similarly their model defines the GDP of country  $i$  as  $Y_i = \theta_i^{1/(1-\sigma)} \Pi_i^{-1}$  which leads them to the following expression for percentage change in nominal GDP

$$(3.3) \quad \Delta y_{ij} \equiv \frac{(\theta_i^{1/(1-\sigma)} \Pi_i^{-1}) - (\theta_{c,i}^{1/(1-\sigma)} \Pi_{c,i}^{-1})}{\theta_{c,i}^{1/(1-\sigma)} \Pi_{c,i}^{-1}} \cdot 100$$

where  $\theta_i \equiv Y_i/Y_w$  and  $Y_w = \sum_{i=1}^N Y_i$  is world GDP with  $N$  countries. To save space I will not include the formal derivation of equation (3.3) and the expression for GDP as this requires a deeper examination of their model. My main point here is to show how they obtain their estimates of the effect of policy changes by comparing a counterfactual and a base scenario. The comparative static principle from Egger and Larch make up the core method for calculating GDP and trade flow effects of TTIP in the IFO study. Clearly, the gravity equation plays a pivotal role for their results.

### 3.2.2 Endogeneity and firm heterogeneity in Egger et al. (2011)

In addition to the paper by Egger and Larch, IFO also relies on the insight from Egger et al. (2011) (IFO 2013b). The aim of this paper is to provide a better empirical gravity model that brings together three important issues in the literature; controlling for multilateral resistance, zero-observations in trade matrices, and the endogeneity of trade agreements. As discussed in the previous chapter, fixed effects and PPML estimation can be used to account for the two first issues.

#### *Endogeneity*

The last issue of controlling for endogeneity of trade agreements is, in my opinion, the biggest contribution of Egger et al. (2011). Furthermore, it is an advantage to the IFO method compared to that of CEPR. Intuitively, trade agreements lead to higher trade flows between members, but countries that trade more are also more likely to engage in trade agreements. This reverse causality calls for instrument variables to be used to avoid biased estimates.

Finding instruments is challenging. They need to satisfy the requirements of relevance and validity, i.e. they need to be significantly correlated with the probability<sup>11</sup> of forming trade agreements (relevance), but they cannot have any effect on exports other than through trade agreements (validity). Egger et al. (2011) propose three instruments; (i) a dummy variable indicating whether there ever was a colonial relationship between the two countries in question, (ii) a dummy variable indicating whether they ever had the same colonizer and (iii) a dummy variable indicating whether they ever were the same country. These variables are elsewhere commonly used in gravity equations to control for historical and cultural factors, but they have not been used as instruments prior to Egger et al. (2011). To test the relevance of the instruments they perform an F-test in the first stage estimation on the joint null hypothesis that all the coefficients on the instruments are equal to zero. The null hypothesis is strongly rejected (Egger et al. 2011).

The instruments validity is harder to prove. They perform two tests to argue for validity. In the first test they include the instruments in the second stage regression and perform an F-test like the one above. In this case the p-value is 0.48 (Egger et al. 2011). Hence, they cannot reject the null hypothesis at any conventional level of confidence. In the second test they

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<sup>11</sup> As trade agreements enter the model as a dummy variable, Egger et al. (2011) use a probit model in the first stage regression. Hence, the correct interpretation of the first stage coefficients is their ability to influence the probability of forming a bilateral trade agreement.

perform a test on the overidentifying restrictions using a log-linearized model which restricts them to positive trade-flow values. Here as well, the null-hypothesis cannot be rejected as the p-value equals 0.48 also in this case (Egger et al. 2011).

It is important to stress that the above tests cannot be taken as proof of instrument validity. They are to be taken as validity arguments only. In other words, the validity of the instruments can still be questioned. There is reason to believe that whether two countries have had a colonial relation, have had the same colonizer or have ever been the same country can affect the bilateral exports other than through the probability of forming a trade agreement. Consider for instance the bilateral relation between Britain and India, who have a previous colonial relationship. One of the reasons for Britain colonizing India was to control India's resources. After India's independence in 1947, it is likely that there still was a demand for Indian goods in Britain (and vice versa), and that this demand has been influenced by the economic ties resulting from years of colonial rule over India. This could lead to a larger trade flow between India and Britain than what would have been the case had Britain not colonized India, even though the countries have never been in a trade agreement. Thus, there is arguably a potential link between bilateral exports and the dummy variable indicating colonial relations other than through trade agreements. This example illustrates the problems with and importance of finding good instruments for trade agreements.

Nonetheless, when controlling for endogeneity of trade agreements using the instruments above Egger et al. (2011) find that the estimates of the coefficient on trade agreements increase relative to the estimates when trade agreements are regarded as exogenous. This leads them to conclude that failure to regard trade agreements as endogenous biases the estimates downwards. This implies that the unobservable factors determining the creation of trade agreements come along with unobservable factors that on average have negative effects on trade flows (Egger et al. 2011). This can explain why the estimated trade flow effect of TTIP is higher in the IFO study than what is normally observed in the literature (e.g in the meta-analysis by Head and Mayer, 2014). However, it is important to stress that the legitimacy of this result hinges critically on the somewhat shaky validity arguments.

#### *Firm heterogeneity*

Egger et al. (2011) also make a distinction between the extensive and intensive margins of firm's production. After controlling for endogeneity, they find that membership in a trade



agreement has a significant impact on the intensive margin, but not the extensive. This implies that trade agreements are effective at reducing marginal costs of trade, such that exporting firms will produce and export more (intensive margin). On the other hand, trade agreements seem to have little effect lowering fixed costs which would have increased the number of exporting firms (extensive margin). This is an important result as it shows that entry into a transatlantic trade agreement might alter the industrial organization of a country. Yet again, this also underlines the importance of NTB reduction in trade agreements. Although NTBs come in a variety of forms it is natural to expect that they in principle can be considered non-proportional, i.e. fixed (IFO 2013, Medin, 2014). Tariffs, on the other hand, are proportional by definition. Thus, the finding in Egger et al. can be taken as evidence that existing trade agreements on average are relatively ineffective at reducing NTBs, and since it is widely agreed upon that NTBs are more important for a transatlantic agreement to be successful, this highlights the challenge facing the TTIP agreement. However, Egger et al. stress that the bias arising due to failure to control for the presence of firm heterogeneity seems less relevant than the endogeneity bias.

### **3.2.3 Discussion of the IFO methodology**

Together with the insights from Egger et al. (2011), the IFO method for estimating the effects of TTIP is based on the comparative statics methodology from Egger and Larch (2011), as sketched above. To construct the counter-factual scenario they estimate the effect of existing trade agreements as in Egger and Larch (2011), only using a more comprehensive dataset on trade agreements. The results of these estimations are then used to simulate the trade effects of TTIP, which is then compared to the base scenario to get percentage change on trade-flows and GDP (IFO, 2013b). This implies the underlying assumption that the TTIP agreement will affect world trade and countries individual GDP according to the average effect of existing trade agreements. All active trade agreements are given equal weights; regardless of the members' initial trade barriers, and the depth and duration of the agreement. This approach is somewhat questionable as it is likely that different trade agreements have different levels of efficiency regarding their ability to reduce trade costs and induce trade amongst its members.

Another crucial assumption inherited in their method is that existing trade agreements have reduced both tariffs and NTBs between its members. By estimating an average treatment effect of trade agreements they therefore claim to have solved the problem of NTB

measurement. All trade barrier reductions accomplished in trade agreements, including both tariffs and NTBs, are assumed to be implicitly accounted for in the average effect. Explicit data on NTBs and tariffs are therefore not included.<sup>12</sup> This is arguably a nice feature as it captures the realistic level of NTB reduction from trade agreements. However, it also assumes that TTIP will follow an average pattern of tariff and NTB reductions observed in other agreements, and makes it impossible to look at different scenarios where the depth of the agreement can be varied, as is done in the CEPR study. An obvious problem with this is that they are unable to look at scenarios where TTIP is assumed to be more effective at NTB reduction compared to the average. Most existing trade agreements are primarily (or only) agreements on tariff reduction (Estevadeordal et al., 2009). Since the importance of NTB reduction is established so clearly in the IFO study, an approach that limits flexibility on this deserves criticism. Furthermore, they are unable to be explicit about how much trade barriers must be reduced to obtain the predicted results.

A final critique of the IFO methodology concerns the long term perspective. IFO states that all the results in their study are to be understood as long term effects (IFO, 2013a). It is generally assumed that the adjustment of the economic variables takes place relatively quickly, within 5 - 8 quarters (IFO 2013a). The motivation for this assumption is unclear. Remembering the results presented above, it seems somewhat extreme that GDP is inspected to increase by 4.95 and 13.38 percent within a maximum of two years, for the EU and US respectively. It is also not clear whether the estimated effects are reported in present value. In the model framework of Egger and Larch (2011) presented in equations (1) – (5) there is no discount factor and they do not mention anything on this in the report. Hence, one reason for the large results could be that they do not discount the future. This might also explain some of the difference of the results compared to the CEPR study where they use a model in which the future is discounted.

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<sup>12</sup> When looking at the limited scenario with tariff elimination only, IFO use data on observable tariffs and change these in the counterfactual scenario. It is only in the comprehensive scenario where they use the general trade agreements effect to capture both tariff and NTB reduction.

### 3.3 CEPR Methodology

The results from the CEPR study presented in section 3.1 are obtained from simulations using the GTAP model (CEPR 2013). GTAP is a multi-region, multi-sector computable general equilibrium (CGE) model of global world trade. It can be used to analyze long-term as well as short-term effects as it allows for trade to impact capital stocks through investment effects (CEPR 2013). GTAP uses real world data where tariffs and tariff revenues are explicit in the database, and is directly incorporated into the analysis. NTBs on the other hand, are not part of the data. To incorporate NTBs into the model CEPR relies on a study by ECORYS (2009a). The ECORYS study investigates the existence and magnitude of NTBs between the EU and US on trade in goods, services and investments on sector level. Based on a comprehensive business survey, ECORYS constructs an NTB index which is used in a gravity model to estimate ad-valorem trade cost equivalents of NTBs. These estimates are used directly in the CEPR study on TTIP. Therefore, the CEPR results are sensitive to the implementation of the gravity model used in the ECORYS study, especially since CEPR constantly emphasize the importance of NTBs. How the ECORYS data on NTBs are gathered, and how the gravity model is utilized to calculate the ad-valorem trade cost equivalents have important consequences for the predictions put forth in the CEPR study.

