Czech University of Life Sciences

Faculty of Economics and Management

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DIPLOMA THESIS
Gravity model and its application in international trade

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CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Department of Economic Theories

Faculty of Economics and Management

DIPLOMA THESIS ASSIGNMENT

Trong Duc Do, BSc

Economics and Management

Thesis title

Gravity model and its application in international trade

Objectives of thesis

Evaluation the trading performance of Czech Republic with EU and Non-EU countries

Methodology

to fulfill the objective, this diploma thesis is based on qualitative and quantitative approaches as well as variety of research methods (such as comparative, synthesis, inductive and deductive analysis methods)

the research paper is devided into three parts:

1. Construction of gravity equation of trade based on the previous mathematic and economic theory (consideration of economic indicators GDP, trade balance, trade barrier, tariff, ect..)

2. Case study of Czech Republic trade flow and trend model over years with application of construced gravity equation.

3. Economic, statistic and econometric verfication of generated research model from the case study.

The proposed extent of the thesis
45-60 pages

Keywords
international trade, trading, globalization, gravity model, Czech Republic, European Union, trade volume,

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Recommended information sources
Czech Trade
H.R. Seddighi, K.A. Lawler, A.V. Katos. Econometrics: A practical approach;
KRUGMAN, P.R., OBSTFELD, M. International Economics, Theory and Policy. 7. vyd. Boston: Pearson-Addison Wesley, 2005. 680 s. ISBN 978-0321293831
MOFFET, M., STONEHILL, EITMAN, D. Fundamentals of Multinational Finance. 4. vyd. New Yersey: Pearson/Prentice Hall, 2011. 544 s. ISBN 978-0132138079
Routledge publisher. 2000
Sonia, Taylor. Business Statistics. 3rd ed. 2007

Expected date of thesis defence
2015/06 (June)

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Prague on 26. 03. 2015

Declaration

I hereby declare that I have worked on my Diploma thesis titled "Gravity model and its application in international trade" solely and completely on my own and that I have marked all quotations in the text. The literature and other material I have used are mentioned in the Preferences section of the thesis.

In Prague on 26th of March 2015 _____

ACKNOWLEDGEMENT

I would like to take this opportunity to thank all those who have helped and supported me in writing this thesis.

First and foremost I would like to express my gratitude to Professor PhDr. Oldřich Ludwig Dittrich, MPH, Ph.D for his guidance, his constructive criticisms and feedback, which were very helpful. His wisdom, clear way of thinking, and great patience impressed me.

Also, I would like to express my thanks to all the teachers of faculty of Economics and Management who have helped me in the entire process of study, as it has been the most memorable study experience in my whole life.

Then, I wish to extend my gratitude to my dear classmates and friends, especially Pham Thu Trang, Nguyen Viet Quang and others, thank you very much for your helps, inspirations and providing useful materials for this diploma thesis.

Finally my biggest appreciation is for my family. Thanks to my mother and sister for supporting me all the time, and encouraging me never to stop following my dreams.

Gravitační model a jeho aplikace v mezinárodní obchodu

Gravity model and its application in international trade

Souhrn:

Svět se v současné době mění rychlým tempem a mezinárodní obchod je považován zaklíčový aspekt kolem nás. Nicméně modelování a pochopení mezinárodního obchodu bylo těžká ekonomická otázka po celá století. Jako jeden z nejspolehlivějších metod, gravitační model obchodu měl empirický úspěch v jeho správnou interpretaci obchodních toků mezi zeměmi. Je zakořeněný v fyzickalním zákona všeobecné gravitace, gravitační model aplikuje přitažlivou sílu mezi dvěma objekty do obchodních toků mezi oběma zeměmi. Transformuje je do jednoduchého lineárního regresního modelu. Tato diplomová práce je vědecký výzkum ve snaze odhadnout a vytvořit stabilní gravitační model a použít jej k analýze obchodní výkonnosti České republiky se zeměmi součastí Evropské unie, tak mimo ni.

Klíčová slova: mezinárodní obchod, obchodování, globalizace, gravitační model, Česká republika, Evropská unie, objem obchodu

Summary

The world is now changing at a rapid rate and international trade is considered to be a key driven in every aspects around us. However modeling and understanding international trade has been a difficult question in economics for centuries. As one of the most reliable methods, gravity model of trade has been an empirical success in its accurate interpretation of trade flows between countries. Rooted from physical law of universal gravitation, gravity model applied attraction force between two objects into trade flows between two countries and transformed them into simple linear regression model. This diploma thesis is the scientific research in attempting to estimate and develop a solid gravity model and use it to analyzing the trading performance of Czech Republic with countries inside and outside European Union.

Keywords: international trade, trading, globalization, gravity model, Czech Republic, European Union, trade volume.

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ABREVIATIONS:

CR	Czech Republic
RTA	Regional trade agreement
GDP	Gross domestic product
EU	European Union
EU28	28 member states of European Union
Non-EU28	Countries outside EU

1 Introduction:

We live today in a world where economic globalization and technical development has created many advantages in exchange of good and services. One of the major fields in economic globalization is international trade. The exchange of goods and services also allows countries to use their assets and natural resources more effectively and efficiently. Therefore international trade encourages firms and corporates to produce more goods and services to export across borders and contribute more into national income. On the other side, trading also creates the opportunities for the domestic consumers to be exposed to goods and services not available in their countries by importing from another country, which increases consumers demand and social welfare. As the results, the global consumers are now enjoying the benefits of international trade in domestic market, where they have plenty of choices in goods and services to satisfy the enormous demand. Overall international trade has become an irreplaceable system, which boosts the world economy, maintains the nations' relationship and unites the countries together.

However, analyzing the trade flows between countries is not a simple task. For centuries, many researchers has developed the economic models in calculation and prediction the movement of goods and services between countries. As the society and consumers' preferences kept changing, there are more and more factors influencing the national import and export over years. One of the most reliable methods is the application of gravity model into international trade. Rooted from the physical law from Newtonian theory of gravitation, gravity model analyzes the bilateral trade flows based on the economic attraction between two countries such as their economic size and distance. This diploma thesis is the scientific research in attempting to develop the possible application of gravity model in analyzing the international trade flows of chosen countries in the case study which will be presented in the next chapters.

2 Thesis objectives and methodology

2.1. Thesis objectives

Aim

This research aimed to evaluate the application of gravity model into international trade. From the theory of physical law of universal gravity in attraction force, a modified model of gravity model was developed and applied into analysis of international trade of Czech Republic from 2000 to 2014 in the case study.

Goal

The case study then was divided into three particular parts.

- The first part is the application of gravity model in analyzing the international trade of Czech Republic with countries of European Union EU28 group
- The second part is the application of gravity model in analyzing the international trade of Czech Republic with countries outside European Union non-EU28 group
- The third part is the application of gravity model in analyzing the international trade of Czech Republic with all countries from EU28 and non-EU28 group

2.2. Methodology

The first part of research was to develop the suitable and applicable of gravity theory in economic theory. From the root of theory, the equation was consisted of specific units illustrating of attraction force, economic size (mass) of countries and distance. Therefore the import and export were chosen to illustrate attraction force, GDP was chosen to illustrate economic size, actual distance between countries and trade resistance was chosen to illustrate the theoretical distance between two objects in origin equation of gravity[1]. This decision leads to the creation of new gravity model of trade as the formulation below:

$$lnX = a0 + a1\ ln\_GDPcz + a2ln\_GDPj + a3ln\ d + b1\ Currency + b1cmbd + b2lang + b3\ landlock + b4\ RTA + c\ year + \varepsilon$$

Where

lnX is the natural logarithms of export or import value between two countries CR and each partner in EU28

ln_GDPcz and *ln_GDPj* respectively are natural logarithms of GDP in CR and each partner in EU28.

ln d is the natural logarithm value of distance between countries.

a0, a1, a2, a3 are generated parameters of the related input variables from regression model,

b1, b2, b3 , b4 are generated parameters of dummy variables.

currency EU (1 – when partners adopted Euro, 0 – otherwise)

cmbd (1 – when a partner has common border with CR, 0 – otherwise)

lang (1 – when a partner's native languages is in Slavic system, 0 – otherwise)

RTA (1 – when a partner's joined EU, 0 – otherwise)

Landlock (1 – when the partner's location is island or sea travel, 0 – otherwise)

year is time vector (2000 = 1, 2001 = 2,… 2014 = 15)

c is the generated parameters of time vector

ε is error term.

[1] Keith Head. Article: "Gravity for beginners" Handbook of International Economics Volume 2 edition. Gopinath, Helpman, Rogoff. 2000. Available at: http://web.efzg.hr/dok/me_gravity%20for%20begin.pdf

The second part was based on quantitative approach to perform the possibilities of application of gravity model in practical case study. The data was collected from available statistic data of Czech statistical office, National account main aggregates database and Eurostat website to conduct the empirical analysis of international trade of CR from 2000 to 2014. The case study then aimed to pursuit three main goals. The first issues performed the linear regression models of gravity model of CR within European Union – EU28 group (27 countries – 405 observations). The goal here is to evaluate the trading relationship between Czech Republic and other EU member states. The second issues strived to evaluate the performance the linear relationship of Czech Republic with chosen trading partners outside of EU – non-EU28 group (18 countries – 270 observations). The last model of case study was to combined two previous models into overall trading performance of Czech Republic with combination of dataset (45 countries – 675 observations)

Each model was applied by the modified equation of gravity model where dependent variable is export (import) value and independent variables are chosen by GDP of each country, actual distance between Czech Republic and each specific country, dummy variables respectively related to common border, similarity of languages and specific year of entering European Union.

Before creating the models, the dataset was tested by correlation matrix of independent variable to detect and prevent the multicollinearity[2]. The main method was to compare the correlation value with criteria of $\pm$ 0.8. If the correlation value between two independent variables is in the interval of (-0.8, 0.8), two variable are not intercorrelated. If the correlation value is in the interval of $(-1, -0.8) \cap (0.8, 1)$, two variable are intercorrelated and result in multicollinearity. The independent variable should be modified to eliminate the multicollinearity[3].

The linear regression models were verified by statistical and econometrical verification. In the statistical verification, the regresson coefficients of independent variables were tested by comparing its related p-value with significant level of 5%. If the p-value is less than 0.05, the regression coefficients are statistically significant and being considered as influencing

[2] Norman J. Glickman, Edwin S. Mills. Econometric Analysis of Regional systems. Academic Press, Inc. 1997. ISBN: 0-12-286550-2. Chapter 2: Methods of regional economic analysis. E-book. Available at: http://www.sciencedirect.com/science/book/9780122865503. Page 13-77

[3] H.R. Seddighi, K.A. Lawler, A.V. Katos. Econometrics: A practical approach; Routledge publisher. 2000; ISBN 0-425-15644-0. Chapter 6. Page 95

factor to the dependent variable (export or import). If the p-value is higher than 0.05, the regression coefficients is statistically insignificant and being considered null value[4].

The econometrical verification aimed to clarify the fitness (reliability) of the gravity model by generating the coefficient of determinations R^2 and standard error of regression ε. The R^2 ($0 < R^2 < 1$) reflect how much of actual dependent variables can be explained by the linear model and the standard error of regresson indicate the interval of reliability, where dependent variable can fluctuate ($-\varepsilon$, $+\varepsilon$)[5]

The regression model were generated by two main software Microsoft Excel and Gretl in creating tables, graphs (figures) and conducting linear regression analysis.

[4] Sonia, Taylor. Business Statistics. 3rd ed. 2007; Plgrave Macmilan publisher. 2007; ISBN: 978-0-230-50646-6. Chapter 5. Page 60

[5] H.R. Seddighi, K.A. Lawler, A.V. Katos. Econometrics: A practical approach; Routledge publisher. 2000; ISBN 0-425-15644-0. Chapter 8. Page 160

3 Literature review

3.1. Brief history of international trade

It is undeniable to say that international trade plays a vital role in the world economy development. A record said the long route exchange of goods has appeared as long as the beginning of ancient civilizations and empires. However for the brief introduction of international trade, we can divide the time line into four period the ancient time, Middle Ages, and modern ages. The ancient time can be recorded from the beginning of trade until the collapse of Roman empires. The majority of trade movement was focused in Mediterranean area, India and Africa and the main exchanged goods were silk, spices, gold and incense. The international trade of middle ages was more active with the exchange of goods between China, India, European countries, Arabian countries and African countries. The main exchanged commodities were also increased by amount and diversity such as tea, rice and raw material for manufacturing. And lastly the modern ages, which begins since the discovery of American continents by Columbus, was considered the first step of international trade theory and development. Begins with theories of mercantilism, the opinions of trading theories kept developed further like theory of absolute advantage, comparative advantage and opportunity cost in production input[6],.. In this time, the European countries also began to colonize the other countries for the extraction of raw material and boosting the national trade and manufacturing. In the beginning of 20th centuries, the trade between countries was suffered as the first and second world war[7]. The exchange of goods was mainly focused into weapon and military equipment. Therefore after the Second World War, many international organizations were established to support and ensure the international trade securities between countries such as GATT (WTO), European Union (EU), and Association of Southeast Asian Nations (ASEAN)[8].

