Effects of WTO accession on Vietnam’s trade:
The gravity model approach

Anh Thi Le

Master of Economic Theory and Econometrics
Department of Economics
University of Oslo

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Preface

Working on this thesis has been both interesting and challenging, and I would not be able to finish it without help and encouragement from several people.

First and foremost, I would like to thank my supervisor Karen Helene Ulltveit-Moe for her help and guidance. I would also like to thank Professor João Santos Silva for his valuable comments on the STATA commands I have used. In addition, I would like to thank friends and family for the proofreading.

Flowers and candies must be given to my partner in crime, Hero Ezat, who was always by my side during the past five years and supported me through hard times.

Last, but far from least, I am grateful to my fiancé for his endless support and encouragement through my frustrations and disappointments.

I bear sole responsibility for any errors or inaccuracies in this thesis.

Anh Thi Le
May 2017
Abstract

The aim of this thesis is to assess the possible effects of Vietnam’s accession to the World Trade Organization on its bilateral trade. In order to accomplish this, I employed an augmented gravity equation and used a panel dataset covering trade between Vietnam and 71 trading partners over the period 1990–2015.

My findings indicated that becoming WTO’s 150th member has boosted Vietnam’s trade, both regarding exports and imports. By contrast, a membership to WTO of a Vietnam’s partner country does not have a significant impact on Vietnam’s trade.
6.4.3 Endogeneity ........................................................................... 31
6.4.4 Year Fixed Effects ................................................................. 32
6.4.5 Zero observations ................................................................. 32
6.4.6 Summing up the econometric approach ............................... 33
6.5 Empirical results .................................................................... 33
  6.5.1 Main estimation results ......................................................... 33
6.6 Discussion of the results ......................................................... 37
  6.6.1 Hausman test .................................................................... 37
  6.6.2 WTO accession’s impact on Vietnam’s bilateral trade ........ 38
  6.6.3 Impacts of other explanatory variables ............................... 39

7 Conclusion .................................................................................. 40

8 Literature .................................................................................... 41

A Vietnam’s trade with its 71 partner countries ............................. 44

B Bilateral trade between Vietnam and most important trading partners in 1990–2014 ......................................................... 45

C Derivation of Anderson and Van wincoop (2003) CES demand function ........................................................................ 48

D Random effects estimation - results ........................................... 50

E List of countries in the dataset ................................................... 51

F List of Vietnam’s Regional Trade Agreements ............................ 52
List of Tables

1 Increase in trade .............................................. 6
2 List of variables ............................................ 26
3 Summary statistics ......................................... 27
4 Correlation matrix on selected variables ............... 27
5 Variance Inflation Factor (VIF) of independent variables ................. 30
6 Wooldridge test for autocorrelation in panel data ................... 30
7 Wooldridge test for autocorrelation in panel data ................... 30
8 Breusch-Pagan / Cook-Weisberg test for heteroskedasticity ........ 31
9 Regression results ........................................... 35
10 (Cont) Regression results .................................. 36
11 Hausman test ................................................ 37
12 Hausman test ................................................ 37

List of Figures

1 Percentage change in exports from Vietnam to most important trading partners in 1990–2014 ............... 10
2 Percentage change in imports to Vietnam from most important trading partners in 1990–2014 ............... 11
1 Introduction

In the year 1986, the political and economic reforms under Doi Moi were launched. The ultimate objective of the Doi Moi policy is to transform Vietnam from a closed and centrally planned economy to an open and market-oriented one. Since then, the reforms have been very successful in enhancing growth, attracting foreign investments and fostering exports. As a result, it has transformed Vietnam from one of the world’s poorest countries to a lower middle-income country.

After 11 years of negotiations, Vietnam became the 150th member of the World Trade Organization (WTO) in January 2007. The accession to WTO is supposed to speed up trade liberalization and improve market access for the new member country’s exports, which should result in increased trade. Hence, it is necessary to assess the effect of accession on all aspects of the economy. The question of whether membership in the WTO has a positive or negative impact on the level of trade remains a subject for debate. The purpose of this thesis is to provide an empirical study of WTO accession on Vietnam’s trade, complementary to the existing ones which assess the impact of WTO accession on Vietnam - one of WTO’s most recent members. To do this, I use a gravity model of trade based on a panel data covering bilateral trade between Vietnam and 71 trading partners over 26 years, 1990–2015. The gravity model in international trade is one of the most successful empirical models in economics, and has been widely used by international trade researchers as it accurately predicts trade flows between countries for many goods and services over a period. The model’s comparative advantage is its ability to use real data to provide a convenient testing bed on which to assess the trade impacts of different trade policies.

There exist many researchers (e.g. Rose 2004a; Subramanian & Wei 2007) who have studied the possible impacts of WTO accession on the foreign trade and economic outcomes of member countries by employing an augmented gravity model. However, the studies have various results.

A study by Rose (2004a) finds surprisingly that the WTO and its predecessor the General Agreement on Tariffs and Trade (GATT) had, on average, no significant effect on foreign trade of its members, though the Generalized System of Preferences (GSP) seems to have a strong effect. In two extensive papers Rose (2004b, 2005), the author is unable to find convincing evidence that the GATT/WTO membership is associated with more bilateral trade policies, and finds little evidence that the membership in the multilateral trade system has a significant dampening effect on trade volatility.

Another study by Subramanian & Wei (2007) uses the import data rather than the total
trade data and distinguishes between developed and developing countries. They find little impact of WTO membership on developing countries’ imports, while for imports of WTO developed country members, imports were over five times higher than for non-members. Interestingly, the authors examine whether the new WTO members have increased their trade more than older members, and report statistically significant and positive results.

The structure of this thesis is as follows: Chapter 2 provides a literature review of the accession to WTO. Chapter 3 gives an overview of Vietnam’s foreign trade both before and after the accession to WTO. Chapter 4 presents an introduction to the gravity model. Here I summarize the literature on the gravity model from the gravity intuition to the theoretical model. I focus in particular on the theoretical model introduced by Anderson and Van Wincoop (2003). In chapter 5, my attention turns to the estimation of gravity model using econometric methods. I discuss estimation and testing the model by Ordinary Least Squares (OLS), with and without fixed effects. Furthermore, I introduce a new estimator that accounts for potential problems with OLS, namely the Poison Pseudo Maximum Likelihood Estimator (PPML). In chapter 6, I apply the theoretical model and discuss the results of my estimations. Chapter 7 summarizes and concludes my thesis.
2 Effects of WTO accession: A literature review

The World Trade Organization (WTO) is an intergovernmental organization which regulates international trade. The WTO came into being on 1 January 1995, replacing the General Agreement on Tariffs and Trade (GATT), which commenced in 1948. The organization deals with regulation of trade between participating countries by providing a framework for negotiating trade agreements, and its primary function is to ensure that trade flows as smoothly, predictably, and freely as possible.

The question of whether GATT/WTO has expanded trade, and then influenced economic outcomes of country members remains a subject for debate. The first class of relevant literature is by Andrew Rose. Rose (2004, 2015) studies the impact of WTO membership on trade policy. In his studies, GATT/WTO membership is econometrically captured by using binary dummy variables, rather than directly identifying the changes in trade policies resulting from a WTO membership.

His initial work (2004a) uses a standard ‘gravity’ model of bilateral trade covers over 50 years of data and 175 countries, but he finds no statistically significant effect of GATT/WTO membership on the value of bilateral trade flows. Although Rose (2004a) tries to provide some possible explanations for the results, he still regards his finding as an interesting mystery.

After his initial work (2004a), he realizes that if GATT/WTO membership has little effect on trade policy, it might also have little effect on trade flows, and so his second work (2004b) begins. Rose (2004b) uses almost 70 measures of trade policy and liberalization to see if GATT/WTO membership is associated with more liberal trade policy. Unfortunately, he was not able to find convincing evidence that membership in the multilateral trade system is associated with more liberal trade policy.

Finally, Rose (2005) compares GATT/WTO with two other significant international institutions that are in the business of liberalizing trade, the International Monetary Fund (IMF) and the Organization for Economic Cooperation and Development (OECD). Despite an extensive search and many robustness checks, he has not been able to find strong indications that GATT/WTO makes trade flows more stable and predictable. Recently, several papers have attempted to solve this puzzle.

A subsequent study by Subramanian and Wei (2007) examines the asymmetries in trade flows across countries and sectors. Contrary to Rose’s findings, they find that GATT/WTO has had a positive impact on trade. GATT/WTO has served to increase world imports substantially, possibly by about 120% of world trade (about US$ 8 trillion
in 2000 alone). The impact has, however, been uneven. This unevenness, in many ways, is consistent with theoretical models of GATT/WTO. According to Subramanian and Wei (2007), the theory suggests that the impact of a country’s membership in GATT/WTO depends on what the country does with its membership, with whom it negotiates and which products the negotiation covers.

This paper diverges from Rose’s studies in two ways. Firstly, this paper distinguishes between the effects of GATT/WTO membership on industrial members and those in developing countries. Secondly, unlike Rose, they adopt a version of the gravity model suggested by Anderson and van Wincoop (2003) that includes country fixed effects in the regression to control for country-specific characteristics.

Their results suggest that there has been little impact of WTO membership on developing countries’ imports. However, the positive impact of WTO membership on an industrial country’s imports meant that developing countries’ exports also increased significantly. Their estimates of developing country exports to industrial countries were at least one and a half times greater because of GATT/WTO. Despite not liberalizing themselves sufficiently, they enjoyed at least some of the benefits of an industrial country’s liberalization. GATT/WTO effectively promotes trade in less protected sectors, but not in agriculture and textile sectors. Besides, the authors also examine whether the new WTO members have increased their trade more than older members and report statistically significant and positive results.

A study by Tomz et al. (2005) considers the measurement of GATT/WTO membership. Using the same data and methods as Rose (2004a), they augment their specification with measures for nonmember participation. The dependent variable is the logarithm of average imports and exports in a given year for each dyad as Rose (2004a). In addition to indicators for whether one or both countries in the dyad participated in GATT, the independent variables in their analysis also include the logarithm of the products of GDP and GDP per capita, the logarithm of the distance between country centroids, a set of political control variables and other controls.

They show that the adverse finding from Rose (2004a) arises from a tendency to overlook the role of nonmember participants, common in most work of international agreements. According to Tomz et al., GATT created rights and obligations not only for contracting parties but also for countries and territories that did not appear on the formal membership roster. By treating colonies, de facto members, and provisional members as if they were outside the organization, previous research has understated the institutional research and economic effects of GATT.
Once they account for all participants, they show that participation in GATT either as a formal member or as a nonmember participant, substantially increased trade. Since grouping nonmember participants and nonparticipants causes a substantial downward bias in the estimated effect of GATT membership, they have to correct this misspecification. When this is corrected, they find that the agreement proved beneficial for both formal members and nonmember participants, which traded at higher levels than countries outside GATT.

3 Vietnam’s foreign trade overview

3.1 From "Doi Moi" reforms to WTO accession

Deep changes have taken place in Vietnam since the end of the Vietnam War in 1975. After April 1975, Vietnam became a unified country under control of North Vietnam’s communist government, with Hanoi as its new capital. With this change of government, Vietnam faced many challenges, and economic reform was the highest priority of the new communist government. Since its reunification, Vietnam has adopted bold measures to enhance economic rehabilitation and development. Before 1980, Vietnam remained under a centrally planned economy where the role of the state is very different from the role of the state in a market economy. All resources are allocated by government decision and administrative mechanisms, rather than the interaction between consumers and businesses.

Facing a sluggish growth, some microeconomic reforms were implemented such as the contract system in rural areas, and the "three plans" for state-owned enterprises (SOEs) in 1981. These microeconomic reforms enhanced voluntary and decentralized interactions between individual agents and created new incentives for producers in raising outputs. Despite a large success in generating growth in production, Vietnam experienced hyperinflation in the first half of the 1980s.

Following the economic experiences in the 1970s and early 1980s, a new economic reform was implemented called Doi Moi (Renovation) in 1986. One of the most important components of the Doi Moi reform is to pursue an open economy and actively participate in the globalization process. With the implementation of this reform, Vietnam experienced unprecedented growth in both productivity and structural changes.

Firstly, Vietnam has successfully managed to achieve a macroeconomic stability. The hyperinflation of more than 600 percent in 1986 was reduced to 30 percent in 1990, and
was only 0.6 percent in 2015 (Diez 2016).

Secondly, Vietnam has enjoyed strong economic growth since the economic policies of Doi Moi. According to the World Bank, Vietnam’s GDP per capita growth since 1990 has been among the fastest in the world, averaging 6.4 percent a year in the 2000s. Vietnam’s economy continued to strengthen in 2015, with an estimated GDP growth rate of 6.7 percent. Overall, the living conditions of the Vietnamese have improved considerably as a consequence of the high growth rates.

Lastly, impressive economic growth has been significantly attributed to improvement in Vietnam’s export performance. Interestingly, Vietnam experienced not only impressive export growth after the Doi Moi reforms, but import growth also increased significantly. As can be seen in Table 1, export sector has expanded by 205 percent while import has increased by over 20 percent during the period 1986–1990.

<table>
<thead>
<tr>
<th>Table 1: Increase in trade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Million US dollar</td>
</tr>
<tr>
<td>Value of export</td>
</tr>
<tr>
<td>Value of import</td>
</tr>
</tbody>
</table>

Source: Author’s calculation based on the Vietnamese international merchandise trade (1986–2005), GSO.

To sum up, the economic and political reforms under Doi Moi have spurred rapid economic growth and development and transformed Vietnam from one of the world’s poorest countries to a lower middle-income country (World Bank). In the years following Vietnam’s accession to ASEAN Free Trade Area in 1995, it signed many free trade agreements and as a result experienced its first major growth in international trade since the war.

More recently, Vietnam has made an impressive progress when it became the 150th member of WTO in January 2007 after 11 years of negotiations. The accession to the WTO is supposed to speed up trade liberalization and improve market access for the new member country’s exports, which should result in increased trade.

3.2 Vietnam’s accession to WTO: a long process of reform

Vietnam joined the World Trade Organization (WTO) in January 2007. The accession to WTO is supposed to speed up trade liberalization and improve market access for the new member country’s exports, which should result in increased trade (Cling et al. 2009).

