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Estimates of the role of non-tariff measures in trade between CZE/EU and Japan

Bachelor thesis

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Abstract

Japan and the European Union negotiated and ratified an agreement about free-trade area that came into effect in January 2019. There haven't been enough data for Japan and the Czech Republic to show the actual impact yet. Gravity model is a useful tool for international trade that can be used to estimate the effect. Various types of methods are used for estimation. The main ones used here in this paper are Random effects and Poisson Pseudo Maximum Likelihood (PPML) estimator. According to PPML model, the impact of the treaty is expected to be 57.3% increase of imports. The model shows positive trade potential for Japan and the Czech Republic. Especially for Japan there is a large gap between model prediction and actual values which means a small trade creation is expected. However, the most of the increasement of bilateral trade should be originated from trade diversion.

Abstrakt

Japonsko a Evropská unie uzavřeli dohodu o volném obchodu, která vešla v platnost v lednu 2019. Zatím není k dispozici dostatek dat, aby se mohl potvrdit či vyvrátit předpokládaný efekt této dohody na obchod mezi Japonskem a Českou republikou. Gravitační model je hojně užívaný způsob odhadování vlivů různých proměnných v mezinárodním trhu. Existuje více metod k vypočítání tohoto modelu, ale v této práci jsou nejdůležitější tyto: *Random effects* a *Poisson Maximum Likelihood estimator (PPML)*. Podle PPML modelu je očekávaný nárůst importu obou zemí 57.3 %. Model dále ukazuje obchodní potenciál obou zemí, tedy rozdíl odhadnutých hodnot od skutečných hodnot importů obou zemí. Japonsko představuje pro Českou republiku obrovskou příležitost ke zvýšení celkového exportu. Ovšem největší nárust vzájemného obchodu bude způsoben přesměrováním již existujících obchodních toků.

Klíčová slova

Gravitační model, mezinárodní obchod, *Random effects, Poisson Maximum Likelihood estimator,* Japonsko, Česká republika, EU, bez-tarifní bariéry, zóna volného obchodu

Keywords

Gravity model, international trade, Random effect, Poisson Maximum Likelihood estimator, Japan, Czech Republic, EU, non-tariff barriers, free-trade area

Range of thesis: 75 564 characters (including spaces)

Declaration of Authorship

1. The author hereby declares that he compiled this thesis independently, using only the listed resources and literature.

2. The author hereby declares that all the sources and literature used have been properly cited.

3. The author hereby declares that the thesis has not been used to obtain a different or the same degree.

Prague … **31.7.2019** **Jan Srna**

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Bachelor's Thesis Proposal

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Proposed Topic:

Estimates of the role of non-tariff measures in trade between the CR/EU and Japan

Preliminary scope of work:

Research question and motivation

My topic will aim to search for additional non-tariff barriers that can be overlooked when constructing ordinary bilateral trade deals. Furthermore I will try to estimate the after-deal situation and compare it with current situation as well as potential ideal situation with no barriers.

FTA (free-trade area) negotiations between the European Union and Japan about FTA are already finished. However, it is still waiting to be ratified and implementation itself can continue for couple more months or years so this thesis could either forecast the situation (if FTA is still not operational by the time of my Bachelor's thesis defense) or explain the situation (if it is already in place fully-functioning).

Contribution

As mentioned earlier results of my work should illustrate the ideal situation of trade between the Czech Republic and Japan as well as identify non-tariff barriers that might be underestimated or simply hidden for people who do not have time and expertise to study the situation closely.

Methodology

I use gravity models for international trade. That includes constructing a regression to estimate parameters of certain barriers in some cases using dummy variables.

Outline

My work will start with improving my knowledge on the exact methodology of gravity models as well as current situation of the negotiations between EU and Japan. To construct my model I will get data from comtrade website not only for bilateral trade of the Czech Republic and Japan but also various other countries to have a proper estimates. Then I will use this data in Rstudio and decide which barriers are important in case of Czech-Japan trade and comment on them.

List of academic literature:

Bibliography

- ***Gravity Equations and Economic Frictions in the World Economy*** by Jeffrey H. Bergstrand and Peter Egger
- ***Gravity for dummies and dummies for gravity equations*** by Richard Baldwin and Daria Taglioni
- ***Gravity Equations: Workhorse, Toolkit and Cookbook*** by Keith Head and Thierry Mayer

Content

Introduction

Gravity model has proven to be a valuable tool when examining the size of trade between two countries. The popularity of the model is given by its empirical relevance combined with decent microeconomic foundations. Any characteristic of a country that could influence the size of its exports or imports can be tested in an econometric model derived from the original concept. Although, traditional gravity model describes relationship between trade, GDPs and distance those are not the only variables included.

The Czech Republic and Japan are countries with no real similarities. Large distance between them, different major trading partners, no real shared colonial history or great diversity in traditions are examples of some major dissimilarities. With increasing number of such characteristics rises the unwillingness to trade. It goes without saying that these aspects lead to poor trading relationship. Neither of those countries presents a significant trading partner for the other one. However, establishment of any trading deal between them should lead to an increase in bilateral trade. Gravity model provides the opportunity to include a dummy variable that works as a substitute for the examined agreement and thus the effect of a treaty can be withdrawn from the model if carefully implemented. Moreover, the treaty has just came into effect in the beginning of year 2019. However, model constructed as explained gives only an average effect of all treaties in the sample. The relevance of potentially significant results depends on many factors. Value of the coefficient itself with no additional explanation does not provide any reasonable conclusion. To show the impact is impossible without data from the future but using gravity model on panel data an average outcome of a treaty can be estimated. Thus, approximate change in trade after the establishment of FTA can also be estimated. The most desired variable in the equation is called “treaty”. To put that in perspective, model used here aims to estimate the impact of any active treaty between countries. Ideally even estimate the impact of reduction of non-tariff barriers (non-tariff measures).

The rest of this thesis is divided into four parts with subsections. First part gives an overview of the expectations connected to the treaty itself. Next chapter is the literature review that summarizes some important ideas about gravity models. The first subsection covers the general evolution of papers that focused on the empirical part and specific uses of the equation. The second part of literature focuses on gradual development of theoretical foundations behind the gravity equation (formula for gravity model estimation). After literature comes a chapter that deals with theoretical background of the equation. Next section discusses the expectation of the results and then estimates the actual equation. Last subsection in the empirical part reports the results and provides possible explanations and logic behind them. Conclusion summarizes the results and methods used to achieve them.

1. Main aspects of the agreement

1.1. EU- Japan agreement basic concepts

As impact study by the European Commission's Directorate (2018) states, the EPA (Economic Partnership Agreement) between Japan and the EU is going even deeper than classic FTA defined by WTO- liberalization should cover almost all trade. In terms of tariffs EU is obligated to eliminate 99% of tariff lines leading to 100% of imports from Japan (not necessarily right away). Japan is expected to abolish 97% tariff lines (99% of imports). Remaining 3% are mostly covered in the agricultural sector which is highly desired by the EU and very sensitive for Japan. Nevertheless, tariffs in agriculture will get significantly weaker and sector itself will experience massive NTBs reduction to counter the persevered tariffs. According to the agreement, EU market should liberalize 96% of tariff lines and almost 50% of duties right away. The rest is going to be eliminated by staging throughout next at most 15 years. For example, highly discussed car sector in the EU should eliminate its 10% tariff in 7 years. Japan should immediately eliminate 95% of tariff lines and more than 50 % of duties and the rest will be dealt with by staging in up to 15 years. Downside for governments is of course the lost in revenues from duties (EUR 2 billion for EU and EUR 1 bn for JAP).

According to European Commission's Directorate (2018), even more cost-savings come from the NTBs (non-tariff barriers) alterations. Relatively closed economy on Japan side and generally different market structures have been an issue especially for European companies to enter Japanese market in many sectors. However, last several years Japan has been involved in various discussions in this matter even accepting some international regulations which eased up the process of negotiations for this particular agreement. Car sector is definitely one of the most important ones in bilateral trade. This treaty ensures that both sides target a full alignment of basic car standards. Japan has recently joined the international standards which improved this process rapidly. Furthermore, the treaty even has safe clause for EU to re-apply tariff in case that Japan cycles back to its own car regulation standards. Pharmaceuticals and medical instruments have also experienced difficulties in terms of different regulation measures between both sides. All 28 countries now provide pharmaceuticals with norms accepted even by Japan. Even beer export is now eased up. Companies are no longer obligated to label beer as soft drinks that contain alcohol. Changes in many different market sectors as well as general trading regulations are included in the agreement. From sanitary and emergency measures all the way to technical barriers to trade.

1.2. Estimated impact of the EU- Japan FTA

1.2.1 EU- Japan situation

As Felbermayr et al. (2017) state, countries in the EU (including the Czech Republic) apply very different export tactic than Japan. The European Union functions as a large open market where countries trade with no tariffs. On the other hand, Japan has been opening its market only recently. In many situations Japan has simply manufactured specific goods inside the targeted country avoiding the traditional export mechanism. Thus, abolishment of tariffs would probably have a larger impact on the welfare of the EU than Japan. However, the mutual agreement about FTA between Japan and the EU should of course, according to the standard trade theory, benefit both sides. Most of the models indicate performance improvement as well as welfare increase resulting from trade liberalization. Especially for Japan the EU is large market full of great potentials with limited access until the establishment of FTA. There are still some restrictions left as well as barriers (natural and men-made) but the transactions costs should decline rapidly.

Felbermayr et al. (2017) provide information on the aspects of the treaty. Both sides have different sectors targeted in the foreign market. For EU it is for example agriculture, food or railroad equipment. In terms of Japan it is definitely automobile industry (here EU has a 10% tariff). Japan and the EU have mostly moderate tariff rates under 10%. The real influencers of trade are the non-tariff barriers. If those are eliminated at a large scale the impact is going to be extremely significant.

Table no. 1: impact on Japan and EU

	Japan		EU	
	GDP growth	Export growth	GDP growth	Export growth
L	0.29%	29%	0.76%	34%
BY	0.86%	N/A	0.21%	N/A

Note: L= Lamprecht (2016), BY= Benz and Yalzin (2013); export growth shows an increase in bilateral trade

At the beginning of the negotiations in 2013 Benz and Yalzin (2013) focused on the economic impact that a treaty between EU and Japan can have on both sides (using computable general equilibrium model- CGE). Their estimated effects on economic growth in Japan and the EU were 0.86% and 0.21% respectively. Lamprecht et al. (2016) published somewhat opposite results (as well via CGE model). Team around Philipp Lamprecht estimated the GDP increase to be 0.76% for the EU and 0.29% for Japan. More importantly (at least for the purposes of this paper) his team stated that the expected effect of treaty on bilateral trade should be 34% (exports from EU to Japan) and 29% (exports from Japan to EU).