[6] https://www.academia.edu/8804175/A_Brief_History_of_International_Trade_Thought_From_Pre-Doctrinal_Contributions_to_Contemporary_Neoclassical_Economics

[7] Raul Prebisch, Economic theory and Mathematical Economics. (1972). Academic Press, Inc. United Kingdom Edition. ISBN: 72-87230. Chapter IV. Economic policy, foreign trade and development. E-book. Available at: http://www.sciencedirect.com/science/book/9780122164507. Page 154

[8] Council of economic advisers. Annual economic report. U.S government printing office. 2006. ISBN 0-16-075418-6. E-book. Available at: http://www.nber.org/erp/2006_erp.pdf . Chapter 7. Page 150

3.2. The effect of trading between countries

The understanding of import and export benefit can be simplified in the example of trade in individual product between two countries A and B. As the simplification of trade sample, there are several things should be considered. First the world only consists of two countries A and B. Second there is only one product, which is produced and consumed in both countries. Third two countries have a same converted currency. In the figure 1, there are two countries A (on the left side) and B (on the right side) in the world. Before international trade opens between these countries, the equilibrium in country A occurs at point IA where the price of certain quantity QA at the level of PA. With the same assumption of country B, equilibrium IB and price of product PB is identify in the figure 1. Country A has higher equilibrium price then country B, PA > PB. The difference of price PA and PB motivates the trade flow between two countries. Once the international trade opens, the consumers in country A tend to import more products from country B. The importation of products makes the suppliers in country A produce less from QA to Q1A while the quantity of good in the market after import is Q2A at cheaper price of world price PW. In contract, with motivation of purchasing from abroad, the suppliers in country B tend to produce more to export with higher price PW while the domestic demand in country B suffers from QB to Q2B.

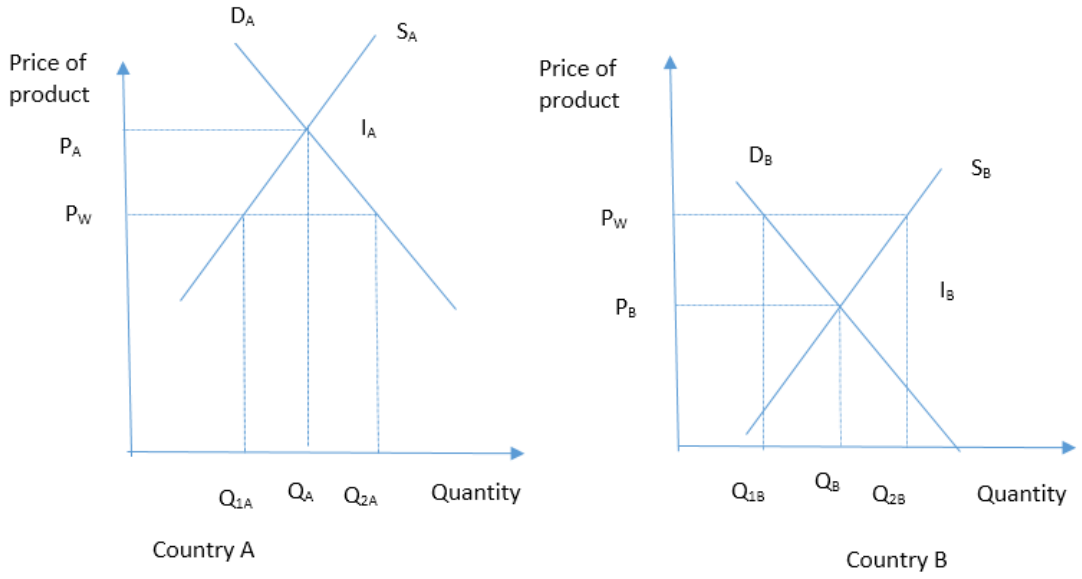

Figure 1 - Example of import and export between two countries A-B – ***source: own illustration***

In conclusion, when two countries open trade, the price of traded product rises in exporting country and falls in importing country, which results in common world price PW. In association with price increasing, the quantity of exchanged goods equal the difference of quantity supplied and quantity demanded in the market, import = export = $Q_2 - Q_1$. Also after the trade, the consumers in importing country are benefited as lower price and more available quantity in the market, while the suppliers suffer as lower market price. On the other side, the suppliers in exporting country enjoy more benefit and consumers are worse off as higher exporting price[9].

The economic effect of tariffs:

From the explanation above, the international trade creates enormous consumers demand in the importing country. However on the supply side, the producers suffer the losses of competitiveness. These losses can result in lower productivity and high unemployment rate. Therefore firms in an importing related industry face lower or even negative profit leading to bankruptcy. In reality, the trading between developing countries and developed countries dominates the worldwide flows of goods as 70% of trade volumes. The differences between labor wages in countries are clearly distinguished. To protect the domestic industry and work force, the importing countries have to apply the specific tariffs upon certain imported goods[10].

The graph in figure 2 illustrates the effect of imported tariff to domestic supply and demand of a certain good in country A (from figure 1). After applying the tariff, the domestic price is increased to a new level of Pt higher than world price PW. The new domestic price Pt also encourages firms to produce more to meet new domestic supply Q_3, which increase the suppliers' surplus in the area of "a". However, the quantity of imported good decreases from previous difference of quantity available with quantity supplied ($Q_2 - Q_1$) to new difference of available quantity available to quantity supplied ($Q_4 - Q_3$). This decreasing in quantity illustrate the diminishing of purchasing domestic purchasing power as lower

[9] W.Charles Sawyer, Richard L. Sprinkle; International Economics, 2nd edition. Pearson Education publisher. ISBN 0-13-170416-8. Chapter 2

[10] Salvatore, Dominick (2005), Introduction to International Economics (First ed.), Hoboken, NJ: Wiley, ISBN 0-471-20226-6. Chapter 4

consumers' surplus (a + b + c +d). The area "c" represents the government revenue when imposing imported tariffs. And areas "b + d" refer to the dead weight loss of a country, which overall is the negative result of total welfare when imposing tariff on imported goods[11].

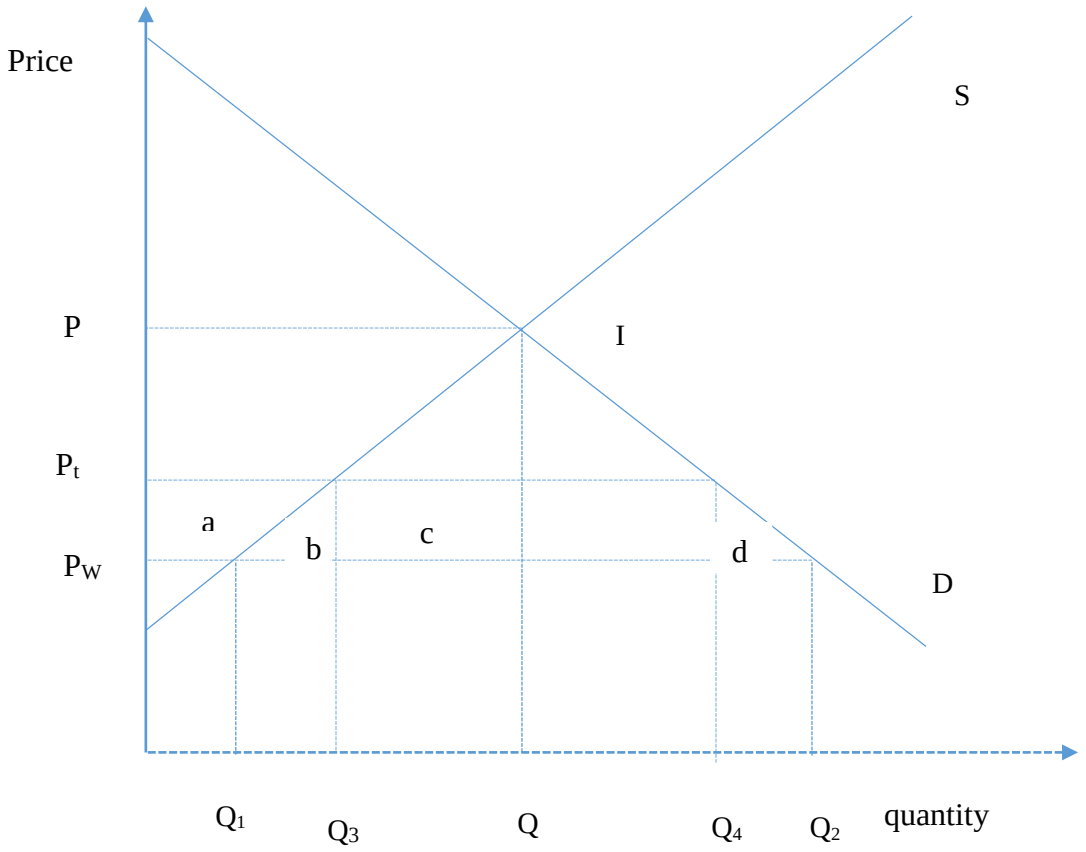

Figure 2- The effect of imposing tariff on the total welfare - *source: own illustration*

[11] W.Charles Sawyer, Richard L. Sprinkle; International Economics, 2nd edition. Pearson Education publisher. ISBN 0-13-170416-8. Chapter 6

3.3. Theory of international trade over time

3.3.1. Mercantilism:

Mercantilism was the earliest effort to develop the trade theory in western countries in sixteen century. The theory believed the nation's wealth was determined by its gold and silver holding. The export created the inflow of gold and silver, which meant foreigners' payment for domestic goods. And import created outflow of gold and silver, which meant domestic consumers' payment to foreigners for their goods. In another word, the country should promote exportaton and discourage importation from another country. From those reasons, the country should export more manufactured goods, which were produce from domestic market at higher price. And discouraging import meant imposing tariffs, quotas and focusing in importing raw material at lower price. Looking back at history of international trade above, the theory of mercantilism was flourished in the time of colonization, when western countries used their colonies to improve their national wealth by exploit the raw materials and export manufactured goods, which also included weapons and military equipment to increase national defense and maintain orders in colonies. Therefore, the countries could achieve the positive trade balance while utilizing the national employment. The philosophy of mercantilism was further developed into strategy of national economics so called protectionism and is still used today. In the modern thinking, protectionism helps countries to protect their key industries, which favor national economy and are partially applied to export-oriented countries like Japan, Taiwan, China and Germany[12].

3.3.2. Absolute advantage:

Absolute advantage was considered as the beginning of free trade theory. The concept was first introduced by Adam Smith in his publication An Inquiry into the Nature and Causes of the Wealth of Nations (1776), in which he questioned the theory of mercantilism. And in his book the wealth of nations, Adam Smith formulated the thinking of mutually trade between two countries[13]. The trade flows should not be regulated by government intervention and

[12] Allen, William R. "Mercantilism." Steve N. Durlauf, Lawrence E.Blume edition, The New Palgrave: A Dictionary of Economics 2010 version. Vol. 3. E-book. ESBN: 9780230301474

[13] Reinhard Schumacher. Adam Smith's theory of absolute advantage and the use of doxographu in the history of economics. Erasmus Journal of Philosophy and Economics. Volume 5, Issue 2. ISSN: 1876-9098.

restriction but should be driven by market forces. Here the concept of absolute advantage was illustrated as the ability of each country in using fewer resources to produce a good than other countries. In his theory of hypothetical world of two countries, Adam Smith reasoned that if country A had possibilities of producing one good (for example cloth) more effectively and efficiently, while country B had possibilities of producing another good (for example machine) better.

Table 1 - Example of production condition in each country

	One person per day of Labor produce	
	Machines	Cloth
Country A	2 machines	15 yards of cloth
Country B	5 machines	10 yards of cloth

Source: Own illustration

In the example of table 1, country A could produce either 2 machine or 15 yards of cloth in unit of one person per day. However country B could produce either 5 machines or 10 yards of cloth in the same unit of labor. Therefore country A had absolute advantage in producing cloth and country B had absolute advantage in producing machines. Assuming that trade opened between these two countries, country A should specialize in producing 15 yards of cloth and ignore in producing 2 machines and country B should specialize in producing 5 machines and ignore 10 yards of cloth. The result in table 2 was an increasing in total world output of 3 machines and 5 yards of cloth. In his concept of absolute advantage, Adam Smith explained the concept that upon the effective case of free trade, two countries could gain mutual benefit simultaneously[14].

Table 2 - Example of production condition in each country

	Change in production of output	
	Machines	Cloth
Country A	-2 machines	+15 yards of cloth
Country B	+5 machines	-10 yards of cloth
Change in world output	+3 machines	+5 yards of cloth

Source: Own illustration

[14] John M. Letiche, International economic policies and their theoretical foundations. 2nd edition. Academic Press, Inc. 1992. ISBN: 0-12-444281-1. Term of trade. Chapter 4: Development of gain from trade theory: Classical to modern literature. E-book. Available at: http://www.sciencedirect.com/science/book/9780124442818. Page 96

3.3.3. Comparative advantage:

From the theory of absolute advantage, there were some challenges that some countries may be better at producing in both goods and the other countries was less productive in producing both goods. Therefore, in 1817 David Ricardo introduced the comparative advantage theory, which explained when country was unable to produce a certain good as efficient as the other country, however it could produce that good more efficient than it could with other goods. Therefore when trade opened, two countries could still enjoy the benefit of increasing total output[15].