#### 3.3.1 Data on NTBs

Contrary to the IFO, the CEPR methodology requires explicit data on NTBs; hence the use of the ECORYS NTB data. Gathering this data is not trivial as NTBs are difficult both to identify and to measure. It also requires a clear definition of NTBs. ECORYS, and hence also CEPR, define NTBs as:

*“All non-price and non-quantity restrictions on trade in goods, services and investments at the federal and state level. This includes border measures (customs procedures, etc.) as well as behind-the-border measures flowing from domestic laws, regulations and practices’.”*

(ECORYS, 2009a pp. xiii)

ECORYS gather data on NTBs using two main sources. First of all they do a comprehensive literature review where they summarize previous studies on NTBs and identify transatlantic NTBs on sector level. Second, they perform a comprehensive business survey on 5500 companies in the EU and US. Each company was asked the question:

*“Consider exporting to the US (EU), keeping in mind your domestic market. If 0 represents a completely “free trade” environment, and 100 represents an entirely closed market due to NTBs, what value between 0 – 100 would you use to describe the overall restrictiveness of the US (EU) market to your export product [...] in this sector?” (ECORYS 2009a, p. 10)*

Based on the answers to this question they construct a NTB index. For each importer  $j$  the index states the average opinion across its exporters on the NTB restrictiveness level. Even with 5500, replies the survey was not comprehensive enough to create an index that varies bilaterally. Hence, the NTBs of country  $j$  is constant for all  $i$ 's in the index, i.e. it varies by importer only. This is an obvious weakness, as it is natural to assume that different exporters will face different levels of NTB regulations for a given importer  $j$ . Remembering the discussion on fixed effects estimation in chapter 2, this also has consequences for estimation as the NTB index does not vary bilaterally.

### 3.3.2 Gravity Estimation in ECORYS

The NTB index constructed on the basis of the business survey is only an index of firm's perceptions of NTB levels and does not translate directly into impacts on costs and prices. Therefore, ECORYS use gravity estimation to estimate corresponding ad-valorem trade cost equivalents. The trade cost equivalents measure the percentage impact on prices of the NTBs, similar to the concept of tariff equivalents. For a given level of a NTB on a product, the trade cost equivalents show what the equal increase in any other variables causing trade frictions would have to be to keep trade at the same level if the NTB was eliminated. The increase can come from tariffs alone or any other variable or combinations of variables that influence trade cost. In the case of gravity modelling, this means all variables used to proxy for the trade cost term  $\tau_{ij}$  in equation (3.1) above.

To calculate the trade cost equivalents, the NTB index is used along with other proxies for trade costs in the gravity model of Anderson and van Wincoop (2003). Specifically, the model used for estimation is the fixed effects model from equation (2.17):

$$(3.4) \quad \ln X_{ij} = C + F_i + F_j + (1 - \sigma) \ln \tau_{ij} + \varepsilon_{ij}$$

All variations that are unique to one country are inherited in the fixed effect terms (see equations (2.19) and (2.20) in chapter 2). The trade cost term is estimated separately as

$$(3.5) \quad \ln \tau_{ij} = \ln(1 + t_{ij}) + \gamma \ln n_{ij} + \delta \ln Dist_{ij} + \zeta Bor_{ij} + \zeta Continent_{ij} + \theta Comlang_{ij} + e_{ij}$$

where  $t_{ij}$  is the tariff rate imposed on country  $i$  by country  $j$ ,  $n_{ij}$  is the NTB of country  $j$  imposed on country  $i$ ,  $Dist_{ij}$  is the distance between the capitals in country  $i$  and  $j$ ,  $Bor_{ij}$  is a dummy variable indicating whether the two countries share a border,  $Continent_{ij}$  is a dummy variable indicating whether they are on the same continent, and  $Comlang_{ij}$  is a dummy variable indicating whether they have the same official language (ECORYS, 2009b). As mentioned above, the NTB data does not vary bilaterally. To solve this problem ECORYS make the NTBs vary bilaterally by interacting them with bilateral dummy variables indicating membership in existing trade agreements:

$$(3.6) \quad \ln n_{ij} = \alpha_1 \ln(1 + D_{ij}^{EU} NTB_j) + \alpha_2 \ln(1 + D_{ij}^{NAFTA} NTB_j) + \alpha_3 \ln(1 + D_{ij}^{ATLAN} NTB_j)$$

Here,  $NTB_j$  is the NTB index, i.e. the average opinion amongst all exporters on the NTB level in country  $j$ ,  $D^{EU}$  and  $D^{NAFTA}$  are dummy variables that equal 1 if both countries  $i$  and  $j$  are members of the EU or NAFTA, and  $D^{ATLAN}$  equals one if the countries are in different groups, i.e. if  $i$  is in EU and  $j$  is in NAFTA or vice versa (ECORYS, 2009b). Interacting the NTB index with the dummy variables makes them vary bilaterally, but the interpretation of the elasticities changes somewhat. This is discussed more thoroughly in the next chapter where I present my own estimations.

To calculate the trade cost equivalents, ECORYS use the following formula calculated from the gravity model in equations (3.4) – (3.6)

$$(3.7) \quad \Delta \ln(1 + \tau_{EU,j}) = \frac{\alpha_3}{\sigma} [\ln(1 + D_{ij}^{ATLAN} NTB_j) - \ln(1 + D_{ij}^{ATLAN} NTB_A)]$$

where  $\tau_{EU,j}$  measures the trade cost equivalent faced by the EU exports to NAFTA member  $j$ , and  $NTB_A$  is the average NTB index across all importers (ECORYS, 2009b). Thus the expression in (3.7) measures the difference in trade costs when exporting to country  $j$  relative to the average trade costs in the sample, when  $D_{ij}^{ATLAN} = 1$ . ECORYS obtain the ad-valorem trade cost equivalents of the NTB index by solving for  $\tau_{EU,j}$  in equation (3.7).

Table 3.4 shows the average results for the goods sectors. Column (1) and (3) shows the trade cost equivalents of NTBs, while column (2) and (4) show the NTB perception index.

Table 3.4: Average NTB trade cost equivalents and NTB perception index for transatlantic trade flows

EU exports to US		US exports to EU	
(1)	(2)	(3)	(4)
Trade cost equivalent	NTB index	Trade cost equivalent	NTB index
25.4 %	40,74	21.5 %	41,0

Source: table 4.2 in ECORYS (2009a). I have calculated the averages myself as they are reported on sector level in the study.

### 3.3.3 Discussion of the CEPR methodology and comparison with IFO

CEPR plug the estimated ad-valorem trade cost equivalents from ECORYS into the GTAP model to estimate the effect of TTIP. Contrary to the IFO study, this enables CEPR to analyze different levels of ambition regarding TTIP's ability to reduce NTBs. Furthermore, the CEPR study does not need assume that the effects of TTIP depends on observed effects of existing trade agreements as is the case in the IFO study. A third strength to CEPR over IFO is that by using a CGE model they distinguish between short and long term effects, and the results are discounted to present value.

The CEPR method is not without problems, however. An important critique regards the use of the GTAP model. This is discussed in the IFO report, which raises three main points of critique (IFO 2013a.). First, the parameterization of the model is not always based on consistent econometric estimates. Second, the model assumes full employment and a fixed labor stock. This limits the model to analyze sectorial interchange of labor rather than long term shifts in equilibrium employment. Third, the model is largely based on perfect competition. In the CEPR study, the model is calibrated such that perfect competition is assumed for most sectors. However, heavy manufacturing sectors are modelled with monopolistic competition and economics of scale, and products from different countries are modelled as imperfect substitutes (CEPR, 2013).

Another important critique concerns the NTB measurement. Relying on perceived levels of NTBs can be problematic. There might be NTBs that are not accounted for by using this method, and so the estimated level of NTB trade cost equivalents might be over- or underestimated. Second, the ECORYS business survey does not distinguish between countries within the EU as is done in the IFO study. A third point is that by calculating ad-valorem

trade cost equivalent, NTBs are effectively converted into proportional trade costs. However, as discussed above it is more natural to consider NTBs as non-proportional costs, which might affect trade in other ways than proportional costs, as argued by Egger et al. (2011).

By looking closely at the methods used in the two studies it becomes clear how the gravity equation can be used in very different ways, and with different purposes. In the IFO study the gravity equation plays a defining role in determining the outcome as they are comparing different gravity estimations. In CEPR on the other hand, the gravity equations plays a smaller role as it is used only to obtain the estimates of NTB cost equivalents to be used in the GTAP model. However, in both studies the impact of NTBs is accounted for through the use of gravity equations; implicitly through the average effect of trade agreements on tariff and NTB reductions in IFO, and explicitly by calculating ad-valorem trade cost equivalents in the ECORYS study used by CEPR.

In the next chapter I run a separate gravity estimation using a dataset including data on tariffs, NTBs and bilateral trade agreements. I rely on data from other sources than both the IFO and CEPR (ECORYS) studies, and my results can therefore be used to verify some of their results, as well as provide further understanding on how the gravity equation is used for trade policy analysis.

## 4 Estimation

In this chapter, I present my own gravity estimations built upon the theoretical and empirical insight from chapter 2. In particular, I estimate the Anderson and van Wincoop (2003) model with data from Kee et al. (2009), who have constructed a comprehensive dataset on NTBs and tariffs. Another important contribution to my dataset is a dummy variable on regional trade agreements (RTA) from de Sousa (2011). Throughout the chapter the focus will be on estimating the effects of NTBs and different RTA dummies on bilateral exports; first, I discuss the econometric specification, second I describe the dataset and discuss some descriptive statistics, and finally I present and discuss the results of my estimations.

### 4.1 Econometric specification

Recall the regression version of the Anderson and van Wincoop gravity equation, along with its log-linearized version from chapter 2, where the multilateral resistance terms  $\Pi_i$  and  $P_j$  are defined by equations (2.13) – (2.14):

$$X_{ij} = \frac{Y_j Y_i}{Y^w} \left( \frac{\tau_{ij}}{\Pi_i P_j} \right)^{1-\sigma} \eta_{ij} \quad (4.1)$$

$$\ln X_{ij} = -\ln Y^w + \ln Y_i + \ln Y_j + (1-\sigma) \ln \tau_{ij} - (1-\sigma) \ln \Pi_i - (1-\sigma) \ln P_j + \underbrace{\varepsilon_{ij}}_{=\ln \eta_{ij}}$$

As mentioned in chapter 2, Anderson and van Wincoop assume symmetrical trade costs,  $\tau_{ij} = \tau_{ji}$ , which makes them able to solve the model in terms of observables (Anderson and van Wincoop, 2003). Then they use NLS estimation to obtain their results. By doing this they avoid log-linearization and exclusion of zero-observations in the regression. However, the assumption of symmetrical trade costs is quite strong, so I will therefore modify their approach. By using the PPML estimator discussed in chapter 2, I avoid the problem of zero-observations and heteroskedasticity. Furthermore, due to lack of bilateral NTB data as in ECORYS (2009a), I use Taylor approximations on the multilateral resistance terms as suggested by Baier and Bergstrand (2009). I will explain the data issue and introduce the Baier and Bergstrand method shortly, but first it is necessary to specify the trade costs.