Felbermayr et al. (2017) also contributed with their own estimation of the possible impact. First view on this matter was performed by this team in 2011 with data collected from previous years (during the financial crisis). Thus, results could have been somewhat misleading. Another advantage of the updated study is the possibility to use similar agreements as a benchmark for the analysis (EU- Korea for example).

All three studies, whose results are mentioned by Felbermayr et al. (2017), support three main outcomes of the agreement. Firstly, trade agreement cuts down transaction costs which leads to lower trading costs resulting in higher bilateral exports. Secondly, higher bilateral exports increase competition (foreign as well as domestic) generates decrease in prices which results in an enhancement of consumer welfare. Lastly, easier trade negotiations attract foreign direct investment. Results differ throughout the three papers but agree that the overall impact is increase in welfare for both sides (higher the number of abolished NTBs higher the boost of welfare). Interesting ratio is provided by one of the papers. It claims that in a situation when treaty covers elimination of all tariffs as well as all NTBs tariff abolishment is responsible for one third of the welfare increase and the rest is caused by the elimination of NTBs (for EU). For Japan in the same situation the welfare boost is mostly cause by abolishment of NTBs.

Felbermayr et al. (2017) and his team apply different CGE model. As a starting point they assume that Japan is a relatively closed economy and EU an opened one. Furthermore, EU- Korea treaty is set as a benchmark for the depth of the agreement because by the time this paper was published the agreement details were still being discussed and ratified. Results from the estimation are presented under three scenarios: only tariffs abolishment, tariff abolishment with NTBs reduction similar to the EU- Korea treaty (this option is probably the closest one to the actual agreement), tariff abolishment and NTBs reduction equal to the average of ordinary FTAs.

The estimation inspired by EU- Korea treaty, according to Felbermayr et al. (2017), shows that the overall impact on the World would be increase in welfare by EUR 18 bn (out of which EUR 9 bn for Japan and EUR 11 bn for EU). But not every country would be better off. For the welfare effect to be positive EUR 18 bn there must be additional countries affected (positively and of course negatively). The biggest losers of this deal are China, Korea and Taiwan (together around EUR 1,5 bn) because of trade diversion this treaty causes.

1.2.2 Czech Republic- Japan situation

For the purposes of my work it is important to look at the expected outcomes (table no. 2 bellow) for Japan and the Czech Republic in Felbermayr et al. (2017). The increase of GDP should be 0.05% for the Czech Republic and 0.23% for Japan. The export from the Czech Republic to Japan should rise by 62.9% and vice versa 54.6%. The upper bound of estimation was the third option mentioned at the end of the last paragraph above first table. The impact under this scenario equals 0.31% increase of GDP for CZE and 1.63% for JAP. Exports from CZE to JAP are expected to increase by 149% and the other way around it should be 160%.

Table no. 2: comparison of the impact on Japan and the Czech Republic[1]

	Japan		Czech Republic	
	GDP growth	Export growth	GDP growth	Export growth
F2	0.23%	54.6%	0.05%	62.9%
F3	1.63%	160%	0.31%	149%
G	0.01%	N/A	0.02%	N/A

Note: F2= Felbermayr option 2, F3= Felbermayr option 3, G= Grübler, Reiter and Stehrer; export growth concerns only bilateral trade

Gravity model is applied for estimation in a study by Grübler, Reiter and Stehrer (2018). They provide GDP growth results for all EU countries as well as Japan. According to them the impact of the treaty will increase GDP by 0.02% for the Czech Republic and 0.01% in case of Japan.

The impact study by Kocourek and Šimanová (2018) extends the estimations for the case of the Czech Republic and Japan. For the Czech Republic alone, the estimated effects are minor. It is estimated that small positive economic growth should be present but after the temporary change period the growth should be negative with almost the same magnitude as initially.

Table no. 3: exporter cost-savings (Million US dollars)

	Tariffs	NTBs
Japan	80	21
Czech Republic	49	59

Table no. 3 provides the results from the paper by Kocourek and Šimanová (2018). Czech exporters should on average spend around 49 Million dollars (per year) less than before the treaty on tariffs. However, the paper lacks the information about the savings of customers.[2] Other cost-cuts should arise with non-tariff barriers 59 Million dollars. Furthermore, Japanese importers should pay about 100 Million dollars a year less saving mostly on custom duties and the remaining amount on non-tariff barriers. According to

[1] From Felbermayr et al. (2017) only option 2 and 3 are used because the agreement covers more than FTA.

[2] Tariffs introduced by a country A appear to be a cost for exporter trying to enter the market. However, portion of the expense is transferred to the consumer in country A because tariffs increase prices. Which means abolishment of tariffs benefits foreign exporters as well as domestic consumers.

the paper, exports from Japan to the Czech Republic are expected to increase more than exports from CZE to JAP enlarging the already existing trading deficit. These results have been provided by CGE (computable general equilibrium) model.

2. Literature review

Bergstrand and Egger (2013) provide a great historical summary of the evolution of gravity models. This model became popular in the second half of the 20th century. It is believed that early roots of the idea appeared at the end of the 19th century and the very beginning of the 20th but first paper that discussed the topic at least a bit in detail was Stewart (1948). Actually, Stewart (1948) touched this topic explaining that the equation resembles Newton's law of energy and not force. He claims that "energy between two objects" has an inverse relationship with distance but „force between masses" depends on the inverse of second power of distance. Thus, to call the model "Gravity" can be somewhat misleading.

Gravity force between two masses: $\boldsymbol{F} = \boldsymbol{G}\frac{\boldsymbol{M_i M_j}}{(\boldsymbol{D_{ij}})^2}$ [3]

Energy force between two masses: $\boldsymbol{E} = \boldsymbol{G}\frac{\boldsymbol{M_i M_j}}{\boldsymbol{D_{ij}}}$

It is important to mention the energy formula is just an extension of the original Newton's law of gravity. The relationship for E works in gravitational field. Intuitively, higher resemblance of gravity used in international trade belongs to the second equation.

Nevertheless, as Bergstrand and Egger (2013) say gravity model is highly used when comes to international trade. It can describe or explain the magnitude of bilateral trade between two countries (and more). For the case of economics, the formula has been modified by GDPs instead of the masses. The equation, as used today (with many improvements throughout the years), became popular in the second half of the 20th century.

[3] Where G is gravitational constant, M is the mass of an object (i or j) and D is the distance between to objects.

2.1. History of Gravity model

2.1.1. Early beginnings - Tinbergen, EIA

The earliest pathfinder of the model was J. Tinbergen. His paper Tinbergen (1962) set up the first gravity equation to test the impact of an active trading treaty. He used dummy variables (dummies) to describe characteristics of the countries in the model such as common border and whether country belongs under a specific international trade deal. The latter was the variable of interest and its coefficient was supposed to be the desired effect.[9] Such usage of dummies to single out the impact of treaties or shared border led to a more realistic result of the effect that GDPs and distance have on trade. Many other econometricians used similar ideas with a different motivation.

According to Bergstrand and Egger (2013) students of Tinbergen also contributed to the international trade theory influenced by his work. Linnemann (1966) came across some groundbreaking ideas about trade flows in general. Firstly, about 50 % of trade flows in the whole world were listed as zeros because they were fairly small. Many econometric models cannot deal with zeros so data samples have to be restricted to non-zero trade flows which could lead to a restriction of data by 50%, significantly lowering the efficiency of the model. Secondly, Linnemann formed a list of centers of countries used by many researchers to calculate bilateral distances. Furthermore, he examined many economic integration agreements and their trade creation or diversion (*ex post)* and provided the aspects of an existence of heteroskedasticity among data.

Bergstrand and Egger (2013) argue that first two papers (that use both Linnemann's and Tinbergen's strategy) with statistically significant results of the impact that EIA[4] has on trade were provided by Aitken (1973) and Sapir (1983). Aitken focused on EFTA (European Free Trade Association) countries and Sapir on developing countries. Aitken (1973) used cross-sectional analysis and concluded that there is an empirical evidence of EIA increasing trade between countries. This thesis should aim to tackle similar issue and use the results to estimate the effect of trade deals specifically on bilateral trade between Japan and the Czech Republic.

[4] EIA = economic integration agreement

2.1.2. 1980-1990's - exchange rate, Linder hypothesis, Border puzzle

Gravity model, as Bergstrand and Egger (2017) claim, also spread into fields that might be connected to international trade such as politics, sociology, finance or culture. Variables referencing to these aspects could be added to the equation. Abrams (1980) and Thursby and Thursby (1987) included the exchange rates into the model.

Abrams (1980) heavily discussed the potential impact of high exchange rate volatility to the size of the actual trade. His macroeconomic model provided results that suggest the relationship between exchange rate uncertainty (high volatility) and size of a trade is negative. In other words, trade decreases with increasing instability of exchange rate. Potential gain from trade are increasingly uncertain.

Thursby and Thursby (1987) provide strong evidence of significance of the Linder hypothesis: when two countries have similar demands, they tend to trade with each other more and two countries that share the same preferences still choose to trade because of comparative advantages. They also show that exchange risk is statistically significant in determining the size of trade.

An interesting paper was written by McCallum (1995) introducing so-called "Border puzzle". He used cross-sectional data from year 1988 to estimate the impact of border on trade between USA and Canada. The dataset contained exports from 30 US states (representing 90% of trade between USA and Canada) and 10 Canadian provinces. He used a common formula for gravity used by many others:

$$\ln(x_{ij}) = \beta_0 + \beta_1 \ln(y_i) + \beta_2 \ln(y_j) + \beta_3 \ln(dist_{ij}) + \beta_4 \delta_{ij} + \varepsilon_{ij}$$

where *ln* stands for natural logarithm[5], x_{ij} is the values of export between region (either state or province) i and region j, y_i is GDP of region i, $dist_{ij}$ stands for distance between region i and j, δ_{ij} is a dummy variable holding the desired effect of a border (in case of McCallum this dummy equals 1 when i and j are provinces and 0 for trade across border). Same structure of equation is used very often usually with δ_{ij} as a dummy describing specific aspect of trade that the author is aiming to explain (border, common language,

[5] Log-forms are popular especially in case of inconsistent data with large outliers to narrow the dataset down. Coefficients in log-log estimation provide elasticities straight away.

colonial history etc.). McCallum (1995) concluded that inter-province trade in Canada was 22 times higher than the trade across the border to United States. However, his estimation lacked the theoretical foundations and according to later papers (Anderson and Van Wincoop, 2003) his results were biased.

2.1.3. Last two decades - currency union, medal errors, meta-analysis

Rose (2000) provides an empirical work on the effect of currency unions (areas where countries share one currency) in contrast with exchange rate volatility. He concludes that currency union as a trade stimulant works almost three times better than overall similarity of two countries. In terms of currency or money, low exchange rate volatility seems also to be a great tool to increase bilateral trade (according to the paper) but currency union (CU) is more efficient.