Table 3 - Example of production condition with opportunity cost

	One person per day of Labor produce		
	Machines	Cloth	Opportunity cost Machine with cloth
Country A	5 machines	15 yards of cloth	1M = 3C
Country B	1 machines	5 yards of cloth	1M = 5C

Source: Own illustration

Again assuming in simple model of two countries – world in table 3, country A had possibility of producing either 5 machines or 15 yards of cloth and country B only had possibility of producing either 1 machines or 5 yards of cloth by one person per day. Clearly country A had absolute advantage in producing both goods while country B had absolute disadvantage in producing both goods. However by analyzing the ability of labor force and specialization, country B could produce cloth more efficiently than machine. Each person in country could produce cloth in 1/5 of machine value. Therefore country B could transfer three labors into producing cloth and gain 15 yards of cloth. On the other hand, country A were more efficient in producing machines relatively compared to country B. in the end, country A could still specialize in producing machines and accept the foregoing of 15 yards of cloth, while country B could specialize in producing cloth and forego the machines. In the end, total world output was positive 2 machines (table 4)

[15] Author O'Shullivan, Steven M. Sheffrin. Economics: Principle in Actions. Pearson Prentice Hall. Wall Street Journal: Class Room Edition. ESBN: 0-13-133483-2. Chapter 11

Table 4 - Example of change to world output

	Change in production of output	
	Machines	Cloth
Country A	+5 machines	-15 yards of cloth
Country B	-3 machines	+15 yards of cloth
Change in world output	+2 machines	0 yards of cloth

Source: Own illustration

3.3.4. Heckscher-Ohlin Theory:

From the two theories of absolute advantage and comparative advantage above, there were several questions left unanswered. First problem was how a country can identify the products that gave it comparative advantage. Second problem was the theories only considered labor was the only factor of production in the national economy, how international trade effected or were affected by other factors of production such as technology and capital. In early 1900s, two Swedish economists, Eli Heckscher and Bertil Ohlin explained the deeper understanding of comparative advantage in their theory of factor proportions theory. They stated that a country should produce and export goods determined by its abundant resource endowments while import goods related to its resource of scarcity[16].

In Heckscher-Ohlin theory, all countries had the same technology in producing two goods in the same combination of factors of production (labor and capital). For example, producing cloth required 4 units of capital and 8 units of labor, while producing machine required 10 units of capital and 5 units labor. Eventually when comparing capital-to-labor ratio (unit of labor over unit of capital), machine was classified as capital intensive goods (10/5) and cloth was more labor intensive goods (4/8).

Table 5 - Example of production factor between two countries A&B

	Unit of capital	Unit of labor	Capital-to-labor ratio
Cloth	4	8	0.5
Machines	10	5	2
	Total units of capital	Total units of labor	Capital-to-labor ratio
Country A	80	200	0.4
Country B	60	100	0.6

Source: Own illustration

[16] Blaug, Mark (1992). The methodology of economics, or how economists explain. Cambridge University Press.Cambridge University Press. ISBN 0-521-43678-8.page 288

Assumption in their model of two countries – two goods (table 5), country A had total units of labor of 200 and total units of capital of 80; country B had total units of labor of 100 and total units of capital of 60. Country A had capital-to-labor ratio of 0.4 lower than country B's ration of 0.6. Therefore, country A was labor abundant compared to country B was capital abundant. From the theory country A should produce more cloth relatively and export cloth to country B, also import machine from country B. and vice versa country B should export more machine relatively and import cloth from country A[17].

3.3.5. Globalization and modern trend of international trade:

The term of globalization was introduced after the Second World War and widely used since the mid 1980s. Globalization refers to the growing interdepence of countries resulting from the intergration of trade, finance, people and ideas in one global market[18]. Classical theories of international trade above focused on the movement of goods between countries and assumed the factors of productions – labor and capital - were immobile. Traditionally, natural resources and raw material dominated the international trade. The developing countries exported natural resources and raw material to developed countries. And final products were manufactured and sold to the domestic market to support the local industry of developed countries. After the Second World War, multilateral agreements in regulations of international trade were adopted by the General Agreement on Tariff and Trade (GATT). These agreements created new trend of international trade, which was represented by liberalization of international trade, decrease in import tariff and significant growth of trade in manufactured goods. The new policy of multinational firms aimed to maximize the productions of goods in global market. The multinational firms allocated their facility at the places normally in developing countries, where they could ultimately minimize their productions and sold the final products back to developed countries to optimize profit[19]. The new trend of international trade was the main feature of globalization in the second half of

[17] Steve Suranovic. International trade: Theory and Policy. George Washington University. 2010, ISBN 13: 978-1-9361264-4-6. Chapter 5

[18] Tatyana P. Soubbotina, Katherine A. Sheram. Beyond Economic Growth: Meeting the Challenges of Global Development. The international Bank for Reconstruction and Development/The World Bank. ISBN: 0-8213-4853-1. Chapter 12. Globalization and International Trade. Page 66- 72.

[19] Raj Aggarwal, Jenny Berrill, Elaine Hutson, Colm Kearney. What is a multinational corporation? Classifying the degree of firm-level multinationality. International Business Review (2011). E-book. ISSN: 0969-5931. ELSEVIER publication. Volume 20. Issuse 5.

20th century. Therefore the economists selected new indicators which reflect the main feature of international trade[20]. Here the theory of gravity model was introduced and developed.

3.4. Gravity model of trade:

3.4.1. Origin of gravity model:

In the beginning of 20th centuries, many economists pointed out that Ricardian and Heckscher-Ohlin theory was incapable of explaining the modern international trade. In the previous theories, comparative advantage played a vital role in the trade flows. However, the modern trade flows was hardly be explained by country's advantage in factors of production. The modern consumers have variety of preferences over differentiated products because of higher development of information exchange, which means a country will consume at least some of every product from every country. The trade of all goods provides a far more complicated structure of trade. Therefore the behavior of trade should be determined by other factors, which can illustrate the deeper understanding of modern international trade flows[21].

The gravity model was based on the same function as the physical equation in "Law of Universal Gravitation" proposed by physician Issac Newton in 1687. It held that the attractive force between two objects i and j is given by

$$F_{ij} = G\frac{M_i M_j}{D_{ij}^2} \quad (1)$$

Where F_{ij} is attractive force, M_i and M_j are the masses of objects, D_{ij} is the distance between two objects and G is the gravitational constant[22].

The adaption of gravity model was first introduced by Jan Tinbergen in 1962. He proposed that the bilateral trade flows between countries is in proportion to their respective sizes of economy and distance. Over decades, the theory of gravity model was developed by many

[20] Irena Pekarskiene. The Assessment of Manifestation of Economic Globlaization: the international trade factor. Procedia – Social and Behavioral Sciences (2014).E-book. ELSEVIRE publication. ISSN: 1877-0428. Volume 156. Page 392 – 397.

[21] Head, Keith and Thierry Mayer, forthcoming, "Gravity Equations: Workhorse, Toolkit, Cook-book" Handbook of International Economics (2014). North-Holland publications. ISBN 978-0-444-54314-1. Volume 4. Page 50-72

[22] I.Bernard Cohen and Anne Whitman, translators: Isaac Newton, The Principia: Mathematical Principles of Natural Philosophy. Preceded by A Guide to Newton's Principia, by I.Bernard Cohen. University of California Press 1999 ISBN 0-520-08816-6. Page 956.

economists and in 2003, two economist Anderson and van Wincoop developed the most stable form of gravity model:

$$X_{ij} = \frac{Y_i Y_j}{Y}\left(\frac{t_{ij}}{R_i R_j}\right)^{(1-\sigma)} \quad (2)$$

Where X_{ij} is the trade flows between two countries, Y is world GDP, Y_i and Y_j are the GDP of countries i and j, t_{ij} is bilateral trade resistance, R_iR_j is multilateral trade resistance of countries i and j. $\sigma > 1$ is the constant elasticity of substitution[23].

The adaption of gravity model has created the extraordinary stability of empirical analysis. When consumers has variety of preferences over differentiated products, the demand for goods are also increased. Eventually this will boost import and export of a country, which contribute into national income. For this larger country import and export more. However trade cost is an obstacle in international trade. The larger distance between countries, the higher trade cost that reduce the movement of exchanged goods[24].

3.4.2. Elements of gravity model:

3.4.2.1 The trade flows:

In the gravity model, the trade flow consists of export and import. These inflow and outflow of goods and services represent the demand and supply forces. The consumers' demand from country i encourage the import from country j, while the country with huge supply also has more motivation to export goods and services to another country. Therefore import and export indicate the interaction between countries. In the other word, trade flows is the attractive forces between two countries in the gravity model[25].

[23] Anderson, J., van Wincoop, E. "Gravity with Gravitas: A Solution to the Border Puzzle." American Economic Review. 2003. Volume 93.page 170. Available at: http://www.econ.ku.dk/nguyen/teaching/Anderson%20van%20Wincoop%202003%20Gravitas.pdf

[24] Marie-Lise E.H. van Veenstra, Mina Yakop, Peter A.G van Bergeijk. "Economic Diplomacy, the Level of Development and Trade."Discussion papers in Diplomacy. Netherlands Institute of International Relations 'Clingedael'. ISSN 1569-2987. Available at:http://www.clingendael.nl/sites/default/files/ 20101000_cdsp_artikel_%20van%20Veenstra,%20Yakop%20and%20van%20Bergeijk.pdf. page 13

[25] Andreas Maurer, Christophe Degain. Staff Working Paper: "Globalization and trade flows: what you see is not what you get!" World Trade Organization: Economic Research and Statistics Division. 2010. Available at: https://www.wto.org/english/res_e/reser_e/ersd201012_e.pdf. Page 6

3.4.2.2 Gross domestic product:

This is the second element, which indicates the economic health of a country. GDP is the monetary value of all finished goods and services produced within a country's border for a period of time. Being calculated from domestic consumption, government expenditure, net export and investment, GDP measures the size of national economy[26]. When country i export to country j, GDPi represents its willingness to supply and GDPj represent the domestic demand of country j and vice versa. From the equation (2), GDP of countries has positive influence upon bilateral trade flow. Meanwhile world GDP has negative impact upon bilateral trade flow, because ceteris paribus if world GDP is bigger, the share of each country in the world is smaller and the bilateral trade flow will also be relatively decreased.

3.4.2.3 Trade resistance:

The distance between two objects in the equation (1) is replaced by trade resistance in gravity model of trade. Those are the factors from inside and outside two countries relationship, which lower the potential trade flows[27].

a. Bilateral trade resistance:

Bilateral trade resistance refers to trade cost between two countries. Higher trade cost usually reduce the expected trade flows. In order to capture the overall picture of trade cost, the actual distance, geographical characteristics and even cultural difference should be taken into the account.

b. Distance between countries:

The distance directly influences the trade cost. The farther distance between countries, the higher transportation cost, which results in significant reduction of attractive force. On the other side, common border reduces the transportation and information cost and greatly encourage the bilateral trade of goods and services.

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[26] Micheal Moffett, Arthur Stonehill, David Eiteman; Fundamentals of multinational finance, 2nd edition. Pearson Education publisher. ISBN: 0-321-28031-8. Page 76. Chapter 3

[27] Keith Head. Article: "Gravity for beginners" Handbook of International Economics Volume 2 edition. Gopinath, Helpman, Rogoff. Available at: http://web.efzg.hr/dok/me_gravity%20for%20begin.pdf

c. Common languages:

Consumers and firms in common languages or relevant cultural features are likely to know more about each other and understand the consuming behaviors. In contract differences in languages and culture create more barriers in information exchange and increase in trade cost. [28]

d. Geographical characteristic:

Geographical characteristic refers to location of countries in the world. Landlocked country or islands greatly impact the transportation cost and information exchange. Eventually the associated trade cost is expected to be higher and interrupt the trade flows.

e. Regional trade agreement:

One of the most important trends in the global economy is the increasing number of regional trade agreements between countries. Two member countries under of common trade agreements enjoy the advantage of trade tariff reduction. Because of tariff barriers of a country are normally hard to be captured as a whole, the condition for trade agreement is easier to include into the gravity model.[29]

f. Multilateral trade resistance:

One of the biggest obstacles in application of gravity model is to identify the multilateral trade resistance. When bilateral trade between two countries occurs, the multilateral indicates how the each country trade with the rest of the world affects the bilateral trade flows. Normally multilateral has positive impact upon the bilateral trade flow. Higher multilateral resistance represents the stronger trading relationship between two countries, because each country create more barrier toward the third country. However this factor is not observable. Therefore it is usually simplified into combination with bilateral trade resistance to create the common trade resistance in the gravity model[30].