### 4.1.1 Trade costs

As bilateral trade costs,  $\tau_{ij}$ , are not directly observable it is necessary to use observable proxies. As is frequently done the gravity literature, I use bilateral distance along with a number of dummy variables containing information on bilateral cultural and historical relationships as proxies. In addition to this, I add a dummy variable for RTAs, data on tariffs and an estimate of the ad-valorem tariff equivalents of NTBs. I use the standard functional form for the trade costs as in equation (2.15). Thus, trade costs are given by

$$(4.2) \quad \tau_{ij} = d_{ij}^p \cdot t_j^k \cdot \omega_j^\alpha \cdot e^{\left[ b_1 RTA_{ij} + b_2 (RTA \cdot \omega)_{ij} + b_3 (RTA \cdot t)_{ij} + b_4 Contig_{ij} + b_5 Comlang_{ij} + b_6 Colony_{ij} + b_7 Comcol_{ij} + b_8 Col45_{ij} + b_9 Smctry_{ij} \right]}$$

where  $d_{ij}$  is the distance between  $i$  and  $j$ ,  $t_j$  are tariffs imposed  $j$ ,  $\omega_j$  are the ad-valorem tariff equivalents of NTBs imposed by  $j$  and  $RTA_{ij}$  is a dummy variable indicating whether  $i$  and  $j$  are fellow members of a trade agreement. Note that both tariffs and NTBs are denoted only with subscript  $j$ . This is because the data is taken from the Kee et al. (2009) dataset, which unfortunately only includes one-dimensional trade barrier data – the same problem faced by ECORYS (2009a).

I have also included interaction terms between the RTA dummy variable and both tariff and non-tariff barriers. Note that since the RTA dummy is bilateral, this makes the interaction terms vary bilaterally as well. It is natural to expect that trade agreements will reduce the impact of trade barriers, but it is not certain how exports are affected differently by NTBs when the RTA dummy is active, relative to when it is inactive. The interaction terms might provide some insight on this, and a simple example using exports and NTBs only will illustrate (country subscripts are dropped for simplicity).

$$(4.3) \quad X = a_0 + a_1 NTB + a_2 RTA + a_3 (NTB \cdot RTA)$$

In this simple case, the effect of NTBs on exports will be given by  $\frac{\partial X}{\partial NTB} = a_1 + a_3 RTA$ .

When there are no trade agreements ( $RTA = 0$ ) we get  $\frac{\partial X}{\partial NTB} = a_1$ , where  $a_1 < 0$  is expected. Now, if the countries in question are engaged in a trade agreement ( $RTA = 1$ ), then  $\frac{\partial X}{\partial NTB} = a_1 + a_3$ . The sign of  $a_3$  is not as straightforward to interpret. It affects the slope of the line in (4.3) with respect to NTBs. A negative sign on  $a_3$  means that each percentage point

reduction in NTB tariff equivalents within a trade agreement (remember,  $RTA = 1$ ) will increase exports more than if  $RTA = 0$ . Or, If a country within a trade agreement decides to deviate and impose a new NTB on its fellow members or to increase an old one (assuming for now that they are able to do so and get away with it), the country's exports will drop *more* than it would if the country was not a member of a trade agreement.

The interpretation of  $a_2$  is not straightforward either. Strictly, it measures the effect of RTA's when NTBs are zero. However, this does not make much sense, economically speaking. It is more fruitful to consider the total effect of RTA's:  $\frac{\partial X}{\partial RTA} = a_2 + a_3 NTB$ .

Finally, the last 6 variables in equation (4.3) are dummy variables controlling for historical and cultural relations. *Contig* indicates if the two countries share a border, *Comlang* indicates whether the two countries share official language, *Colony* indicates whether the two countries were ever in a colonial relationship, *Comcol* indicates if they have had the same colonizer after 1945, *Col45* indicates whether a country pair have been in a colonial relationship after 1945 and *Smctry* indicates whether two countries ever have been the same country.

#### 4.1.2 Baier and Bergstrand (2009) – an alternative to fixed effects estimation

As discussed in the previous chapter, the data used in the ECORYS (2009a) study had the same problem with one-dimensional NTB-data. They solved the problem by constructing interaction terms between the NTB cost equivalents with bilateral dummy variables. But as shown in the example above, this makes the interpretation of the coefficients a bit messy. I will try to avoid this in my estimation which means that I cannot use fixed effects.

To tackle this problem, Baier and Bergstrand (2009) suggest a different approach. By using a first-order log-linear Taylor-series expansion of the multilateral resistance terms in equations (2.13) and (2.14) they arrive at the following expressions for the multilateral resistance terms

$$(4.4) \quad \ln \Pi_i = \sum_{j=1}^N \frac{Y_j}{\bar{Y}^w} \ln \tau_{ij} - \frac{1}{2} \sum_{i=1}^N \sum_{j=1}^N \frac{Y_i}{\bar{Y}^w} \frac{Y_j}{\bar{Y}^w} \ln \tau_{ij}$$

$$(4.5) \quad \ln P_j = \sum_{i=1}^N \frac{Y_i}{\bar{Y}^w} \ln \tau_{ij} - \frac{1}{2} \sum_{i=1}^N \sum_{j=1}^N \frac{Y_i}{\bar{Y}^w} \frac{Y_j}{\bar{Y}^w} \ln \tau_{ij}$$

which are analogous to (2.13) and (2.14) (Baier and Bergstrand (2009)). To make their results comparable to Anderson and van Wincoop (2003), Baier and Bergstrand assume symmetrical trade costs, but they stress that, for estimation, the multilateral resistance approximations in (4.4) and (4.5) are “...effectively identical under symmetric or asymmetric bilateral trade costs” (Baier and Bergstrand, 2009 footnote 5). Adding the terms yields

$$(4.6) \quad \ln \Pi_i + \ln P_j = \sum_{i=1}^N \frac{Y_i}{Y^w} \ln \tau_{ij} \sum_{j=1}^N \frac{Y_j}{Y^w} \ln \tau_{ij} - \sum_{i=1}^N \sum_{j=1}^N \frac{Y_i}{Y^w} \frac{Y_j}{Y^w} \ln \tau_{ij}$$

This can be inserted into the log linearized version of the model in equation (4.1) to get:

$$(4.7) \quad \ln X_{ij} = \underbrace{C}_{-\ln Y^w} + \ln Y_i + \ln Y_j + (1 - \sigma) \ln \tau_{ij}^* + \varepsilon_{ij}$$

where

$$(4.8) \quad \ln \tau_{ij}^* = \ln \tau_{ij} - \sum_{i=1}^N \frac{Y_i}{Y^w} \ln \tau_{ij} - \sum_{j=1}^N \frac{Y_j}{Y^w} \ln \tau_{ij} + \sum_{i=1}^N \sum_{j=1}^N \frac{Y_i}{Y^w} \frac{Y_j}{Y^w} \ln \tau_{ij}$$

Baier and Bergstrand (2009) use the same dataset as Anderson and van Wincoop (2003) and get very similar results. They also do various Monte Carlo exercises and show that the multilateral resistance approximations give virtually identical coefficients compared to fixed effects and nonlinear least squares estimation. Next, I incorporate this into my model. Taking the logs of the trade costs in (4.2) yields:

$$(4.9) \quad \begin{aligned} \ln \tau_{ij} = & \rho \ln d_{ij} + \kappa \ln t_j + \alpha \ln \omega_j + b_1 RTA_{ij} + b_2 (RTA \cdot \omega)_{ij} + b_3 (RTA \cdot t)_{ij} \\ & + b_4 Contig_{ij} + b_5 Comlang_{ij} + b_6 Colony_{ij} + b_7 Comcol_{ij} + b_8 Col45_{ij} \\ & + b_9 Smctry_{ij} \end{aligned}$$

Furthermore, I follow Shepard (2013) and assume that  $\frac{Y_j}{Y^w} = \frac{Y_i}{Y^w} = \frac{1}{N}$ , i.e. that all countries have an equal share of world GDP. This assumption is quite strong, but it makes it possible to regard the terms in (4.8) as means, which simplifies calculations. Inserting (4.9) and  $\frac{Y_j}{Y^w} = \frac{Y_i}{Y^w} = \frac{1}{N}$  into (4.8) yields the expression for trade costs (see appendix A3 for the calculation):

$$(4.10) \quad \ln \tau_{ij}^* = \rho \ln d_{ij}^* + \kappa \ln t_j^* + \alpha \ln \omega_j^* + b_1 RTA_{ij}^* + b_2 (RTA \cdot \omega)_{ij}^* + b_3 (RTA \cdot t)_{ij}^* + b_4 Contig_{ij}^* + b_5 Comlang_{ij}^* + b_6 Comcol_{ij}^* + b_7 Colony_{ij}^* + b_8 Col45_{ij}^* + b_9 Smctry_{ij}^*$$

where the different terms are defined as follows:

$$(4.11) \quad \ln d_{ij}^* = \ln d_{ij} - \frac{1}{N} \sum_{i=1}^N \ln d_{ij} - \frac{1}{N} \sum_{j=1}^N \ln d_{ij} + \frac{1}{N^2} \sum_{i=1}^N \sum_{j=1}^N \ln d_{ij}$$

$$(4.12) \quad \ln t_j^* = \ln t_j - \frac{1}{N} \sum_{i=1}^N \ln t_j - \frac{1}{N} \sum_{j=1}^N \ln t_j + \frac{1}{N^2} \sum_{i=1}^N \sum_{j=1}^N \ln t_j$$

$$(4.13) \quad \ln \omega_j^* = \ln \omega_j - \frac{1}{N} \sum_{i=1}^N \ln \omega_j - \frac{1}{N} \sum_{j=1}^N \ln \omega_j + \frac{1}{N^2} \sum_{i=1}^N \sum_{j=1}^N \ln \omega_j$$

$$(4.14) \quad RTA_{ij}^* = RTA_{ij} - \frac{1}{N} \sum_{i=1}^N RTA_{ij} - \frac{1}{N} \sum_{j=1}^N RTA_{ij} + \frac{1}{N^2} \sum_{i=1}^N \sum_{j=1}^N RTA_{ij}$$

$$(4.15) \quad (RTA \cdot \omega)_{ij}^* = (RTA \cdot \omega)_{ij} - \frac{1}{N} \sum_{i=1}^N (RTA \cdot \omega)_{ij} - \frac{1}{N} \sum_{j=1}^N (RTA \cdot \omega)_{ij} + \frac{1}{N^2} \sum_{i=1}^N \sum_{j=1}^N (RTA \cdot \omega)_{ij}$$

$$(4.16) \quad (RTA \cdot t)_{ij}^* = (RTA \cdot t)_{ij} - \frac{1}{N} \sum_{i=1}^N (RTA \cdot t)_{ij} - \frac{1}{N} \sum_{j=1}^N (RTA \cdot t)_{ij} + \frac{1}{N^2} \sum_{i=1}^N \sum_{j=1}^N (RTA \cdot t)_{ij}$$

The cultural and historical variables,  $Contig_{ij}^*$ ,  $Comlang_{ij}^*$ ,  $Comcol_{ij}^*$ ,  $Colony_{ij}^*$ ,  $Col45_{ij}^*$  and  $Smctry_{ij}^*$  are constructed in a similar manner, following the same pattern. To save space, I have moved these expressions to appendix A4.