However, Baldwin and Taglioni (2006) mention several empirical papers (including theirs) to show that not only is the power of currency areas exaggerated but it is not even significant and/or close to zero. In some cases, the effect is also slightly negative. Countries joining in with the same currency are usually already very close trading partners with several treaties affecting trade in place. Which means biased results of the effect can appear when other negotiations within partner countries are not included in the model.

Furthermore, in next subsection that discusses the theoretical foundations we mention three errors categorized as Gold, Silver, and Bronze by Baldwin and Taglioni (2006). Rose (2000) is one of the papers that Baldwin and Taglioni use as the example of those mistakes. Gold medal mistake- endogeneity is present because currency union is also part of the omitted variable that includes or the aspect that determine the bilateral trade. Most of the factors that can determine bilateral trade and its size are likely to be omitted from the model and that does not bias the results unless there is an evidence of correlation between those and the explanatory variables. Gold medal error can be avoided partly or entirely using nation dummies and pair dummies respectively. First follows the logic of separating observations for each country that basically sums up all the determinants of its trade. However, it works for cross-sectional data. In case of panel data correlation can appear over time. For panel data it is easier to use the second option- pair dummies. In other words, model should be constructed with additional information about every country-pair in the sample to avoid already included variables being biased. Including dummy variable for time could help with the remaining bias.

Fairly different but not less interesting is paper done by T. Havránek (2010). Havránek (2010) provides a meta-analysis on the effect that currency area have on the size of bilateral trade- he uses the term Rose effect that originated in paper by Rose (2000) mentioned earlier. He examines the publication bias that connects to the Rose effect which treats currency areas as undeniably great tools for increase of trade. Meta-analysis was originally invented as a method that increases the power that results in a specific field have in terms of statistics (in other words increase the number of observations to fit in a more general way). Its strength and credibility rise with number of studies of the specific field that are included in the model. It is useful not only to discover biased results but also the nature and origin of the bias. Havránek also comments on the reason that previous authors in this field had to omit certain papers in the meta-analysis claiming that all papers should be included with no personal judgement. Dataset for his empirical part consists of 61 papers that discuss the impact of currency union on trade (out of which 28 focus on Euro-zone). Generally, these papers suggest that the impact of euro-zone is smaller than the average effect of currency union around the world. Problem is that despite several studies and hypothesis it is still uncertain why is this the case. Average effect taken from all papers is not really meaningful when papers differ by significant numbers. Havránek mentions that the pooled estimation of the results provided by papers focused on euro-zone effect was about 4%.

2.2. Evolution of theoretical foundations

2.2.1. Theoretical roots - Cobb-Douglas, Potluck assumption

Anderson (1979) was probably the first one to cover the roots of gravity model in terms of microeconomics. Many others have been inspired by his work improving it with additional assumption because originally, he derived the basic form of the formula in a fairly simplified world. The intuition rests on Cobb-Douglass system of expenditure. All countries produce just one good and there are no tariffs in the system. Using following equations:

$$M_{ij} = b_i Y_j;\ Y_i = b_i(\sum_j Y_j) \Rightarrow M_{ij} = Y_i Y_j / \sum_j Y_j$$

where M_{ij} is the value of imports of good produced by country i to country j, b_i describes how much of its income country j spends on good i (this values stays the same for all countries in Cobb-Douglass system) and Y equals the income of country i or j.

As Baldwin and Taglioni (2006) claim the resulting equation is similar to what Leamer and Stern (1970) called the "Potluck assumption". The size of the import depends on the proportional incomes of both countries to the rest of the world. Anderson (1979) expanded his model for more goods, tradeable or not, distance as well as tariffs. Even with basic theory behind the gravity extraction still large portion of the foundations had been unexplained in the 80's. Deardorff (1984) showed a significant level of uncertainty about the theory and legitimacy of derivation of gravity model. Soon there were several papers seeking to lay down the foundations (for example Bergstrand 1985 and 1990) explaining parts of the theoretical roots vital for specific cases.

2.2.2. Cross-sectional data

Significant step towards explaining the theory behind gravity is paper by Anderson and Van Wincoop (2003). This work builds upon the border puzzle from McCallum (1995). With data from 1993 they use McCallum's equation enriched by remoteness of region that averages the distance of a region from others except the current trading partner. This method hadn't been explained by theory until that point but as mentioned later in this paper it is a stable part of gravity formula for various reasons. They concluded that the border effect has a coefficient equal to 14.5 which compared to 22 is a sign of an included bias. Furthermore, even smaller was the estimate calculated according to theory which was 10.7. For United States the result calculated from theory was 2.24 which means that border increases trade within states almost 5 times less than within provinces in Canada.

However, main point of the paper by Anderson and Van Wincoop (2003) was theory. They continue with theory starting from CES expenditure model used by Anderson (1979) as well as others. Value added to the theory by them is more general process of gravity model derivation avoiding many of the "ad hoc" assumptions previously used in this area. An important idea in this paper is that one has to be careful when examining the bilateral trade barriers that two countries face. The size of bilateral trade between two countries does not depend only on the restrictions between them but also their relative status to the average restrictions both countries face with all other trading partners. This explains the necessity of distances to other countries in McCallum's model. Furthermore, using the theoretical foundation this paper shows the connection between size of a country and its volatility with respect to changes in trade restrictions. To compare the effect of barriers on large and small countries it is viable to take size-adjusted results. Simply because the percentage change can be used in comparative statistics and thus be applied in the theory. Authors show that trade barrier has a larger decreasing effect on bilateral trade of two large countries than two small countries probably because larger countries have the option to shift international trade towards a different partner to neglect the rising costs of trade. Smaller countries do not have such a variety of options thus they cannot change so rapidly. However, trade restrictions increase trade within smaller countries more than within the large ones because a rise in multilateral barriers equals fall in the relative restrictions (bilateral versus multilateral-dominator increases). For a small country the impact of additional trade barrier is larger than in case of a large country. These two outcomes of the theoretical study imply that the decrease of domestic trade (within a country) relative to international trade is greater if the exporting country is larger and the importing one smaller.

2.2.3. Panel data, Bonus Vetus OLS

Later, Baldwin and Taglioni (2006) tackle the same issue as Anderson and Van Wincoop for panel data. They use Anderson and Van Wincoop (2003) as starting point and expend the logic across panel data. According to them, gravity behaves similarly as expenditure equation where market demand equals supply thus agreeing to some extend with the derivation done by Anderson (1979). The resemblance of the two models doesn't mean that one can be explained by the other as whole. They extend the model as well as implement some important additional factors. To be precise Baldwin and Taglioni (2006, page 2) say:" is not a model in the usual sense – it is the regression of endogenous variables on endogenous variables." Their paper focuses on the mistakes that are common among econometricians using gravity model- so called Gold, Silver and Bronze medal errors. Gold medal error is a problem of endogeneity caused by omitting variables that are correlated to trade-cost terms which are used when deriving gravity from expenditure. In other words, results are biased in case that at least one of the aspects that determine bilateral trade and depend on relative prices is included but not all of them. Silver medal error can appear when researchers want to explain bilateral trade both ways not only from one direction using elasticities. Theory shows that there is a difference between logarithm of average of two exports (from country A to B and vice versa) and taking the average of logarithm of export from A to B and logarithm of export from B to A. The latter is the correct way to use this technique. For two countries that export to one another approximately the same amount there is almost no bias. However, with increasing difference of the size of bilateral exports of two countries bias rises as well. Third- Bronze medal mistake is the unjustified use of price indexes (US or others) to deflate nominal prices of goods traded. The use of PPIs and CPIs often leads to biases especially in case of trade flows that follow very different patterns. the standard inflation rates that are used around the globe.

Following the study of Anderson and Van Wincoop (2003) is a paper by Baier and Bergstrand (2009) called “Bonus Vetus OLS”. Authors introduce a new method of estimation using the Taylor expansion to estimate a simplified form of a gravity model with OLS (ordinary least squares). Results are tested by “Monte Carlo simulation”. This method models the probability of various outcomes in a process that interferes with random variables and thus is too difficult to predict. The main purpose is to comprehend the influence that uncertainty and risk have on the outcome observed. Similarly, to papers mentioned earlier Baier and Bergstrand (2009) focus on issues with traditional gravity equation- inclusion of costs of trade of country A to country B relative to the rest of trading partners. Their papers suggests a method that uses OLS estimation different than Fixed effects. To approximate the multilateral resistance terms, they use first order Taylor expansion in log-linear form. Unlike traditional simple Fixed effects in this case when OLS estimation is applied results can be used for comparative statistics because of derivation with theoretical foundation. This method follows a different path of estimation but to improve its potential it is important to include the county-pair dummies. Furthermore, paper provides empirical results of Taylor expansion and compare the results with Anderson and Van Wincoop (2003) to show how precise their estimation is.

2.2.4. Zero trade - Poisson Pseudo Maximum Likelihood estimator

An influential paper is provided in a paper by Silva and Tenreyro (2006). They compare various methods of estimation gravity model and show under what circumstances those models give efficient results. The fundamental statement that their paper is built upon is called Jensen's inequality. As Silva and Tenreyro (2006, page 1) define: ”the expected value of a logarithm of a random variable is different from the logarithm of its expected value.”

Silva and Tenreyro (2006) believe Jensen's inequality to be highly important issue in classic estimations of the traditional log-linear models. Coefficients in the model are vulnerable in presence of heteroskedasticity. Normally the solution for situations (when variance of disturbances is not constant) to acquire efficient coefficients are robust standard errors. But as authors show heteroskedasticity in log-linear model leads to potential bias of coefficients. Even when model controls for fixed effects specific for every country bias is highly probable. In order to have a homoscedastic model the error term should be statistically independent of the explanatory variables used in the equation. Because the log-linear model is estimated with logarithms of all the variables in the model (including the dependent variable and error term) the logarithm of error term has to be independent of the regressors as well. Problem is that expected value of a random variable in logarithm depends not only on the mean value but also other order statistics of its distribution. Thus, mutually dependent regressor with error term causes logarithm of error term to be dependent as well leading the model to have inconsistent results.

Furthermore, Silva and Tenreyro (2006) focus on the issue of zeros in the dataset and the best way to treat them. That is something the original Newton's gravitational law does not have to deal with because the gravitational force could drop very close to zero but not equal zero. On the other hand, trade between two countries does not have to exist and therefore be exactly equal to zero. That leads to another problem with log-linear models- logarithm of zero is not defined. Some authors simply take out those observations that consist of zero trade and estimate without them. Unfortunately, certain countries trade with only a small amount of countries and thus dropping those observations out would lead to a loss of significant information. Unintentional withdrawal of observations that have actual values different than zero cannot be classified as an example of publication bias but the impact on estimation is similar (biased results). Different tactic is to add 1 to all the export values but that should lead to an inconsistent estimator.