To qualify the participation conditions, Vietnam has cut down thousands of tariff lines (around 10 600 tariff lines) in line with the framework committed to the WTO. For example, the average tariff rate was cut to 17.4 percent on the eve of accession compared with 23.3 percent ten years earlier, and then the rate was cut to 13.4 percent in accordance with WTO commitments. The effective rate of protection
fell even more quickly, as it more than halved from 59.54 percent in 1997 to 26.23 percent in 2001 (Table 6 in Athukorala, 2006). The ERP fell even further from 20.43 percent in 2006 to 16.93 percent at the time of WTO accession (Appendix 2 in Vo and Nguyen 2009). After the U.S. trade embargo on Vietnam was lifted in February 1994, Vietnam has signed many trade agreements that have boosted its process economic growth and international integration.

In 1995, Vietnam became a member of ASEAN (Association of South-East Asian Nations). By becoming a full member of ASEAN, Vietnam immediately became a member of Asian Free Trade Area (AFTA). To move towards a fully functioning AFTA, each country member needs to implement the so-called Common Effective Preferential Tariff Scheme (CEPT). The schedule for the program implementation depended on each country member’s conditions: the six original ASEAN members including Brunei, Indonesia, Malaysia, Philippines, Singapore, Thailand needed to complete CEPT by 2003, Laos and Myanmar by 2008, and Cambodia by 2010 (Pham 2000). The tariff reduction schedule for Vietnam started in 2001, and the country completed the CEPT in 2006.

Vietnam has signed some Bilateral Trade Agreements (BTA) such as Vietnam-Switzerland BTA in 1992, Vietnam-Japan Economic Partnership Agreement in 2009, etc.. Regarding the bilateral trade agreements, the most important BTA is perhaps the Vietnam and United States BTA (VUBTA) which came into force in December 2001. The trade agreement consisted of four parts: market access, trade in services, intellectual property rights, and investment.

- Some of the steps Vietnam needed to take in order to open its markets are to guarantee most-favored-nation (MFN) treatment to the U.S. goods and treat imports the same as domestically produced products (also known as “national treatment”).
- Vietnam has agreed to allow U.S. companies and individuals to invest in markets in a wide range of service sectors, including accounting, advertising, banking, computer, distribution, education, insurance, legal and telecommunications.
- Vietnam has committed to provide protections and enforcement for US intellectual property rights.
- Vietnam has agreed to open its services market to US companies.
- Vietnam has agreed to create fair and transparent rules and regulations to US investors.

Fulfilling the two governments’ commitment, the BTA is considered as a stepping stone towards Vietnam’s accession to the WTO as the Vietnam-US BTA already contains many fundamental principles of the WTO, which cover MFN treatment, national treatment, transparency, lowering trade barriers through negotiations, promoting fair competition, and encourage development and economic reform (WTO.org).

\(^1\)The ERP is a measure of the total effect of the entire tariff structure on the value added per unit of output in each industry when both intermediate and final goods are imported.

\(^2\)ASEAN is a regional organization comprising ten South-East Asian states: Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam

\(^3\)The CEPT is an agreement between ten ASEAN member countries to reduce regional import tariffs and eliminate non-tariff barriers to trade. The CEPT only applies to goods originating within the ASEAN.

\(^4\)For more information about the Vietnam-US BTA, see Mark E. Manyin (2001)
3.3 Vietnam’s international trade

In this section, I will try to statistically assess the impact of WTO accession on Vietnam’s bilateral trade. Figure 1 and 2 illustrate trade between Vietnam and its most important trading partners from 1990 to 2014. More specifically, figure 1 presents the percentage change in exports from Vietnam to its most important trading partners whereas figure 2 presents the percentage change in imports to Vietnam from the same trading partners. A more detailed data is provided in Appendix B.

Before I give a presentation of Vietnam’s foreign trade after its accession to WTO, it is essential to start with an overview of Vietnam’s trade prior the event. Firstly, the bilateral trade between Vietnam and EU-countries varies a lot from year to year, for instance, for some reasons export growth rate in 1992 was about 100 percent, but it was negative in 1993. The growth rate rose again the next period, and remained relatively high until it dropped again from 90 percent in 1997 to about 29 percent in 1998. Imports from EU to Vietnam also vary between years, for instance, import growth rate was negative in 1992 but increased by 79.5 percent the next period. The import growth rate remained positive until it dropped from 15.8 percent in 1997 to 6.7 percent in 1998. The significant drop in both exports to the EU and imports from the EU may be the results of the Asian financial crisis in the 1997–1998 period.

Secondly, the accession to ASEAN in 1995 has a significant impact on the bilateral trade between Vietnam and ASEAN. Export growth rate increased significantly from 1995 to 1996 while the growth rate in import decreased from 44.7 percent to 28 percent in the same period. If compared these growth rates in a longer horizon, for instance, between 1995 to 2000 export growth rate increased by about 157.37 percent and import growth rate increased by about 95.98 percent in the same period. As mentioned in section 3.2, when Vietnam became a member of ASEAN it immediately became a member of AFTA. When the tariff reductions occurred in 2001 under the CEPT/AFTA, trade between Vietnam ad ASEAN members changed. On the one hand, export growth rate to ASEAN countries was negative in 2002, but it increased by 21.3 percent a year after. On the other hand, import growth rate was positive both in 2002 and the years later.

Thirdly, significant changes occurred as a result of the United States trade embargo on Vietnam which was lifted in 1994 and, most importantly, the Bilateral Trade Agreement between Vietnam and the United States in 2001. When the Vietnam - U.S. BTA took effect, export growth rate increased rapidly from 45 percent in 2001 to over 100 percent in 2002. The impressive growth rate in exports from Vietnam to the U.S. compared to other main trading partners making the U.S. Vietnam’s major export destination. The growth rate in imports from the US to Vietnam varies, somehow, more than exports. For instance, import growth rate was almost the same in the period 2001–2002, and grew rapidly in 2003, an increased by 149 percent. It suddenly dropped in 2004 and even further in 2005.

Fourthly, the bilateral trade between Vietnam and Japan increased significantly as a result of the

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5I wished to extend the period up to 2015 but unfortunately, the data for this year was not available or not published yet on the General Statistics Office of Vietnam. Since the primary purpose of this section is to give an insight of Vietnam’s foreign trade with its main trading partners both before and after its accession to WTO in 2007, it is enough to have data up to 2014.

6Exports from Vietnam to ASEAN in 1995 was 1017.6 mill US$ and 2619.0 mill US$ in 2000. An increase by \( \frac{2619.0 - 1017.6}{1017.6} \times 100 = 157.37 \) percent. Imports from ASEAN countries to Vietnam in 1995 and 2000 were 2270.1 and 4449.0, respectively. An increase by \( \frac{4449.0 - 2270.1}{2270.1} \times 100 = 95.98 \) percent.

7The export growth rate to the US in 1994 was an outlier (about 94800 percent), and hence to see the percentage change the years after I chose to drop this observation from the graph.
ASEAN-Japan Comprehensive Economic Partnership (CEP) proposed by Japan in 2002. For instance, the export growth rate increased from minus 3 percent in 2002 to 19 percent a year after.

Lastly, China has always been an important trading partner to Vietnam and the ASEAN-China FTA which began in 2003 has helped to boost its trade relation to China. For example, the growth rate in exports was 24 percent in 2003, and doubled in 2004 while import growth rate increased more than 100 percent in 2004.

The impact of WTO accession on Vietnam’s foreign trade can be easily seen from the figures below. In the year of the accession, in 2007, exports from Vietnam to its main trading partners were relatively high. The impressive value of exports from Vietnam to the United States confirms that the U.S. is Vietnam’s major export destination that I mentioned earlier. Interestingly, in 2007, imports from EU to Vietnam increased by over 64 percent while imports from the US to Vietnam increased by about 72 percent. However, imports to Vietnam from Japan experienced a rate smaller than the others, only 31.6 and, surprisingly, imports from ASEAN - member countries faced a decrease in growth rate, from 34.5 percent in 2006 to 26.8 percent in the accession year.

Figures below also provide information on the growth rate of the total merchandise exports and imports of Vietnam in the period 1990–2014. The export growth rate increased from 22 percent in 2007 to 29 percent in 2008. According to Pham (2011), the increase in export growth was less due more to the enhanced market access under the WTO framework than to other factors such as a surge in the world commodity prices. Unlike export growth rate, the Vietnamese import growth rate decreased from 39.8 percent to 28.6 percent in the same period.

It is worth noticing that, in 2009, total export growth rate decreased from 29 percent (in 2008) to 8.9 percent and total import growth rate decreased even further from 28 percent (in 2008) to 13 percent. It is likely to be a result of the 2007 financial crisis (Pham 2011). The growth rate of exports from Vietnam to the EU, ASEAN, United States also faced a reduction by 13.7 percent, 15.2 percent and 4 percent, respectively. The most reduction in export growth rate among the most important trading partners was Japan with a reduction in growth rate to 25.2 percent. Interestingly, exports from Vietnam to China did not experience a negative growth rate as the others, but an increase in rate by 11.4 percent. The growth rate in imports to Vietnam in 2009 from trading partners also decreased. For instance, the import growth rate from EU to Vietnam decreased to 4.3 percent, from ASEAN-member countries the rate decreased to 15.9 percent, from Japan the rate reduced to 17 percent, and from China the rate fell to 3.5 percent. An exception is imports from the US to Vietnam, the growth rate was still positive, but decreased from 55.6 percent in 2008 to 2.4 percent in 2009. This is also likely to be a result of the 2007 financial crisis.

From 2010 to 2014, both export growth rate and import growth rate remain positive and relatively high. The export growth rate seemed, however, to have a decreasing trend and so did the import growth rate. By looking at the total merchandise exports, the growth rate decreased from 34.2 percent in 2011 to 15.3 percent a year after and dropped further to 13.8 percent in 2014. The growth rate on imports declined from 25.8 percent in 2011 to 6.6 in 2012. In 2013, the rate somehow increased to 16 percent, but then decreased to 12 percent.

\[8\] Except for import growth rate: from EU in 2014, from AESAN in 2012 and from Japan in 2013.
The question of whether the accession to WTO has an impact on Vietnam’s foreign trade is quite difficult to answer. First of all, the negotiation took 11 years started from 31 January 1995 (WTO.org). In the mean time, Vietnam became a member of ASEAN and numbers of free trade agreements were established since then. These free trade agreements may have an impact on the increase in Vietnam’s foreign trade. Second, WTO membership seemed to have a positive impact on both exports and imports until 2009 when Vietnam faced negative growth rates on both exports and imports, mainly due to the 2007 financial crisis. Hence, such financial crisis may create disturbances when assessing the real impact of WTO accession on Vietnam’s foreign trade.

**Figure 1**: Percentage change in exports from Vietnam to most important trading partners in 1990–2014

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9 Application of WTO membership was received on 4 January 1995 and an accession working party established on 31 January 1995. For more information on the Vietnam’s accession to WTO, see WTO.org.
Figure 2: Percentage change in imports to Vietnam from most important trading partners in 1990–2014
4 The Gravity Model of International Trade

4.1 The traditional gravity equation

The gravity model in international trade is one of the most successful empirical models in economics, and has been widely used by international trade researchers as it accurately predicts trade flows between countries for many goods and services over a period.

Nobel laureate Jan Tinbergen (1962) was the one to introduce the gravity model to examine international trade flows. It is based on the Newton’s universal laws of gravitation to describe the patterns of bilateral aggregate trade flows between two countries A and B as proportional to the product of countries size (in gross domestic products) and inversely proportional to the distance between them. The simplest form of gravity model in international trade is expressed as follows:

$$X_{ij} = \alpha_0 Y_i^{\alpha_1} Y_j^{\alpha_2} D_{ij}^{-\alpha_3}$$  \hspace{1cm} (4.1.1)

where $\alpha_0, \alpha_1, \alpha_2, \alpha_3$ are unknown parameters.

The gravity model is quite simple, as it connects bilateral trade (exports or imports) from country i to country j, denoted by $X_{ij}$, with the following explanatory variables: $Y_i$ and $Y_j$ are the gross domestic products of country i and country j, respectively, $D_{ij}$ is the geographical distance between country i and country j.

The model assumes that there is a positive relationship between the bilateral trade flows and the size of a trading partner. A country tends to trade more with a larger partner, holding all other factors constant. The distance between partners is assumed to be negatively linked to the bilateral trade flows. The greater the distance, the bigger the resistance to trade.

4.1.1 Problems with the traditional gravity model

Although the popularity amongst economists since 1960s, the traditional gravity model specification got a lot of difficulties and received considerable criticism once more advanced concepts from trade literature were introduced.

One of the problems with the basic model arises when we consider the impact on trade between countries i and j of a change in trade costs between countries i and k. Suppose countries i and k enter into a preferential trade agreement that lowers tariffs on their respective goods. Basic economic theory suggests that such a change may have an impact on trade of country j, even though it is not part of this agreement. Trade creation and trade diversion are the familiar concepts of such effects. However, the traditional gravity model does not account for this issue at all.

Another problem related to the traditional model arises if we consider equal decreases in trade costs across all routes, including domestic trade (goods that a country sells within the country). An example of such problems could be a fall in the price of oil, which lowers transport costs everywhere, including within countries. In the traditional model, this move would result in proportional increases in trade across all bilateral routes, including domestic trade. It is worth to keep in mind that despite the change in trade costs, relative prices have not changed at all. In the absence of a change in relative prices, we
would expect consumption patterns to remain constant for a given amount of total production (GDP). This is a second instance in which the traditional gravity model makes predictions that are at odds with standard economic theory.

4.2 The theoretical foundations for the gravity equation

While the traditional gravity model has long been criticized for lack of theoretical underpinnings, many studies attempt to fill this theoretical gap, for instance, Anderson (1979), Bergstrand (1985) and Bergstrand (1989, 1990) and, more recently, a paper by Head and Mayer (2014).

4.2.1 The theoretical models

Anderson (1979) provides a theoretical basis for gravity models where goods are differentiated by country of origin (the so-called Armington assumption) and where consumers have constant elasticity of substitution (CES) preferences defined over all the differentiated products. This means that, whatever the price, a country will consume at least some of every good from every country. All goods are traded, all countries trade and, in equilibrium, national income is the sum of home and foreign demand for the unique good that each country produces. This, in turn, implies that larger countries will import and export more than smaller countries. According to Anderson, trade costs are modeled as 'iceberg' costs, that is, only a fraction of the good shipped arrives destination, the rest is melted in transit. If imports are measured at the CIF (Cost, Insurance, and Freight) value, transport costs reduce trade flows.

The gravity equation is derived from the properties of expenditure systems and is an alternative method of doing cross-section budget studies. However, the use of this study is limited in the sense that the structure of traded-goods preference of the countries, trade tax structures and transport cost structures of the countries are very similar.