Putting it all together yields the following gravity equation, which controls for multilateral resistance while still allowing for country-specific variation:

$$(4.17) \quad \ln X_{ij} = C + \ln Y_i + \ln Y_j + (1 - \sigma) \left[ \rho \ln d_{ij}^* + \kappa \ln t_j^* + \alpha \ln \omega_j^* + b_1 RTA_{ij}^* + b_2 (RTA \cdot \omega)_{ij}^* + b_3 (RTA \cdot t)_{ij}^* + b_4 Contig_{ij}^* + b_5 Comlang_{ij}^* + b_6 Comcol_{ij}^* + b_7 Colony_{ij}^* + b_8 Col45_{ij}^* + b_9 Smctry_{ij}^* \right] + \varepsilon_{ij}$$

Equation (4.17) is the econometric version on the Anderson and van Wincoop gravity model when using proxies for trade costs, and controlling for multilateral resistance through use of Taylor approximations according to Baier and Bergstrand (2009).

### **4.1.3 PPML estimation**

If I were to follow Baier and Bergstrand (2009) I would estimate (4.17) using OLS. However, I wish to use PPML estimation to avoid the heteroskedasticity and zero-observation bias, as discussed in chapter 2. Therefore I will modify (4.17) in the regression by using exports instead of log of exports on the left hand side while keeping the right hand side variables in log form. This way of specifying the PPML-regression highly is convenient for interpretation of the results as it allows me to keep interpreting the coefficients as elasticities as in the log-log OLS model (Shepard, 2013). The dummy variables also have the same interpretations. This way of specifying PPML-regressions of gravity models has become standard in the literature and is used in many papers, including Silva and Tenreyro (2006), Shepard (2013) and Egger and Larch (2011). However, the main inspiration comes from Francois and Manchin (2013) who use PPML estimation with Taylor approximations for multilateral resistance in their gravity estimation.

### **4.1.4 Summing up the econometric approach**

Three important points emerge from the discussion so far. First, Anderson and van Wincoop (2003) emphasize the need to control for multilateral resistance. Second, since my variables of interest, i.e. tariffs and NTBs vary by country only, I cannot use fixed effects estimation. Therefore, I follow Baier and Bergstrand (2009) and use a first-order log-linear Taylor-series expansion of the multilateral resistance terms. Third, I eliminate the potential heteroskedasticity and selection biases from using log-linear OLS estimation by using the PPML estimator as suggested by Silva and Tenreyro (2006).

## **4.2 Data**

The dataset combines data on bilateral trade relations within five sectors for 100 countries. The data is gathered from five separate sources and contains data on bilateral exports, the trade barriers faced by exporters (tariff as well as non-tariff barriers), trade agreements, GDP, bilateral distances and a number of historical and cultural relations. The purpose of this section is to explain how the different data sources have been adapted and put together to make the final gravity dataset, and to discuss its strengths and limitations.

## 4.2.1 Data on trade barriers

The dataset on trade restrictiveness by Kee et al. (2009) is the point of departure for the final dataset as the main goal of my estimations is to estimate the effect of tariffs and NTBs on trade flows. Kee et al. (2009) have constructed a comprehensive dataset with trade barrier data on a six-digit level of product division for 104 countries. The variables of interest in their dataset for my purposes are data on import tariffs and ad-valorem estimates of NTBs. Kee et al. (2009) define NTBs as price control measures, quantity restrictions and technical regulations (hereunder also health and hygiene regulations). This is an important contrast to ECORYS and CEPR, where quantity and price control measures are excluded from the definition (see chapter 3). In this sense the Kee et al. definition of NTBs is broader than the ECORYS definition.

Using estimated tariff equivalents of NTBs is the same method used by CEPR in their study on TTIP. However, there are some crucial differences between the dataset by Kee et al. (2009) and the one used by CEPR. Recall that CEPR uses estimates of trade cost equivalents of NTBs from the ECORYS 2009 study<sup>13</sup>. For their study, ECORYS constructed a unique dataset based mainly on business surveys (see chapter 3). Kee. et al. (2009) use a different approach. They rely on tariff and NTB data from the TRAINS<sup>14</sup> database. The NTB data in this database is gathered from a large number of sources. NTBs applied by countries are collected from national sources such as Ministries of Trade, Ministries of Agriculture etc. (UNCTAD, 2009). Data from the private sector is gathered from two different sources; (i) firm level surveys as in ECORYS and (ii) firms reporting NTBs they meet when exporting to a particular country on UNCTADs<sup>15</sup> web-based portal (UNCTAD, 2009). Both these methods can be somewhat unsatisfactory as it leaves the question of who is reporting, what is reported, and who it is that answer the surveys. Custom delays and bad infrastructure, e.g. bad roads or communications in importing country, are an example of a trade barrier which may not be reported as frequently as e.g. import quotas or sanitary requirements. However, these trade barriers, particularly infrastructure, are important determinants of trade costs (Limão and Venables, 1999). Also, as mentioned in chapter 2 it is important to keep in mind that firms survey's might also produce incomplete data, as it is not given that all NTBs facing a firm

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<sup>13</sup> Note that Kee et al. (2009) calculate *tariff* equivalents and ECOYRS calculate *trade-cost* equivalents.

<sup>14</sup> TRAINS: Trade Analysis and Information System

<sup>15</sup> UNCTAD: United Nations Conference on Trade and Development

will be picked up by the survey. These arguments show how the TRAINS database on NTBs might be incomplete, which is important to keep in mind when reviewing the results.

Kee et al. (2009) use the NTB data from TRAINS to create a comprehensive dataset at the six-digit level of the Harmonized System of Trade Classification (HS-6). As mentioned in the previous section the data is constant across exporters for a given importer, i.e. it does not vary bilaterally. Kee et al. constructs NTBs as dummy variables; if product  $k$  in country  $i$  is subject to a NTB, then  $NTB_{ki} = 1$ . This is contrary to ECORYS (2009a) who, based on their business survey, constructs a NTB index.

The ad-valorem tariff equivalents of the NTB dummies are obtained, as in ECORYS (2009a), through gravity analysis. For each product, they estimate what a tariff would have to be to keep trade at the same level if the NTB was eliminated.

#### *Limitations due to the Kee et al. dataset*

A limitation in the Kee et al. (2009) dataset is that it is a cross section. This means that I am unable to use a panel dataset in the analysis. The data is gathered from whenever the most recent year data is available between 2000 and 2004.<sup>16</sup> They claim that more than half of the tariffs are from 2003 or 2004, while only three countries have data from 2000. Of these, only two are included in my final dataset<sup>17</sup>.

The NTB data is gathered over a larger time period; from 1992 to 2004. This poses a potential problem as the removal of NTBs or creations of new NTBs might not be picked up.

Furthermore, I am unable to analyze how NTBs have evolved relative to tariffs over time. It would have been ideal to have better data, so I could construct a panel and see whether the relative importance of tariffs and NTBs have changed over time, as is argued by e.g. the World Bank (2012). There are two main reasons for why a panel might show signs of this. First, since 2004 there has been more integration of the world into trade agreements, and given the nature of NTBs, it is more difficult to eliminate these in trade agreements relative to tariffs. Hence, most trade agreements have better cover of tariffs than of NTBs, as argued by Estevadeordal et al. (2009), and it is natural to assume that more tariff than non-tariff barriers have been removed in recent years.

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<sup>16</sup> Although the paper was published in 2009 the dataset was constructed and made available for download on the World Bank website in 2005. Therefore the data is from 2004 and before.

<sup>17</sup> Kazakhstan and Peru are included. Egypt is excluded due to lack of export data.

Second, it might be the case that countries have used NTBs as substitutes for tariffs as trade agreements have forced tariff levels down. Kee et al. (2009) provides some evidence of this in the paper accompanying their dataset. They regress NTBs on tariffs and discover a negative relationship, indicating that NTBs act as substitutes for tariffs when controlling for both product and country specific effects (Kee et al., 2009 table 2). The result is highly significant, but small in magnitude, with an elasticity of -0.003, meaning that a one percent decrease in tariffs will lead to a 0.003 percent increase in the ad-valorem tariff equivalent of NTBs. If this is true we would expect to see NTB levels increase relative to tariffs.

### *Countries in the final dataset*

Since data on tariffs and NTBs are crucial for the regression analysis, the Kee et al. dataset limits the number of includable countries. See appendix A5 for a complete list of the countries that are included in the final dataset. Note that the final number only amounts to 100 countries. This is due to lack of export data for some countries (more on this below). Note also that most EU and European countries, as well as USA, are included<sup>18</sup>. Also, most other countries in Europe, the US and the largest economies in Asia, Africa, North and South America are included.

100 countries is an adequate number for gravity analysis<sup>19</sup>. It would be preferable, however, to be able to include more. While the largest economies in the world and the most important trade partners for both the EU and the US are included, many smaller economies are excluded. In some lower income countries or countries with lower level of transparency, statistical databases might not be as easily accessible and it might be harder to administer the distribution of firm level surveys, or to establish systems for reporting trade barriers. This gives rise to a potential selection bias as the exclusion cannot be said to be totally random. As an illustration of this, the mean GDP (measured in million USD) is 564.3 in the Kee et al. dataset and 213.3 in the original data from the World Development Index (WDI), which contains GDP data on the whole world. In other words, excluding countries due to limitations in Kee et al. (2009) raises the average GDP by more than half. While a formal discussion of this is beyond the scope my thesis, it is important to keep this potential bias in mind.

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<sup>18</sup> Cyprus, Slovakia, Luxemburg, Lichtenstein and Malta are the only excluded countries from the EU and the EEA

<sup>19</sup> IFO use 126 and ECORYS use 40.



## Sectors

Kee et al. (2009) provide high level of disaggregation in their trade barrier data. For my purpose, such a level of detail is not necessary. However, it is desirable with some form of disaggregation as it can be interesting to look at how NTBs affect sectors asymmetrically. Therefore I have made use of the high level of disaggregation in the original dataset and divided the tariff data into five main sectors. Table 4.1 gives a summary of these sectors and how they correspond to the HS 1996 product classification system. The classification is taken from Melchior et al. (2014).