Another issue with zeros, according to Silva and Tenreyro (2006), is that they might appear in the dataset because of wrong use of reporting strategies. Exports are often reported in thousands and to avoid dealing with decimals rounding have to be involved. Thus, in this case trade with actual value under 500 can be reported as zero. That doesn't have to be a problem as long as those rounded numbers are distributed randomly throughout the data and also there is a similar quantity of values rounded up to counter the loss of information. These conditions are not fulfilled most of the time because number rounded down to zero concentrate mostly within small countries. Zeros can also be a missing observations that usually data provider (or reporter) wanted to include and wrongly reported as zeros. Those should be found an eliminated from the dataset or corrected as N/A (not available). Authors recommend using the Poisson Pseudo Maximum Likelihood (PPML) estimators to avoid troubles with zeros as well as with heteroskedasticity.

However empirical part of their paper shows how well the model performs containing only strictly positive input data. Their second paper Silva and Tenreyro (2011) answers question about behavior of the estimator in dataset that consists of many zeros (which is fairly common in the international trade analysis). Results are tested with "Monte Carlo" simulation method. Paper provides empirical results showing that Poisson estimator behaves well even with large number of zeros in the dataset. Moreover, it suggests Poisson as the right method of estimation in that exact situation because traditional log-OLS estimations have to deal with zero and drop the observation.[21]

In the last decade, most of the work in this field focuses more on many specific details than general idea of the equation. For example, Westerlund and Wilhemsson (2011) as many other experts also tackle the "zero trade" issue. Traditional log-linear estimation of a dataset that contains zeros will lead to an error as was mentioned in previous paragraph. They argue that simple withdrawal of problematic numbers can be done only when zeros are randomly distributed across all the data. However, panel data gathered for a gravity model estimation do not fulfill this assumption. Various countries trade only with some others and the rest are just zeros. Larger countries usually have more variety when it comes to trade partners. Therefore, problematic numbers are not distributed randomly. Westerlund and Wilhemsson (2011) showed that Poisson Pseudo Maximum Likelihood estimator is a great tool to avoid problems with zeros.

A somewhat summary of potential causes of problems when estimating an impact of a trading agreement (specifically PTA- preferential trade area) with gravity models is provided in Cardamone (2009). Author examines over 110 papers that use various forms of estimation. Results differ widely by the impact size as well as sign. She concludes that most of the papers, possibly all of them, report biased results caused mainly by following mistakes: use of a dummy for the impact of PTA (has to be carefully implemented otherwise can include the country-pair effects), no specification of the range of each PTA in the sample, understand values of trade equal to zero as missing values or violation of the exogeneity assumption of explanatory variables.

3. Methodology

3.1. Theoretical background

3.1.1. Fundamental equation for gravity model

According to Bergstrand and Egger (2013), the traditional standard empirical version of gravity equation (applied on cross-sectional data) used by many has the following structure:

$$\ln X_{ij} = \ln\beta_0 + \beta_1 \ln GDP_i + \beta_2 \ln GDP_j + \beta_3 \ln DIST_{ij} + \ln \varepsilon_{ij}$$

where X is the value of export from country i to country j, respective GDPs, DIST is a distance between two countries and epsilon is the error term.

Formula used above is of course a simple form when no additional characteristics of bilateral trade are estimated. Problem is that estimated coefficient of distance between countries A and B would probably be biased. In terms of trade the effect of distance is definitely correlated with some other trade-determining aspects that are included in the error term in this equation. Thus, the model suffers from endogeneity. In other words, the effect of distance is not constant and depends on additional measures. For example, the existence of a large market nearby a country such as Germany for the Czech Republic. Germany is a great potential trading partner because of its size and since it is worth it establishing trading routes for other countries towards Germany it is than less costly to access the Czech Republic. Which means econometricians found out that trade depends on the distance to third countries as well soon after the introduction of gravity model.

Different characteristic of a country that the effect of distance depends on is the "natural" barrier surrounding the country. Country in the middle of ocean has limited way of transportation increasing the influence of distance on trade. Furthermore, actual separation from other countries (via water, mountains etc.) is a liability for the establishment of trade routes as mentioned before.

3.1.2. Fixed and Random effects, PPML

For the purpose of this work and curiosity, estimation is done twice: once by Fixed effects, Random effects (depends on the behavior and satisfaction of necessary assumption) and once with Poisson Maximum Likelihood. If the dataset is correctly handled (no misplaced zeros etc.) and it contains at most only few zero observations results of Random effects and PPML should be similar.[6] Each estimation is set for all countries and best performing model is then applied on restricted data for the Czech Republic and Japan respectively. Restricted models can give an overall idea of country's suggestibility when it comes to trade deals. However, as mentioned before they work only with a fraction of the whole picture therefore, the results can be biased. Moreover, with no data from 2019 (year when FTA between JAP and CZE came into effect) and years after it is difficult to reject the hypothesis. Estimation using all countries provides objective result not specified for either of the countries. Comparing all three results can be helpful.

There are, by definition, several assumptions that each data and model itself should satisfy for estimates to be unbiased, efficient and consistent. R software has the ability to detect violations of desired features of data. One has to keep an eye for violations of homoskedasticity, exogeneity, different types of correlations etc. For some problems R offers a solution (such as robust standard errors in case of heteroskedasticity). In other cases, model has to be carefully re-estimated with different structure to avoid them.

Silva and Tenreyro (2006) suggest using Poisson Pseudo Likelihood Estimator following the work of McCullagh and Nelder (1989). Silva and Tenreyro (2006, page 645) claim that: „β can be estimated by solving the following set of first-order conditions:

$$\sum_{i=1}^{n}[\boldsymbol{y_i} - \mathbf{exp}(\boldsymbol{x_i}\widehat{\boldsymbol{\beta}})]\,\boldsymbol{x_i} = \mathbf{0}\text{“}$$

[6] With increasing number of zero observations RE loses variability diverging increasingly from PPML.

Results of this estimator done by Silva and Tenreyro contradict other papers with their coefficient estimates of gravity equation. They argue that GDP actually has significantly smaller effect than most papers claim. That means the ratio of trade to GDP declines with raising GDP supporting this idea by the fact that small countries are usually open more widely towards international trade.

3.2. Data

3.2.1. Data extraction

To acquire panel data for gravity model we needed to get at least 10 years of data (after discussion with my supervisor 10 is a sufficient amount of years for the purposes of this work) for as many countries as possible. Both aspects are crucial to avoid disturbances that are specific for a certain country, area or even a year. Ideally, dataset should consist of as many years as possible. But as long as the gathered data fulfill basic criteria for specific models the estimation should be sufficient. To put this in perspective an easy example is the Financial Crisis of 2007-2008. Parts of the world are still to this day dealing with the consequences but in general the crisis lasted until 2011-2012. Data extracted only from those years would probably be biased comparing to other years. Same logic holds up in case of the number of countries included in the model. When focusing only on a few countries many region-specific characteristics of international trade can appear causing the model to give us shifted results. Moreover, regional crisis usually lasts longer than crisis in the whole world. It does not have to be the case all the time but logically speaking with more countries involved there are more sources to deal with a crisis. Therefore, model for only a several countries should consist of quite more than just 10 years to add the diversity.

Export and import for years 2007-2017 where extracted from *WITS* website. *WITS* cooperates with data from *COMTRADE* that has a database of international trade for over 190 countries. Main advantage of *WITS* is the possibility to choose various all countries both as reporters and partners which speeds up the process of data extraction. Additionally, a researcher can decide what type of trade should desired data contain. In this case, “All Commodities” type is checked to generate data on all goods. However, it provides only 100 000 lines of data in Excel file at one time therefore the process had to be split in several rounds. It is interesting to examine the data to see that in many cases exports from country A to country B do not match imports of B from A. That can be caused by various aspects such as different valuation, different concept of classification or processing errors. Therefore, it would be unwise to fill missing values (in cases that for example export of A to B is reporter but import of B from A is not) with corresponding values from the other point of view. Statistical software (such as R used in this thesis) can work with unbalanced panels. Thus, if it is not the case that every second value is missing data can still be used quite well.

Clear comprehension of missing values in general is also necessary. Filling a zero in a place where a country did not report anything is a mistake that can add significant bias to the result. In terms of bilateral trade, it is sometimes difficult to decide. When uncertain about particular observation, it is helpful to examine the remaining years for the same country-pair (for example two significant trading partners should not suddenly have bilateral trade equal to zero). But in terms of GDP or population (included into the dataset later) it is clear that an existing country cannot have a zero when missing a report.

For a basic concept of a gravity model *Gross Domestic Product (GDP)* and *distance*[7] are the most common usually statistically significant explanatory variables. Extraction of *GDP* is possible for example through the *World Bank* website. Distance is provided by Mayer and Soledad (2011) via *Cepii*[8]. Additional datasets by *Cepii,* that are useful for gravity models, include dummies such as: *common border, common language, former colonies or landlocked*. All mentioned dummies are included in the dataset. Despite those mentioned before there is also *GNI per capita* and *population* both available from *World Bank.*

Dür, Baccini and Elsing (2019) formed two datasets that give information about trade agreements as well as their depth is provided on *Desta* website. First dataset contains all the agreements that are in effect around the World according to WTO (World Trade Organization). Second dataset offers additional information about all agreements mentioned in the previous one. For every agreement there are 6 different areas that can

[7] Technique of measurement by Mayer and Soledad (2011, page 4): "calculate distance between two countries based on bilateral distances between the biggest cities of those two countries, those inter-city distances being weighted by share of the city in overall country's population."
[8] Cepii = Centre d'Etudes Prospectives et d'Informations Internationales

deepen the relationship between both sides. An example is a categorical variable for FTA in the agreement (1 if there is abolishment of tariffs present in the treaty, 0 otherwise).

Merge can be done in Excel or statistical software. In my case I used functions in Excel such as: *vlookup, hlookup, sumifs* etc. Important aspect is to inspect the results. When no value corresponding to the definition that is set in the function (for example find GDP for specific country in a specific year using sumif function) is found Excel tends to write zero instead of leaving the cell blank. Simple *if* or *iferror* function are sufficient in this case.

3.2.2. Definition of available variables

The main dummy in the dataset is "treaty". In this case it equals one if there is any trade deal active between two countries for a given year. This variable is created as a general acknowledgement of existing country. Therefore, coefficient of this dummy variable cannot be defined as the effect of an FTA on trade. It is quite necessary simplification for this work. For deeper analysis a dummy called "depth" is created. In any case when dummy *treaty* is one *depth* provides additional study of existing treaties. This variable should help determine if there are any additional barriers besides tariffs that heavily affect the trade or if for example simple FTA is sufficient. As declared in the first chapter, the EU- Japan agreement goes far beyond tariffs.