Jeffrey Bergstrand is the second author to provide a theoretical foundation for the gravity model. Bergstrand (1985) uses CES preferences over the Armington assumption, like Anderson, to derive a reduced-form equation for a bilateral trade involving price indices. To test his assumptions of product differentiation, he uses GDP deflators to approximate these price indices. The CES preferences were also nested with two different elasticities, one CES between domestic and importable goods and one CES among importables. This way of specification allows the CES between domestic and importable goods and that among importables to differ (Bergstrand 1985). His empirical estimates support the assumption that goods are not perfect substitutes and that imports are closer substitutes for each other than for domestic goods.10

In Bergstrand’s later work (1989, 1990), he develops a relationship between trade theory and bilateral trade, and includes the supply side of the economy explicitly (cited in van Bergeijk & Brakman 2010, page 8). Besides, he highlights the (complicated) price terms, which are absent in Anderson’s (1979) derivation. The income of destination countries enters the equation because of the demand side, while the income of exporting countries enters the equation because it reflects the supply capacity of the exporting

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10Bergstrand finds that the elasticity of substitution among importables exceeds unity whereas the elasticity of substitution between domestic and imported goods is below unity.
countries. Bergstrand introduces proxies for multilateral price terms for importers and exporters, showing empirically their importance in explaining bilateral trade between countries.

4.2.2 The general formulation

The general formulation of gravity model can be written as in Head & Mayer (2014), and has the following multiplicative form:

\[ X_{ij} = G S_i M_j \phi_{ij} \]  

(4.2.1)

where \( X_{ij} \) is bilateral exports from country \( i \) to country \( j \). \( S_i \) represents "capabilities" of exporter \( i \) as a supplier to all destinations and \( M_j \) captures all characteristics of the importer market \( j \). Bilateral accessibility of importer \( j \) to exporter \( i \) is captured by \( \phi_{ij} \) with \( \phi_{ij} \in (0, 1) \) and it combines all the concept of frictions in trade. This includes both natural trade costs such as distance and geographical placement, and politically motivated trade costs such as borders, tariffs, and non-tariff barriers. Lastly, \( G \) is a gravitational constant which is held constant in the cross-section, but it is allowed to vary over time if the above equation was estimated using panel data analysis.

Equation (4.2.1) has two important features. The first important feature is that each term in the equation enters multiplicatively which is similar to the gravity equation in physics. The second, and most important feature in the equation above is that all third - country effects must be mediated via the multilateral terms \( S_i \) and \( M_j \). By imposing a small set of additional conditions, Head & Mayer (2014) express the exporter and importer terms in equation (4.2.1), \( S_i \) and \( M_j \), as functions of observables:

\[ X_{ij} = Y_i \frac{X_j}{\Omega_j} \phi_{ij} \]  

(4.2.2)

where \( S_i = \frac{Y_i}{\Omega_i} \) and \( M_j = \frac{X_j}{\Phi_j} \). Equation (4.2.2) is called the structural gravity equation. Here, country \( i \)'s value of production, \( Y_i = \sum_j X_{ij} \), is defined as the sum of its exports to all countries whereas the value of country \( j \)'s expenditure, \( X_j = \sum_i X_{ji} \), is defined as the sum of its imports from all source countries.

The multilateral resistance terms, \( \Omega_i \) and \( \Phi_j \), are defined as:

\[ \Phi_j = \sum_l \frac{\phi_{jl} Y_l}{\Omega_l} \quad \text{and} \quad \Omega_i = \sum_l \frac{\phi_{il} X_l}{\Phi_l} \]  

(4.2.3)

The multilateral resistance terms (MRTs) defined above capture all the frictions in trade for all trading partners between two countries, \( i \) and \( j \), i.e., all \( l \neq i, j \). Any frictions such as bilateral trade agreement between two countries, say \( i \) and \( l \), will have an impact on country \( i \)'s trade with country \( j \). A bilateral trade agreement will, in general, reduce the trade costs between \( i \) and \( l \). Hence, \( i \)'s imports from \( j \) and exports to \( j \) will reduce towards \( l \).

Despite the fact that each term enters multiplicatively in equation (4.2.1) which is an analogy with gravity equation in physics, it does not necessarily reflect any features of the economic theory. Also, this type of gravity model is difficult for estimation purposes. Hence, a more elaborate theoretical framework is needed. A presentation of a general theoretical framework from Anderson and Van Wincoop (2003) will be presented in the next section with its limitations.

\[ ^{11} \text{In principle, } X_{ij} \text{ also represents bilateral imports from country } j \text{ to country } i \]
4.3 Anderson and Van Wincoop (2003)

Anderson (1979) presents a theoretical foundation for the gravity model by assuming constant elasticity of substitution (CES) preferences and goods that are differentiated by country of origin. His work provides a sound microeconomic foundation. However, the applied literature has only paid serious attention to the theoretical model developed by Anderson and van Wincoop (2003).

Their proposal was inspired by an article of McCallum in 1995 called National Borders Matter: Canada-U.S. Regional Trade Patterns who studies the importance of border effects. In short, McCallum (1995) finds that the US-Canada border led to trade between provinces in Canada is 22 (2,200%) times larger than trade between Canadian provinces and the US states, holding other determinants of trade fixed. Obstfeld and Rogoff (2000) pose this result as one of their six puzzles of open economy macro-economics.

To solve the border puzzle, Anderson & van Wincoop (2003) develop a new theoretical framework of the gravity equation that includes a theoretical specification for the multilateral resistance term. Using the same database, they claim that there are two factors contribute to making McCallum’s ratio of inter-provincial to province-state trade so large. The first one is because that McCallum (1995)’s equation suffered from the omission of variables since he did not include a measure of the multilateral resistance terms. The second one is due to the relatively small size of the Canadian economy which was not taken into account. The theoretical gravity equation developed by Anderson and van Wincoop (2003) is provided below together with their main assumptions and limitations of the model.

4.3.1 Assumptions

There are two main assumptions in the work of Anderson and van Wincoop (2003):

- First, they assume that all goods are differentiated by place of origin. As mentioned in the previous section, this is the so-called Armington assumption. This assumption stems from Armington (1969) who assumes that products of different countries competing in the same market are imperfect substitutes. Following the work of Deardorff (1998), they assume that each region is specialized in the production of only one good and the supply of each good is fixed.

- Second, they assume that consumers have identical and homothetic preferences. Thus, a constant elasticity of substitution (CES) utility function is applied.

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12 Obstenfeld & Rogoff (2000) refer to this puzzle as the home bias in trade puzzle. The other five puzzles are: the Feldstein - Horioka puzzle, the home bias in equity portfolios puzzle, the international consumption correlations puzzle, the purchasing-power-parity puzzle and the exchange - rate disconnect puzzle.

13 Consumers with identical and homothetic preferences means that they have the same preferences and as their incomes increase, their consumptions also increase proportionally, i.e., the income elasticity of demand of each good is 1.
4.3.2 Derivation of Anderson and van Wincoop (2003) gravity model

The CES utility function of consumers in region j is given by:

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

(4.3.1)

subject to the budget constraint

\[ \sum_{i=1}^{N} p_{ij} c_{ij} = Y_j \]  

(4.3.2)

The elasticity of substitution between goods is given by \( \sigma \), \( N \) is the number of countries and \( c_{ij} \) is consumption of good i by region j consumers. \( \beta_i \) is a positive distribution parameter which can be thought as an inverse measure of quality\(^{14}\). \( Y_j \) is the nominal income of region j residents and \( p_{ij} \) is the price of region i goods for region j consumers. Prices differ between regions due to trade costs that are not directly observable, and therefore, it is appropriate to identify these costs. Let \( p_i \) denote the exporter supply price, net of trade costs, and let \( \tau_{ij} \) be the trade cost factor between i and j\(^{15}\). Formally, the price of i goods in j can be written as \( p_{ij} = p_i \tau_{ij} \) where \( \tau_{ij} = 1 + t_{ij} \). The nominal value of exports from i to j (j's payments to i) is \( X_{ij} = p_{ij} c_{ij} = p_i \tau_{ij} c_{ij} \). Total income of region i is therefore given by \( Y_i = \sum_{j=1}^{N} X_{ij} \). This can be thought as a market clearing condition.

Maximizing equation (4.3.1) subject to the budget constraint (4.3.2) with respect to \( c_{ij} \), the nominal demand for region i goods by region j consumers is given by (for full derivation, see Appendix C):

\[ X_{ij} = \left[ \frac{\beta_i p_i \tau_{ij}}{P_j} \right]^{\left(1-\sigma\right)} Y_j \]  

(4.3.3)

where \( P_j \) is the consumer price index of j, given by

\[ P_j = \left[ \left( \sum_{i=1}^{N} (\beta_i p_i \tau_{ij}) \right)^{\sigma} \right]^{\frac{1}{\sigma}} \]  

(4.3.4)

Anderson and van Wincoop (2003) refer to this price index as multilateral trade resistance as it depends positively on trade barriers with all trading partners. Inserting equation (4.3.3) into the market clearing condition implies:

\[ Y_i = \sum_{j=1}^{N} X_{ij} = \sum_{j=1}^{N} \left( \frac{\beta_i p_i \tau_{ij}}{P_j} \right)^{\left(1-\sigma\right)} Y_j, \quad \forall i. \]  

(4.3.5)

\(^{14}\)Head and Mayer (2014) use \( A_i = 1/\beta_i \) in their estimation method. They prefer to use this specified method because it allows them to think of \( A_i \) as the attractiveness of country i’s product.

\(^{15}\)This way of specifying the trade costs is slightly different from the specification in Anderson and van Wincoop (2003). They assume that trade costs are borne by the exporter and for each good shipped from i to j the exporter incurs export costs equal to \( t_{ij} - 1 \) of country i goods. The exporter passes on these trade costs on the importer. Either way of specifying the trade costs, the implications are the same. I decide to use the iceberg analogy as it is commonly used in the literature.
Solving further for \((\beta_i p_i)^{1-\sigma}\) we get

\[
(\beta_i p_i)^{1-\sigma} = \frac{Y_i}{\sum_{j=1}^{N}(\frac{\tau_{ij}}{P_j})^{1-\sigma} Y_j} \tag{4.3.6}
\]

Define the nominal world GDP as \(Y^w = \sum_{j=1}^{N} Y_j\) and multiplying the right-hand sight of equation (4.3.6) by \((\frac{1}{Y^w})(\frac{1}{Y^w})^{-1}\), that is

\[
(\beta_i p_i)^{1-\sigma} = \frac{Y_i}{\sum_{j=1}^{N}(\frac{\tau_{ij}}{P_j})^{1-\sigma} Y_j} \left(\frac{1}{Y^w}\right) \left(\frac{1}{Y^w}\right)^{-1}
= \frac{Y_i}{Y^w} \left\{ \frac{1}{\sum(\frac{\tau_{ij}}{P_j})^{1-\sigma} Y_j/Y^w} \right\} \tag{4.3.7}
\]

Inserting this back to the nominal demand equation (4.3.3) we get

\[
X_{ij} = (\frac{\tau_{ij}}{P_j})^{1-\sigma} \frac{Y_i Y_j}{Y^w} \left\{ \sum(\frac{\tau_{ij}}{P_j})^{1-\sigma} \frac{Y_j}{Y^w} \right\}^{-1} \tag{4.3.8}
\]

Rearranging equation (4.3.8) yields the Anderson and van Wincoop (2003) gravity equation:

\[
X_{ij} = \frac{Y_i Y_j}{Y^w} (\frac{\tau_{ij}}{P_i P_j})^{1-\sigma} \tag{4.3.9}
\]

where \(P_i^{1-\sigma}\) and \(P_j^{1-\sigma}\) are the multilateral resistance terms. More specifically, they called the first one the outward multilateral resistance and it captures the fact that exports from country \(i\) to country \(j\) depend on trade costs across all possible export markets. The second is called inward multilateral resistance and it captures the dependence of imports into country \(i\) from country \(j\) on trade costs across all possible suppliers.

The multilateral resistance terms, \(P_i^{1-\sigma}\) and \(P_j^{1-\sigma}\) are defined as:

\[
P_i^{1-\sigma} = \sum_{j=1}^{N}(\frac{\tau_{ij}}{P_j})^{1-\sigma} \frac{Y_j}{Y^w} \tag{4.3.10}
\]

\[
P_j^{1-\sigma} = \sum_{i=1}^{N}(\frac{\tau_{ij}}{P_i})^{1-\sigma} \frac{Y_i}{Y^w} \tag{4.3.11}
\]

Roughly interpreted, the multilateral resistance terms (MRTs) mean that if two countries surrounded by other large trading economies, say Belgium and the Netherlands bordered by France and Germany respectively as well as by each other, will trade less among themselves than if they were surrounded by

\[16\]I follow this tip of calculation by Theie (2014)

\[17\]This is found by inserting equation (4.3.7) back to the consumer price index (4.3.4). After doing some algebraic manipulation, the result is in equation (4.3.11).
oceans (such as Australia and New Zealand) or by vast stretches of deserts and mountains (such as the Kyrgyz Republic and Kazakhstan).

Besides, since the trade cost term in equation (4.3.3) is not directly observable, Anderson and van Wincoop develop their estimation by using the following proxy for trade costs:

\[ \tau_{ij} = e^{\gamma b_{ij} d_{ij}} \]  

(4.3.12)

The unobservable trade cost, \( \tau_{ij} \), is defined as a log-linear function of unobservables: bilateral distance between country \( i \) and country \( j \), \( d_{ij} \), and a dummy variable on whether there is an international border between them, \( b_{ij} \).

4.3.3 Limitations of the Anderson and van Wincoop model

Despite the popularity of the model developed by Anderson and van Wincoop (2003), the model has its limitations. One of the problems is the assumption that each region is specialized in the production of only one good. According to them, with this assumption, they suppress the fact that resistance to trade does differ among goods and saying that something is to be learned from this disaggregation.

Another problem of the model is the difficulty of the estimation. Although the gravity equation provided by Anderson and van Wincoop, equation (4.3.9), looks simple it is difficult to estimate. By looking at the MRTs equations, (4.3.10) and (4.3.11), it is easy to see that the MRTs depend both on trade costs and the MRTs themselves, which are part of the estimation. This causes a circular dependency in the estimation of equation (4.3.9). Anderson and van Wincoop solve this problem by assuming that bilateral trade costs are symmetric, i.e \( \tau_{ij} = \tau_{ji} \). Bergstrand et al. (2007) provide evidence that, in reality, trade cost are not bilaterally symmetric. Using bilateral tariff data from the Global Trade Analysis Project (GTAP) in 67 countries in 2001, they find that only 42 percent of the bilateral tariff rates are symmetric while 58 percent are not. They conclude that the asymmetry can be as high as 150 percent.