Table 4.1: Sector classification			
Sector no.	Sector name	Content keywords	HS Chapters
1	Agriculture	Agriculture and seafood	1-24
2	Oil and Gas		2709-2711
3	Heavy Industries	Chemicals and plastic, metals and other minerals	25, 26, 27 ex. oil and gas, 28-39, 72, 7401-7413, 75, 7601-14, 78-81
4	Light Industries	Textile goods, shoes, leather goods and other industries	40-71, 73, 7414-19, 7615-16, 82, 83, 91-97
5	Machinery and transport equipment		84-90

Unfortunately, the data provided by Kee et al. is incomplete when it comes to oil and gas. In the dataset there is only tariff and NTB data on gas (HS 2711), not on crude oil (HS 2709) or crude oil products (HS 2710). Therefore, I have decided to exclude the oil and gas sector from the analysis.

### 4.2.2 Other data sources

#### *Data on bilateral trade*

Data on bilateral trade is taken from the UN COMTRADE database. I use data on bilateral exports on sector level from 2004 in accordance with the HS 1996 sector classification in Table 4.1. There are some exceptions however. Due to lack of 2004 data for Nepal, Nigeria and the Central African Republic data on these countries is from 2003. For Bhutan there is

data for 2005 only. A total of four countries from the Kee et al (2009) dataset are excluded from the final dataset due to lack of data on exports; Chad, Lao PDR, Equatorial Guinea and Egypt.

#### *CEPII gravity data*

The French CEPII<sup>20</sup> institute has published a dataset containing many of the variables and dummies commonly used in gravity estimations. The primary variable of interest for my purposes is the measure of bilateral distances between countries' capitols. Additionally, there are bilateral dummy variables on cultural and historical relations as explained above.

#### *Data on GDP*

For GDP data I have used the World Development Index of 2005. GDP is measured in current USD.

#### *Data on regional trade agreements (RTAs)*

I also use bilateral dummy variables indicating whether given a pair of importers and exporters are partners in a trade agreement. I use data for 2004 only. This data is constructed by José de Sousa (2011) and are gathered from three different sources. One potential issue is that I use trade data for 2004. In May 2004 the EU was expanded by ten countries. It might be that the effects of the expansion are not fully accounted for in the trade data for 2004.

## **4.3 Descriptive statistics**

Table 4.2 reports summary statistics for the main variables to be used in the estimations. Some interesting points emerge. The average tariff barrier in the dataset is 10 percent across all sectors<sup>21</sup>. This is lower than the estimated ad-valorem tariff equivalent for NTBs which average 13.8 percent in the data. Note also that the standard deviation on tariffs is much lower compared to the standard deviation on NTBs. This has two implications. First, the summary data indicate that NTBs are a bigger problem for international trade flows than tariffs. This highlights the importance of including regulations on NTBs for current and future trade agreements such as TTIP. This argument is also put forth by both IFO and CEPR. Second, the standard deviations imply that NTBs are more unevenly spread and that their effect on trade

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<sup>20</sup> Centre d'Etudes Prospectives et d'Informations Internationales

<sup>21</sup> Excluding oil and gas as there is limited data on trade barriers in these sectors.

flows might vary substantially across products and sectors. A more thorough discussion on this follows below.

Table 4.2: Summary statistics

Variable	Mean	Standard deviation	Min	Max
Log of exporter GDP	18.2237	1.9805	13.4627	23.2310
Log of importer GDP	18.15406	2.0059	13.4627	23.2310
Tariffs	0.1002	0.1008	0	0.7330
NTB dummy	0.3759	0.4035	0	1
NTB tariff equivalent	0.1381	0.1629	0	0.7445
RTA dummy	0.1710	0.3765	0	1
Restricted RTA Dummy	0.0516	0.2213	0	1
Log of distance	8.6252	0.8552	4.3943	9.8920
Contiguity	0.0339	0.1810	0	1
Common colonizer	0.0583	0.2344	0	1
Common language	0.1423	0.3493	0	1
Colony post 1945	0.0119	0.1084	0	1
Same country	0.0116	0.1072	0	1

Summary statistics excludes oil and gas sectors. Total observations: 30519.

I have also included summary statistics for the original dummy variable on NTBs used by Kee. et al (2009) as the basis for their estimations of NTB tariff equivalents. This shows that 37.6 percent of the products in the dataset are subject to a NTB. Once again this highlights the importance of NTBs in world trade.

Table 4.2 shows that of the 9900 bilateral trade relations, 17 percent are fellow members of a trade agreement.<sup>22</sup> I have also included summary statistics for a RTA dummy restricted to the

<sup>22</sup>  $N$  countries gives  $N(N-1)$  bilateral country pairs. With 100 countries:  $100*99 = 9900$ .

EU and EEA, NAFTA and ANZCERTA trade agreements<sup>23</sup>. Note that five percent of the bilateral trade relations in the dataset are covered by these trade agreements. They are included based on a somewhat ad hoc assumption that they are the world's most efficient at reducing trade barriers amongst their members. However, in recent years many comprehensive trade agreements have been signed. In a meta-analysis on the effects of RTAs on bilateral trade flows in gravity studies Cipollina and Slavatici (2010) find that the effect of RTAs "...tend to get larger as for more recent years, which could be a consequence of the evolution from "shallow" to "deep" trade agreements" (pp. 77). I argue that since I use somewhat old data (from 2004), the agreements covered by the restricted RTA dummy can indeed be considered among the most efficient at reducing trade barriers in the sample. The efficiency of these trade agreements is to some extent supported by the findings in Estevadeordal et al. (2009) and Cipollina and Salavatici (2010). However, I wish to stress that the restriction on the RTA dummy is somewhat ad hoc, which might influence the results, but that a thorough discussion on the relative efficiency of existing RTAs is beyond the scope of my thesis. Note that when use I the term *efficiency* in association with trade agreements in the following, it refers to the extent the trade agreement is able to reduce trade barriers, and thus induce trade amongst the member countries.

The last five rows of table 4.2 show summary statistics for the various historical and cultural dummy variables. The common language variable is by far the most prominent one. On average more than 14 percent of the country pairs share a common official language. The remaining historical and cultural variables are less prominent with means varying between 1 and 5 percent.

### 4.3.1 Sector-level summary statistics

As mentioned above, there is reason to believe that NTBs and tariffs are unevenly spread across sectors. Therefore I also include disaggregated summary statistics for selected variables in table 4.3. Here, the data have been divided according to table 4.1, excluding the

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<sup>23</sup> EU (2004): Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Poland, Portugal, Slovenia, Spain, Sweden, United Kingdom, Cyprus, Slovakia, Luxemburg and Malta. The last four are excluded due to data restrictions.

EEA: Iceland, Norway, Switzerland and Liechtenstein. Liechtenstein is excluded due to data restrictions.

NAFTA: Canada, Mexico and USA

ANZERTA: Australia and New Zealand

Table 4.3: Summary statistics for selected variables on sector level

Variable	Sector							
	Agriculture		Heavy industries		Light industries		Machinery and Transport equipment	
	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.
Tariffs	0.1783	0.1236	0.0407	0.0564	0.1178	0.0905	0.0627	0.0550
NTB dummy	0.6275	0.3539	0.4316	0.4843	0.2689	0.3053	0.1954	0.3106
NTB tariff equivalents	0.2214	0.1377	0.1872	0.2197	0.0808	0.0965	0.0726	0.1215
Observations	7385		7281		8163		7690	

oil and gas sector. The agricultural sector is subject to the highest trade protection both in terms of tariffs and NTBs; over 60 percent of agricultural products are subject to a NTB and the estimated tariff equivalents of NTBs are higher than the observed tariffs.

This is also the case for the heavy industries sector. Note that in this case the difference between estimated NTB tariff equivalents and observed tariffs are very large. This can be taken as an indication that this sector is most prone to substituting tariffs with NTBs. In the two remaining sectors, NTB means are significantly lower at 8 and 7 percent. Also, the difference between NTBs and tariffs are smaller in these sectors.

### 4.3.2 TTIP summary statistics

Table 4.4 is a version of table 4.3 including TTIP members only (i.e. EU and US). Here, aggregated summary statistics and exports for all sectors are included as well to give an impression of the relative trade volume. Observe that all the four sectors reported show substantial trade. It is also evident that the trade falls with the level of trade protection. In the machinery and transport equipment sector, trade is largest, while tariffs and estimated NTB tariff equivalents are very low with means around one percent.

In agriculture the trade barriers are high. An average of 75.5 percent of all products is subject to a NTB giving an estimated 30 percent tariff equivalent in this sector. The tariffs are also very high compared to the other sectors. Consequently, transatlantic trade in this sector is lower than in the others. This shows the potential inherited in a transatlantic trade agreement for the agricultural sector. According to IFO (2013a), agriculture will be the sector where

there is most to gain in TTIP. Looking at table 4.4 this becomes obvious; there is huge potential in lowering agricultural trade barriers. However, whether this is realistic is not clear. Agriculture is an area where the EU and US do not necessarily agree; an example is the case of Genetically Modified Organisms (GMO) where there is much debate around where to draw the line (NFD, 2014).

There is a clear distinction between the summary statistics in table 4.4 and the CEPR data. The average NTB tariff equivalent is 13.1 percent while the average is 22.5 percent for goods trade in the CEPR study (CEPR, 2013). Furthermore, table 4.4 shows that tariffs and NTBs are low in the machinery and transport sector, while this is one of the sectors where CEPR predicts the largest gains from TTIP. This might be an aggregation issue as CEPR have more sectors, or it might have to do with the broader definition of NTBs in Kee et al. (2009). In any case, this shows how unstable NTB data can be, and how difficult it is to get good data.

Table 4.4: Summary statistics for selected variables on sector level, TTIP only

Variable	Sector								
	Agriculture		Heavy industries		Light industries		Machinery and Transport equipment		All
	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.	Mean
Tariffs	0.1296	0.0510	0.0038	0.0104	0.0330	0.0278	0.0166	0.0264	0.0458
NTB dummy	0.7556	0.2592	0.2041	0.3913	0.3382	0.1808	0.0363	0.6820	0.3335
NTB tariff equivalents	0.3066	0.1250	0.0967	0.1825	0.1112	0.0684	0.0102	0.0190	0.1312
Exports	418.9	977.6	1302.6	3001.0	962.2	1937.7	2398.7	5873.8	1270.6
Observations	420		420		420		420		1680
NB: exports measured in current million USD									

### 4.3.3 Correlation matrices

Table 4.5 contains correlations between selected variables. Correlations only show the linear association between the variables, and cannot be used to make any conclusions. For this,

formal estimation is needed. However, it is useful to examine the correlation matrix to get a sense of the general behavior in the data.

Overall the correlations in table 4.5 are in line with intuition; there is a negative linear association between exports and both tariffs and NTBs, and a positive linear association between exports and the RTA dummy. Note that in panel B the RTA dummy variable is restricted to the EU and EEA, NAFTA and ANZCERTA agreements only. In this case the correlation between exports and tariffs is stronger. Note also that the unrestricted dummy variable in panel A show a weak positive correlation with NTBs, while in panel B the correlation is negative and larger in absolute value, i.e. there is a reversal of the direction and a strengthening of the linear relationship between the RTA dummy and NTBs when restricting the RTA dummy. Again it is important to stress that no conclusions can be made from correlations alone. In particular, the correlations must not be taken as causal arguments.