Generally, agreements considering international trade aim to increase exports and imports of specific countries. The hypothesis about these two variables assumes that no matter what type of a deal countries have the effect should be positive (of course in case of statistical significance). Thus, coefficient that belongs to *treaty* can give a broad overview of the situation. As mentioned earlier in the literature review the Gold medal error is possible in this case. Explanatory variables used for estimation should be carefully chosen and in case of a problem additional dummies to correct for the mistake can be included.

Nevertheless, other dummies have potential to shift the trade as well. Colony describes the relationship of trade between countries that used to be mutual colonies one way or the other. Logic behind the null hypothesis here is that former colonized countries tend to trade more with their colonizers simply because trading roots were already established. Moreover, their languages can be similar as well as the traditions even though this should be covered within the corresponding dummies. Based on the logic behind this, for instance, United Kingdom should be trading more with India than a similar country to UK such as France. On the other side, in case that colonizer left during recent years there might still lack of trust on either side. Common language or border should have similar impact on the trade. Dataset also contains of year dummies to avoid previously mentioned problem with correlation in time (form of spurious correlation). Time dummies are a significant part of panel data estimations to avoid that. In many cases two variables can have no actual dependence but grow in time with similar tendency.

Special variable added to the dataset using R statistical software is “countrypair”. Its purpose is to single out every country pair throughout all the data to avoid Gold medal error (explained in the literature part) when estimating with Fixed or Random effect. This variable acquires a different number for every country pair starting with 1 all the way to 35558. *WITS* provides data reported from 178 countries with 243 trading partners. Obviously, not every country trades with all potential partners.

4. Empirical part

4.1. Expectation

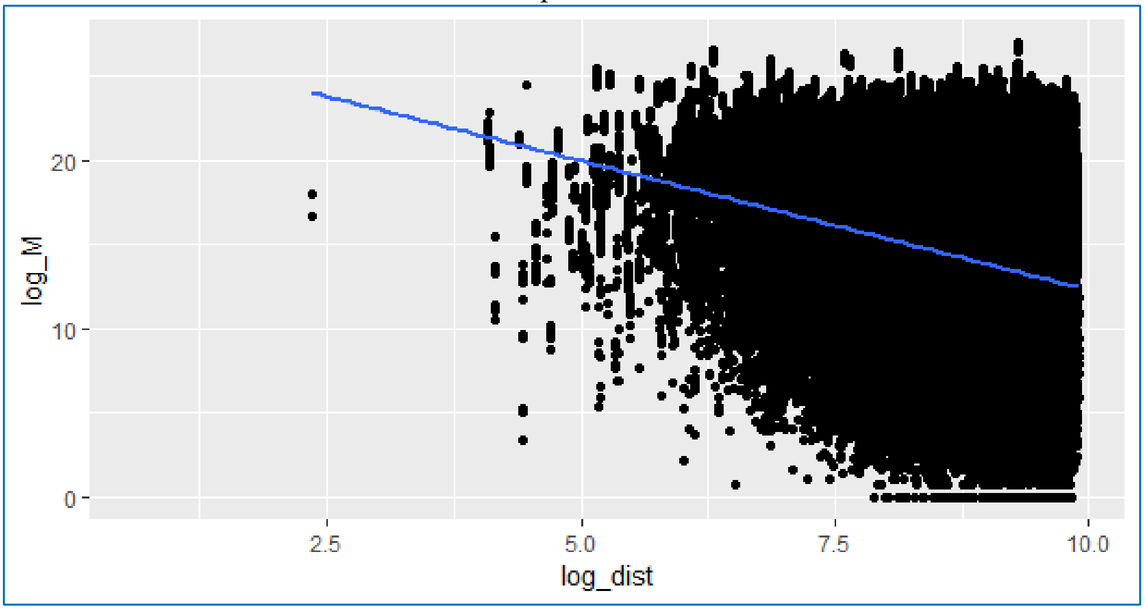
4.1.1. Early examination of data

Before this paper gets to model estimation, it is useful to set some expectations about the impact of explanatories on export and to examine the data structure. The actual values of coefficients differ based on many characteristics of the dataset. Distance tends to have a negative impact on export with a coefficient of a similar size as GDP. However, for both variables there might be a situation when these expectations are not fulfilled.

Theoretically, for example distance can have a positive effect under certain circumstances. With narrow dataset which contains only several countries (including some country A) distance could have a positive coefficient when the closest country to country A is in a military conflict with A. In fact, technically this would be an example of a miss-specified model which causes an omitted variable bias. Distances in that situation contains also the information about the ongoing war but the coefficient could be positive in that particular case. Furthermore, both coefficients of GDP in various papers had values around positive 1. Lately, researchers have showed theoretical foundations for both values being actually smaller than 1 (around 0.7-0.8). Some researchers even claim to have GDP coefficients bellow 0.5. Graphs bellow support these hypotheses.

Before actual estimation it is important to explain the logic behind my choice to apply estimations on imports instead of exports. Data containing exports and imports were gained from WITS website. After initial inspection we found out that there are 30 000 more observations among imports than exports. Thus, we chose to estimate with imports to get higher diversity of data from my two samples. In practice this change only switches reporter for partner in every observation. Otherwise, since the main goal of gravity is to study trade itself, the relationship can be studied the same way. It should not be even a problem that usually reported imports are slightly higher than exports.[9] First notion of the relationship tendency behaves according to expectation is a simple graph:

Graph no. 1



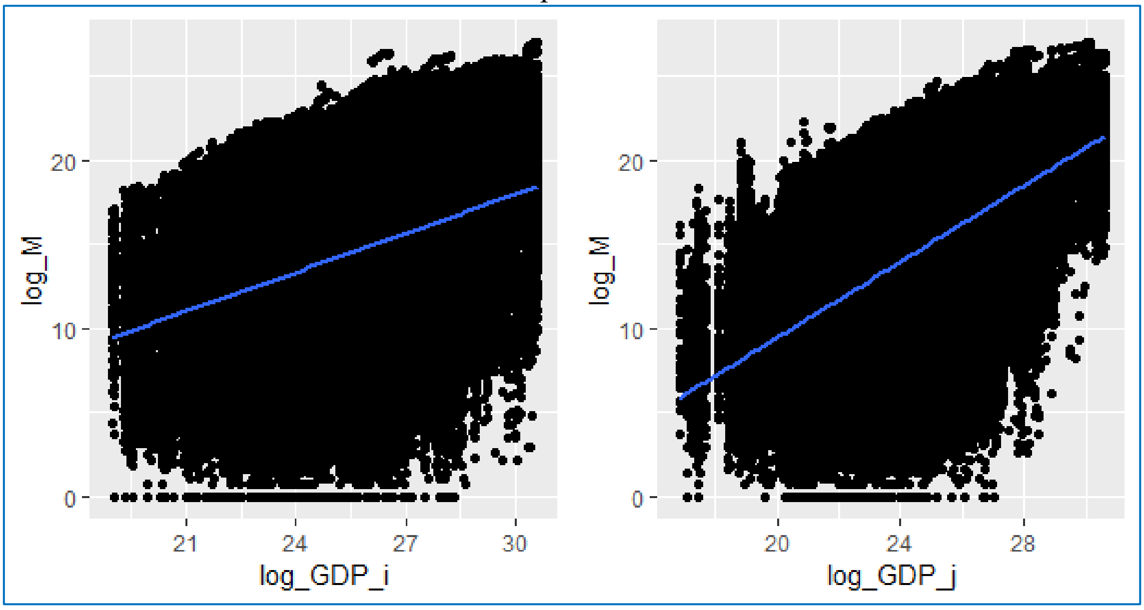
Note: horizontal line = natural logarithm of distance; vertical line = natural logarithm of import.

It cannot be taken as a proof of the relationship between distance and import, but the slope of the linear line is negative as expected. Argument can be laid on the fit of a linear line on such huge scramble of points. But linear relationship seems to be negative. About 22600 observations were found missing and thus excluded from the graph. It is vital to find the reason behind it. In this case, missing values are concentrated among smaller (usually developing) countries with missing information about their distances.

[9] Ccommon sense hints that export from A to B should be the same as import of B from A but it is usually not the case since import reporting country often includes trade barriers and etc. to the prices reported.

Next graphs show the situations in case of import depending on GDP_i and GDP_j:

Graph no. 2



Note: both graphs vertical line = natural logarithm of import; horizontal line = natural logarithms of GDPs

In both cases there is a positive slope of the linear relationship line. However, it would be wrong to claim straight away that these two variable are mutually dependent when they both might be sharing some additional characteristics. Some variable that covers contribution of time should be included into the model to clear the potential codependence.[10]

There is a linear line going through points in the picture. This gives a hint of the relationship but cannot be taken as too important factor. For the graph on the left 17000 observations were excluded, right hand side shows 34500 missing values. Concerning the fact that most of the countries are used as reporters as well as partner in the dataset this is quite an extreme difference. After inspection of these values it is clear that used dataset contains more countries in the section "Partner" than section "Reporter". Reason is simple. Some countries do not report their numbers or there is a limited access to these information. Such countries appear only on the partnering side.[11]

[10] With constantly improving technology as well as liberalization of the international trade it is only logical that exports, GDPs, population etc. increase with time.

[11] Usually developing countries or countries with difficult political situation provide limited access to its data. For countries of short existence with lack of experience in the field (former colonies or separated parts of a large country) the reporting system even within the country might not be established well. Theoretically in a situation where import and export of a country A (trading with country B) is reported and data from country B are missing it is possible to extract them from reported data of country A (import changes to export and vice versa). Unfortunately, values of exports tend to vary from imports and

4.1.2. Missing values

Some variables prepared for the model are missing quite a few observations causing whole line to be taken away when estimation comes. This is a problem of merging different datasets together. *WITS* provides exports and imports for over 190 countries but there are not as many exports as imports in the dataset. Countries might be more precise when reporting about how much is coming than how much is leaving. Which means when estimation is performed with export on left side (as a variable that applied model aims to explain) there are too many missing values. In previous paragraphs numbers of missing values of exports and imports are mentioned. According to R software there are only 22600 missing values for graph that links distance to import. Furthermore, *GDP_i* and *GDP_j* have 17000 and 34500 missing values respectively. *Cepii* provides GDPs for many countries but it does not have identical set of countries like *WITS* has.[12] Similar issue comes with distance. This leads to an outcome that it might be better to use import as the dependent variable in the model.

4.2. Estimation

Bias in results is partly prevented by additional variables created and explained in subsection "Data". There are of course many other causes of that. One of those is high collinearity between explanatory variables. Ideally there should be no linear relationship between any of explanatories. However, estimating a model with GDP, population and GNI per capita would be a perfect example of such situation. Values of estimated coefficients are highly shifted from expected positions. That is a sign of a need for deeper inspection of the model setup. GDP basically describes the size of a country in not only figurative but also literal way. There are of course some countries (such as Persian Gulf countries etc.) with unusually large GDP/size ratio but on average the larger the GDP the larger the size of a country. Population describes different characteristic of a country but works on a similar manner as GDP in terms of a size of a country. Therefore, these two variables possibly share a common trend and thus the model suffers from collinearity. To

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countries themselves can use slightly different techniques for reporting. Such data extraction would then lead into biased values potentially devaluating the whole model.