As an estimation method, Anderson and van Wincoop propose to use non-linear least square estimation (NLS). To obtain MRTs, they use the observables in their model such as distances, borders. However, this estimation method creates various difficulties. Firstly, deciding an appropriate non-linear function is not an easy task. Secondly, it is often cumbersome to estimate non-linear specifications and analyze the properties of the resulting estimators. Lastly, estimation results from an NLS method may not be easily interpreted (Kuan 2004, page 177).

A simpler way to control for the MRTs is to include a proxy for these indexes called "remoteness variable." The remoteness is calculated as follow:

\[ REM_i = \sum_j \frac{dist_{ij}}{GDP_j/GDP_w} \]  

(4.3.13)

where the numerator is distance among two countries, and the denominator is the share between each country’s GDP in the rest of the world’s GDP. Anderson and van Wincoop (2003) include this variable in their regression and compare the previous results with a regression including the remoteness variable. They conclude that adding a remoteness variable does not change anything and it is in discordance with
theory. The reason is that it is simply a function of distance and it does not capture other trade barriers to trade.

5 Estimating the Gravity Model - Methodology

5.1 Estimation by Ordinary Least Squares

OLS estimation is the best fit used to show the connection between trade and GDP, or between trade and distance as it minimizes the sum of squared errors. The OLS estimator chooses the regression coefficients so that the estimated regression line is as close as possible to the observed data. The OLS equation in its log-linear form has the following formula:

\[ \ln X_{ij} = \ln G + \ln S_i + \ln M_j + \ln \phi_{ij} + \ln \epsilon_{ij} \]

Under certain assumptions as to the error terms, \( \epsilon_{ij} \), OLS gives parameter estimates that are not only intuitively appealing, but have useful statistical properties that enable us to conduct hypothesis tests and draw inferences. Three necessary and sufficient conditions that OLS estimates of the gravity model will be statistically useful:

- The errors must have mean zero and be uncorrelated with each of the explanatory variables (the orthogonality assumption).
- The errors must be independently drawn from a normal distribution with a given (fixed) variance (the homoskedasticity assumption).
- None of the explanatory variables is a linear combination of other explanatory variables (the full rank assumption).

If all three conditions hold, then OLS estimates are consistent, unbiased and efficient with the class of linear models. By consistent, I mean that the spread of the OLS coefficient estimates around the true parameter approaches zero as the sample size increases. Unbiased estimates say that the OLS coefficient estimates on repeated samples are centered around the true parameter even though they are based on a sample rather than the full population. Efficient estimates mean that there are no other estimators within the class that produce lower variance than the OLS coefficient estimates.

However, the homoskedasticity assumption is very strong and may not hold. Let \( u_{ij} \) denotes errors from the gravity model where \( i \) labels origins (say Vietnam), and \( d \) labels destinations (say country \( j \)) and OLS assumes that \( u_{ij} \) is independent of \( u_{ji} \). For instance, country \( i \)'s exports to \( j \) are independent of imports to \( i \) from \( j \). This assumption may not hold because \( i \) may produce intermediate inputs and these inputs are used in the production of \( j \)'s products. Hence, if the gravity error terms are dependent, OLS estimates of the gravity model parameters are inefficient, but consistent and unbiased. The reason for this is because according to the classical OLS assumptions dependence between errors induces inefficiency, but does not constitute a threat to consistency and unbiasedness.

Another problem when gravity model is log-linearized is the presence of zero-observations in trade data. According to Silva and Tenreyro (2011), in the presence of zero valued observations and due to logarithm
transformation of the gravity equation, OLS (both truncated and censored\[15\]) are inconsistent and have very large bias which do not vanish as the sample size increase. I review in later section that Poisson Pseudo - Maximum Likelihood Estimation is a better method than OLS in the presence of zero observation bias and heteroscedasticity (Silva & Tenreyro 2006).

5.1.1 Fixed effects model

One way to control for the multilateral resistance terms that are omitted in the traditional gravity model is the use of fixed effects estimation. This approach does not require the assumption of symmetrical trade costs. It assumes that the unobserved components in the regression are constant over time. By creating a dummy variable for every exporter and importer included in the estimation, all country specific effects are taken into account. Formally, by taking logs of equation (4.3.9), we get:

\[
\ln X_{ij} = -\ln Y^w + \ln Y_i + \ln Y_j + (1 - \sigma)\left[\ln \tau_{ij} - \ln P_i - \ln P_j\right] + \ln \epsilon_{ij}
\]

Grouping terms together for exporters and importers allow us to get:

\[
\ln X_{ij} = C + F_i + F_j + (1 - \sigma)\ln \tau_{ij} + \ln \epsilon_{ij}
\]

\[C = -\ln Y^w\]

\[F_i = \ln Y_i - (1 - \sigma)\ln P_i\]

\[F_j = \ln Y_j - (1 - \sigma)\ln P_j\]

Equation (5.1.2) is a standard gravity equation used for fixed effects estimation with exporter fixed effects \((F_i)\) and importer fixed effects \((F_j)\), defined by equations (5.1.4) and (5.1.5). Fixed effects mean dummy variables equal to unity each time a particular exporter or importer appears in the dataset. The coefficients on these dummy variables should reflect the multilateral resistance terms of each country. Finally, \(C\) defined by equation (5.1.3) is simply a regression constant. In terms of theory, it is equal to the world GDP. For estimation purposes, it is captured as a coefficient multiplied by a constant term since it is constant across all exporters and importers.

Estimating gravity models with fixed effects is convenient, and recommended by major empirical trading economist as all we need to do is to create the dummies since fixed effects are simply dummy variables. Then we need to add them as explanatory variables to the model. Assuming all three core assumptions of OLS are satisfied, OLS remains a consistent, unbiased and efficient estimator.

However, this way of estimating gravity models does introduce a significant restriction on the model due

\[18\] Without going into details, censored and truncated regression models handle specific kinds of missing data problems. In censored regression, the dependent variable \((Y)\) is censored when we observe the explanatory variables \((X)\) for all observations, but we only know the true value of \(Y\) for a restricted range of observations. A truncated regression model arises when we only observe \(X\) for observations where \(Y\) would not be censored. This is a special case of a sample selection problem.
to the third assumption: variables that vary only in the same dimension as the fixed effects cannot be included in the model, because they would be perfectly collinear with the fixed effects. This means that we are unable to separately identify the impact of a variable such as an importer’s (exporter’s) GDP, which is constant across all exporters (importers).

According to Shepherd (2012), one way of dealing with this problem is to identify the effect of variables that vary bilaterally in fixed effects gravity models. That is to take variables that vary by exporters or importers and transform them artificially into a variable that varies bilaterally. Such variables can be included without difficulty, however, a consequence of transforming variables in this way is that the model results become harder to interpret. For instance, multiplying those variables together, the result is a variable that is unique to each country pair and therefore varies across importers for each exporter and exporters for each importer. Unfortunately, we cannot distinguish the impact of changes in importer policies from that of exporter policies, which is potentially an important question.

5.1.2 Random effects model

An alternative to fixed effects estimation that still accounts for unobserved heterogeneity, but allows the inclusion of variables that would be collinear with the fixed effects is the random effects model. Unlike the fixed effects model, the variation across entities in the random effects model is assumed to be random and uncorrelated with the predictor or independent variables included in the model. An advantage of random effects model is that we can include time invariant variables, such as distance and shared border, etc.. In the fixed effects model, such variables are absorbed by the intercept.

In the context of the theoretical gravity model, the random effects model requires us to assume that the distribution of the unobserved heterogeneous component of the regression is distributed as a random variable with given mean and variance. It means that some specific factors in a country affect trade but are not related to GDP, distance or other factors included as regressors. Unlike random effects, fixed effects allow for this type of correlation. If there are enough evidence to suspect that the correlation is zero, the random effects model should be employed. The reason is that random effects will provide more efficient estimators in this case than fixed effects model. In contrast, if we are not sure whether or not the correlation is zero, fixed effects should be applied. To decide whether to use fixed effects or random effects, a Hausman test can be used where the null hypothesis is that the preferred model is random effects. I will come back to this test in the empirical results section.

5.1.3 Dealing with Endogeneity

We need to pay particular attention to the problem of endogeneity because it often arises in gravity models when estimating the impact of trade policies. Regional trade agreements (RTAs) is a typical example because they are unlikely to be purely exogenous: Countries are likely to form RTAs with partners with which they already trade a lot (following the "natural trading partners hypothesis"). This is the so-called reverse causality problem. The RTA dummy on the right-hand side of the gravity equation will be correlated with the error term because unobserved characteristics of some country-pairs explain why they

\[ \text{If an independent variable in an equation is an exact linear combination of the other independent variables; then we say the model suffers from perfect collinearity.} \]
trade a lot and at the same time make it more likely that they would form an RTA. Hence, endogeneity of an explanatory variable violates the first OLS assumption (the orthogonality assumption).

As a result, researchers have to be very cautious when interpreting the results of gravity models with policy variables: the estimated parameters could be severely biased due to endogeneity, if they are left uncorrected (Shepherd 2012).

According to Shepherd (2012), one way of dealing with the problem of endogeneity is to create an instrumental variable - a variable that is correlated with the potentially endogenous variable but not with trade through any other mechanism. If we are able to do so, then we can use it to purge the problematic variable of its endogenous variation. A Two - Stage Least Squares (2SLS) is often used to estimate instrumental variable.

5.2 Alternative gravity model estimator

5.2.1 The Poison Pseudo Maximum Likelihood Estimator (PPML)

According to Silva & Tenreyro (2006), the log-linearization of the empirical model in the presence of heteroskedasticity leads to inconsistent estimates because the expected value of the logarithm of a random variable depends on higher-order moments of its distribution. If the errors are heteroskedastic, the transformed errors will be correlated with the covariates. Another problem of log-linearization is that it is incompatible with the existence of zeros in trade data, which led to unsatisfactory solutions.

Heteroskedasticity

Recall the nonlinear form of the Anderson and Wincoop gravity model from equation (4.3.9) with a multiplicative error term:

\[ X_{ij} = \frac{Y_i Y_j}{P_i P_j} \left( \frac{\tau_{ij}}{\tau_{ij}} \right)^{1-\sigma} \epsilon_{ij} \]  (5.2.1)

where \( \epsilon_{ij} \) is independently and identically distributed. Also, the error term is assumed to be statistically independent of the regressors, i.e. \( E(\epsilon_{ij}|Y_i, Y_j, Y^w, \tau_{ij}, P_i, P_j) = 1 \),

Taking logarithms gives the standard gravity model in linearized form:

\[ \ln X_{ij} = \ln Y_i + \ln Y_j - \ln Y^w + (1 - \sigma)[\ln \tau_{ij} - \ln P_i - \ln P_j] + \ln \epsilon_{ij} \]  (5.2.2)

The assumption that \( \epsilon_{ij} \), and therefore \( \ln \epsilon_{ij} \), are statistically independent of the regressors are critical on the validity of this procedure. The reason is that, as mentioned above, the expected value of the logarithm of a random variable, say \( E(\ln \epsilon_{ij}) \), depends both on its means and on the higher-order moments of its distribution, \( \epsilon_{ij} \). For instance, if \( \epsilon_{ij} \) depends on \( Y_i, Y_j, Y^w, \tau_{ij}, P_i \) or \( P_j \), then the expected value on \( \ln \epsilon_{ij} \) will also rely on the regressors. This violates the condition for consistency of OLS.

Silva & Tenreyro (2006) find evidence that the error terms in the general log-linear specification of the gravity equation are heteroskedastic, which violates the assumption that \( \ln \epsilon_{ij} \) is statistically independent.
of the regressors. They conclude that this estimation method leads to inconsistent estimates of the elasticities of interest.

**Zero trade flows**

As mentioned in section 4.1, the gravity equation has its roots based on the Newton’s universal laws of gravitation. A problem with the analogy between of Newtonian gravity and trade is that the gravitational force can be very small (but never zero), whereas trade between several pairs of countries can be zero.

Zeros may occur in trade data due to several reasons. Firstly, these zeros occur because some pairs of countries did not trade in a given period. According to Silva & Tenreyro (2006), these zeros pose no problem for the estimation of gravity equations in their multiplicative form. In contrast, these zeros create problem when the gravity equation has a log-linear form, and the dependent variable is zero. Secondly, zeros can be a result of rounding errors. For instance, if trade is measured in thousands of dollars, and the bilateral trade between pairs of countries did not reach a minimum value, the value of trade is then registered as zero. Finally, these zeros occur just due to missing observations that are wrongly recorded as zeros. In the second and the last case, the problems are more likely to occur when small countries are considered. Hence the measurement error will depend on the value of the covariates and will lead to the inconsistency of the estimators. Overall, log-linearization is incompatible with the existence of zeros in trade data which leads to unsatisfactory solutions.

Silva & Tenreyro suggest, as a solution to both the existence of zeros and the presence of heteroskedasticity in trade data, to estimate the model in levels rather than taking logarithms. They propose two alternative methods to OLS: non-linear least squared (NLS) and Poisson Pseudo Maximum Likelihood (PPML). By performing Monte Carlo simulations, they conclude that in the presence of heteroskedasticity, the standard methods can severely bias the estimated coefficients. As a result, the PPML is more preferred since it is robust to different patterns of heteroskedasticity and, in addition, provides a natural way to deal with zeros in trade data. It is important to notice that since we are dealing with a pseudo-maximum likelihood estimator, it is not necessary that the dependent variable is Poisson distributed (Shepherd 2012).

The Poisson estimator has several advantages and has been used by many applied policy researchers when using gravity models. First of all, the Poisson estimator is consistent in the presence of fixed effects which can be entered as dummy variables as in simple OLS. Second, the Poisson estimator naturally includes zero observations which are dropped from the OLS model because the logarithm of zero is undefined. Finally, the Poisson estimator allows interpreting the coefficients of any independent variables entered in logarithms as elasticities, and those independent variables entered in levels as semi-elasticities, as under OLS.