Table 4.5: Correlation matrix on selected variables				
Panel A: using the unrestricted RTA dummy				
	RTA dummy	Exports	Tariffs	NTBs
RTA dummy	1	-	-	-
Exports	0.0998	1	-	-
Tariffs	-0.0652	-0.605	1	-
NTBs	0.0077	-0.0249	0.1713	1
Panel B: using the restricted RTA dummy				
	Restricted RTA dummy	Exports	Tariffs	NTBs
Restricted RTA dummy	1	-	-	-
Exports	0.1504	1	-	-
Tariffs	-0.1211	-0.605	1	-
NTBs	-0.0103	-0.0249	0.1713	1
NB: the correlations are based on the original formatting of the data from Kee et al. (2009), i.e. I do not use applied tariffs and NTBs here like in the regressions. This is because there is no need to have the data on tariffs and NTBs in log form. When using log of applied tariffs and NTBs instead however, the signs all stay the same and the correlations are very similar in magnitude.				

## 4.4 Estimation results

### 4.4.1 Main regression results

The results are presented in table 4.6 which contains five different estimations. I use Stata version 13.1 for all my estimations. Columns (i) and (ii) contain my main regression results. Here the dependent variables inherited in the trade cost term from equation (4.2) correspond to equation (4.11) – (4.22) and thus include Taylor approximations of the multilateral trade cost terms, following Baier and Bergstrand (2009). Also, to combat the issue of heteroskedasticity and zero-observations, columns (i) and (ii) are estimated using PPML-estimation. Note that even though the dependent variable in columns (i) and (ii) are exports rather than log of exports the dependent variables are still specified as logarithms (except for the dummy variables), as discussed above.

#### *A note on interpretation of the coefficients with multilateral resistance*

The regressions in columns (i) and (ii) in table 4.6 are based on the Taylor approximation of the multilateral resistance terms as in Baier and Bergstrand (2009). This changes their interpretation somewhat. The coefficients now account for both the *direct effect* of a change in an independent variable for a bilateral relation  $i$  and  $j$ , and the *indirect effect* of a change in the same variable between country  $i$  and all other countries, as well as with  $j$  and all other countries. For instance, the RTA dummy variable accounts for the effect of trading with a fellow member of a trade agreement, but it also accounts for the effect of other trading partners being part of a trade agreement. This could have a negative effect for the exports of a country, as it will be faced with relatively less demand if other trading partners are engaged in trade agreements. This is the nature of the multilateral resistance concept, but when using fixed effects estimation, as in e.g. ECORYS (2009) the indirect effect is soaked up by the country dummies. For all my results the direct effect dominates, so the coefficients can be interpreted straightforward, but the indirect effects might alter the magnitude of the effects.

### 4.4.2 Other empirical specifications

Columns (iii) and (iv) are estimated using fixed effects with PPML and OLS estimation. I have also included estimation of the naïve gravity equation in column (v), i.e.  $\ln X_{ij} = C + \alpha \ln GDP_i + \beta \ln GDP_j + \gamma \ln d_{ij} + \varepsilon_{ij}$ , where the only proxy for trade costs is bilateral



Table 4.6: Regression results

Independent variables:	Method of estimation				
	PPML		PPML, fixed effects	OLS, fixed effects	OLS
	(i)	(ii)	(iii)	(iv)	(v)
	Dependent variable: Exports			Dependent variable: log of exports	
Log of exporter GDP	0.7829** (0.000)	0.7760** (0.000)	-	-	1.2605** (0.000)
Log of importer GDP	0.7836** (0.000)	0.7806** (0.000)	-	-	0.8961** (0.000)
Log of tariffs	-3.348** (0.000)	-3.8620** (0.000)	-	-	-
Log of NTBs	-2.405 ** (0.000)	-2.2400** (0.000)	-	-	-
RTA tariff Interaction	-1.6370 (0.251)	0.6005 (0.495)	-	-	-
RTA NTB interaction	-0.5223 (0.290)	-1.7512** (0.000)	-	-	-
RTA dummy	0.7692** (0.000)	0.4499** (0.001)	0.9003** (0.000)	0.5536** (0.000)	-
Log of distance	-0.5403** (0.000)	-0.6494** (0.000)	-0.5148** (0.000)	-1.3613** (0.000)	-1.3851** (0.000)
Contiguity dummy	0.1806 (0.328)	0.2120 (0.204)	0.3359** (0.001)	0.4425** (0.004)	-
Colony dummy	0.0261 (0.888)	-0.0791 (0.670)	0.1520 (0.278)	0.4380** (0.002)	-
Common colonizer dummy	0.0014 (0.998)	-0.1360 (0.824)	0.7137** (0.000)	1.0543** (0.000)	-
Common language dummy	0.1245 (0.500)	0.1799 (0.323)	0.0756 (0.485)	0.6141** (0.000)	-
Colony post 1945 dummy	0.9665** (0.000)	1.0593** (0.000)	0.9410** (0.000)	1.0543** (0.000)	-
Same country Dummy	1.264** (0.001)	1.3690** (0.003)	0.1742 (0.334)	0.5199* (0.035)	-
Constant term	-6.8514** (0.003)	-4.1478* (0.019)	5.1206** (0.000)	8.8037** (0.000)	-20.042** (0.000)
R <sup>2</sup>	0.48	0.48	0.55	0.68	0.58
Observations	30519	30519	30519	30517	30517
RTA dummy:	Full	Restricted	Full	Full	-

\*\* and \* denotes significance at the 1% and 5% level, respectively. P-values are reported in the parenthesis. I use robust standard errors as is standard in the gravity literature (Shepard, 2013).

distance, and multilateral resistance is not controlled for. As discussed above, the estimations in column (iii) – (v) cannot be used to discuss the impact of the NTBs in my dataset, and are included only for robustness and comparison with the literature. Looking at the different methods of estimation in table 3.7 some interesting points can be made. Observe the different pattern when using PPML estimations compared to OLS. First of all the coefficients on GDP are strikingly different in column (i) and (iv). OLS regressions of gravity equations tend to show the same pattern of a higher value on the coefficient on GDP (Silva and Tenreyro, 2006). It is also a familiar result that the true coefficients on GDP are close to 1, as discussed in chapter 2. Both these observations are non-existent when using the PPML estimator. As in Silva and Tenreyro (2006), the GDP estimates in column (i) and (ii) are between 0.7 and 0.8 and quite similar in magnitude.

Another point, also put forth by Silva and Tenreyro (2006), is that the coefficient on distance drops dramatically when using the PPML estimator. This leads us to conclude that geographical distance is not as important a trade barrier as previously thought. Lastly, and also in accordance with Silva and Tenreyro, fewer of the coefficients on historical and cultural linkages are statistically significant.

All in all it is evident that the estimation results are sensitive to the estimation method. Using the PPML gives more reliable results as they allow for both heteroskedasticity and zero-trade flows. For this reason, the PPML-estimator has become the workhorse estimator for gravity equations (Shepard, 2013). Furthermore, the results in table 4.6 indicate that my dataset behaves as expected relative what is common in the literature according to e.g. Silva and Tenreyro (2006) and Head and Mayer (2014).

## **4.5 Discussion of the results**

### **4.5.1 Tariff and NTB results**

The coefficients on tariffs and NTBs in column (i) are both large in magnitude, negative and highly significant. As expected, exports are highly sensitive to protective measures like tariffs and NTBs. Perhaps surprisingly, the elasticity on tariffs is larger than the elasticity on NTBs. However, it is important to stress that this does not mean that my results violate the argument that NTBs are more important trade barriers than tariffs. The coefficients on NTBs and tariffs

in table 4.6 are elasticities and do not contain any information on the relative importance of either NTBs or tariffs. Furthermore, as shown above, tariff levels are relatively low, so the possibility for tariff reductions is limited, while NTB levels are higher and the scope for reductions is larger. Therefore, it is likely that there is more potential for trade increases due to NTB reductions, as is argued by both IFO and CEPR.

Another reason for the larger coefficient on tariffs relative to NTBs in table 4.6 could be that the indirect effect through multilateral resistance terms is larger for NTBs than for tariffs. Since tariffs are more discriminatory, as argued in the previous chapter, it is likely that exports from  $i$  to  $j$  will increase more if tariffs rather than NTBs are reduced between them, since this reduction will concern  $i$  and  $j$  only. On the other hand, if NTBs are reduced between  $i$  and  $j$ , this may implicitly reduce NTBs between all  $i$  and  $j$ 's trading partners through the spillover effects. Thus, bilateral trade between  $i$  and  $j$  will be lower relative to what it would have been with an equal tariff reduction since frictions between all trading partners of  $i$  and  $j$  are controlled for through multilateral resistance.

In any case, it is clear from the results that there are gains to be made from both tariff and NTB reductions. Therefore, if TTIP eliminates tariffs only it can still be called a success. This is confirmed by the limited scenarios in both TTIP and CEPR, at least for member countries (see table 3.2 and 3.3), although the effects are smaller than in the comprehensive scenarios with NTB reductions as well.

## 4.5.2 RTA results

The results in column (i) of table 4.6 have some interesting implications relating to the discussion of the effect of trade agreements. First of all, note that the impact of trading with a member of a free trade agreement is highly significant and positive. Exports will (on average) be about 76 percent higher if exporting to a fellow member of a trade agreement. This observation lines up with the standard result in the literature. Head and Mayer (2014) conduct a meta-analysis of various policy dummies often used in gravity papers. Based on 257 independent studies they report an average RTA coefficient of 0.59, albeit with a high standard deviation of 0.5. Another meta-analysis is performed by Cipollina and Salvatici (2010). They find that the estimated effect ranges from 40 – 65 percent depending on the methods used.

Secondly, the coefficients on both interaction terms are not significantly different from zero, with high p-values at 0.251 and 0.290 for tariffs and NTBs interaction terms respectively. Building on the interpretation example from equation (4.3), this gives very little insight as to how the RTAs affect the impact of NTBs on trade flows.

#### *Restricted RTA dummy*

One possibility is that the effects of more efficient trade agreements are diluted by more inefficient ones, and therefore the average effect on the interaction term shown in the regression in column (i) is uncertain. To check this, I run a separate regression where I restrict the RTA dummy to the EU and EEA, NAFTA and ANZCERTA, which I assume to be relatively efficient at reducing trade barriers, as discussed above. The result of the regression using the restricted RTA dummy is shown in column (ii). Apart from using the restricted RTA dummy, the regression is identical to the one in column (i).