[28] Min Zhou. Intensification of geo-cultural homophily in global trade: Evidence from the gravity model. Social Science Research. Volume 40. E-book.ELSEVIER publication. ISSN: 0049-089X.
[29] Vincent Vicard. Determinants of successful regional trade agreements. Economics Letter. Volume 68. E-book. Available at: http://www.sciencedirect.com.infozdroje.czu.cz/science/article/pii/S0014292114000208
[30] Juan M. Ruiz, Josep M. Vilarrubia. "The wise use of dummies in gravity models: export potentials in the Euromed region". Unidad Publication, Madrid. ESBN: 0213-2710. Page 19

3.4.3. Estimating the gravity model:

From the equation (2) of gravity model above

$$X_{ij} = \frac{Y_i Y_j}{Y}\left(\frac{t_{ij}}{R_i R_j}\right)^{(1-\sigma)} (2)$$

Where X_{ij} is the trade flows between two countries, Y is world GDP, Y_i and Y_j are the GDP of countries i and j, tij is bilateral trade resistance, R_iR_j is multilateral trade resistance of countries i and j. $\sigma > 1$ is the constant elasticity of substitution.

The standard procedure for estimating is to simplified it into natural logarithms of all variables into log linear form of

$$lnX_{ij} = a_0 + a_1 \ln GDP_i + a_2 lnGDP_j + a_3 \ln t_{ij} + \varepsilon \ (3)$$

Where X_{ij} is the natural logarithms of trade flows value between two countries i and j, $lnGDP_i$ and $lnGDP_j$ respectively are natural logarithms of GDP in each country i and j. lnt_{ij} is the natural logarithms of trade resistance between two countries. a_0,a_1 ,a_2 ,a_3 are generated parameters from regression model. And *ε is* error term[31].

In the definition of the trade resistance in general, the variable consists of distance, common border, common languages, geographical characteristics and regional trade agreement. So t_{ij} is recalculated in more detail form with 4 dummy variables:

$$t_{ij} = d_{ij}^{a_3}.e^{b_1 cmbd + b_2 lang + b_3 landlock + b_4 RTA} \ (4)$$

Where t_{ij} is trade resistance between two countries, d_{ij} is the distance between two countries (measured from capital of one country to another), the dummy variables cmdb, lang, landlock, RTA stand for common border, common languages, geographical characteristic and regional trade agreement. From the two equations (3) and (4), a new model gravity of trade is reformulated into[32]:

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[31] Joao Santos Silva, Silvana Tereyro. Article: "The Log of Gravity".The Review of Economics and Statistics. November 2006. E-book. E-ISBN: 1530-9142. Page 649. Available at: http://personal.lse.ac.uk/tenreyro/jensen08k.pdf

[32] Marc Bacchetta, Cisuni Beverelli, Olivier Cadot, Roberta Piermartini. A Practical Guide to Trade Policy Analysis. WTO publications. 2012. WTO ISBN 978-92-870-3812-8. E-book. Available at: https://www.wto.org/english/res_e/publications_e/wto_unctad12_e.pdf. Page 107-108.

$$lnX_{ij} = a_0 + a_1 \, ln \, GDP_i + a_2 lnGDP_j + a_3 ln \, d_{ij} + b_1 cmbd + b_2 lang$$
$$+ b_3 \, landlock + b_4 \, RTA + c \, year + \varepsilon$$

Where

X_{ij} is the natural logarithms of trade flows value between two countries i and j,

$lnGDP_i$ and $lnGDP_j$ respectively are natural logarithms of GDP in each country i and j.

$ln \, d_{ij}$ is the natural logarithm value of distance between countries.

a0, a1, a2, a3 are generated parameters of the related input variables from regression model,

b1, b2, b3 , b4 are generated parameters of dummy variables.

cmbd (1 – when two countries have a common border, 0 – otherwise)

lang (1 – when two countries has a similar native languages, 0 – otherwise)

RTA (1 – when two countries engage in RTA, 0 – otherwise)

Landlock (1 – when one of two country is island or in landlocked area, 0 – otherwise)

year is time vector (2000 = 1, 2001 = 2,… 2014 = 15)

c is the generated parameters of time vector

ε is error term.

4 Case study

Czech Republic is a developed country in the central area of Europe. With population of more than 10 millions inhabitants and GDP of 285 billions USD (2012), Czech Republic is catergorized in high income and high living standard country. However, the national economy fluctuated due to its complex change in regime and government policies over time. Notably, since the seperation with Slovakia in 1993, CR began the new economic and politic reform[33]. Over year, the economic structure changed to adapt the enomous trade flow of goods and services with western countries. In 2004, the country became the official member of European Union, a single market that empowers the trade and economic activities within the member state[34]. Therefore like majority of other countries, the sectoral structure of national economy is roughly 37% of industry, 3% of agriculture and 60% of service[35].

After joining EU, Czech Repubic provided excellent logistics centers for numerous distribution sites connecting Eastern and Western Eupean countries. Because of long industry tradition, Czech Republic helped EU stays technologically competitive and productive in the global market[36]. EU accession greatly supported the globalization process of CR. The producers and entrepreneurs of CR had more opportunity to exploit larger market. The consumers also were benefited lower price and wider choice of goods and services. Overall, globalization significantly boosted economic growth and trade flow of CR as well as other member states of EU28. However, globalization also granted easier access for other countries to CR markets. Facing the fierce competition in global scale, rising in importation had threathened local enterprises in unskilled job (textile, agricultural,…). In contract, CR had more comparative advantages in labor force from high educated sector (machinery, industrial equipment, and engineering)[37].

[33] Jan Bruha, Jiri Podpiera, Stanislav Polak. The convergence dynamics of a transition economy: The case of Czech Republic. Economic Modelling. Volume 27, 2010. E-book. Available at: http://www.sciencedirect.com/science/article/pii/S0264999309001394#

[34] International Monetary Fund, 2012. 'Czech Republic – 2012 Article IV Consultation Concluding Statement', IMF News : IMF website. Available at: http://www.imf.org/external/np/ms/2012/022712.htm

[35] Index of Economic Freedom: Outline of Czech Republic. 2015. Internet source. Available at: http://www.heritage.org/index/country/czechrepublic

[36] World Bank Summary Report. Czech Republic: Toward EU Accession. World Bank publication (1999). ISBN: 0-8213-4589-3. Page 15

[37] Marina Mastrostefano, Lewis Dijkstra, Hugo Poelman. Regions 2020. Globalistion challenges for European Regions. Commission of the European Community (2009). Online article. Available at: http://ec.europa.eu/regional_policy/sources/docoffic/working/regions2020/pdf/regions2020_globalisation.pdf

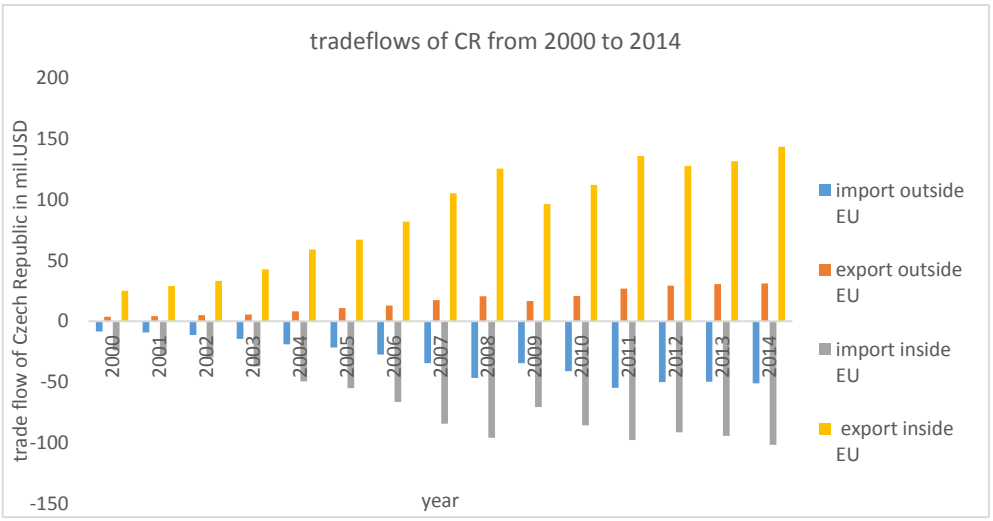


Figure 3 - Emport and export of Czech Republic to countries inside and outside EU28 – *sources: Czech statistical office*

Even though from the figure, CR faced the trade deficit with countries outside EU28. The total export of CR exceeded total import over years, which resulted from the surplus of CR export to EU28. The trading relationship of CR with other EU member states dominates the total world trade (roughly 85% of export and 71% of import). Due to its location, CR is specially opened to international trade of goods and services. As one of the advanced industrialized countries, the country engages in exporting the manufactured goods in production of automobiles, furnitures, chemical and electrical appliances. In return, the country also imports variety of commodities such as machinery, transportation equipment, chemical equipment, fuels, raw material and textiles[38].

Table 6 - The tradeflows of CR inside EU28 and the world

Year	Export EU in mil. USD	Import EU in mil.USD	Net balance	Total export	Total import	Total net balance	%export EU/world	%import EU/world
2000	25 088.12	-23 866.58	1 221.54	28 997.39	-32 058.02	-3 060.63	86.52%	74.45%
2001	29 048.47	-27 246.74	1 801.73	33 358.21	-36 431.23	-3 073.02	87.08%	74.79%
2002	33 221.79	-29 568.28	3 653.51	38 459.63	-40 691.98	-2 232.35	86.38%	72.66%
2003	42 811.52	-36 836.00	5 975.53	48 576.28	-51 179.87	-2 603.59	88.13%	71.97%
2004	58 901.71	-49 319.95	9 581.76	67 135.07	-68 140.41	-1 005.34	87.74%	72.38%

[38] Eurostat, European Commission. External and intra-European Union trade. 2010 edition. Publications office of the European Union. Luxembourg. 2011. ISBN: 978-92-79-16352-4

2005	67 102.06	-54 699.96	12 402.11	77 928.40	-76 248.67	1 679.73	86.11%	71.74%
2006	81 974.95	-66 130.99	15 843.95	95 091.70	-93 323.42	1 768.28	86.21%	70.86%
2007	105220.36	-83 931.16	21 289.19	122705.50	-118 299.13	4 406.37	85.75%	70.95%
2008	125452.03	-95 532.97	29 919.06	146107.07	-141 872.57	4 234.50	85.86%	67.34%
2009	96 308.42	-70 431.20	25 877.22	113122.25	-104 824.74	8 297.51	85.14%	67.19%
2010	112137.70	-85 251.83	26 885.87	132933.30	-126 133.18	6 800.12	84.36%	67.59%
2011	135754.91	-97 290.92	38 463.99	162794.43	-151 713.63	11 080.80	83.39%	64.13%
2012	127673.89	-91 018.25	36 655.65	157035.51	-140 886.66	16 148.85	81.30%	64.60%
2013	131548.59	-94 109.12	37 439.47	162181.24	-143 590.91	18 590.33	81.11%	65.54%
2014	143310.78	-101 430.66	41 880.12	174336.54	-152 247.71	22 088.83	82.20%	66.62%

Data was collected from Czech statistical office and own computation

4.1.International trade of CR within EU28

The time line from 2000 to 2010 can be divided into three specific periods; 2000-2004, 2004-2009 and 2009-2014. The first period from 2000-2004 was considered as pre-EU accession. CR was in a group of CEEC5 (Central and Eastern European countries /CR, Slovakia, Slovenia, Poland, Estonia)[39]. The main object was to implement the preparation of EU-accession in 2004 with adjustment of exchange rate regime and macroeconomic policies. The second period from 2004 to 2009, after becoming EU member state, CR maintained its pegged exchange rate with Euro currency and became more open to market outside European Union as the share with EU28 trade began to drop from 88% (2004) to 85% (2009)[40]. However the financial crisis in 2008/2009 also damaged the trade flow of Czech Republic drastically as both import and export suffered the declining in value from 125 000 mil. USD (2008) to 96 mil. USD (2009). The third period started from 2009 until 2014, as the economy recover, CR began to interact more with countries outside EU and both export and import with other EU28 partners drop to 81% even though the total value kept increasing over years.

4.1.1. Dataset and gravity model

The data was collected from available statistic data of Czech statistical office, National account main aggregates database and Eurostat website to conduct the empirical analysis of international trade of Czech Republic from 2000 to 2014 into the dataset of 406 observations. For each year, the table of dataset gathered the GDP of CR, GDP of each countries in EU28 (Austria, Belgium, Bulgaria, Croatia, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, Netherland, Poland, Portugal, Romania, Slovenia, Slovakia, Spain, Sweden, UK)[41], the distance from Prague toward each partners' main cities respectively in the record of GDPcz, GDP in bil. USD, distance in km.