### 6 Estimation

In the empirical part of my thesis, I will study the trade flows (exports and imports) between Vietnam and 71 trading partners in the years 1990–2015 using the gravity model of trade. Exports from Vietnam to these countries represent approximately 85% of total exports and imports from these 71 countries to...
Vietnam cover roughly 79% of total imports. As these numbers are relatively high, this study will include the vast majority of Vietnamese trade flows. It can also be seen from figure 3 and 4 in Appendix A.

6.1 Data sources

The dataset contains information on bilateral trade relations between Vietnam and 71 trading partners over 26 years, 1990–2015. The data is gathered from several sources and contains nominal bilateral trade flows (exports and imports), GDPs, regional trade agreements, bilateral distance, and some historical and cultural relations.

Dependent variables are exports and imports of Vietnam and trade partners. I use data on nominal bilateral exports, and imports from International Monetary Fund’s Direction of Trade Statistics (IMF’s DOTS) for Vietnam and 71 countries over the years 1990–2015. Bilateral trade on FOB (Free on Board) exports and CIF (Cost, Insurance, and Freight) imports is recorded in U.S. dollars. These data are then scaled by GDP deflator to generate real trade flows for the panel data analysis. I do this in the same way as Baier et al. (2008) do in their paper.

Data on Gross Domestic Product (GDP) is from World Bank’s World Development Indicators for Vietnam and 71 countries over 26 years. GDPs are measured in current U.S. dollars. These are also scaled by GDP deflator to generate real GDPs for the panel analysis. It is expected that trade increases with the country size, as measured by GDP while other factors are kept constant (see Chionis & Liargovas 2002; Frankel 1993).

The distance between countries explains how much countries trade with each other as indicated by Tinbergen (1962). Distance is involved in the analysis as a proxy for transportation cost between Vietnam and the 71 trading partners covered in this study. It is calculated by distance in kilometers between Hanoi, the capital of Vietnam, and the capital city of its 71 trading partners. Data on distance is taken from the GeoDist dataset provided by the French CEPII Institute (Centre d’Etudes Prospectives et d’Informations Internationales). The coefficient on $\text{Dist}_{ij}$ is expected to be negative (see Frankel 1993; Clarete et al. 2003).

In addition, there are bilateral dummies on whether or not they share common border (contiguous), if they have had a colonial relationship (colony) or had a common colonizer post-1945 (comcol). These variables are available in the GeoDist dataset. Since commonly shared borders, common colonizer or have been in a colony tend to reduce cultural distance and therefore encourage bilateral trade, it is expected that the coefficients on these dummy variables to be positive (see Clarete et al. 2003).

Empirical studies have shown that exchange rate has a significant impact on explaining trade variations among participating countries. The link between trade flow, and the exchange rate is well recognized in economics and is supported by several empirical studies. Bergstrand (1985) indicates that a rise in exchange rate index implies an appreciation (depreciation) of the importer’s (exporter’s) currency from.

---

20To construct these numbers, I calculated sum of exports from Vietnam to 71 countries in the year 1990, 1991,...,2015 separately and got 26 different numbers. I then divided these 26 numbers to exports from Vietnam to the world (total exports) to get means for 26 years. Finally, I summarized all the means and divided them by 26 to get the mean for all countries over 26 years (0.849869). I used the same procedure to get the mean for imports from Vietnam to these 71 countries, and ended up with 0.791247.
the base. He finds that an appreciation of the importer’s currency increases the trade flow from country i to country j. Another study by Sharma (2003) shows that a 10 percent appreciation of the Indian rupee reduces the Indian export demand by 3.4 percent. To calculate exchange rate between Vietnam and country j, I use the following formula:

\[ RER_{it} = \left( \frac{CPI_{it}}{CPI_{jt}} \right) \left( \frac{NER_{it}/\$t}{NER_{jt}/\$t} \right) \]

Data for real bilateral exchange rate, \( RER_{it} \), is collected from International Financial Statistics database. I construct it in the same way as Brun et al. (2005) do in their paper where \( NER_{it}/\$t \) is Vietnamese currency value for US$ at date t, and \( NER_{jt}/\$t \) is country j’s currency value for US$ at date t. \( CPI_{it} \) is the consumption price index for country i (j) at date t. Data on consumer price index is from World Bank’s World Development Indicators with 2010 as the base year, i.e., 2010=100. \(^{21}\) For each pair of countries, the real exchange rate is specified such that its mean over the period is zero. The coefficient for the real exchange rate is expected to have a negative sign.

The RTA dummy variable is included in the regression, and indicates whether Vietnam and country j are members of the same trade agreement. Data for Vietnam’s regional trade agreements is mainly from the gravity-cepii dataset - the French CEPII Institute. Because this dataset only contains data from 1948 to 2006, I had to collect additional information from several sources: UNCTAD, WTO-list of all RTAs in force. The list of Vietnam’s regional trade agreements is presented in Appendix F. The coefficient of RTA dummy variable is expected to affect trade flows positively (see Baier & Bergstrand 2007, Magee 2008).

To access the possible impacts of WTO accession on Vietnam’s trade I include two additional variables, \( VNin_{it} \) and \( Partin_{jt} \). \( VNin_{it} \) captures the potential effects of Vietnam’s WTO accession on its bilateral trade whereas \( Partin_{jt} \) captures effects of WTO membership of Vietnam’s partner countries on Vietnam’s bilateral trade. I do this in the same way Pham (2011) does in her paper. The gravity-cepii dataset also provides a list of whether countries are members of GATT/WTO. Since this dataset only contains a period from 1948 to 2006, I use WTO homepage to search for whether the countries that were not GATT/WTO members before 2006, but became members post-2006.

Among others, coefficients \( \gamma_1 \) and \( \gamma_2 \) are the most important ones because, as mentioned, they capture the impacts of WTO membership on Vietnam’s trade. Coefficients \( \gamma_1 \) measure the impact of Vietnam’s accession to WTO on its trade while coefficients \( \gamma_2 \) measure the impacts of WTO membership of Vietnam’s partner countries. A positive value of \( \gamma_2 \) supports the trade creation effect, whereas a negative value of \( \gamma_2 \) supports the trade diversion effect of WTO membership of Vietnam’s trading partners. \(^{22}\) Table 2 provides a list of variables used in the estimation.

\(^{21}\) I used GDP deflator where CPI were not available

\(^{22}\) In general, trade creation means that a free trade area creates trade that would not have existed otherwise. Trade diversion means that a free trade area diverts trade, away from a more efficient supplier outside the FTA, towards a less efficient supplier within the FTA
Table 2: List of variables

<table>
<thead>
<tr>
<th>i</th>
<th>Vietnam</th>
</tr>
</thead>
<tbody>
<tr>
<td>j</td>
<td>1,2,...,71 (partner countries)</td>
</tr>
<tr>
<td>t</td>
<td>1990,1991,...,2015</td>
</tr>
<tr>
<td>EXijt</td>
<td>Real exports from Vietnam to country j in year t</td>
</tr>
<tr>
<td>IMijt</td>
<td>Real imports from country j to Vietnam in year t</td>
</tr>
<tr>
<td>Yit</td>
<td>Vietnam real GDP in year t</td>
</tr>
<tr>
<td>Yjt</td>
<td>Country j real GDP in year t</td>
</tr>
<tr>
<td>Distij</td>
<td>Distance in kilometers between Vietnam and country j</td>
</tr>
<tr>
<td>RERijt</td>
<td>Bilateral real exchange rate between Vietnamese dong and country j’s currency</td>
</tr>
<tr>
<td>Contigij</td>
<td>Binary variable, = 1 if Vietnam and country j share common border</td>
</tr>
<tr>
<td>Comcolij</td>
<td>Binary variable, =1 if Vietnam and country j have had a common colonizer post-1945</td>
</tr>
<tr>
<td>Colonyij</td>
<td>Binary variable, =1 if Vietnam and country j have had a colonial link</td>
</tr>
<tr>
<td>Smctryij</td>
<td>Binary variable, =1 if Vietnam and country j were/are the same country</td>
</tr>
<tr>
<td>RTAijt</td>
<td>Binary variable, =1 if Vietnam and country j are members of the same trade agreement in year t</td>
</tr>
<tr>
<td>Partinjt</td>
<td>Binary variable, = 1 if Vietnam’s partner country j is GATT/WTO member in year t</td>
</tr>
</tbody>
</table>

6.2 Descriptive statistics

Table 3 reports summary for the variables used in the regression analysis. A summary statistics helps us to simplify large amounts of data and reduces into a simpler summary.

For instance, the RTA dummy shows that out of 1846 observations, 15.3 percent are fellow members of a trade agreement. It is surprising that 81.3 percent that Vietnam’s partner country j is a GATT/WTO member, and it is 34.6 percent that Vietnam is a GATT/WTO member. I have also included summary statistics for various historical and cultural dummy variables. The dummy variables are not prominent ranging with means varying from 1 and 9 percent.

6.2.1 Correlation matrices

The first step in examining the intuition behind the gravity model is to consider the correlations among the variables. Table 4 presents the correlation matrix between selected variables. Overall the correlations given in the table are consistent with the general intuition. That is, as expected, trade increases with the country size as measured by GDP and with the regional trade agreements. As can be seen from the table, the coefficients of lnGDPit, lnGDPjt, and RTA on lnEXijt and lnIMijt are positive.

There is a negative relationship between distance and bilateral trade flows (exports and imports) - as distance increases, bilateral trade decreases. The real exchange rate (lnRER) affects the trade flows negatively as the coefficients are negative. The coefficient between distance and RTA dummy is negative,
consistent with the theory that the larger is the distance between a given pair of countries, the less is the possibility that these countries will form a trade agreement. The correlation between VNin and trade flows is positive meaning that the WTO membership has a positive impact on Vietnam’s trade. Lastly, the relationship between Partin and trade flows is positive meaning that a partner’s WTO membership has a positive impact on Vietnam’s trade.

Despite the fact that the correlation matrix provides evidence that is consistent with the theory, these correlations are not sufficient to infer the presence of causal relationships (i.e. a correlation between two variables does not imply that one variable causes the other).

Table 3: Summary statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log of Vietnam’s GDP</td>
<td>1,846</td>
<td>25.24124</td>
<td>.2300085</td>
<td>24.75482</td>
<td>25.61202</td>
</tr>
<tr>
<td>Log of country j’s GDP</td>
<td>1,790</td>
<td>25.75835</td>
<td>2.220633</td>
<td>20.92223</td>
<td>44.30256</td>
</tr>
<tr>
<td>Log of distance</td>
<td>1,846</td>
<td>8.729312</td>
<td>.6798487</td>
<td>6.170767</td>
<td>9.83108</td>
</tr>
<tr>
<td>Log of real exchange rate</td>
<td>1,538</td>
<td>8.472215</td>
<td>5.441562</td>
<td>-4.104964</td>
<td>63.77137</td>
</tr>
<tr>
<td>Common border</td>
<td>1,846</td>
<td>.0422535</td>
<td>.2012215</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Colony</td>
<td>1,846</td>
<td>.0140845</td>
<td>.1178714</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Common colonizer post 1945</td>
<td>1,846</td>
<td>.0985915</td>
<td>.2981936</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Same country</td>
<td>1,846</td>
<td>.028169</td>
<td>.1655003</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>RTA</td>
<td>1,846</td>
<td>.1533044</td>
<td>.3603783</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>VNin</td>
<td>1,846</td>
<td>.3461538</td>
<td>.4758719</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Partin</td>
<td>1,846</td>
<td>.8131094</td>
<td>.3899293</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 4: Correlation matrix on selected variables

<table>
<thead>
<tr>
<th></th>
<th>lnEXijt</th>
<th>lnIMijt</th>
<th>lnGDPit</th>
<th>lnGDPjt</th>
<th>lnDist</th>
<th>lnRER</th>
<th>RTA</th>
<th>VNin</th>
<th>Partin</th>
</tr>
</thead>
<tbody>
<tr>
<td>lnEXijt</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnIMijt</td>
<td>0.8232</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnGDPit</td>
<td>0.4859</td>
<td>0.4020</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnGDPjt</td>
<td>0.4921</td>
<td>0.5019</td>
<td>0.0282</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnDist</td>
<td>-0.2356</td>
<td>-0.3077</td>
<td>-0.0587</td>
<td>0.3700</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnRER</td>
<td>-0.1919</td>
<td>-0.0647</td>
<td>-0.3256</td>
<td>0.2948</td>
<td>0.3015</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RTA</td>
<td>0.3823</td>
<td>0.4445</td>
<td>0.3384</td>
<td>-0.1033</td>
<td>-0.5361</td>
<td>-0.1711</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VNin</td>
<td>0.4503</td>
<td>0.3921</td>
<td>0.8448</td>
<td>0.0888</td>
<td>-0.0602</td>
<td>-0.1709</td>
<td>0.2971</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Partin</td>
<td>0.1236</td>
<td>0.1655</td>
<td>0.1339</td>
<td>0.2597</td>
<td>0.2500</td>
<td>0.2039</td>
<td>0.0776</td>
<td>0.1361</td>
<td>1.000</td>
</tr>
</tbody>
</table>
6.3 Econometric specification

6.3.1 The model specification and variables

The estimations use annual data consisting of 26 x 71 = 1846 country pairs for Vietnam (Vietnam’s trade with its 71 potential partner countries for the period from 1990 through 2015). Following the work of Subramanian and Wei (2007), I use export and import data separately rather than total trade data to investigate the impacts of WTO on Vietnam’s bilateral trade.