In this case the coefficient on the interaction between RTAs and NTBs is now highly significant and negative. This implies that when two countries  $i$  and  $j$  are fellow members of one of the RTAs covered by the restricted RTA dummy, an increase in the NTBs imposed on  $i$  by  $j$  will reduce  $i$ 's export to  $j$  by *more* than if  $i$  and  $j$  were not tied together in one of these RTAs. In other words, RTA members are punished relatively more than non-members for enforcing NTBs within the agreement. Or, on the other hand, if these trade agreements manage to reduce NTB levels further, every percentage decrease will result in a larger increase in exports than would be the case outside these agreements. Thus it seems that trade agreements not only reduce NTBs, but they increase the effect of reducing them – at least within more efficient trade agreements, i.e. the ones covered by the restricted RTA dummy in my sample. The same pattern cannot be seen for tariffs; the coefficient on the interaction between tariffs and RTAs is still not significantly different from zero in column (ii) (the p-value has actually increased).

Another interesting result in column (ii) is that the coefficient on the RTA dummy, while still being positive, is much smaller in magnitude compared to the coefficient in column (i). One possible explanation for this is that the indirect effect through the multilateral resistance terms is stronger in this case. Since only 5 percent of the bilateral relations in the sample are covered by these trade agreements (see table 4.2), most countries stand outside. Since the gravity model measures the average effect of RTAs on exports, and in this case the average

bilateral relation is not a member of the RTAs in question, the result in column (ii) indicates that it is more severe for countries to stand outside these trade agreements than the trade agreements in column (i).

Another important result emerging from the results in column (ii) is related to the discussion on the two TTIP studies in the previous chapter. The changes in the coefficients when restricting the RTA dummy provides the basis for a critique against the IFO study on TTIP. It proves that the average effect of trade agreements is dependent on which trade agreements that are inherited in the dummy. By assuming that the tariff and NTB reductions will equal the average of all existing trade agreements they are losing the ability to make any statements regarding effects of different levels of depth in the agreements ability to reduce trade frictions.

## 5 Conclusion

This thesis set out to discuss how the gravity model is used to account for the presence of NTBs in world trade, and how different methods affect the results. This is discussed through how the model is employed differently in the studies by CEPR and IFO that try to predict the effects of a trade agreement between the EU and US. I have also run my own gravity regression using a unique dataset to further supplement the discussion.

Overall, the thesis confirms that NTBs are a substantial friction to trade. My regressions estimate that an average decrease in NTBs of one percent will increase average bilateral trade with 2.4 percent, when controlling for multilateral resistance. Furthermore, the data shows that the average estimated ad-valorem tariff equivalent of NTBs in the sample is 13.8, which is 3.8 percentage points larger than the average observed tariff, and that 37.6 percent of the products in the sample is subject to a NTB. Thus, I argue that the success of a transatlantic trade agreement – or any trade agreements for that matter – to a large extent will hinge on the ability to reduce non-tariff barriers.

Both CEPR and IFO confirm this statement, and emphasize NTB reductions their studies. However, there are significant differences in their findings, particularly regarding the magnitude of TTIP's impact. This can be explained, at least in part, by how they utilize the gravity equation to account for NTBs. The CEPR study relies mainly on a business survey on transatlantic NTBs, which are calculated into ad-valorem trade cost equivalents using the gravity model. These estimates are then used in a CGE model to predict the results. In other words, they only use the gravity equation to obtain data on NTBs which then are used in the CGE modelling. However, since NTBs plays such an important role in their study, the specification of the gravity model still plays a vital role. In the IFO study, the gravity model is used more directly. Here, the problem of NTB data shortage is avoided by assuming that the effects of TTIP can be calculated from the average effect of existing trade agreements. They compare two gravity estimations; one where a simulated TTIP agreement is in place, and one where it is not. The simulated TTIP scenario is based on the estimated effects of existing RTAs.

Both methods have their weaknesses. With the CEPR method there are structural issues regarding how NTBs are defined in the survey and whether one can trust that the respondents' answers reflect actual NTB levels. IFO avoids this as their average effect will include average

NTB reductions in existing trade agreements, as well as average tariff reductions. Therefore, they do not need explicit data on NTBs. However, their study is severely limited as their method hinders them in being explicit about different scenarios of NTB reductions within TTIP.

The two TTIP studies demonstrate how the gravity model can be used in very different ways to account for the presence of NTBs. It is my opinion that the CEPR method of using estimated ad-valorem trade cost equivalents is superior, at least for the purpose of predicting the outcome of a transatlantic trade agreement, as it allows for flexibility in terms of NTB reduction.

To further discuss the presence of NTBs and to provide an alternative to the CEPR and IFO studies, I have constructed an independent dataset and run a separate regression. I base the data upon the dataset compiled by Kee et al (2009) who have made a comprehensive dataset with estimations of ad-valorem tariff equivalents of NTBs. The data confirm many of the points made by both IFO and CEPR; transatlantic NTBs are high, and consistently larger than tariffs in nearly all sectors. Furthermore, there are significant gains to be made from reducing NTBs, and I find that this effect increases within efficient trade agreements, i.e. the ones covered by the restricted RTA dummy in my sample. My regressions also show that there still are significant gains to be made from reducing tariff barriers. This is also evident from looking at the data, which shows that transatlantic as well as worldwide tariffs still are present. This means that if TTIP fails at reducing NTBs it can still be called a success, at least to some extent, as there are gains to be made from tariff reductions alone. Both CEPR and IFO confirm this, although the gains are substantially smaller than in the more ambitious scenarios where NTBs are removed as well.

Further, my regressions show that when using the restricted RTA dummy, where less efficient trade agreements are neglected, the results change. This shows that an “average” effect of existing trade agreements, as is used by IFO, hinges on which agreements are included in the sample. The IFO report is not clear on which trade agreements they include, or why they assume that TTIP will be affected according to the average effect of these particular agreements.

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# Appendix

## A1 Deriving the CES demand function

Multiplying through the first order condition (2.8) with  $c_{ij}$  gives

$$(A1.1) \quad \lambda \tau_{ij} p_i c_{ij} = \left[ \sum_{i=1}^N \beta_i^{(1-\sigma)/\sigma} \cdot c_{ij}^{(\sigma-1)/\sigma} \right]^{1/(\sigma-1)} \beta_i^{(1-\sigma)/\sigma} c_{ij}^{(\sigma-1)/\sigma}$$

Then, summing over all  $i$ 's:

$$(A1.2) \quad \lambda \underbrace{\sum_{i=1}^N p_i c_{ij} \tau_{ij}}_{=Y_j} = \left[ \sum_{i=1}^N \beta_i^{(1-\sigma)/\sigma} \cdot c_{ij}^{(\sigma-1)/\sigma} \right]^{1/(\sigma-1)} \sum_{i=1}^N \beta_i^{(1-\sigma)/\sigma} c_{ij}^{\sigma-1/\sigma}$$

Then, inserting  $\lambda$  from equation (A1.1), cancelling out terms and rearranging yield:

$$(A1.3) \quad \tau_{ij} p_i = \frac{Y_j \beta_i^{(1-\sigma)/\sigma} c_{ij}^{-1/\sigma}}{\sum_{i=1}^N \beta_i^{(1-\sigma)/\sigma} c_{ij}^{\sigma-1/\sigma}}$$

Raise both sides to the power of  $-\sigma$ , then multiply by  $\tau_{ij} p_i$  and finally rearrange again to get:

$$(A1.4) \quad (\tau_{ij} p_i \beta_i)^{1-\sigma} = \frac{Y_j^{-\sigma} c_{ij} \tau_{ij} p_i}{\left[ \sum_{i=1}^N \beta_i^{(1-\sigma)/\sigma} c_{ij}^{\sigma-1/\sigma} \right]^{-\sigma}}$$

Sum over all  $i$ 's:

$$(A1.5) \quad \sum_{i=1}^N (\tau_{ij} p_i \beta_i)^{1-\sigma} = \frac{Y_j^{-\sigma} \overbrace{\sum_{i=1}^N c_{ij} \tau_{ij} p_i}^{=Y_j}}{\sum_{i=1}^N \beta_i^{(1-\sigma)/\sigma} c_{ij}^{\sigma-1/\sigma}}$$

Define the price index of country  $j$  as  $P_j = \left[ \sum_{i=1}^N (\tau_{ij} p_i \beta_i)^{1-\sigma} \right]^{1/(1-\sigma)}$ :

$$(A1.6) \quad \sum_{i=1}^N \beta_i^{(1-\sigma)/\sigma} c_{ij}^{\sigma-1/\sigma} = \frac{Y_j^{1-\sigma}}{P_j^{1-\sigma}}$$

Inserting this back into (A1.4):

$$(A1.7) \quad (\tau_{ij} p_i \beta_i)^{1-\sigma} = \frac{c_{ij} \tau_{ij} p_i}{Y_j} P_j^{1-\sigma}$$

Recall from chapter 2 that the nominal value of exports from  $i$  to  $j$  is  $X_{ij} = \tau_{ij} p_i c_{ij}$ . Inserting (A1.7) into this expression yields the demand for  $i$  goods by  $j$  consumers:

$$(A1.8) \quad X_{ij} = \frac{(\tau_{ij} p_i \beta_i)^{1-\sigma}}{P_j^{1-\sigma}} Y_j$$

## A2 The Bergstrand, Egger and Larch gravity model

This specification of the gravity model is based on the Dixit-Stiglitz-Krugman framework (Dixit and Stieglitz, 1977; Krugman, 1979 and 1980). There is a single industry with monopolistic competitive market, increasing returns to scale in production and labor as the only input factor (MC-IR model). This leads each firm to produce a unique variety of the industry good. Consumers are assumed to follow the same CES utility structure as in the Anderson and van Wincoop model with the additional assumption that preferences are determined by a “love for variety”. To simplify the derivation it is assumed that all firms within each country are symmetrical so that the equilibrium prices are equalized and each variety is consumed in equal amounts.

### *Consumers*

Let  $n_i$  be the number of varieties of the good produced in  $i$ . The utility function of a consumer in  $j$  is:

$$(A2.1) \quad U_j = \left[ \sum_{i=1}^N n_i c_{ij}^{(\sigma-1)/\sigma} \right]^{\sigma/(\sigma-1)}$$

Note that compared to equation (2.5) the only difference is that the exogenous preference parameter,  $\beta_i^{1-\sigma/\sigma}$ , is replaced by the endogenous number of varieties  $n_i$ , i.e. the number of firms. Assuming the same structure of trade costs and prices as before, consumers maximize (A2.1) subject to the budget constraint:

$$(A2.2) \quad Y_j = \sum_{i=1}^N n_i p_i \tau_{ij} c_{ij}$$

This yields the demand for each variety:

$$(A2.3) \quad c_{ij} = \frac{(p_i \tau_{ij})^{-\sigma}}{P_j^{1-\sigma}} Y_j$$

Where  $n_i$  also replaces  $\beta_i^{1-\sigma/\sigma}$  in the price index from the Anderson and van Wincoop model:  $P_j = \left[ \sum_{i=1}^N n_i (\tau_{ij} p_i)^{1-\sigma} \right]^{1/(1-\sigma)}$ .