[39] Robert J. Corker, Craig Beaumont, Rachel van Elkan, Dora M. Iakova. Exchange rate regimes in selected advanced transition economies – Copingwith Transition, Capital inflows and EU accession (2000). IMF publication. ISSN: 1934 – 7456.
[40] Jana Simkaova, Daniel Stavarek. Exchange-Rate impact on Industry-Level trade flows in the Czech Republic. Procedia Economics and Finance. ELSEVIER publication (2014). E-book. ISSN: 2212-5671. Volume 12. Page 679 – 686.
[41] Elena-Daniela Viorica, Econometric Analysis of Foreign Trade efficiency of E.U Members Using Gravity Equations. Procedia Economics and Finance. Volime 20. Page 670-678. 2015. ISSN: 2212-5671

For the purpose of applying of gravity model into linear regression analysis, the dataset of *export (import) in mil. USD, GDPcz, GDP in bil. USD, distance in km* was required to be transited into natural logarithm value as *lnX, ln_GDPcz, ln_GDP, ln_d_{ij}*

$$lnX = a_0 + a_1\, ln\_GDP_{cz} + a_2 ln\_GDP_j + a_3 ln\, d + b_1\, Currency + b_2 cmbd + b_3 lang + b_4\, landlock + b_5\, RTA + c*year + \varepsilon$$

Where: *lnX* is the natural logarithms of export or import value between two countries CR and each partner in EU28

ln_GDP$_{cz}$ and ln_GDP$_j$ respectively are natural logarithms of GDP in CR and each partner in EU28.

ln d is the natural logarithm value of distance between countries.

a_0, a_1, a_2, a_3 are generated parameters of the related input variables from regression model,

b_1, b_2, b_3 , b_4, b_5 are generated parameters of dummy variables.

currency EU (1 – when partners adopted Euro, 0 – otherwise)

cmbd (1 – when a partner has common border with CR, 0 – otherwise)

lang (1 – when a partner's native languages is in Slavic system, 0 – otherwise)

RTA (1 – when a partner's joined EU, 0 – otherwise)

Landlock (1 – when the partner's location is island or sea travel, 0 – otherwise)

year is time vector (2000 = 1, 2001 = 2,… 2014 = 15)

c is the generated parameters of time vector

ε is error term.

The collected data was checked for the multicollinearity before putting into the program to generate the regression model. After checking with correlated criteria of ±0.8, the correlation matrix did not detect any intercorrelated variable in the dataset

Table 7 - EU28: correlation matrix of independent variables

	lnGDPcz	*lnGDP*	*lndis*	*currency EU*	*cmbd*	*Lang*	*landlock*	*RTA1*
lnGDPcz	1.000							
lnGDP	0.198	1.000						
Lndis	0.001	-0.154	1.000					
currency EU	0.152	0.394	0.070	1.000				
Cmbd	0.001	0.248	-0.619	0.273	1.000			
Lang	0.001	-0.240	-0.234	-0.372	0.070	1.000		
Landlock	0.001	-0.035	0.392	-0.124	-0.247	-0.282	1.000	
RTA1	0.449	0.458	0.069	0.450	0.102	-0.357	0.130	1.000

Source: table generated from Microsoft excel- United National Statistics Division

4.1.2. The exportation of Czech Republic to EU28

Interrelationship with other core gravity elements:

From figure 4 of Czech export toward the partners in EU, the trend linear function is generated as Y1 = -7.0707x1 + 11731 for its relationship with partners' distance and Y2 = 6.9861x2 + 316.96 for its relationship with partners' GDP. In the trading with EU, Germany, Poland, and Slovakia were recorded as the biggest export partners (40%, 6% and 10% of total export value). In comparison of Germany and other big countries in EU (UK, France, Spain,…) toward CR, Germany dominated the export flows as higher GDP and lower distance.

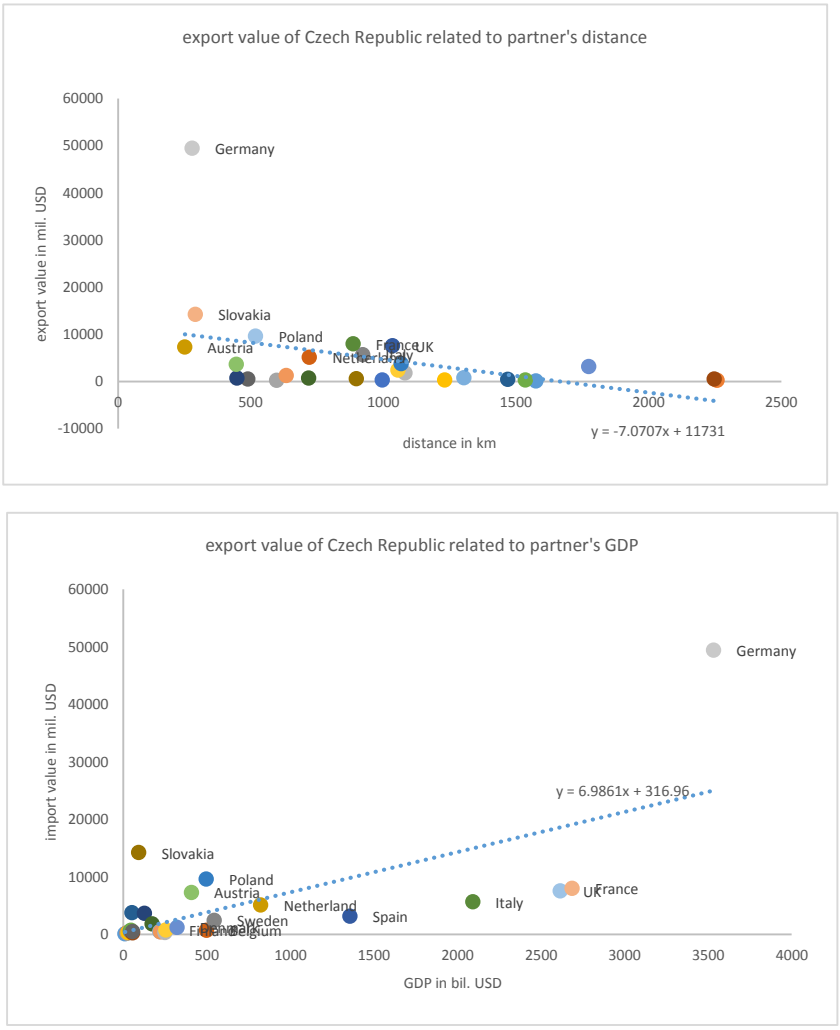


Figure 4 – EU28: Linear relationship between exportation with GDP and distance of CR – *source: Czech statistical office - United National Statistics Division*

Linear regression of exportation EU28

Statistical verification

From the table 7, when p-value was compared with level of significant 5%, the GDP of CR, GDP of partner, distance, Euro currency, common border, languages, landlock location were statistically significant to exportation of CR to partners in EU28. Only the coefficient of RTA (regional trade agreement) was not statistically significant or being considered as null value.

Econometrical verification:

The R2 value coefficient of determination 0.87 is the value illustrates the fitness of generated model. In the other words, all the generated values of CR export toward the partners in EU28 can explain 86% of actual export of CR in EU28 in the real life with the tolerant value of S.E of regression (standard error) is 0.674486 or $e^{0.674486}$ = 1.963 million USD.

Table 8 - EU28 exportation: table of regression result

	Coefficient	*t-ratio*	*p-value*
const	*4.37198*	*4.2451*	*0.00003****
lnGDPcz	*0.48202*	*2.3007*	*0.02193***
lnGDP	*0.781513*	*33.1721*	*<0.00001****
Lnd	*−0.584717*	*-7.0897*	*<0.00001****
currencyEU	*−0.921444*	*-10.2392*	*<0.00001****
cmbd	*1.23942*	*9.3310*	*<0.00001****
lang	*0.208934*	*2.0117*	*0.04494***
landlock	*−0.6586*	*-7.3242*	*<0.00001****
RTA	*−0.126124*	*-0.9963*	*0.31970*
year	*0.0503081*	*2.1946*	*0.02878***

**** Statistically significant at 1%, ** statistically significant at 5%,* Statistically significant at 10%*

Mean dependent var	6.687606		S.D. dependent var	1.828573
Sum squared resid	179.2430		S.E. of regression	0.674486
R-squared	0.866981		Adjusted R-squared	0.863943

Source: generated from Gretl software

From the result of regression, the function of gravity model of CR exportation to EU was written as:

lnX_{ex}= ***4.37*** + ***0.48 ln_GDP$_{cz}$*** + ***0.78 ln_GDP$_j$*** – ***0.58 ln d -0.92 Currency*** + ***1.23 cmbd*** + *0.2 lang* ***-0.66 landlock -0.13 RTA*** + ***0.05 year*** ± *ln 1.936*

Where

lnX_{im} is the natural logarithms of import value of countries CR from each partner in EU28

ln_GDP$_{cz}$ and ln_GDP_j respectively are natural logarithms of GDP in CR and each partner in EU28.

ln d is the natural logarithm value of distance between countries.

currency EU (1 – when partners adopted Euro, 0 – otherwise)

cmbd (1 – when a partner has common border with CR, 0 – otherwise)

lang (1 – when a partner's native languages is in Slavic system, 0 – otherwise)

Landlock (1 – when the partner's location is island or sea travel, 0 – otherwise)

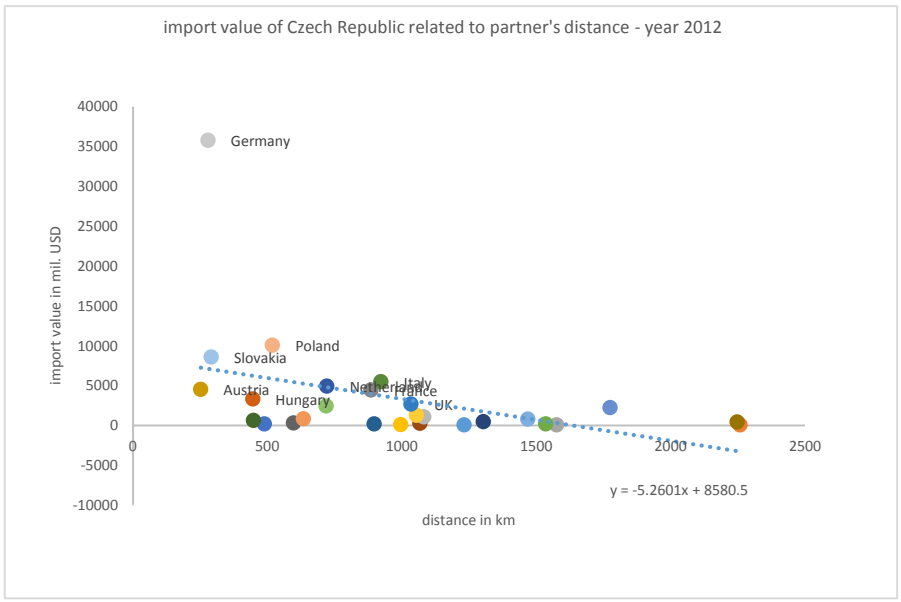
RTA (1 – when a partner's joined EU, 0 – otherwise)

year is time vector (2000 = 1, 2001 = 2,… 2014 = 15)

(the **bold number** and **letter** indicate statistically significant values (p-value < 5%))

4.1.3. The importation of Czech Republic from EU28

In the same argument with exportation case, the importation of CR toward EU partners experienced the same relationship of distance and GDP of partners related to import value. The two linear functions were created to illustrate the negative effect of distance upon import value (y = -5.2601x + 8580.5) and positive effect of partner's GDP upon import value (y = 4.8768x + 291.35)



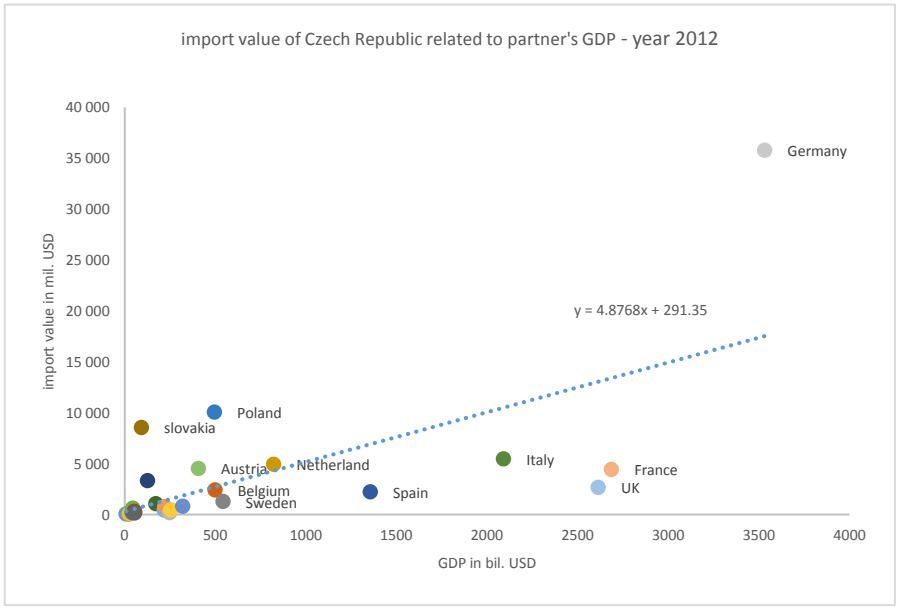


Figure 5 - EU28: linear relationship between importation with GDP and distance - *source: Czech statistical office - United National Statistics Division*

Linear regression model of importation EU28

Statistical verification:

From the comparison of p-value with significant level of 5%, the parameters of partner's GDP, distance between countries, dummy variable of common border, languages, regional trade agreement are statistically significant to the import flows from EU28 to CR. Meanwhile parameter related to GDP of CR, dummy variable of Euro adoption, landlocked location are statistically insignificant to importation from other countries of EU28 to CR.