The gravity equation for bilateral export has the following form:

\[ EX_{ijt} = \beta_{10} Y_{it}^{\beta_{11}} Y_{jt}^{\beta_{12}} Dist_{ij}^{\beta_{13}} RER_{ijt}^{\eta_{1}} U_{ij} e^{RTA_{ijt}} e^{\gamma_{11} VNin_{jt}} e^{\gamma_{12} Partin_{jt}} \epsilon_{ijt} \] (6.3.1)

where \( U_{ij} \) is a vector of dummy variables controlling for historical and cultural relations between Vietnam and country \( j \):

\[ U_{ij} = \beta_{14} Contig_{ij} + \beta_{15} Comcol_{ij} + \beta_{16} Colony_{ij} + \beta_{17} Smctry_{ij} \]

and \( RTA_{ijt} \) is a vector of Vietnam’s regional trade agreements:

\[ RTA_{ijt} = \mu_{11} AFTA_{ijt} + \mu_{12} AANZFTA_{ijt} + \mu_{13} AICEC_{ijt} + \mu_{14} AJCEP_{ijt} + \mu_{15} ACFTA_{ijt} + \mu_{16} AKFTA_{ijt} + \mu_{17} JVEPA_{ijt} + \mu_{18} VCFTA_{ijt} + \mu_{19} VEEUFTA_{ijt} + \mu_{20} VKFTA_{ijt} + \mu_{21} VUBTA_{ijt} + \mu_{22} VSBTA_{ijt} \]

After applying log transformation, equations (6.3.1) and (6.3.2) become:

\[ \ln EX_{ijt} = \ln \beta_{10} + \beta_{11} \ln Y_{it} + \beta_{12} \ln Y_{jt} + \beta_{13} \ln Dist_{ij} + \eta_{1} \ln RER_{ijt} + U_{ij} + RTA_{ijt} + \gamma_{11} VNin_{jt} + \gamma_{12} Partin_{jt} + \ln \epsilon_{ijt} \] (6.3.3)

\[ \ln IM_{ijt} = \ln \beta_{20} + \beta_{21} \ln Y_{it} + \beta_{22} \ln Y_{jt} + \beta_{23} \ln Dist_{ij} + \eta_{2} \ln RER_{ijt} + U_{ij}^{*} + RTA_{ijt}^{*} + \gamma_{21} VNin_{jt} + \gamma_{22} Partin_{jt} + \ln \epsilon_{ijt}^{*} \] (6.3.4)
It is worth noting that variables with subscript t in equations (6.3.3) and (6.3.4) are time dependent, and those without t are time independent which will disappear when we estimate the models with fixed effects. The equations above contain both log - variables and binary variables. Binary variables are also called dummy variables that take value 0 or 1. The coefficient of log-variables can be interpreted as elasticities, and saying, for instance, how much trade between country-pair increases when GDP of either Vietnam or country j increases by one percent while keeping other things constant. The coefficient of dummy variables can be interpreted as the mean change in the dependent variable when the dummy changes from 0 to 1, holding other variables fixed.

6.4 Econometric Issues

6.4.1 Multicollinearity

One of the most important problems with panel data, and gravity equations is the problem of multicollinearity. Multicollinearity is a correlation or multiple correlations of sufficient magnitude to have the potential to affect regression estimates adversely. In the presence of multicollinearity, the estimate of one variable’s impact on the dependent variable while controlling for the others tends to be less precise than if predictors were uncorrelated with one another.

In order to avoid multicollinearity, we need to assume that variables are not perfectly correlated, meaning that one variable can be linearly predicted from the others with a substantial degree of accuracy. Otherwise, we will have multicollinearity in our estimation. To test for multicollinearity, I use the well-known Variance Inflation Factor (VIF) which is defined as the reciprocal of tolerance (1/VIF):

\[ VIF = \frac{1}{1 - R^2} \]

\[ \text{tolerance} = 1 - R^2 \]

\( R^2 \) is the coefficient of determination of a regression. The tolerance is the percentage of variance in the independent variable that is not accounted for by other variables. Most commonly, tolerance values of 0.10 or less are cited as problematic. In practice, we want larger tolerance levels than 0.10. Our VIF indicates the degree to which the standard errors are inflated due to levels of collinearity. As a rule of thumbs, VIF values greater than 10 or mean VIF greater than one are often cited as indicative of problematic collinearity.

As can be seen from Table 5, the VIF value ranges from 1.02 to 7.23 and the (1/VIF) value ranges from 0.138 to 0.979. The mean VIF is 2.82 when \( \ln EX_{ijt} \) is the dependent variable and it is 2.99 when \( \ln IM_{ijt} \) is the dependent variable. Since the VIF values are below 10, but the mean VIF for both dependent variables are above 1, there is a suspicion that there exist correlations between independent variables even though they are not perfectly correlated.
Table 5: Variance Inflation Factor (VIF) of independent variables

<table>
<thead>
<tr>
<th></th>
<th>lnEX_{ijt}</th>
<th>lnIM_{ijt}</th>
<th>lnEX_{jyt}</th>
<th>lnIM_{jyt}</th>
</tr>
</thead>
<tbody>
<tr>
<td>lnGDP_{it}</td>
<td>3.95</td>
<td>4.18</td>
<td>0.252966</td>
<td>0.239043</td>
</tr>
<tr>
<td>lnGDP_{jt}</td>
<td>1.60</td>
<td>1.51</td>
<td>0.624370</td>
<td>0.661765</td>
</tr>
<tr>
<td>lnDist</td>
<td>2.30</td>
<td>2.32</td>
<td>0.434966</td>
<td>0.431518</td>
</tr>
<tr>
<td>lnRER_{ijt}</td>
<td>1.45</td>
<td>1.44</td>
<td>0.691646</td>
<td>0.692740</td>
</tr>
<tr>
<td>contig</td>
<td>5.57</td>
<td>5.66</td>
<td>0.179573</td>
<td>0.176640</td>
</tr>
<tr>
<td>comcol</td>
<td>2.18</td>
<td>2.78</td>
<td>0.458171</td>
<td>0.359991</td>
</tr>
<tr>
<td>colony</td>
<td>1.02</td>
<td>1.03</td>
<td>0.979803</td>
<td>0.974860</td>
</tr>
<tr>
<td>smctry</td>
<td>6.46</td>
<td>7.23</td>
<td>0.154912</td>
<td>0.138315</td>
</tr>
<tr>
<td>RTA_{ijt}</td>
<td>1.74</td>
<td>1.70</td>
<td>0.576283</td>
<td>0.587057</td>
</tr>
<tr>
<td>V nin_{jyt}</td>
<td>3.46</td>
<td>3.68</td>
<td>0.288962</td>
<td>0.272059</td>
</tr>
<tr>
<td>Partin_{jyt}</td>
<td>1.29</td>
<td>1.31</td>
<td>0.774455</td>
<td>0.762679</td>
</tr>
<tr>
<td>Mean VIF</td>
<td>2.82</td>
<td>2.99</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.4.2 Heteroskedasticity and Serial Correlation

Serial correlation occurs when one observation’s error term is correlated with another observation’s error term. We say that the errors are serially correlated. Serial correlation is a problem since it causes the standard errors of the coefficients to be smaller than they actually are and R-squared higher than otherwise. In order to test for the existence of serial correlation, I use the Wooldridge test. Table 6 and 7 provide results of the Wooldridge tests for serial correlation (autocorrelation) in panel data for equations (6.3.3) and (6.3.4), respectively.

The null hypothesis for both equations are no serial correlation. According to the p-values in both cases, we can reject the null and conclude that the Wooldridge test support the evidence of serial correlation in the idiosyncratic error term in each gravity equation.

Table 6: Wooldridge test for autocorrelation in panel data

\[ H_0: \text{no first order autocorrelation} \]
\[ F(1, 65) = 52.412 \]
\[ \text{Prob} > F = 0.0000 \]

Table 7: Wooldridge test for autocorrelation in panel data

\[ H_0: \text{no first order autocorrelation} \]
\[ F(1, 61) = 27.788 \]
\[ \text{Prob} > F = 0.0000 \]

---

23 The term serial correlation can also be referred to as 'autocorrelation' or 'lagged correlation.'

24 Two alternative tests for serial correlation in residuals are the Durbin - Watson test and the Breusch - Godfrey test. I did not use the Durbin - Watson test because it only tests for first order serial correlation (i.e., AR(1) type serial correlation). The Breusch - Godfrey test takes into account higher order serial correlation with command `estat bgodfrey` but, for some reasons, it was unable to run it in Stata (14). As a result, a Woolridge test was used. This test was also done by Pham (2011)
The homoskedasticity assumption states that the variance of the unobserved error, $\epsilon$, conditional on the independent variables, is constant. Homoskedasticity fails whenever the variance of the unobserved error changes across different segments of the population, where the segments are determined by the different values of the explanatory variables. The method for checking for heteroskedasticity is the Breush-Pagan/Cool-Weisberg test with command `estat hettest`.

Table 8 provides a Breusch-Pagan / Cook-Weisberg test for heteroskedasticity. It tests the null hypothesis that the error variances are all equal (no heteroskedasticity) versus the alternative that the error variances are a multiplicative function of none or more variables (heteroskedasticity). Notice that the p-values are less than 0.05 for both the fitted variables of $lnEX_{ijt}$ and $lnIM_{ijt}$ and the chi-squared are relatively large, 88.77 and 92.85. The results indicate that there is significant evidence of heteroskedasticity in the model.

Table 8: Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

<table>
<thead>
<tr>
<th>H0 Variables</th>
<th>Chi2(1)</th>
<th>Prob &gt; chi2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant variance fitted values of $lnEX_{ijt}$</td>
<td>88.77</td>
<td>0.0000</td>
</tr>
<tr>
<td>Constant variance fitted values of $lnIM_{ijt}$</td>
<td>92.85</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

In order to control for both heteroskedasticity and autocorrelation, I use robust cluster (distcap) command in my estimation as in Shepherd (2012) to provide robust standard errors. The robust command is widely used in the literature. According to Shepherd (2012), the robust command produces standard errors that are robust to arbitrary patterns of heteroskedasticity in the data. The cluster (variable) is commonly used by gravity modelers as it allows for correlation of the error terms within groups defined by variable. 'Failure to account for clustering in data with multiple levels of aggregation can result in greatly understated standard errors' (Shepherd 2012, page 29). Errors are likely to be correlated by country pair in the gravity model. Therefore it is important to allow for clustering by country pair. Distance is unique to each country pair but is identical for both directions of trade. Distance in kilometers between capitals is used in my estimation, I then use the robust cluster (distcap) option throughout the estimation.

6.4.3 Endogeneity

As mentioned in section (5.1.3), a problem of endogeneity often arises in gravity models when estimating the impact of trade policies. Regional trade agreements is a typical example because they are unlikely to be purely exogenous. Failing to account for endogeneity can cause a serious problem for applied economist as the estimated parameters could be severely biased.

A popular way to fix the endogeneity problem is to use an instrument variable (IV) approach. Unfortunately, this is a time - consuming approach and finding a well-behaved IV is beyond the scope of this thesis. Hence, in order to overcome part of the endogeneity problem, country-pair fixed effects are used in the estimation (UNCTAD 2012, page 118).

25 An alternative test for heteroskedasticity is the White-test
6.4.4 Year Fixed Effects

It is important to include year fixed effects in time series and panel regressions in order to control for global economic effects such as booms or slowdowns in the global economy. Year fixed effects are known as year dummies and merely a set of dummies, one for each year (excluding the first year). Time series regressions and therefore panel regressions which fail to control for year effects will pick up the influence of aggregate (time series) trends which have nothing to do with causal relationships (Dartmouth.edu). Hence, I will include year fixed effects in my estimation to control for global economic effects that are common to all countries but vary over time.

6.4.5 Zero observations

Despite the fact that the dataset contains a large set of information on trade between Vietnam and its 71 partner countries, it is far from perfect. There are some missing values both on the dependent variables and the independent variables in the dataset. Missing data problems may result in systematically biased samples, and it is often a more serious problem than omitted variable bias (See King et al. 2001).

It has been hard to comprehend whether these missing values are genuinely missing or have been explicitly reported as zeros since IMF Direction of Trade Statistics (IMF DOTS) does not provide such information. Luckily, a paper by Gleditsch (2002) (cited in Felbermayr & Kohler 2006) investigates this issue by carefully compares the IMF DOTS with other databases such as COMTRADE basis of the UN, data from the WTO or national accounts. Gleditsch concludes that 80% of all observations coded as missing do in fact represent zeros. With this conclusion in mind, I feel comfortable enough to assume that these missing values are zeros.

In the existence of zero observations and the presence of heteroskedasticity in the dataset, a Pseudo Poisson maximum likelihood (PPML) method is employed. This method can be applied to the levels of trade, thus estimating the non-linear form of the gravity model directly and avoiding dropping zero trade. According to Santos Silva & Tenreyro (2006), in the presence of heteroskedasticity, the PPML is a robust approach. Thus, I estimate the gravity equations in the same way as Silva & Tenreyro (2006) with bilateral export and bilateral import in levels on the LHS and the independent variables on the RHS remain in log forms:

\[
EX_{ijt} = \ln \beta_0 + \beta_1 \ln Y_{it} + \beta_2 \ln Y_{jt} + \beta_3 \ln Dist_{ij} + \eta_1 \ln RER_{ijt} + U_{ij} + RTA_{ijt} + \gamma_1 VNin_{jt} + \gamma_2 Partin_{jt} + \ln \epsilon_{ijt}
\] (6.4.1)

\[
IM_{ijt} = \ln \beta_{20} + \beta_{21} \ln Y_{it} + \beta_{22} \ln Y_{jt} + \beta_{23} \ln Dist_{ij} + \eta_2 \ln RER_{ijt} + U^\ast_{ij} + RTA^\ast_{ijt} + \gamma_{21} VNin_{jt} + \gamma_{22} Partin_{jt} + \ln \epsilon^\ast_{ijt}
\] (6.4.2)

This way of specifying the PPML-equation is convenient as it still allows me to interpret the independent variables entered in logarithms as elasticities and the coefficients of independent variables entered in levels are interpreted as semi-elasticities, as under OLS while the dependent variables are specified in levels rather than in logarithms (Shepherd 2012). I estimate the model by using PPML estimator (without

---

26See Dartmouth.edu for more details and an example that illustrates the results of failing to control for year effects
fixed effects), as suggested by Silva and Tenreyro (2006), and then I will do it with country-pair and year fixed effects PPML.

6.4.6 Summing up the econometric approach

To sum up, I regress the model first as simple OLS without fixed effects. To control for country-specific characteristics and also to overcome part of the endogeneity problem, I then regress the model with country-pair fixed effects OLS estimation. Since the fixed effects model only consists of time-variant variables, variables that do not change over time will be omitted from the model. To solve this problem, I regress the model using the random effects model. To decide which model is more appropriate to use, I run a Hausman test. To control for any global economic effects such as booms or slowdowns in the global economy, I regress the model with year fixed effects. Lastly, to deal with heteroskedasticity and, more importantly, zero observation bias, I use the Poisson Pseudo Maximum Likelihood (PPML) estimation without fixed effects and with country-pair and year fixed effects.

6.5 Empirical results

6.5.1 Main estimation results

Table 9 presents the results of four different estimations for equations (6.3.3) and (6.3.4). The dependent variable for the first four columns is the log of exports, whereas the last four columns have the log of imports as their dependent variable. All models in Table 9 are estimated using OLS.

Columns (1) and (5) are a representation of the "naive" gravity equation where neither country-pair fixed effects nor year fixed effects are included. Columns (2) and (6) are estimated with only year fixed effects.