[12] Major countries are included in all datasets used in this thesis. However, some smaller developing countries might be included in dataset for GDP and missing from the dataset of bilateral trades.

be sure it is useful to compare results from a model that includes both variables and a restricted version with just one. Coefficient of a variable that belongs to both models should not be affected. Which is obviously not the case here.

4.2.1. Fixed or Random effects

Fixed and random effects are calculated to decide which method suits better to this data. Both methods are based on this basic specification to which either random or fixed effects were added:

$$\begin{aligned}\log(M_{ijt}) = \beta_0 + \beta_1 \log(dist_{ij}) + \beta_2 \log(GDP_{it}) + \beta_3 \log(GDP_{jt}) + \\ +\beta_4 treaty_{ijt} + \beta_5 contig_{ij} + \beta_6 colony_{ij} + \beta_7 landlocked_{ij} + \\ + \beta_8 com.lang.off_{ij} + \beta_9 year_t + \mu_{ijt}\end{aligned}$$

where βs are desired coefficients, *year* covers all dummies created for every single year (they are necessary in the model, but their effects are not really a concern) and μ are disturbances.

Fixed effects (R-code available in Appendix- Part 1):

- number of observations = 209343
- R-squared (overall) = 44,9%
- F- statistics: p-value = 0.000[13]

Table no.4: results from Fixed effects estimation[14]

	term	estimate	std. error	t-statistic	p.value
1	***log_GDP_i***	0.773	0.022	34.905	0.000
2	***log_GDP_j***	0.37	0.02	18.836	0.000
3	***treaty***	0.022	0.024	0.927	0.354
5	***dummy2009***	-0.13	0.014	-9.156	0.000

Note: all numbers are rounded to the third decimal place

All variables that remain fixed in time were dropped out of the model (including distance). Only one dummy describing the characteristics of the relationship (not time) is

[13] F- statistics reject null hypothesis (Pooled OLS)
[14] Table with results of all variables available in Appendix- Part 2

left in the model. Treaty differs from other dummies because some countries started in 2007 with no trade deal and ended up bargaining one through the years included in the dataset. The highest coefficients out of year dummies is included in the table as well. It seems to be according expectations that year 2009 decreased the trade the most.

Random effects (R code available in Appendix- Part 1):

- number of observations = 209343
- R-squared (overall) = 66.9%
- Adjusted R-squared (overall)= 66.9%

Table no. 5: results from Random effects estimation[15]

	term	estimate	std. error	t-statistic	p.value
1	***(Intercept)***	-27.23	0.278	-97.777	0
2	***log_dist***	-1.349	0.019	-70.783	0
3	***log_GDP_i***	1.001	0.006	163.516	0
4	***log_GDP_j***	1.152	0.006	202.838	0
5	***treaty***	0.151	0.02	7.66	0.000
6	***contig***	1.107	0.112	9.909	0.000
7	***colony***	0.937	0.122	7.674	0.000
8	***landlocked_i***	-0.654	0.036	-18.152	0.000
9	***landlocked_j***	-1.102	0.036	-30.762	0.000
10	***com_lang_off***	1.026	0.04	25.718	0.000
11	***dummy2008***	0.09	0.014	6.365	0.000
12	***dummy2009***	0.052	0.014	3.845	0.0001
16	***dummy2013***	-0.199	0.013	-15.378	0.000

Note: all numbers are rounded to the third decimal place

Now it is possible to compare both models and decide which one suits the situation better given these specific circumstances (table no.4 FE, table no. 5 RE). First obvious difference is present among the GDP coefficients. Especially GDP_j coefficient under the

[15] Table with results of all variables available in Appendix- Part 2

Fixed effects method has a suspiciously small magnitude which is highly unlikely. Also, for the purposes of this work it is vital to have variable treaty statistically significant. Moreover, R-squared under FE is smaller than RE by over 20%. Despite that being true, low R-squared does not mean one cannot use the model to analyze the effects of certain variables. But in this type of situation Random effect estimation results make more sense and provide better explanation for the whole import thus it is more useful to use it.[16]

Year dummies behave differently than one would expect under RE. 2008-2009 were official year of Financial Crisis, yet both their coefficients have positive effects. Contrary, 2013 has the highest magnitude of all year dummies and it is negative.[17]

4.2.2. Random effects results

- N (number of observations) = 209343
- R- squared (overall) = 66.9%
- Adjusted R- squared (overall) = 66.9%

Table no. 6: results from Random effect estimation with populations included[18]

	term	estimate	std. error	t-statistic	p.value
1	***(Intercept)***	-27.114	0.279	-97.213	0
2	***log_dist***	-1.357	0.019	-71.263	0
3	***log_GDP_i***	0.932	0.009	101.351	0
4	***log_GDP_j***	1.176	0.009	131.642	0
5	***log_pop_i***	0.102	0.01	10.024	0.000
6	***log_pop_j***	-0.033	0.01	-3.271	0.001
7	***treaty***	0.146	0.02	7.437	0.000
8	***contig***	1.056	0.112	9.455	0.000
9	***colony***	0.954	0.122	7.834	0.000
10	***landlocked_i***	-0.723	0.037	-19.743	0.000
11	***landlocked_j***	-1.078	0.037	-29.43	0.000

[16] However, Hausman test rejects the null hypothesis (RE) suggesting that there are explanatory variables correlated with errors under Random effects method.

[17] Financial Crisis lasted longer than those two years. Some countries still deal with the consequences. However, I would expect the results to be the other way around.

[18] Table with results of all variables available in Appendix- Part 2

	term	estimate	std. error	t-statistic	p.value
12	***com_lang_off***	1.021	0.04	25.656	0.000
13	***dummy2008***	0.09	0.014	6.333	0.000
14	***dummy2009***	0.047	0.014	3.469	0.0005
18	***dummy2013***	-0.194	0.013	-14.961	0.000

Note: all numbers are rounded to the third decimal place

Adjusted R-squared increase almost insignificantly when population were added to the model. Moreover, both coefficients of GDPs slightly changed in the second model. That hints a possible correlation between populations and GDPs. Additionally, as mentioned in the earlier subsection these numbers usually have a causal relationship. Restricted model without population variables is safer in this case.

Model estimated on the whole dataset with Random effects method gives reasonable results with expected signs (table no. 4). Distance has a statistically significant coefficient slightly below negative one. One percent increase in distance between two countries decrease trade by one percent.[19] This corresponds to theory as well as other papers. GDPs of both reporter and partner have coefficients close to 1 which aligns with expectations based on previous works. All dummy variables are statistically significant as well. The largest impact out of all dummies belongs to "*contig*". This variable equals one when the two countries examined share a border otherwise zero. According to the results when trading partners share a border with each other their mutual import increases by 183.5%.[20] Contig variable becomes one when countries are neighbors which raises import by 45%. Impact of two countries sharing a history in bilateral colonizing equals 40%. An interesting result is -25% effect of landlocked countries (country with no access to sea). The main dummy to be examined in the model is treaty. As regression shows the effect of countries sharing a trading deal is 11%. Out of dummies that represent each year there were statistically significant several of them but two of them stand out- 2007, 2008. Effects of those years were 16 and 10 percent respectively. R-squared is almost 67% indicating that a decent part of trade is explained by the model. Adjusted R-squared remains unchanged for both RE models.

[19] To be precise import to country A from country B decreases by one percent in case distance between them raises by one percent.
[20] Percentage impact of all dummies is reported as a change of particular dummy from 0 to 1 with other values holding constant.

4.2.3. PPML

All three PPML models are based on this basic specification:

$$\boldsymbol{M_{ijt} = exp[\beta_0 + \beta_1 \log(dist_{ij}) + \beta_2 \log(GDP_{it}) + \beta_3 \log(GDP_{jt}) + +\beta_4 treaty_{ijt} + \beta_5 contig_{ij} + \beta_6 colony_{ij} + \beta_7 landlocked_{ij} + + \beta_8 com.lang.off_{ij} + \beta_9 year_t] * \mu_{ijt}}$$

Poisson (R code available in Appendix- Part 1):

- number of observations = 209659
- R-squared (overal) = 59.5 %[21]

Table no. 7: results from PPML estimation with only one dummy connected to treaty[22]

	term	estimate	std. error	statistic	p.value
1	***(Intercept)***	-19.04	0.429	-44.37	0
2	***dist_log***	-0.437	0.016	-27.855	0.000
3	***log_GDP_i***	0.804	0.01	78.674	0
4	***log_GDP_j***	0.813	0.007	109.18	0
5	***treaty***	0.286	0.034	8.487	0.000
6	***contig***	0.677	0.048	13.966	0.000
7	***colony***	-0.043	0.039	-1.118	0.264
8	***landlocked_i***	-0.126	0.034	-3.654	0.0003
9	***landlocked_j***	-0.083	0.029	-2.864	0.004
10	***com_lang_off***	0.196	0.039	5.054	0.000
11	***dummy2008***	0.122	0.052	2.354	0.019

Note: all numbers are rounded to the third decimal place

Poisson estimator should give a better results in case of large amount of zero values. A simple OLS log-form method cannot deal with zeros in logarithms and those values are dropped from the sample. In case of small number of zeros simple OLS (fixed or random) should be sufficient. Additionally, on average there are about 20 000 missing values among the explanatories (in case of exports its about 50 000). According to R

[21] Number of observations is the same for all three PPML models. R-squared also stays similar since only different "types" of treaty are used.
[22] Table with results of all variables available in Appendix- Part 2

software both types of estimations used similar number of observations. Neither of the models gives an advantage in variability. The decision rests on individual preference. Based on the Literature review (for example Baldwin and Taglioni, 2006) and results we prefer PPML.

Coefficients of GDPs seem to be only slightly smaller using PPML than RE. Values around 0.8 lay inside the expected interval.[23] With one percent increase in either one of the GDPs less than one percent of import increases. The impact of distance is still negative but with smaller magnitude than expected. Coefficients that belong to dummy variables are not that simple to analyze.[24] The highest effect (of all dummies) belongs to variable *contig*- coefficient equal to 0.677. After proper calculation the actual effect is 96.8%. The estimated impact of an agreement between two countries is 33.1%. Lamprecht et al. (2016) suggests the effect to be in similar numbers. His team performed the estimation before the details of the agreement were established which means that their numbers are calculated, similarly to this first PPML model, more generally.