Econometrical verification:

The coefficient of determination in the import model ~0.90 indicates the fitness of model upon real data. Like in the export model, the generated data of import can be used to explain 90% of actual data import of CR from other member states of EU28. And the standard error of regression 0.638571 indicates the tolerance of error value in $e^{0.638571}$ or equal 1.894 million USD.

Table 9 - EU28 importation: table of regression result

	Coefficient	*t-ratio*	*p-value*
const	8.98691	9.2170	<0.00001***
lnGDPcz	0.0734308	0.3702	0.71144
lnGDP	0.844073	37.8426	<0.00001***
lndis	−1.21962	-15.6195	<0.00001***
currencyEU	−0.00609663	-0.0716	0.94299
cmbd	0.458811	3.6484	0.00030***
lang	0.512154	5.2085	<0.00001***
landlock	0.0114599	0.1346	0.89299
RTA	0.38803	3.2377	0.00131***
year	0.04282	1.9730	0.04920**

**** Statistically significant at 1%, ** statistically significant at 5%,* Statistically significant at 10%*

Mean dependent var	6.266072		S.D. dependent var	1.984902
Sum squared resid	160.6627		S.E. of regression	0.638571
R-squared	0.898811		Adjusted R-squared	0.896500

Source: generated from Gretl software

From the result of regression, the function of gravity model of CR importation from EU28 was written as:

lnX_{im}= ***8.986*** + ***0.07 ln_GDP$_{cz}$*** + ***0.84 ln_GDP$_j$*** – ***1.22 ln d*** *-0.006 Currency* + ***0.45 cmbd*** + ***0.51 lang*** *-0.01 landlock* - ***0.39 RTA*** + ***0.042 year*** ± *ln 1.894*

Where

lnX_{im} is the natural logarithms of import value of countries CR from each partner in EU28

ln_GDP$_{cz}$ and ln_GDP_j respectively are natural logarithms of GDP in CR and each partner in EU28.

ln d is the natural logarithm value of distance between countries.

currency EU (1 – when partners adopted Euro, 0 – otherwise)

cmbd (1 – when a partner has common border with CR, 0 – otherwise)

lang (1 – when a partner's native languages is in Slavic system, 0 – otherwise)

Landlock (1 – when the partner's location is island or sea travel, 0 – otherwise)

RTA (1 – when a partner's joined EU, 0 – otherwise)

year is time vector (2000 = 1, 2001 = 2,… 2014 = 15)

(the **bold number** and **letter** indicate statistically significant values (p-value < 5%))

4.1.4. The result of linear regresson model of trade with EU28:

After the statistical and econometrical verification, the linear regression models of export and import of CR within EU28 are reformulated as below:

lnX_{ex} = ***4.37 + 0.48 ln_GDP$_{cz}$ + 0.78 ln_GDP$_j$ – 0.58 lnd -0.92 Currency + 1.23 cmbd + 0.2 lang - 0.65 landlock*** *- 0.12 RTA* ***+ 0.05 year*** ± *ln 1.936*

lnX_{im} = ***8.986*** *+ 0.07 ln_GDP$_{cz}$* + ***0.84 ln_GDP$_j$*** *–* ***1.22 ln d*** *-0.006 Currency +* ***0.45 cmbd + 0.51 lang*** *-0.01 landlock* ***- 0.39 RTA*** *+* ***0.042 year*** ± *ln 1.894*

Where

lnX_{ex} is the natural logarithms of export value of countries CR from each partner in EU28

lnX_{im} is the natural logarithms of import value of countries CR from each partner in EU28

ln_GDP$_{cz}$ and ln_GDP$_j$ respectively are natural logarithms of GDP in CR and each partner in EU28.

ln d is the natural logarithm value of distance between countries.

currency EU (1 – when partners adopted Euro, 0 – otherwise)

cmbd (1 – when a partner has common border with CR, 0 – otherwise)

lang (1 – when a partner's native languages is in Slavic system, 0 – otherwise)

Landlock (1 – when the partner's location is island or sea travel, 0 – otherwise)

RTA (1 – when a partner's joined EU, 0 – otherwise)

year is time vector (2000 = 1, 2001 = 2,… 2014 = 15)

(the **bold number** and **letter** indicate statistically significant values (p-value < 5%))

From the two models, the statistically significant independent variables are GDP of partners, distance between two countries, common border factor and languages factors. While the GDP of CR was statistically insignificant in importation, and less important compared to GDP of other countries in EU28 (0.48 < 0.78). Therefore GDP of partners, common border factors and languages factor enhanced the trade flows of CR (in both importation and exportation) and the distance between countries discourage the trade flows of CR. Also the GDP of partner had more statistical impacts on trade flows then the GDP of CR. The coefficient of determination R^2 in both models were very high value 0.87 and 0.90, which proved high reliability of gravity model in the case of EU28.

4.2.International trade of Czech Republic outside the European Union/non-EU28:

Apply the same function as gravity model of trade flows between CR and EU28, the data was collected from available statistic data of Czech statistical office, National account main aggregates database and Eurostat website to conduct the empirical analysis of international trade of Czech Republic from 2000 to 2014 into the dataset of 270 observations. For each year, the table of dataset gathered GDP of CR, GDP of 18 top countries with highest export and import value to CR (China, US, Russia, Azerbaijan, Belarus, Israel, India, Japan, Kazakhstan, Mexico, Malaysia, Singapore, Thailand, Turkey, Ukraine, Vietnam) and the distance from Prague toward each partners' main cities respectively in the record of *GDPcz, GDP in bil. USD, distance in km.*

Since none of group non-EU28 uses Euro currency and being bordered with CR, the dummy related to these variable were also be excluded out of the gravity model. After modifying into natural logarithm for the conducting of linear regression analysis, the gravity model has the formulated as below:

$lnX = a_0 + a_1\ ln\_GDP_{cz} + a_2 ln\_GDP_j + a_3 ln\ d + b_1 lang + b_2\ landlock + b_3\ RTA + c*year + \varepsilon$

Where

lnX is the natural logarithms of export or import value between two countries CR and each partner in non-EU28

ln_GDP_{cz} and $\ln\_GDP_j$ respectively are natural logarithms of GDP in CR and each partner in non-EU28.

ln d is the natural logarithm value of distance between countries.

a_0, a_1, a_2, a_3 are generated parameters of the related input variables from regression model,

b_1, b_2, b_3 are generated parameters of dummy variables.

lang (1 – when a partner's native languages is in Slavic system, 0 – otherwise)

Landlock (1 – when the partner's location is island or sea travel, 0 – otherwise)

RTA (1 – when CR joined EU, 0 – otherwise)

year is time vector (2000 = 1, 2001 = 2,… 2014 = 15)

c is the generated parameters of time vector

ε *is* error term.

The collected was checked for the multicollinearity before putting into the program to generate the regression model. After checking with correlated criteria of ±0.8, the correlation matrix did not detect any intercorrelated variable in the dataset

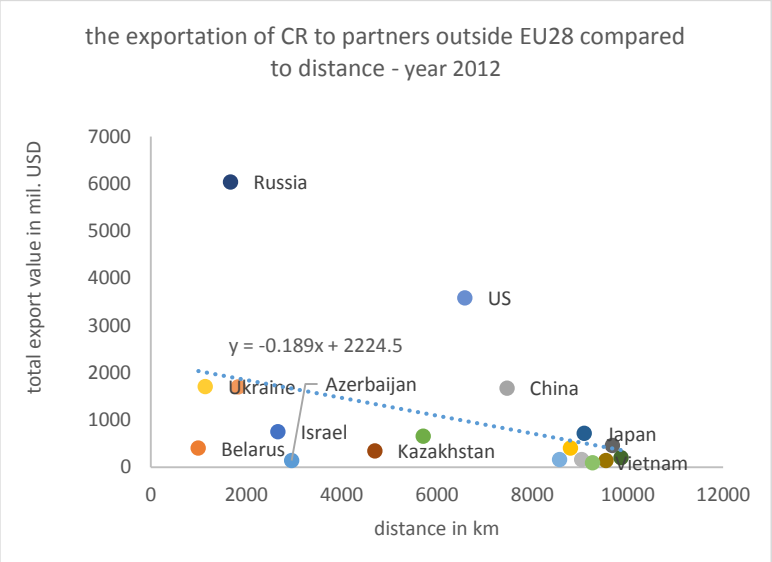
Table 10 -Non- EU28: correlation matrix of independent variables

	lnGDPcz	*lnGDP*	*lndistance*	*landlock*	*lang*	*RTA1*
lnGDPcz	1.0000					
lnGDP	0.2634	1.0000				
lndistance	0.0000	0.3271	1.0000			
landlock	0.0000	0.1242	0.6017	1.0000		
lang	0.0000	-0.4768	-0.7295	-0.4385	1.0000	
RTA1	0.4845	0.1114	0.0000	0.0000	0.0000	1.0000

Source: table generated from MS Excel

4.2.1. Exportation of CR to non-EU28:

The value of export outside EU was relatively small and contributed roughly 20% of total export recently. However since CR is in a trade route connecting Western and Eastern Europe, the country has a good relationship with Slavic countries such as Russian, Ukraine, Azerbaijan. Also the advantage in industrial sector helped CR to attract more domestic demand from big countries such as US, China and Japan, which contributed over 80% of total export non-EU28 annually. The linear relationships of distance with export value and GDP compared to export value were reflected by two functions of trend line in the graph (y = -0.189x + 2224.5) and (y = 0.1735x + 699.17)



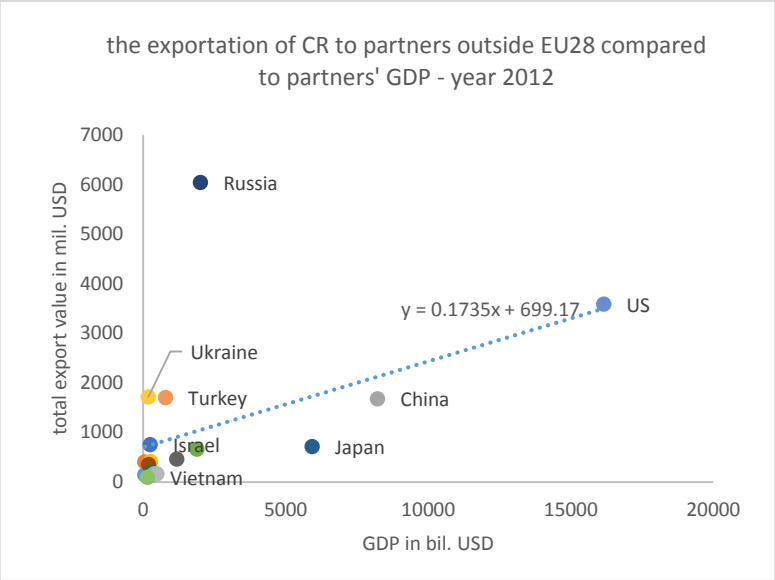


Figure 6 - Non EU28: relationship between exportation with distance and GDP of CR - *source: Czech statistical office - United National Statistics Division*

Linear regression model of exportation to non-EU28

Statistical verification:

From the comparison of p-value with level of significance 5%, the natural logarithms of partners' GDP and distance have statistically significant impacts upon the export flows of CR toward countries non-EU28. The impacts from the dummy variables of landlocked location, languages and RTA are not statistically significant to export flows of CR

Econometrical verification:

The coefficient of determination R2 are 0.87 reflects the fitness of gravity model to actual export data, which means the gravity model can explain 87% of real life exportation of CR toward countries non-EU28. The standard error of regression 0.506977 explains the tolerant value of ε. When the error is reverted back from natural logarithm, the value of error is equal $e^{0.506977}$ = 1.660 million USD

Table 11 - Non-EU28 exportation: table of regression result

	Coefficient	*t-ratio*	*p-value*
const	*9.15245*	*7.8296*	*<0.00001****
lnGDPcz	*0.0198336*	*0.0807*	*0.93578*
lnGDP	*0.622442*	*29.2638*	*<0.00001****
lndistance	*−0.988084*	*-15.1489*	*<0.00001****
landlock	*0.104095*	*1.2628*	*0.20779*

lang	*0.19385*	*1.7750*	*0.07706**
RTA	*0.229094*	*1.5922*	*0.11254*
year	*0.0778093*	*3.6476*	*0.00032****

**** Statistically significant at 1%, ** statistically significant at 5%,* Statistically significant at 10%*

Mean dependent var	5.393099		S.D. dependent var	1.378364
Sum squared resid	67.34072		S.E. of regression	0.506977
R-squared	0.868236		Adjusted R-squared	0.864715

Source: generated from Gretl software

The gravity model of CZ export to countries has a formulate as

$$lnX_{ex} = \mathbf{9.15} + 0.019\ ln\_GDP_{cz} + \mathbf{0.62\ ln\_GDP_j - 0.99ln\ d} + 0.104\ landlock + 0.19\ lang + 0.23RTA + \mathbf{0.077year} \pm ln\ 1.660$$

Where

lnX is the natural logarithms of export or import value between two countries CR and each partner in non-EU28

ln_GDP_{cz} and ln_GDP_j respectively are natural logarithms of GDP in CR and each partner in EU28.

ln d is the natural logarithm value of distance between countries.

a_0, a_1, a_2, a_3 are generated parameters of the related input variables from regression model,

b_1, b_2, b_3 are generated parameters of dummy variables.

lang (1 – when a partner's native languages is in Slavic system, 0 – otherwise)

Landlock (1 – when the partner's location is island or sea travel, 0 – otherwise)

RTA (1 – when CR joined EU, 0 – otherwise)

year is time vector (2000 = 1, 2001 = 2,… 2014 = 15)

c is the generated parameters of time vector

ε is error term.