Columns (3) and (7) are estimated with country-pair fixed effects, but not year fixed effects. As expected, all the variables that are time-invariant such as distance, common border, colony, common colonizer and same country are dropped from the estimation.

The last two columns, (4) and (8), include both country-pair fixed effects and year fixed effects. Again, all time-invariant variables are dropped from the estimation. Also, Vietnam’s GDP is dropped because it is collinear with the year dummies.

Overall, the estimated coefficients are statistically significant with expected signs. Firstly, distance is involved in the analysis as a proxy for transportation, and it is expected that distance will affect Vietnam’s bilateral trade negatively. Columns (1), (2), (5) and (6) provide evidence that distance between Vietnam and country j reduces Vietnam’s trade. The coefficients on distance are negative and statistically significant at 1 percent level. Secondly, it is expected that trade increases as country’s economic size increases, as measured by GDP. Columns (3) and (7) provide the evidence that Vietnam’s bilateral trade increases as Vietnam’s GDP increases. In fact, an increase in Vietnam’s GDP by one percent is expected to increase Vietnam’s exports, and imports by 2.9 percent and 2.1 percent, respectively. Besides, an increase in country j’s GDP by one percent is expected to increase Vietnam’s exports and imports by about 1.1 percent and 1 percent, respectively. The effects of country j’s GDP on Vietnam’s trade remain almost the same when both country-pair and year fixed effects are included.
However, when the gravity model is log-linearized in the presence of heteroskedasticity and, more importantly, the existence of zero-observations, OLS estimates are inconsistent and have a large bias. As such, I have estimated exports and imports in levels, as proposed by Silva & Tenreyro (2006). My primary estimated results are presented in Table 10. Since the dependent variables consist of large values, I have rescaled and divided them by 1000.

Columns (9) and (12) are estimated without any fixed effects and the command `ppml` is used. Columns (10) and (13) are estimated including year fixed effect. Again, Vietnam’s GDP is collinear with year dummies, therefore it is omitted from the model.

Columns (11) and (14) provide results when both country-pair fixed effects and year fixed effects are included. Because the `ppml` command in Stata does not have an option to include country-pair fixed effects, I implemented the `xtpqml` command provided by Timothy Simcoe (2007). This command provides a wrapper for "xtpoisson, fe" that computes robust standard errors.

---

27I wished to add additional columns where only country-pair fixed effects are included, but I did not manage to get robust standard errors for imports. The problem may due to the way I arranged the data. Hence, I decided to not include them since the main focus is to compare those without fixed effects, and those with both fixed effects.
Table 9: Regression results

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Log of exports</th>
<th>Log of imports</th>
<th>Log of exports</th>
<th>Log of imports</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS (1)</td>
<td>OLS (2)</td>
<td>OLS (3)</td>
<td>OLS (4)</td>
</tr>
<tr>
<td>Log of VN’s GDP</td>
<td>5.216***</td>
<td>3.913</td>
<td>2.905***</td>
<td>4.078***</td>
</tr>
<tr>
<td></td>
<td>(0.638)</td>
<td>(2.802)</td>
<td>(0.565)</td>
<td>(0.689)</td>
</tr>
<tr>
<td>Log of j’s GDP</td>
<td>0.984***</td>
<td>1.024***</td>
<td>1.196***</td>
<td>1.035***</td>
</tr>
<tr>
<td></td>
<td>(0.069)</td>
<td>(0.069)</td>
<td>(0.127)</td>
<td>(0.101)</td>
</tr>
<tr>
<td>Log of distance</td>
<td>−0.988***</td>
<td>−1.188***</td>
<td>−1.512***</td>
<td>−1.704***</td>
</tr>
<tr>
<td></td>
<td>(0.245)</td>
<td>(0.268)</td>
<td>(0.295)</td>
<td>(0.318)</td>
</tr>
<tr>
<td>Log of RER</td>
<td>−0.069***</td>
<td>−0.023</td>
<td>−0.242***</td>
<td>−0.134*</td>
</tr>
<tr>
<td></td>
<td>(0.031)</td>
<td>(0.029)</td>
<td>(0.044)</td>
<td>(0.035)</td>
</tr>
<tr>
<td>Common border</td>
<td>−0.093</td>
<td>0.011</td>
<td>−0.516</td>
<td>−0.429</td>
</tr>
<tr>
<td></td>
<td>(0.373)</td>
<td>(0.335)</td>
<td>(0.538)</td>
<td>(0.502)</td>
</tr>
<tr>
<td>Colony</td>
<td>1.012***</td>
<td>1.450***</td>
<td>1.378***</td>
<td>1.741***</td>
</tr>
<tr>
<td></td>
<td>(0.253)</td>
<td>(0.261)</td>
<td>(0.301)</td>
<td>(0.310)</td>
</tr>
<tr>
<td>Common colonizer</td>
<td>0.889*</td>
<td>1.032**</td>
<td>0.457</td>
<td>0.712</td>
</tr>
<tr>
<td></td>
<td>(0.455)</td>
<td>(0.476)</td>
<td>(1.207)</td>
<td>(1.199)</td>
</tr>
<tr>
<td>Same country</td>
<td>1.571**</td>
<td>1.513**</td>
<td>1.573</td>
<td>1.444</td>
</tr>
<tr>
<td></td>
<td>(0.746)</td>
<td>(0.747)</td>
<td>(1.286)</td>
<td>(1.278)</td>
</tr>
<tr>
<td>RTA</td>
<td>0.621***</td>
<td>0.185</td>
<td>0.413</td>
<td>0.194</td>
</tr>
<tr>
<td></td>
<td>(0.271)</td>
<td>(0.297)</td>
<td>(0.417)</td>
<td>(0.470)</td>
</tr>
<tr>
<td>VNin</td>
<td>−0.236</td>
<td>2.951**</td>
<td>0.248</td>
<td>3.964***</td>
</tr>
<tr>
<td></td>
<td>(0.172)</td>
<td>(1.326)</td>
<td>(0.153)</td>
<td>(0.626)</td>
</tr>
<tr>
<td>Partin</td>
<td>0.524</td>
<td>0.520</td>
<td>0.109</td>
<td>−0.074</td>
</tr>
<tr>
<td></td>
<td>(0.365)</td>
<td>(0.334)</td>
<td>(0.488)</td>
<td>(0.446)</td>
</tr>
<tr>
<td>Constant</td>
<td>−146***</td>
<td>−114</td>
<td>−99***</td>
<td>−27***</td>
</tr>
<tr>
<td></td>
<td>(5.091)</td>
<td>(17.809)</td>
<td>(12.14)</td>
<td>(13.617)</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses, clustered by country-pair distance. Fixed effects intercepts are not reported due to space limitations. R - squared for models (3), (4),(7) and (8) are R - squared within regression.

* p < 0.1, ** p < 0.05, *** p < 0.01
**Table 10: (Cont) Regression results**

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Exports</th>
<th>Imports</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PPML (9)</td>
<td>PPML (10)</td>
</tr>
<tr>
<td>Log of VN's GDP</td>
<td>−1.679 (1.066)</td>
<td>1.691**</td>
</tr>
<tr>
<td>Log of j's GDP</td>
<td>0.833*** (0.041)</td>
<td>0.946*** (0.095)</td>
</tr>
<tr>
<td>Log of distance</td>
<td>−0.348*** (0.121)</td>
<td>−1.582*** (0.205)</td>
</tr>
<tr>
<td>Log of RER</td>
<td>−0.064*** (0.012)</td>
<td>−0.022 (0.024)</td>
</tr>
<tr>
<td>Common border</td>
<td>−0.456** (0.189)</td>
<td>−0.383 (0.276)</td>
</tr>
<tr>
<td>Colony</td>
<td>−0.885*** (0.212)</td>
<td>0.522** (0.258)</td>
</tr>
<tr>
<td>Common colonizer</td>
<td>0.319 (0.509)</td>
<td>1.526* (0.816)</td>
</tr>
<tr>
<td>Same country</td>
<td>1.745** (0.748)</td>
<td>−1.979** (0.871)</td>
</tr>
<tr>
<td>RTA</td>
<td>1.050*** (0.229)</td>
<td>0.759** (0.321)</td>
</tr>
<tr>
<td>VNin</td>
<td>1.534*** (0.373)</td>
<td>0.153 (0.157)</td>
</tr>
<tr>
<td>Partin</td>
<td>−0.574** (0.279)</td>
<td>−0.980*** (0.255)</td>
</tr>
<tr>
<td>Constant</td>
<td>22.23 (25.97)</td>
<td>−54.88*** (17.94)</td>
</tr>
</tbody>
</table>

Country-pair fixed effects: NO, NO, YES, NO, NO, YES
Year fixed effects: NO, YES, YES, NO, YES, YES
Observations: 1151, 1151, 1149, 1063, 1063, 1061
R-squared: 0.999, 0.999, 0.953, 0.999
Wald chi2(29): 1508, 1293

Robust standard errors in parentheses, clustered by country-pair distance. Fixed effects intercepts are not reported due to space limitations.

* p < 0.1, ** p < 0.05, *** p < 0.01
6.6 Discussion of the results

6.6.1 Hausman test

In order to decide whether fixed effects model or random effects model is more appropriate to use, I run a Hausman test for equations (6.3.3), and (6.3.4) separately. The null hypothesis is the random effects vs. the alternative the fixed effects.

It tests whether the errors are correlated with the regressors, and the null hypothesis is that they are not. To run the test, I first run the fixed effects model and save the estimates. I then run the random effects model and save the estimates. The command for running both fixed and random effects is \texttt{xtreg}. Finally, the test is performed with command \texttt{hausman fixed random}. Results for the log of exports as dependent variable are provided in Table 11 while results for the log of imports are provided in Table 12.

As can be seen from both tables, the p values are statistically smaller than 0.05. I then reject the null hypothesis and conclude that the fixed effects model is more preferred. The results from random effects model are not included in the regression results, but is presented in Appendix D.

\begin{table}[h]
\centering
\caption{Hausman test}
\begin{tabular}{lcccc}
\hline
Dependent variable: Log of exports & (b) & (B) & (b-B) & sqrt(diag(V_{b} - V_{B})) \\
\hline
 & fixed & random & Difference & S.E. \\
\hline
Log of Vietnam’s GDP & 2.905275 & 3.609945 & -.7046697 & .0550782 \\
Log of country j’s GDP & 1.195772 & 1.11029 & .085482 & .0264396 \\
Log of RER & -.2419475 & -.1761734 & -.0657741 & .0083769 \\
RTA & .4134091 & .5123075 & -.0988984 & .0163492 \\
Vnin & .2478609 & .1019706 & .1458903 & \\
Partin & .109015 & .1742964 & -.0652814 & .1094894 \\
\hline
Chi2(7) & 49.34 \\
Prob > Chi2 & 0.0000 \\
\hline
\end{tabular}
\end{table}

\begin{table}[h]
\centering
\caption{Hausman test}
\begin{tabular}{lcccc}
\hline
Dependent variable: Log of imports & (b) & (B) & (b-B) & sqrt(diag(V_{b} - V_{B})) \\
\hline
 & fixed & random & Difference & S.E. \\
\hline
Log of Vietnam’s GDP & 2.125356 & 2.548474 & -.4231177 & .0546761 \\
Log of country j’s GDP & 1.03406 & 1.117583 & -.0835236 & .049612 \\
Log of RER & -.1603297 & -.1205906 & -.0397391 & .0073517 \\
RTA & .6006937 & .6850274 & -.0843338 & .0054297 \\
Vnin & .2784623 & .1456052 & .1328571 & \\
Partin & .2848825 & .3973939 & -.1125113 & .0748343 \\
\hline
Chi2(7) & 37.91 \\
Prob > Chi2 & 0.0000 \\
\hline
\end{tabular}
\end{table}
6.6.2 WTO accession’s impact on Vietnam’s bilateral trade

As mentioned in section 6.1, in order to assess the potential impacts of WTO accession on Vietnam’s bilateral trade I include two additional dummies, namely VNin and Partin. Hence, in this section I will discuss the possible impacts of these two variables and some attentions will be given to the effects of other explanatory variables in the next section.

The estimated coefficients of the VNin dummy when estimated with OLS country-pair and year fixed effects are both positive and statistically significant. These are 3.964 and 4.425 on exports and imports, respectively. When I estimated the regression with PPML country-pair and year fixed effects, these coefficients drop down to 2.146 and 2.801, but they are still statistically significant at 1 percent level. That is, exports from Vietnam to partner countries increased by approximately 214.6% while imports to Vietnam increased by about 280.1% when Vietnam entered the WTO. The Vietnamese imports increased rapidly after the accession, with the primary cause being the tariff reduction which is in line with the framework committed to the WTO. The Vietnamese exports also increased significantly after the accession which is also in line with what WTO’s members have agreed to do in return for Vietnam’s trade liberalization commitments. Overall, the estimated coefficients of VNin dummy indicate that joining the WTO positively affects Vietnam’s bilateral trade, both regarding exports and imports.

Pham (2011) investigates the impact of WTO accession on the dynamics of Vietnam’s foreign direct investment and trade by employing an augmented gravity model. She finds that Vietnam’s imports increased significantly when joining WTO, but the accession has no effect on Vietnam’s exports. Several reasons may explain why my results vary from her study.

Firstly, Pham’s dataset consists of bilateral trade between Vietnam and its 17 most important countries from 1990 to 2008, which is only one year after the accession. My dataset has an advantage in a way that it contains more trading partners, also it contains data for 8 years after the accession and as such it is able to capture more of the impacts that follow after the accession.

Secondly, Pham includes two additional dummies, \( CRI_{jt}^{1} \) and \( CRI_{jt}^{2} \), which are unity if country \( j \) has suffered from the Asian financial crisis in 1997 and if country \( j \) suffered from the 2007 financial crisis, respectively. Instead of including two separate dummies as she does, I include the year fixed effects. The advantage of these year fixed effects, as mentioned in section 6.3.4, is its ability to control for global economic effects such as financial crisis in the global economy.

Lastly, together with a random-effect estimation (GLS) to estimate the gravity equations she employs an instrument variable (IV) method to tackle the potential endogeneity problem. The coefficients of VNin dummy on imports are 106% and 116% when she uses GLS and IV, respectively. Both coefficients are statistically significant at 1% level. However, the coefficients of VNin dummy on exports in both methods are positive but insignificant. Since finding instrument variables is not an easy task and because it is time-consuming, I chose to include country-pair fixed effects to overcome part of the endogeneity problem.