The only year dummy with statistical significance seems to be year 2008 surprisingly with a positive coefficient. Relatively unexpected is also dummy variable *colony* which seems to be statistically insignificant.

Poisson with treaty and depth:

- number of observations = 209659
- R-squared (overal) = 59.5%

Table no.8: results from PPML estimation with treaty and depth of a treaty[25]

	term	estimate	st. error	t-statistic	p.value
1	***(Intercept)***	-18.577	0.436	-42.574	0
2	***dist_log***	-0.45	0.015	-29.845	0.000
3	***log_GDP_i***	0.797	0.01	77.838	0
4	***log_GDP_j***	0.807	0.008	105.425	0
5	***treaty***	0.091	0.044	2.082	0.037
6	***depth_index***	0.057	0.008	7.26	0.000

[23] By expected interval is meant within the range of values from various papers mentioned in the Literature part.
[24] The actual impact in percentages is calculated via following formula: (exp(β_x) – 1)*100
[25] Table with results of all variables available in Appendix – Part 2

	term	estimate	st. error	t-statistic	p.value
7	***contig***	0.672	0.045	14.777	0.000
8	***colony***	-0.045	0.038	-1.168	0.243
9	***landlocked_i***	-0.13	0.034	-3.806	0.0001
10	***landlocked_j***	-0.095	0.028	-3.358	0.0008
11	***com_lang_off***	0.209	0.038	5.511	0.000
12	***dummy2008***	0.125	0.051	2.442	0.015

Note: all numbers are rounded to the third decimal place

Table no. 8 shows results from PPML estimation when variable *depth_index* is added. As expected, the coefficient is positive but fairly small. When examined side by side with *treaty* variable it seems like the effect is split between both of them. It is statistically significant which means that depth of a trade agreement affects the actual trade. The effect of an existence of an average treaty equals to 9.5%.

Logic behind depth is fairly complicated. It is not a simple dummy variable since it can have values from 0 to 7. However, the positive sign of its coefficient and statistical significance show that additional information about treaty is vital to calculate its true impact.

Poisson with 7 dummy variables of depth:

- number of observations = 209659
- R-squared (overall) = 61%

Table no. 9: results from PPML estimation with all 7 dummies that describe depth[26]

	term	estimate	std. error	t-statistic	p.value
1	***(Intercept)***	-18.693	0.422	-44.271	0
2	***dist_log***	-0.434	0.02	-21.479	0.000
3	***log_GDP_i***	0.797	0.01	81.981	0
4	***log_GDP_j***	0.806	0.008	106.578	0

[26] Result table with all variables available in Appendix – Part 2

	term	estimate	std. error	t-statistic	p.value
5	***full_fta***	0.271	0.056	4.825	0.000
6	***standards***	0.175	0.045	3.892	0.000
7	***investments***	-0.429	0.064	-6.738	0.000
8	***services***	0.395	0.041	9.579	0.000
9	***procurement***	-0.272	0.044	-6.232	0.000
10	***competition***	-0.128	0.031	-4.159	0.000
11	***iprs***	0.441	0.062	7.125	0.000
12	***contig***	0.684	0.046	14.817	0.000
13	***colony***	-0.02	0.04	-0.483	0.629
14	***landlocked_i***	-0.229	0.032	-7.088	0.000
15	***landlocked_j***	-0.155	0.029	-5.317	0.000
16	***com_lang_off***	0.203	0.038	5.349	0.000
17	***dummy2008***	0.128	0.051	2.536	0.011

Note: all numbers are rounded to the third decimal place

Variables in logarithmic form stay very similar throughout all three types of PPML estimation. When all depth dummies are added together their effect is 57.3%. This corresponds to Felbermayr et al. (2017) estimation of scenario no. 2 (the closest option to the actual treaty).

An interesting dummy here is *full_fta* which stands for tariff abolishment. The estimated effect by itself is 31.1%. *Investment* is a specific dummy since the treaty, according to European Commission (2018) does not interfere in this region (only promoting additional investment) because negotiations in this field have not been concluded yet. Negative impact of investment (-34.9%) supports the initial claim about export system of especially Japan.[27]

Remaining dummies that are used to describe the depth[28] of an agreement can be comprehended as the non-tariff barriers. When all these aspects are present in a treaty the impact is 84.2%. Here comes the struggle of dummies in a logarithmic model. When

[27] Increase in investment towards the Czech Republic to construct a factory to manufacture goods offshore (such as cars) decreases the value of exports. In reality, those goods are still technically produced by Japan but no longer need to be exported.

[28] Except investment

investment is included into the effect of NTBs before transferring to percentages suddenly the impact of NTBs drops to 20% (not 49.3% as simple summation would suggest). These effects are calculated with other variables holding fixed.[29]

4.2.4. Trade potential JAP- CZE

Table no. 10

	log_M	prediction	trade_potential
JPN_CZE-2007	19.991	21.808	1.817
JPN_CZE-2008	20.083	22.073	1.99
JPN_CZE-2009	19.868	21.995	2.127
JPN_CZE-2010	20.1	22.068	1.968
JPN_CZE-2011	20.264	22.205	1.941
JPN_CZE-2012	20.421	22.135	1.714
JPN_CZE-2013	20.498	21.996	1.498
JPN_CZE-2014	20.467	21.941	1.474
JPN_CZE-2015	20.343	21.776	1.433
JPN_CZE-2016	20.457	21.907	1.45
JPN_CZE-2017	20.567	21.974	1.407

Note: restricted data for bilateral trade between Japan and the Czech Republic (Japan as importer and reporter)

In previous table every line gives values for specific year with Japan as reporter (as well as importer) and the Czech Republic as partner. First column shows the actual size of import in logarithmic form provided by WITS. Second column is prediction when gravity model is estimated by PPML while being applied on specific portion of data. Restricted panel data where Japan is the only reporter with all its trading partners is the next step. When both the actual value of log-import and the predicted one were compared prediction exceeded the real value by 1.711. Thus, Japan imports from the Czech Republic

[29] It is possible that all three PPML models do not account for fixed effects (country pairs). We haven't been able to discover the potential flaw with R. There are reasons to believe that country pairs might affect the estimated coefficients. Control estimation was done in Stata. Model applied with clustered standard errors (with respect to country pair specific information) provided similar coefficients but different results for errors. Some dummy variables were no longer statistically significant.

less than model predicts for an average country. Which leads to a positive trade gap (potential).

4.2.5. Trade potential CZE- JAP

Table no. 11

	log_M	prediction	trade_potential
CZE_JPN-2007	22.072	21.765	-0.307
CZE_JPN-2008	22.275	22.028	-0.247
CZE_JPN-2009	21.914	21.952	0.038
CZE_JPN-2010	21.845	22.026	0.181
CZE_JPN-2011	21.858	22.163	0.305
CZE_JPN-2012	21.771	22.094	0.323
CZE_JPN-2013	21.67	21.953	0.283
CZE_JPN-2014	21.659	21.897	0.238
CZE_JPN-2015	21.549	21.733	0.184
CZE_JPN-2016	21.632	21.864	0.232
CZE_JPN-2017	21.781	21.931	0.15

Note: restricted data for bilateral trade between the Czech Republic and Japan (the Czech Republic as importer and reporter)

Prediction in R applied on data restricted only for the country pair- Czech Republic and Japan shows how close is the bilateral trade between these two countries to the average of the World. Predictions of imports to the Czech Republic from Japan exceed the actual values on average by 0.125.

These two results indicate that there is larger potential for additional trade of goods from the Czech Republic to Japan (trade creation). Imports to the Czech Republic seem to be fairly close to prediction so no significant gap there. It might also be the case that this model is not well- specified, and some relevant variables are missing. In that case, results would underpredict the actual situation. That would mean that treaty between Japan and the Czech Republic won't increase the overall trade of either one of the countries by much. A high possibility is that some part of their import will be shifted from different countries to Japan (or the Czech Republic) so called trade diversion. Overall no significant increase is of imports in general is predicted.

Conclusion

The objective of this thesis was to examine the newly introduced trade agreement between the European Union and Japan via gravity model. The main ambition was to quantify the effect of such treaty on bilateral trade between the Czech Republic and Japan, ideally even separate the effects of tariffs abolishment and non-tariff barriers reduction. The model was estimated using Fixed and Random effects as well as Poisson Pseudo Maximum Likelihood method to decide which models performs better and generates the most reasonable results. All types included similar number of observations with no clear advantage in variability of the model. Results differ for some variables but overall do not generate completely contradicting findings to theory or other papers. The choice is left on personal preferences based on reliable papers. I chose PPML as my main method due to its variability when difficulties among data arise (also Fixed and Random effect were not satisfactory). It has to be considered that my estimation was performed with imports (not exports as most of the papers do). Slight alteration of the results is possible but overall the impact stays the same.

According to the first PPML model in this thesis the effect of an active treaty between two countries is 33% increase of import. This is a general effect that an average treaty in the World has on the trade with no specification on the depth of the treaty. Coherence with results published by Lamprecht et al. (2016) is satisfactory because their results were estimated before the finalization of the aspects of the treaty.

The third PPML model was designed to estimate the effect of a treaty with a major depth (such as EU- Japan or EU- Korea). The overall impact of such treaty is estimated to be 57.3%. This result correspond with findings published by Felbermayr et al. (2017). For the purposes of this thesis it is necessary to separate the impact of tariff abolishment (FTA) from the rest (non-tariff barriers). The increase of imports caused only by the FTA establishment is 31%. On the other hand, treaty defined only to deal with non-tariff barriers (without investment and FTA) is estimated to increase imports by 84.2%. These results support the assumptions that significant reduction of non-tariff barriers should have a larger impact on bilateral trade than tariff abolishment. Last part of the treaty is investment. Negotiations about investment being a part of the cooperation have not been finished yet. Nevertheless, a treaty defined only to focus on investment is expected to decrease the bilateral trade by 35%. Larger investment attracts offshore production (common strategy for Japan). Japanese companies often constructed factories in the destination countries. Such goods no longer need to be exported.

Results from the second PPML were used on restricted dataset for bilateral trade of the Czech Republic and Japan. In case of the Czech Republic, predictions exceeded the actual values which means that the Czech Republic imports from Japan a little less than is expected by the general model- small positive trade potential. On the other hand, Japan imports from the Czech Republic less than is predicted which generates large positive trade potential. However, it is not expected for the agreement to cause large trade creation. Most experts expect to see the trade being shifted from countries not included in the treaty (as mentioned earlier especially China, Korea, Taiwan). Trade potentials suggest that a small emergence of "new trade" is possible with Japan as a receiver and the Czech Republic as an exporter.

This thesis proposes many options for deeper analysis. Proper dataset on the size and structure of non-tariff barriers of all countries would increase the reliability and consistency of the results. It is also recommended to apply different methods of estimations. Additional years of data as well as additional explanatory variables could increase the variability of the dataset and potentially explain large portion of the trade.