(the **bold number** and **letter** indicate statistically significant values (p-value < 5%))

4.2.2. Importation of CR from non-EU28:

The total value of importation from partner's of non-EU28 exceed to CR exportation over years. CR imported from these countries' variety of goods such as oil related products, textiles, foods and telecommunication devices that overall creating the imbalance between import and export of the country. Eventually, the trend line of function of relationship between distance and importation was relatively flat (y = -0.0319x + 2414.1). However the trend line of function of relationship between GDP and importation still met the expectation (y = 0.4452x + 1258)

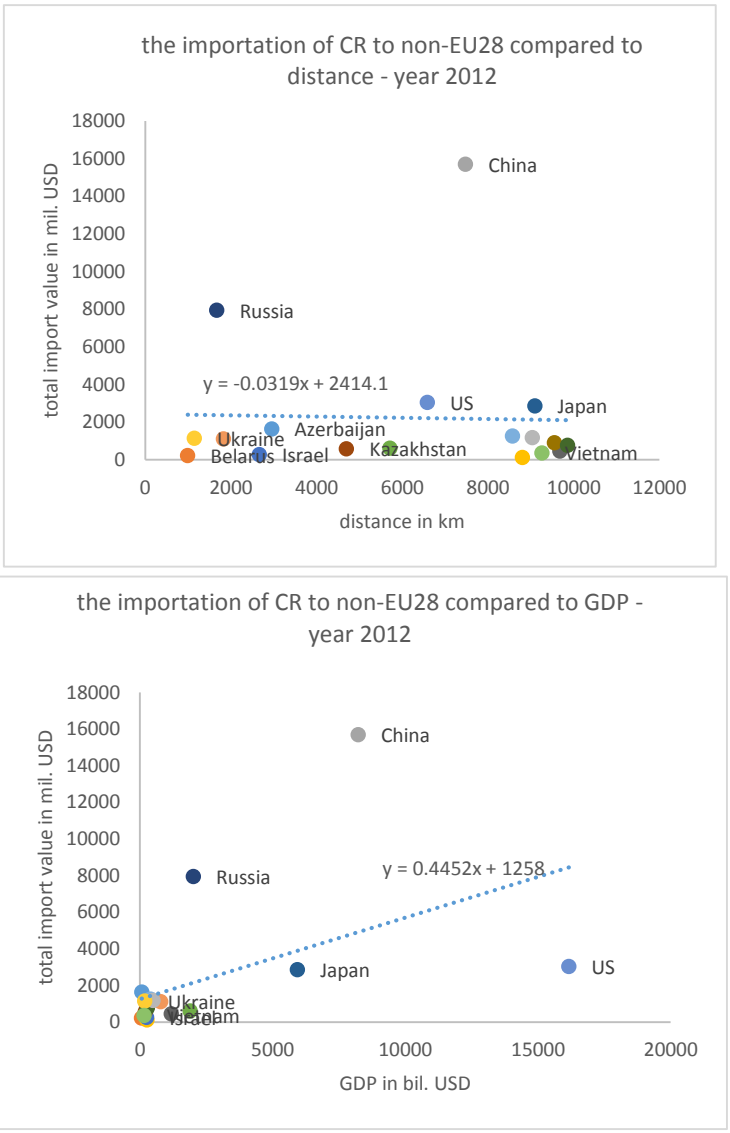


Figure 7 - Non-EU28: linear relationship between importation with distance and GDP - ***source: Czech statistical office - United National Statistics Division***

The linear regression model of importation from non-EU28:

Statistical verification:

From the comparison of p-value with level of significance of 5%, the variables of partners' GDP, distance and languages are statistically significant with importation of CR from countries of non-EU28. While GDP of CR, dummy variables of landlocked location and RTA are not statistically significant to importation of CR related from these countries

Econometrical verification

The R^2 value coefficient of determination 0.65 is the value illustrating the fitness of generated model. It indicates only 65% of importation data can be explained by the regression models. The tolerant value of S.E of regression (standard error) is 0.863555, when reverted back from natural logarithm, the error of trade flows is equals $e^{0.863555}$ = 2.37 million USD

Table 12 - Non EU28 importation: table of regression result

	Coefficient	*t-ratio*	*p-value*
const	−3.79909	-1.9080	0.05748*
lnGDPcz	0.709288	1.6933	0.09159
lnGDP	0.631531	17.4311	<0.00001***
lndistance	0.283212	2.5492	0.01137**
landlock	−0.210874	-1.5018	0.13434
lang	1.39259	7.4862	<0.00001***
RTA	0.169773	0.6927	0.48910
year	−0.00673879	-0.1855	0.85301

**** Statistically significant at 1%, ** statistically significant at 5%,* Statistically significant at 10%*

Mean dependent var	6.241396		S.D. dependent var	1.434905
Sum squared resid	195.3807		S.E. of regression	0.863555
R-squared	0.647237		Adjusted R-squared	0.637812

Source: generated from Gretl software

From the results of regression table, the gravity model of importation has the formulation as:

$$lnX_{im} = -3.8 + 0.7\ ln\_GDP_{cz} + \mathbf{0.63\ ln\_GDP_j} + \mathbf{0.28\ ln\ d} - 0.2\ landlock + \mathbf{1.39\ lang} + 0.169\ RTA - 0.0067\ year \pm ln\ 2.37$$

Where

lnX is the natural logarithms of export or import value between two countries CR and each partner non-EU28

ln_GDP_{cz} and ln_GDP_j respectively are natural logarithms of GDP in CR and each partner in EU28.

ln d is the natural logarithm value of distance between countries.

a_0, a_1, a_2, a_3 are generated parameters of the related input variables from regression model,

b_1, b_2, b_3 are generated parameters of dummy variables.

lang (1 – when a partner's native languages is in Slavic system, 0 – otherwise)

Landlock (1 – when the partner's location is island or sea travel, 0 – otherwise)

RTA (1 – when CR joined EU, 0 – otherwise)

year is time vector (2000 = 1, 2001 = 2,… 2014 = 15)

c is the generated parameters of time vector

ε *is* error term.

(the **bold number** and **letter** indicate statistically significant values (p-value < 5%))

4.2.3. The results of linear regression model of trade with non-EU28

From the gravity models of importation and exportation, the applied equation has the formulation as:

$$lnX_{im} = -3.8 + 0.7\ ln\_GDP_{cz} + \mathbf{0.63\ ln\_GDP_j} + \mathbf{0.28\ lnd} - 0.2\ landlock + \mathbf{1.39\ lang} + 0.169\ RTA - 0.0067\ year \pm ln\ 2.37$$

$$lnX_{ex} = \mathbf{9.15} + 0.019\ ln\_GDP_{cz} + \mathbf{0.62\ ln\_GDP_j} - \mathbf{0.99ln\ d} + 0.104\ landlock + 0.19\ lang + 0.23RTA + \mathbf{0.077year} \pm ln\ 1.660$$

Where

lnX_{ex} and lnX_{im} is the natural logarithms of export and import value between two countries CR and each partner of non-in EU28

ln_GDP_{cz} and ln_GDP_j respectively are natural logarithms of GDP in CR and each partner in EU28.

ln d is the natural logarithm value of distance between countries.

a_0, a_1, a_2, a_3 are generated parameters of the related input variables from regression model,

b_1, b_2, b_3 are generated parameters of dummy variables.

lang (1 – when a partner's native languages is in Slavic system, 0 – otherwise)

Landlock (1 – when the partner's location is island or sea travel, 0 – otherwise)

RTA (1 – when CR joined EU, 0 – otherwise)

year is time vector (2000 = 1, 2001 = 2,… 2014 = 15)

c is the generated parameters of time vector

ε is error term.

From both models of trade between CR with non-EU28 group, the results are different from EU28 group. The GDP of CR, landlock and RTA are not statistically significant in both two models. The languages factor is only statistically significant in regression model of importation. The variable of distance is statistically significant. However, in the model of importation, the distance factor has a positive impact on trade flows. This model creates a conflict with the theory of gravity, which expects the distance between countries has negative effect on trade flows. With the coefficient of determination R^2 of importation only achieve 64%, which is relatively low. The value R^2 also leads to high standard error ε. Therefore the model of importation in non-EU28 is facing misleading in interpretation and prediction. The reason will be explained in the subchapter limitation of the thesis.

On the other size, the model of exportation has relatively high value of $R^{2\ 0.87}$, low value of ε 0.5, positive coefficient of GDP of partner 0.62 and negative coefficient of distance -0.99. Eventually in the gravity model of exportation, the trade flow is affected by GDP of partner and distance between countries. Countries with large economy have more positive impact on trade flows from CR and the distance between countries discourage the exportation from CR to countries outside EU.

4.3.Total trade of CR with all countries

This subchapter aimed to combine the two previous regression into two models of total importation and exportation of CR republic with 45 countries (Austria, Belgium, Bulgaria, Croatia, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, Netherland, Poland, Portugal, Romania, Slovenia, Slovakia, Spain, Sweden, UK, China, US, Russia, Azerbaijan, Belarus, Israel, India, Japan, Kazakhstan, Mexico, Malaysia, Singapore, Thailand, Turkey, Ukraine, Vietnam) with the dataset of 675 observations from the same period from 2000 to 2014. The regression formulation was kept the same as:

$$lnX = a_0 + a_1\, ln\_GDP_{cz} + a_2 ln\_GDP_j + a_3 ln\, d + b_1\, Currency + b_2 cmbd + b_3 landlock + b_4\, lang + b_5\, RTA + c\, year + \varepsilon$$

Where

lnX is the natural logarithms of export or import value between two countries CR and each partner from 45 countries

ln_GDP_{cz} and ln_GDP_j respectively are natural logarithms of GDP in CR and each partner from 45 countries

ln d is the natural logarithm value of distance between countries.

a_0, a_1, a_2, a_3 are generated parameters of the related input variables from regression model,

b_1, b_2, b_3 , b_4 , b_5 are generated parameters of dummy variables.

currency EU (1 – when partners adopted Euro, 0 – otherwise)

cmbd (1 – when a partner has common border with CR, 0 – otherwise)

lang (1 – when a partner's native languages is in Slavic system, 0 – otherwise)

RTA (1 – when a partner's joined EU, 0 – otherwise)

Landlock (1 – when the partner's location is island or sea travel, 0 – otherwise)

year is time vector (2000 = 1, 2001 = 2,… 2014 = 15)

c is the generated parameters of time vector

ε is error term.

4.3.1. The overall exportation of CR:

Statistical verification

- Except the dummy variable of RTA, all of the regression coeffiecients was statistically significant to total exportation of CR when compared to level of significance 5%.
- The variable GDP of CR, GDP of partners, common border factor have positive impacts on the exportation of CR partners.
- The variable of distance, EU currency and landlock factor have negative impacts on the exportation of CR to partners.
- The RTA factor is statistically insignificant and being considered as null value

Econometrical verification

- The coefficient of determination R^2 is 0.86, which presents the fitness of regresson model 86%. The generated regresson model can explain 86% of actual exportation data. These explained datas fluctuate in the error interval of ($-e^{0.66}$, $+e^{0.66}$) or ± 1.93 million USD.

Table 13 - Overall exportation: table of regression result

	Coefficient	*t-ratio*	*p-value*
const	7.8309	10.9478	<0.00001***
lnGDPcz	0.435856	2.6446	0.00837***
lnGDP	0.683213	40.8867	<0.00001***
ln_distance	−1.04861	-33.5124	<0.00001***
currencyEU	−0.551014	-7.7997	<0.00001***
cmbd	0.934302	8.8820	<0.00001***
landlock	−0.207884	-3.2554	0.00119***
lang	0.186097	2.4926	0.01292**
RTA	−0.0376952	-0.4168	0.67693
year	0.050486	2.9316	0.00349***

**** Statistically significant at 1%, ** statistically significant at 5%,* Statistically significant at 10%*

Mean dependent var	6.169035		S.D. dependent var	1.778932
Sum squared resid	287.7100		S.E. of regression	0.658254
R-squared	0.864911		Adjusted R-squared	0.863080

Source: generated from Gretl software

The linear regression model of total exportation was generated as below:

$$lnX_{ex} = \mathbf{7.83} + \mathbf{0.44\ ln\_GDP_{cz}} + \mathbf{0.68\ ln\_GDP_j} \mathbf{-1.04\ ln\ d} - \mathbf{0.55\ Currency} + \mathbf{0.93\ cmbd} - \mathbf{0.2\ landlock} + \mathbf{0.18\ lang} - 0.04\ RTA + \mathbf{0.05year} \pm ln\ 1.93$$

Where

lnX is the natural logarithms of export value between two countries CR and each partner from 45 countries

ln_GDP_{cz} and $\ln\_GDP_j$ respectively are natural logarithms of GDP in CR and each partner from 45 countries

ln d is the natural logarithm value of distance between countries.

a_0, a_1, a_2, a_3 are generated parameters of the related input variables from regression model,

b_1, b_2, b_3 , b_4 are generated parameters of dummy variables.

currency EU (1 – when partners adopted Euro, 0 – otherwise)

cmbd (1 – when a partner has common border with CR, 0 – otherwise)

lang (1 – when a partner's native languages is in Slavic system, 0 – otherwise)

RTA (1 – when a partner's joined EU, 0 – otherwise)

Landlock (1 – when the partner's location is island or sea travel, 0 – otherwise)

year is time vector (2000 = 1, 2001 = 2,… 2014 = 15)

c is the generated parameters of time vector

ε is error term.