Another important finding in my thesis is the impacts of WTO accession of Vietnam’s partner countries affect Vietnam’s bilateral trade as captured by the Partin dummy. Pham’s findings indicate that a partner’s WTO membership does not influence Vietnam’s bilateral trade. The same results can be seen from columns (11) and (14) in my regression results table. The estimated coefficients of the Partin dummy are -0.366 and -0.164 for exports and imports, respectively. However, both coefficients are insignificant.
My results also indicate that a WTO membership of a partner country does not influence Vietnam’s bilateral trade. The reason why a partner’s WTO membership does not have any impact on Vietnam’s trade is difficult to say, but it may influence other aspects of the Vietnamese economy such as foreign direct investment.

To sum up, Vietnam’s accession to WTO and its partner’s accession to WTO affected Vietnam’s bilateral trade differently. Vietnam’s accession to WTO has positive impacts on both its exports and imports. Accession to WTO increased Vietnam’s bilateral trade more than 200%. By contrast, a trading partner’s WTO membership does not have any impact on Vietnam’s bilateral trade.

6.6.3 Impacts of other explanatory variables

I start with the effect of a regional trade agreement between Vietnam and partner countries. The RTA dummy affects exports and imports differently. On the one hand, the estimated coefficient of the RTA dummy on exports when both country-pair and year fixed effects are included is positive, but it is insignificant. On the other hand, the RTA dummy has a positive and statistically significant effect on imports. Imports will, on average, be about 58% higher if importing from a fellow member of the same RTA. Unfortunately, there are reasons why I cannot trust these coefficients completely. The most important reason to cast doubt on the RTA coefficients is due to the endogeneity problem. By including country-pair fixed effects, only part of the endogeneity problem is solved.

Due to the collinearity between Vietnam’s GDP and year dummies, I cannot comment on this variable. The estimated coefficients of partner countries’ GDP are positive and statistically significant at 1% level. A 10% increase in country j’s GDP increases Vietnam’s exports by 11.5% and Vietnam’s imports by 9.5%. These coefficients indicate that Vietnam’s bilateral trade depends on the economic growth of its partner countries, as expected.

Lastly, is the impact of the bilateral real exchange rate between the Vietnam dong and country j’s currency on Vietnam’s bilateral trade. The estimated coefficient of RER is negative and statistically significant at 1% level in the export equation. The estimated coefficient of RER on exports is -0.132. The negative elasticity of exports from Vietnam to partner countries with respect to the real exchange rate implies that the real appreciation of the Vietnam dong adversely affects Vietnamese exports. That is a 10% appreciation of the Vietnam dong reduces exports from Vietnam to partner countries by 1.3%. By contrast, the changes in RER in Table 10 had no significant impact on imports.
7 Conclusion

The main purpose of this thesis has been trying to assess the possible effects of Vietnam’s accession to WTO on its bilateral trade. In order to accomplish this, I employed an augmented gravity equation and used a panel dataset covering bilateral trade between Vietnam and the 71 trading partners I covered in this study, over the period 1990-2015.

In the presence of heteroskedasticity and existence of several zero-observations in my dataset, I chose to employ the Poisson Pseudo - Maximum Likelihood (PPML) estimation method proposed by Silva & Tenreyro (2006) as my main estimation method. In addition, I have included results from estimations using OLS as robust checks.

The empirical results in Table 10 provide two significant findings. The first of these is that Vietnam’s WTO accession has boosted Vietnam’s bilateral trade, both regarding exports, and imports. Becoming a member of WTO, Vietnam’s exports increased by 214% during the period 2007-2015 while Vietnam’s imports increased by 280% during the same period. The second interesting finding is that if trading partners belong to or join the GATT/WTO will not influence Vietnam’s bilateral trade. This is consistent with the finding from Pham (2011) on WTO membership of Vietnam’s partners.

As this study investigated and proved the importance of Vietnam’s accession to WTO on its bilateral trade, a possible idea for future research could be a study on how the benefits of WTO membership affects the unemployment level, especially for rural residents in Vietnam.
8 Literature


General Statistic Office of Vietnam - GSO.


URL: [https://www.dartmouth.edu/~ethang/Lectures/Class17/Always%20Control%20for%20Year%20Effects%20in%20Panel%20Regressions.pdf.](https://www.dartmouth.edu/~ethang/Lectures/Class17/Always%20Control%20for%20Year%20Effects%20in%20Panel%20Regressions.pdf) [Accessed 15.04.2017]


Theie, M. G. (2014). "Non-tariff barriers, trade integration and the gravity model", *University of Oslo, Department of Economics*.


A Vietnam's trade with its 71 partner countries

Figure 3: Vietnam’s exports to its 71 partner countries

Figure 4: Vietnam’s imports from its 71 partner countries
### Bilateral trade between Vietnam and most important trading partners in 1990–2014

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
<th>EU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Value(in million US$)</td>
<td>% change</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>1990</td>
<td>2404,0</td>
<td>2752,0</td>
</tr>
<tr>
<td>1991</td>
<td>2087,0</td>
<td>2338,0</td>
</tr>
<tr>
<td>1992</td>
<td>2581,0</td>
<td>2541,0</td>
</tr>
<tr>
<td>1993</td>
<td>2985,0</td>
<td>3924,0</td>
</tr>
<tr>
<td>1994</td>
<td>4054,0</td>
<td>5826,0</td>
</tr>
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<td>1997</td>
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<td>11500,0</td>
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Note: (1) denotes exports from Vietnam to trading partners whereas (2) denotes imports from trading partners to Vietnam. Number of countries in EU varies between years such as in 2007 and fourth, it contains 27 countries whereas this number is 25 in 2006.

<table>
<thead>
<tr>
<th>Year</th>
<th>ASEAN Value (in million US$)</th>
<th>% change</th>
<th>United States Value (in million US$)</th>
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Note: (1) denotes exports from Vietnam to trading partners whereas (2) denotes imports from trading partners to Vietnam. Number of countries in EU varies between years such as in 2007 and fourth, it contains 27 countries whereas this number is 25 in 2006.

<table>
<thead>
<tr>
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<th>% change</th>
<th>China Value (in million US$)</th>
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</table>

Note: (1) denotes exports from Vietnam to trading partners whereas (2) denotes imports from trading partners to Vietnam. Number of countries in EU varies between years such as in 2007 and fourth, it contains 27 countries whereas this number is 25 in 2006.

C Derivation of Anderson and Van wincoop (2003) CES demand function

In the following section, I present a complete derivation of the CES demand function provided by Theie (2014).

Maximizing the CES utility function, (4.3.1), subject to the budget constraint, (4.3.2) gives the following Lagrangian:

\[
L = \sum_{i=1}^{N} \beta^{(1-\sigma)/\sigma} (\sigma c_{ij}^{(1-\sigma)} / \sigma c_{ij})^{\sigma/(\sigma-1)} - \lambda \left( \sum_{i=1}^{N} \tau_{ij} c_{ij} - Y_j \right)
\]  

(C.0.1)

First order condition with respect to \(c_{ij}\):

\[
\frac{\partial L}{\partial c_{ij}} = \sum_{i=1}^{N} \beta^{1-\sigma} c_{ij}^{\sigma-1} \beta^{1-\sigma} c_{ij}^{\sigma-1} - \lambda \tau_{ij} p_i = 0
\]  

(C.0.2)

where \(\lambda\) is the Lagrangian multiplier. Multiply both sides of (B.0.2) by \(c_{ij}\) yields:

\[
\lambda \tau_{ij} p_i c_{ij} = \sum_{i=1}^{N} \beta^{1-\sigma} c_{ij}^{\sigma-1} \beta^{1-\sigma} c_{ij}^{\sigma-1} \tau_{ij} p_i
\]  

(C.0.3)

Summing over all i’s:

\[
\lambda \sum_{i=1}^{N} \tau_{ij} p_i c_{ij} = \sum_{i=1}^{N} \beta^{1-\sigma} c_{ij}^{\sigma-1} \beta^{1-\sigma} c_{ij}^{\sigma-1} \sum_{i=1}^{N} \tau_{ij} p_i
\]  

(C.0.4)

From chapter 4, we know that \(Y_j = \sum_{i=1}^{N} p_i c_{ij} = \sum_{i=1}^{N} p_i \tau_{ij} c_{ij}\), hence

\[
\lambda Y_j = \sum_{i=1}^{N} \beta^{1-\sigma} c_{ij}^{\sigma-1} \sum_{i=1}^{N} \beta^{1-\sigma} c_{ij}^{\sigma-1}
\]  

(C.0.5)

Insert for \(\lambda\) from (B.0.3):

\[
\frac{\sum_{i=1}^{N} \beta^{1-\sigma} c_{ij}^{\sigma-1} \tau_{ij} p_i c_{ij}}{\tau_{ij} p_i c_{ij}} Y_j = \left[ \sum_{i=1}^{N} \beta^{1-\sigma} c_{ij}^{\sigma-1} \right] \frac{1-\sigma}{\sigma} \left[ \sum_{i=1}^{N} \beta^{1-\sigma} c_{ij}^{\sigma-1} \right]^{-\sigma}
\]  

(C.0.6)

Rearrange such that:

\[
\tau_{ij} p_i = \frac{\beta^{1-\sigma} c_{ij}^{\sigma-1}}{\sum_{i=1}^{N} \beta^{1-\sigma} c_{ij}^{\sigma-1}} Y_j
\]  

(C.0.7)
Raise both sides to the power of \(-\sigma\) and multiply both sides by \(\tau_{ij}p_i\):

\[
(\tau_{ij}p_i)^{1-\sigma} = \frac{\beta_i^{\sigma-1}c_{ij}\tau_{ij}p_i}{\sum_{i=1}^{N} \beta^{\frac{1-\sigma}{\sigma-1}}_{i} \frac{c_{ij}}{c_{ij}}} Y_j^{-\sigma}
\]

(C.0.8)

Divide both sides by \(\beta_i^{\sigma-1}\):

\[
(\tau_{ij}p_i\beta_i)^{1-\sigma} = \frac{c_{ij}\tau_{ij}p_i Y_j^{-\sigma}}{\sum_{i=1}^{N} \beta_i^{\frac{1-\sigma}{\sigma-1}} \frac{c_{ij}}{c_{ij}}}
\]

(C.0.9)

Sum over all i’s:

\[
\sum_{i=1}^{N} (\tau_{ij}p_i\beta_i)^{1-\sigma} = \frac{Y_j^{-\sigma} \sum_{i=1}^{N} c_{ij}\tau_{ij}p_i}{\sum_{i=1}^{N} \beta_i^{\frac{1-\sigma}{\sigma-1}} \frac{c_{ij}}{c_{ij}}}
\]

(C.0.10)

Multiply both sides by \(\sum_{i=1}^{N} \beta_i^{\frac{1-\sigma}{\sigma-1}} \frac{c_{ij}}{c_{ij}}\) and recall that \(Y_j = \sum_i^{N} c_{ij}\tau_{ij}p_i\):

\[
\sum_{i=1}^{N} \beta_i^{\frac{1-\sigma}{\sigma-1}} \frac{c_{ij}}{c_{ij}} = \frac{Y_j^{1-\sigma}}{\sum_{i=1}^{N} (\tau_{ij}p_i\beta_i)^{1-\sigma}}
\]

(C.0.11)

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

\[
\sum_{i=1}^{N} \beta_i^{\frac{1-\sigma}{\sigma-1}} \frac{c_{ij}}{c_{ij}} = \frac{Y_j^{1-\sigma}}{P_j^{1-\sigma}}
\]

(C.0.12)

Insert this back into (B.0.9):

\[
(\tau_{ij}p_i\beta_i)^{1-\sigma} = \frac{c_{ij}\tau_{ij}p_i P_j^{1-\sigma}}{Y_j}
\]

(C.0.13)

Recall from chapter 4 that the nominal value of exports from i to j is denoted as \(X_{ij} = \tau_{ij}p_i c_{ij}\). Inserting (B.0.13) into this expression and rearrange it yields the nominal demand for region i goods by region j consumers:

\[
X_{ij} = \left[ \frac{\beta_i p_i \tau_{ij}}{P_j} \right]^{1-\sigma} Y_j
\]

(C.0.14)
### Random effects estimation - results

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<tr>
<th>Independent variable</th>
<th>Log of exports</th>
<th>Log of imports</th>
</tr>
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<tr>
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<td>(0.320)</td>
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**R-squared:**
- within: 0.5931, 0.5061
- between: 0.6259, 0.7090
- overall: 0.6702, 0.6407

**Chi2:** 581, 2466

Robust standard errors in parentheses, clustered by country-pair distance.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
### List of countries in the dataset

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<td>Norway</td>
<td>Syria</td>
<td></td>
</tr>
</tbody>
</table>
# List of Vietnam’s Regional Trade Agreements

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>RTA Name</th>
<th>Date of entry into force</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFTA</td>
<td>ASEAN Free Trade Area</td>
<td>1995</td>
</tr>
<tr>
<td>AANZFTA</td>
<td>ASEAN – Australia - New Zealand Free Trade Agreement</td>
<td>1 Jan. 2010</td>
</tr>
<tr>
<td>AICEC</td>
<td>ASEAN – India Comprehensive Economic Cooperation</td>
<td>1 Jan. 2010</td>
</tr>
<tr>
<td>AJCEP</td>
<td>ASEAN – Japan Comprehensive Economic Partnership</td>
<td>1 Dec. 2008</td>
</tr>
<tr>
<td>ACFTA</td>
<td>ASEAN – People’s Republic of China Comprehensive Economic Cooperation Agreement</td>
<td>1 Jul. 2005</td>
</tr>
<tr>
<td>AKFTA</td>
<td>ASEAN – (Republic of ) Korea Comprehensive Economic Cooperation Agreement</td>
<td>1 Jan. 2010</td>
</tr>
<tr>
<td>VCFTA</td>
<td>Vietnam – Chile Free Trade Agreement</td>
<td>1 Jan. 2014</td>
</tr>
<tr>
<td>VKFTA</td>
<td>Vietnam – Korea Free Trade Agreement</td>
<td>20 Dec. 2015</td>
</tr>
<tr>
<td>VSBTA</td>
<td>Vietnam – Switzerland Bilateral Trade Agreement</td>
<td>3 Dec. 1992</td>
</tr>
</tbody>
</table>

Sources: UNCTAD, WTO-list of all RTAs and gravity-cepii dataset from CEPII.