## Producers

The increasing returns to scale element enters the model via the assumed cost function

$$(A2.4) \quad l_i = \alpha + \varphi y_i$$

where  $l_i$  is the labor used by the representative firm in country  $i$  (remember, they are all equal within countries) and  $y_i$  is the firm's output.  $\alpha$  is the fixed cost and  $\varphi_i$  is the marginal cost. Maximization of profits,  $\pi_i = p_i y_i - w_i l_i$ , where  $w_i$  is the factor price (the wage) yields the following equilibrium conditions (Bergstrand et al. 2013)<sup>24</sup>.

$$(A2.5) \quad p_i = \frac{\sigma}{\sigma - 1} \varphi w_i$$

$$(A2.6) \quad y_i = \frac{\alpha}{\varphi} (\sigma - 1)$$

Furthermore, assuming full employment assures that the number of varieties are determined by the exogenous factor endowment, i.e. the labor stock,  $L_i$ , which is unique to each country:

$$(A2.7) \quad n_i l_i = L_i \Rightarrow n_i (\alpha + \varphi y_i) = L_i \Leftrightarrow n_i = \frac{L_i}{\alpha \sigma}$$

## The gravity equation

Following Krugman (1980) and Feenstra (2004) aggregate exports from  $i$  to  $j$  is given by

$X_{ij} = n_i p_i \tau_{ij} c_{ij}$ . Inserting the demand function (A2.3), the equilibrium number of firms (A2.6) and the equilibrium price (A2.5), Bergstrand et al. reach the following gravity equation:

$$(A2.8) \quad X_{ij} = Y_i Y_j \frac{(Y_i / L_i)^{-\sigma} \tau_{ij}^{1-\sigma}}{\sum_{l=1}^N Y_l (Y_l / L_l)^{-\sigma} \tau_{lj}^{1-\sigma}}$$

Equation (A2.8), subject to the same market clearing condition,  $Y_i = \sum_j X_{ij}$ , as in Anderson and van Wincoop (2003) is the alternative structural gravity equation based on a unconditional general equilibrium framework.

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<sup>24</sup> To save space I do not show the derivation of the consumer or the producer problems. They follow the standard derivation of the MC-IR model as in Krugman (1980) and Feenstra (2004).

*The empirical fixed effects version of the model*

Log linearizing equation (A2.8) yields

$$(A2.9) \quad \ln X_{ij} = \alpha + \beta_i + \gamma_j + (1 - \sigma) \ln t_{ij} + u_{ij}$$

Where the country fixed effects terms  $\beta_i$  and  $\gamma_j$  are given as:

$$(A2.10) \quad \beta_i = \sigma \ln L_i + (1 - \sigma) \ln Y_i$$

$$(A2.11) \quad \gamma_j = \ln Y_j - \ln \sum_{l=1}^N Y_l (Y_l / L_l)^{-\sigma} \tau_{lj}^{1-\sigma}$$

and  $u_{ij}$  is a stochastic error term. Note that (A2.9) is the exact same as the fixed effects equation (2.17) derived from the Anderson van Wincoop model. The only difference lies in the specification of the theoretical model and thus how the multilateral resistance terms are specified.



## A3 Calculating the trade cost term

Inserting  $\frac{Y_j}{Y^w} = \frac{Y_i}{Y^w} = 1/N$  in (4.8) gives

$$(A3.1) \quad \ln \tau_{ij}^* = \ln \tau_{ij} - \frac{1}{N} \sum_{i=1}^N \ln \tau_{ij} - \frac{1}{N} \sum_{j=1}^N \ln \tau_{ij} + \frac{1}{N^2} \sum_{i=1}^N \sum_{j=1}^N \ln \tau_{ij}$$

To keep the presentation from getting too messy, I simplify the trade cost term in (4.9) and assume that it consists of distance, tariffs and NTBs only:

$$(A3.2) \quad \ln \tau_{ij} = \rho \ln d_{ij} + \kappa \ln t_j + \alpha \ln \omega_j$$

Now, inserting this expression in equation (A3.1):

$$(A3.3) \quad \begin{aligned} \ln \tau_{ij}^* = & \ln(\rho \ln d_{ij} + \kappa \ln t_j + \alpha \ln \omega_j) \\ & - \frac{1}{N} \sum_{i=1}^N \ln(\rho \ln d_{ij} + \kappa \ln t_j + \alpha \ln \omega_j) \\ & - \frac{1}{N} \sum_{j=1}^N \ln(\rho \ln d_{ij} + \kappa \ln t_j + \alpha \ln \omega_j) \\ & + \frac{1}{N^2} \sum_{i=1}^N \sum_{j=1}^N \ln(\rho \ln d_{ij} + \kappa \ln t_j + \alpha \ln \omega_j) \end{aligned}$$

Then, rearranging terms:

$$(A3.4) \quad \begin{aligned} \ln \tau_{ij}^* = & \rho \left[ \ln d_{ij} - \frac{1}{N} \sum_{i=1}^N \ln d_{ij} - \frac{1}{N} \sum_{j=1}^N \ln d_{ij} + \frac{1}{N^2} \sum_{i=1}^N \sum_{j=1}^N \ln d_{ij} \right] \\ & + \kappa \left[ \ln t_j - \frac{1}{N} \sum_{i=1}^N \ln t_j - \frac{1}{N} \sum_{j=1}^N \ln t_j + \frac{1}{N^2} \sum_{i=1}^N \sum_{j=1}^N \ln t_j \right] \\ & + \alpha \left[ \ln \omega_j - \frac{1}{N} \sum_{i=1}^N \ln \omega_j - \frac{1}{N} \sum_{j=1}^N \ln \omega_j + \frac{1}{N^2} \sum_{i=1}^N \sum_{j=1}^N \ln \omega_j \right] \end{aligned}$$

This can be written as

$$(A3.5) \quad \ln \tau_{ij}^* = \rho \ln d_{ij}^* + \kappa \ln t_j^* + \alpha \ln \omega_j^*$$

where  $\ln d_{ij}^*$ ,  $\ln t_j^*$  and  $\ln \omega_j^*$  are given by (4.11) – (4.13). Equation (A3.5) is the same as (4.10), only including fewer trade costs proxies for illustrative purposes.

## A4 Taylor approximations of the cultural and historical variables used in the estimations

The cultural and historical dummy variables used in the estimation,  $Contig_{ij}^*$ ,  $Comlang_{ij}^*$ ,  $Comcol_{ij}^*$ ,  $Colony_{ij}^*$ ,  $Col45_{ij}^*$  and  $Smctry_{ij}^*$ , are calculated using equation (4.8). Thus, they are defined as follows:

$$(A4.1) \quad Contig_{ij}^* = Contig_{ij} - \frac{1}{N} \sum_{i=1}^N Contig_{ij} - \frac{1}{N} \sum_{j=1}^N Contig_{ij} + \frac{1}{N^2} \sum_{i=1}^N \sum_{j=1}^N Contig_{ij}$$

$$(A4.2) \quad \begin{aligned} &Comlang_{ij}^* = \\ &Comlang_{ij} - \frac{1}{N} \sum_{i=1}^N Comlang_{ij} - \frac{1}{N} \sum_{j=1}^N Comlang_{ij} + \frac{1}{N^2} \sum_{i=1}^N \sum_{j=1}^N Comlang_{ij} \end{aligned}$$

$$(A4.3) \quad Comcol_{ij}^* = Comcol_{ij} - \frac{1}{N} \sum_{i=1}^N Comcol_{ij} - \frac{1}{N} \sum_{j=1}^N Comcol_{ij} + \frac{1}{N^2} \sum_{i=1}^N \sum_{j=1}^N Comcol_{ij}$$

$$(A4.4) \quad Colony_{ij}^* = Colony_{ij} - \frac{1}{N} \sum_{i=1}^N Colony_{ij} - \frac{1}{N} \sum_{j=1}^N Colony_{ij} + \frac{1}{N^2} \sum_{i=1}^N \sum_{j=1}^N Colony_{ij}$$

$$(A4.5) \quad Col45_{ij}^* = Col45_{ij} - \frac{1}{N} \sum_{i=1}^N Col45_{ij} - \frac{1}{N} \sum_{j=1}^N Col45_{ij} + \frac{1}{N^2} \sum_{i=1}^N \sum_{j=1}^N Col45_{ij}$$

$$(A4.6) \quad Smctry_{ij}^* = Smctry_{ij} - \frac{1}{N} \sum_{i=1}^N Smctry_{ij} - \frac{1}{N} \sum_{j=1}^N Smctry_{ij} + \frac{1}{N^2} \sum_{i=1}^N \sum_{j=1}^N Smctry_{ij}$$

## A5 List of countries in the dataset

1	Algeria	34	Guatemala	67	Pakistan
2	Argentina	35	Honduras	68	Papua New Guinea
3	Australia	36	Hong Kong	69	Paraguay
4	Austria	37	Hungary	70	Peru
5	Bahrain	38	Iceland	71	Philippines
6	Bangladesh	39	India	72	Poland
7	Belarus	40	Indonesia	73	Portugal
8	Belguim	41	Ireland	74	Republic of Moldova
9	Bolivia	42	Italy	75	Romania
10	Brazil	43	Ivory Coast	76	Russian Federation
11	Brunei	44	Japan	77	Rwanda
12	Burkina Faso	45	Jordan	78	Saudi Arabia
13	Butan	46	Kazakstan	79	Senegal
14	Cameroon	47	Kenya	80	Slovenia
15	Canada	48	Kyrgyzstan	81	South Africa
16	Central African Republic	49	Latvia	82	Spain
17	Czech Republic	50	Lebanon	83	Sri Lanka
18	Chile	51	Lithuania	84	Sudan
19	China	52	Madagascar	85	Sweden
20	Colombia	53	Malawi	86	Switzerland
21	Costa Rica	54	Malaysia	87	Tanzania
22	Country	55	Mali	88	Thailand
23	Denmark	56	Mauritsius	89	Trinidad And Tobago
24	Ecuador	57	Mexico	90	Tunisia
25	EL Salvador	58	Morcocco	91	Turkey
26	Estonia	59	Mozambique	92	Uganda
27	Ethiopia	60	Nepal	93	Ukraine
28	Finland	61	Netherlands	94	United Kingdom
29	France	62	New Zealand	95	Uruguay
30	Gabon	63	Nicaragua	96	USA
31	Germany	64	Nigeria	97	Venezuela
32	Ghana	65	Norway	98	Vietnam
33	Greece	66	Oman	99	Zambia
				100	Zimbabwe