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Appendix

Part 1

Fixed effect R code:

$$plm\big(formula = \log(M) \sim \log(dist) + \log(GDP_i) + \log\big(GDP_j\big) + \text{treaty} + \text{contig} + \text{colony} + \text{landlocked}_\text{i} + \text{landlocked}_\text{j} + com.lang.off + dummy2007 + dummy2008 + dummy2009 + dummy2010 + dummy2011 + dummy2012 + dummy2013 + dummy2014 + dummy2015 + dummy2016,\ \ data = data,\ model = \text{within},\ \ \text{index} = \text{c}(\text{countrypair}, year)\big)$$

Random effect R code:

$plm(formula = \log(M) \sim \log(dist) + \log(GDP_i) + \log(GDP_j) + \log(pop_i) + \log(pop_j) + \mathrm{treaty} + \mathrm{contig} + \mathrm{colony} + \mathrm{landlocked_i} + \mathrm{landlocked_j} + com.lang.off + dummy2007 + dummy2008 + dummy2009 + dummy2010 + dummy2011 + dummy2012 + dummy2013 + dummy2014 + dummy2015 + dummy2016,\ data = data,\ model = random,\ index = c(countrypair,\ year);$

PPML R code:

$glm(formula = M \sim \log(dist) + \log(GDP_i) + \log(GDP_j) + \mathrm{treaty} + \mathrm{contig} + \mathrm{colony} + \mathrm{landlocked_i} + \mathrm{landlocked_j} + com.lang.off + dummy2007 + dummy2008 + dummy2009 + dummy2010 + dummy2011 + dummy2012 + dummy2013 + dummy2014 + dummy2015 + dummy2016,\ family = quasipoisson(link = log), data = data, index = \text{"}countrypair\text{"});$

Part 2

Fixed effects

- number of observations = 209343
- R-squared (overall) = 44,9%

Table no. 4 all variables- Fixed effects

	term	estimate	std. error	t-statistic	p.value
1	***log_GDP_i***	0.773	0.022	34.905	0.000
2	***log_GDP_j***	0.37	0.02	18.836	0.000
3	***treaty***	0.022	0.024	0.927	0.354
4	***dummy2008***	-0.031	0.014	-2.163	0.031
5	***dummy2009***	-0.13	0.014	-9.156	0.000
6	***dummy2010***	-0.124	0.013	-9.333	0.000
7	***dummy2011***	-0.074	0.013	-5.694	0.000
8	***dummy2012***	-0.05	0.013	-3.776	0.000
9	***dummy2013***	-0.072	0.013	-5.517	0.000
10	***dummy2014***	-0.055	0.013	-4.144	0.000
11	***dummy2015***	-0.035	0.013	-2.711	0.007
12	***dummy2016***	-0.028	0.013	-2.142	0.032

Random effects:

- number of observations = 209343
- R-squared (overall) = 66.9%
- Adjusted R-squared (overall)= 66.9%

Table no. 5 all variables- Random effects

	term	estimate	std. error	t-statistic	p.value
1	***(Intercept)***	-27.23	0.278	-97.777	0
2	***log_dist***	-1.349	0.019	-70.783	0
3	***log_GDP_i***	1.001	0.006	163.516	0
4	***log_GDP_j***	1.152	0.006	202.838	0
5	***treaty***	0.151	0.02	7.66	0.000
6	***contig***	1.107	0.112	9.909	0.000
7	***colony***	0.937	0.122	7.674	0.000
8	***landlocked_i***	-0.654	0.036	-18.152	0.000
9	***landlocked_j***	-1.102	0.036	-30.762	0.000
10	***com_lang_off***	1.026	0.04	25.718	0.000
11	***dummy2008***	0.09	0.014	6.365	0.000
12	***dummy2009***	0.052	0.014	3.845	0.0001
13	***dummy2010***	-0.044	0.013	-3.352	0.0008
14	***dummy2011***	-0.119	0.013	-9.084	0.000
15	***dummy2012***	-0.125	0.013	-9.529	0.000
16	***dummy2013***	-0.199	0.013	-15.378	0.000
17	***dummy2014***	-0.21	0.013	-16.154	0.000
18	***dummy2015***	-0.106	0.013	-8.142	0.000
19	***dummy2016***	-0.106	0.013	-8.151	0.000

Random effects:

- N (number of observations) = 209343
- R- squared (overall) = 66.9%
- Adjusted R- squared (overall) = 66.9%

Table no. 6 all variables- Random effects including populations

	term	estimate	std. error	t-statistic	p.value
1	***(Intercept)***	-27.114	0.279	-97.213	0
2	***log_dist***	-1.357	0.019	-71.263	0
3	***log_GDP_i***	0.932	0.009	101.351	0
4	***log_GDP_j***	1.176	0.009	131.642	0
5	***log_pop_i***	0.102	0.01	10.024	0.000
6	***log_pop_j***	-0.033	0.01	-3.271	0.001
7	***treaty***	0.146	0.02	7.437	0.000
8	***contig***	1.056	0.112	9.455	0.000
9	***colony***	0.954	0.122	7.834	0.000
10	***landlocked_i***	-0.723	0.037	-19.743	0.000
11	***landlocked_j***	-1.078	0.037	-29.43	0.000
12	***com_lang_off***	1.021	0.04	25.656	0.000
13	***dummy2008***	0.09	0.014	6.333	0.000
14	***dummy2009***	0.047	0.014	3.469	0.0005
15	***dummy2010***	-0.046	0.013	-3.496	0.0005
16	***dummy2011***	-0.116	0.013	-8.833	0.000
17	***dummy2012***	-0.122	0.013	-9.277	0.000
18	***dummy2013***	-0.194	0.013	-14.961	0.000
19	***dummy2014***	-0.205	0.013	-15.68	0.000
20	***dummy2015***	-0.105	0.013	-8.116	0.000
21	***dummy2016***	-0.106	0.013	-8.161	0.000

PPML with treaty:

- number of observations = 209659
- R-squared (overall) = 59.5%

Table no. 7 all variables- PPML with treaty

	term	estimate	std. error	statistic	p.value
1	***(Intercept)***	-19.04	0.429	-44.37	0

	term	estimate	std. error	statistic	p.value
2	***dist_log***	-0.437	0.016	-27.855	0.000
3	***log_GDP_i***	0.804	0.01	78.674	0
4	***log_GDP_j***	0.813	0.007	109.18	0
5	***treaty***	0.286	0.034	8.487	0.000
6	***contig***	0.677	0.048	13.966	0.000
7	***colony***	-0.043	0.039	-1.118	0.264
8	***landlocked_i***	-0.126	0.034	-3.654	0.0003
9	***landlocked_j***	-0.083	0.029	-2.864	0.004
10	***com_lang_off***	0.196	0.039	5.054	0.000
11	***dummy2008***	0.122	0.052	2.354	0.019
12	***dummy2009***	-0.011	0.052	-0.216	0.829
13	***dummy2010***	0.041	0.053	0.77	0.442
14	***dummy2011***	0.041	0.051	0.807	0.419
15	***dummy2012***	0.04	0.052	0.776	0.438
16	***dummy2013***	-0.01	0.052	-0.184	0.854
17	***dummy2014***	-0.044	0.052	-0.829	0.407
18	***dummy2015***	-0.044	0.057	-0.779	0.436
19	***dummy2016***	-0.076	0.053	-1.452	0.147

PPML with treaty and depth:

- number of observations = 209659
- R-squared (overall) = 59.5%

Table no. 8 all variables- PPML with treaty and depth

	term	estimate	st. error	t-statistic	p.value
1	***(Intercept)***	-18.577	0.436	-42.574	0
2	***dist_log***	-0.45	0.015	-29.845	0.000
3	***log_GDP_i***	0.797	0.01	77.838	0
4	***log_GDP_j***	0.807	0.008	105.425	0

	term	estimate	st. error	t-statistic	p.value
5	***treaty***	0.091	0.044	2.082	0.037
6	***depth_index***	0.057	0.008	7.26	0.000
7	***contig***	0.672	0.045	14.777	0.000
8	***colony***	-0.045	0.038	-1.168	0.243
9	***landlocked_i***	-0.13	0.034	-3.806	0.0001
10	***landlocked_j***	-0.095	0.028	-3.358	0.0008
11	***com_lang_off***	0.209	0.038	5.511	0.000
12	***dummy2008***	0.125	0.051	2.442	0.015
13	***dummy2009***	-0.006	0.052	-0.123	0.902
14	***dummy2010***	0.046	0.052	0.887	0.375
15	***dummy2011***	0.048	0.05	0.958	0.338
16	***dummy2012***	0.046	0.051	0.908	0.364
17	***dummy2013***	-0.003	0.051	-0.05	0.96
18	***dummy2014***	-0.038	0.052	-0.723	0.47
19	***dummy2015***	-0.039	0.056	-0.696	0.486
20	***dummy2016***	-0.079	0.052	-1.514	0.13

PPML with all 7 dummy variables describing the size of a treaty:

- number of observations = 209659
- R-squared (overall) = 61%

Table no. 9 all variables- PPML with 7 dummies describing the depth of a treaty

	term	estimate	std. error	t-statistic	p.value
1	***(Intercept)***	-18.693	0.422	-44.271	0
2	***dist_log***	-0.434	0.02	-21.479	0.000
3	***log_GDP_i***	0.797	0.01	81.981	0
4	***log_GDP_j***	0.806	0.008	106.578	0
5	***full_fta***	0.271	0.056	4.825	0.000
6	***standards***	0.175	0.045	3.892	0.000

	term	estimate	std. error	t-statistic	p.value
7	***investments***	-0.429	0.064	-6.738	0.000
8	***services***	0.395	0.041	9.579	0.000
9	***procurement***	-0.272	0.044	-6.232	0.000
10	***competition***	-0.128	0.031	-4.159	0.000
11	***iprs***	0.441	0.062	7.125	0.000
12	***contig***	0.684	0.046	14.817	0.000
13	***colony***	-0.02	0.04	-0.483	0.629
14	***landlocked_i***	-0.229	0.032	-7.088	0.000
15	***landlocked_j***	-0.155	0.029	-5.317	0.000
16	***com_lang_off***	0.203	0.038	5.349	0.000
17	***dummy2008***	0.128	0.051	2.536	0.011
18	***dummy2009***	-0.006	0.051	-0.118	0.906
19	***dummy2010***	0.047	0.051	0.907	0.364
20	***dummy2011***	0.049	0.05	0.986	0.324
21	***dummy2012***	0.047	0.05	0.934	0.35
22	***dummy2013***	-0.003	0.051	-0.051	0.96
23	***dummy2014***	-0.038	0.051	-0.73	0.465
24	***dummy2015***	-0.042	0.055	-0.769	0.442
25	***dummy2016***	-0.081	0.051	-1.593	0.111