(the **bold number** and **letter** indicate statistically significant values (p-value < 5%))

4.3.2. The overall importation of CR:

After comparison of p-value with level of significance 5%, the verification is shown as below

Statistical verification:

- The GDP of partner, common border, languages and RTA are statistically significant and have positive impact on importation of CR from 45 countries.
- The distance, Euro currency are statistically significant and have negative impact on importation of CR from 45 countries
- The GDP of CR and landlock factor are statistically insignificant and being considered as null value

Econometrical verification:

- The coefficient of determination R^2 is 0.78, which presents the fitness of regresson model 78%. The generated regresson model can explain 78% of actual exportation data. These explained datas fluctuate in the error interval of $(-e^{0.84}, +e^{0.84})$ or ± 2.31 million USD.

Table 14 - Overall importation: table of regression result

	Coefficient	*t-ratio*	*p-value*
const	2.79946	3.0724	0.00221***
lnGDPcz	0.25903	1.2338	0.21770
lnGDP	0.787232	36.9844	<0.00001***
ln_distance	−0.371739	-9.3265	<0.00001***
currencyEU	−0.195901	-2.1769	0.02984**
cmbd	1.38373	10.3268	<0.00001***
landlock	−0.0783058	-0.9627	0.33607
lang	0.743871	7.8217	<0.00001***
RTA	0.368005	3.1947	0.00147***
year	0.0224266	1.0223	0.30700

**** Statistically significant at 1%, ** statistically significant at 5%,* statistically significant at 10%*

Mean dependent var	6.256187		S.D. dependent var	1.783910
Sum squared resid	466.8477		S.E. of regression	0.838501
R-squared	0.782021		Adjusted R-squared	0.779067

Source: generated from Gretl software

The overall importation of CR was created as function of gravity model below:

$$lnX_{im} = \mathbf{2.80} + 0.26\ ln\_GDP_{cz} + \mathbf{0.79\ ln\_GDP_j - 0.37\ ln\ d - 0.20\ Currency} + \mathbf{1.38cmbd} - 0.07\ landlock + \mathbf{0.74\ lang} + \mathbf{0.37\ RTA} + 0.022year \pm ln2.31$$

lnX_{im} is the natural logarithms of import value between two countries CR and each partner from 45 countries

ln_GDP_{cz} and $\ln\_GDP_j$ respectively are natural logarithms of GDP in CR and each partner from 45 countries

ln d is the natural logarithm value of distance between countries.

a_0, a_1, a_2, a_3 are generated parameters of the related input variables from regression model,

b_1, b_2, b_3 , b_4 are generated parameters of dummy variables.

currency EU (1 – when partners adopted Euro, 0 – otherwise)

cmbd (1 – when a partner has common border with CR, 0 – otherwise)

lang (1 – when a partner's native languages is in Slavic system, 0 – otherwise)

RTA (1 – when a partner's joined EU, 0 – otherwise)

Landlock (1 – when the partner's location is island or sea travel, 0 – otherwise)

year is time vector (2000 = 1, 2001 = 2,… 2014 = 15)

c is the generated parameters of time vector

ε is error term.

(the **bold number** and **letter** indicate statistically significant values (p-value < 5%))

4.4.Evaluation of the regressions:

In the case of exportation, three models has proved a strong reliability of gravity model of trade for analysis of international trade shown by high value the coefficient of determination R2 (0.87, 0.87, 0.86). The GDP of partner country and distance between CR and specific country also played a vital role in the gravity model. The value of parameters related to the impact of Euro currency, common border, landlocked location of partners and languages may vary differently but also had important impacts to outflow of goods of CR. Only the dummy variable of RTA was not statiscally significant in three models. Compared to the GDP of partner, GDP of CR was likely less important for two reasons. First reason is in the model of export non-EU, the variable of GDPcz was statistically insignificant. Second reason is the regression coefficient of GDPcz (0.48 and 0.44) was smaller than GDP of partners (0.78 and 0.68). As we know, GDP of CR was relatively smaller with other countries in the analysis area. For that the GDP of CR was less decisive in the gravity model. Therefore, from the tables summarizing the exportation of CR, the size of economy positively encourages the attraction force between two countries and the distance between countries has the opposite effect. In the three models, the size of partner GDP is statistically more decisive to exportation than the country of origin. And the most important factor is common border, which has the highest regression coefficient.

Table 15 - Evaluation: table of three regression models of exportation between CR and selected group

Generated model of export	Export EU28	Export non-EU28	Overall export
Independent variable	Regression coefficient	Regression coefficient	Regression coefficient
const	**4.37**	**9.15**	**7.83**
lnGDPcz	**0.48**	0.019	**0.44**
lnGDP	**0.78**	**0.62**	**0.68**
ln_distance	**−0.58**	**−0.98**	**−1.05**
currencyEU	**−0.92**	Not available	**−0.55**
cmbd	**1.24**	Not available	**0.93**
landlock	**0.2**	0.22	**−0.21**
lang	**−0.67**	0.07	**0.19**
RTA	−0.13	9.15	−0.04
year	**0.05**	**0.02**	**0.05**
R^2	0,87	0,87	0,86
Standard error ε	0,67	0,50	0,66

Source: generated from Gretl software

In the case of importation, the application of gravity model was relatively weaker compared to the case of exportation. The coefficient of determination R2 varied differently in three area of countries of origin. The highest value of reliability lied in the importation from EU28, while the lowest value belonged to the importation from outside EU28. However the overall reliability achieved the value of 78%. Here, the GDP of CR was not statistically significant in all three models. It is less likely the domestic demand of small country like CR affects the inflow of goods. However the deciding factors lied in the exporting countries as the variable of partners' GDP had more statistical influences. The distance between countries also provided a confusing prediction as the positive value in the case of trading with countries outside EU28 because of the weaker reliability R^2. With the domination of trading within EU28, the overall value of distance had a negative value to the importation. As the dummy variable of language and trade agreement (RTA) factor had the positive effects, the similarity of culture and trading group were more likely to enforce the inflow of goods to CR. However, the importation of goods and services was also not statistically influenced by the factor of landlocked or difficult location country of origin. Therefore the economic size of country of origin has a positive impact upon the inflow of good toward the domestic demand and distance has opposite effect. Country with relatively smaller size of economy is less likely to influence the inflows of goods and commodities. The similarity of languages and common border are important factors in analyzing the importation between countries.

Table 16 - Evaluation: table of three regression models of importation between CR and selected group

Generated model of import	import EU28	import non-EU28	Overall import
Independent variable	Regression coefficient	Regression coefficient	Regression coefficient
const	**8.99**	−3.80	**2.80**
lnGDPcz	0.07	0.70	0.26
lnGDP	**0.84**	**0.63**	**0.79**
ln_distance	**−1.21**	**0.28**	**−0.37**
currencyEU	−0.006	Not available	**−0.20**
cmbd	**0.46**	Not available	**1.38**
landlock	0.011	−0.21	−0.078
lang	**0.51**	**1.39**	**0.74**
RTA	**0.39**	0.17	**0.37**
year	**0.043**	−0.007	0.022
R^2	0,90	0,65	0,78
Standard error ε	0,63	0,86	0,83

Source: generated from Gretl software

The two tables above are the results of applying gravity model of trade into analysis of international trade of Czech Republic in three cases (trade within EU28, trade outside EU28, and total trade). Here all of the parameters (regression coefficient) of independent variables are gathered. The **bold numbers** indicate the statistically significant parameters (p-value <5%)

4.5.Limitation of the thesis

In the gravity model of analyzing the trade performance of CR with non-EU28 group, the regression model of importation did not meet the expectation of gravity model. The reason was explained by trade deficit with East Asia countries. This is the most divergent region in the world. In detail, the population ranges from 1.3 billion in China to 5.4 million in Singapore, GDP per capita ranges from 1,300USD in Vietnam to 50,000USD in Japan and Singapore. Each country has different languages, cultural, geographical and political characteristics. The selected gravity model of importation could not control the trade resistance term. The linear regression model of importation from non-EU28. And the chosen dummy variables were unable to explain the relationship between importation and distance between countries. Therefore the gravity model of trade failed to interpret the importation of CR from non-EU28 countries[42].

[42] Shoiw-Mei Tseng, Trade flows between Czech Republic and East Asia. Online magazine: Review of Economic Perspectives. Masaryk University, Brno, Czech Republic Publisher. ISSN 1213-2446. Volume 13 (2013). Page 146-458

5 Conclusion:

From the previous theories of gravity model, the research has selected a suitable method to apply the theory of gravity model in the stated case study. The the first approach was to control the multilateral trade resistances, which was statistically unobservable, by replacing them with dummy variables of different factors such as currency, common border, landlocked location and regional trade area. These dummy variables, which reflected the characteristics of each country, enhanced the bilaterial trade resistance and created a solid gravity model in interpretation of trade flows movement.

Secondly, the research applied the constructed gravity model into analyzing the case study of Czech Republic and generating six linear regression models of importation and exportation. After statistical testing and verification, one unexpected model was the linear regression model of importation to Czech Republic from countries outside of European Union. The contructed gravity model was unable to control the trade resistance in this and achieved the difference results as the distance between countries has positive influence with the trade flows. Therefore this model should be re-examinied as a specific case. However 5 out of 6 regression models have approved the gravity theory after the same testing and verification procedures. The size of national economy supported the trade flows (attraction force) between countries and the distance between countries discouraged the movement of importation and exportation. The trade flows were also greatly affected by the additional factors such as common border and languages.

Therefore this master research has evaluated the performance of international trade relationship of Czech Republic with chosen countries by using the application of gravity model of trade. From the empirical analysis, Czech Republic is recently facing the uncontrollable importation of goods to the country. The economic size of a country was not statistically significant enough to affect the import flow of good (GDP of CR ranked 30^{th} in the overall countries GDP in 2013). The import flow was mainly influenced by the GDP of the partner countries, common border factors and similarity in languages. Even though the trade surplus with the other state members of has overcome the traded deficit with countries outside EU. But in the future, it is necessary to select a better empirical estimation for the

importation with countries outside EU and complete the whole picture of international trade of Czech Republic.

6 References:

1. Author O'Shullivan, Steven M. Sheffrin. Economics: Principle in Actions. Pearson Prentice Hall. Wall Street Journal: Class Room Edition. ESBN: 0-13-133483-2
2. Blaug, Mark. The methodology of economics, or how economists explain. Cambridge University Press.Cambridge University Press.1992. ISBN 0-521-43678-8.
3. Czech statistical office: External trade in good – cross-border concept. Available at: https://www.czso.cz/csu/czso/external_trade_in_goods_according_to_the_movement_-cross_border_concept-_ [last retrieve 03/2015]
4. Elena-Daniela Viorica, Econometric Analysis of Foreign Trade efficiency of E.U Members Using Gravity Equations. Procedia Economics and Finance. Volime 20. Page 670-678. 2015. ISSN: 2212-5671
5. Eurostat, European Commission. External and intra-European Union trade. 2010 edition. Publications office of the European Union. Luxembourg. 2011. ISBN: 978-92-79-16352-4
6. Gary Magee, M. Ishaq Bhtti, Alice Shuaishuai Li. The economic modeling of migration and consumption partterns in the English-speaking world. Economic Modelling. ISSN: 0264-9993. E-book: available at: http://www.sciencedirect.com/science/article/pii/S0264999314002910 [last retrieve 03/2015]
7. H.R. Seddighi, K.A. Lawler, A.V. Katos. Econometrics: A practical approach; Routledge publisher. 2000; ISBN 0-425-15644-0
8. Head, Keith and Thierry Mayer, forthcoming, "Gravity Equations: Workhorse, Toolkit, Cook-book" Handbook of International Economics (2014). North-Holland publications. ISBN 978-0-444-54314-1. Volume 4 edition. Gopinath, Helpman, Rogoff. 2013.
9. Allen, William R. "Mercantilism." Steve N. Durlauf, Lawrence E.Blume edition, The New Palgrave: A Dictionary of Economics 2010 version. Vol. 3. E-book. ESBN: 9780230301474.

10. Anderson, J., van Wincoop, E. "Gravity with Gravitas: A Solution to the Border Puzzle." American Economic Review. 2003. Volume 93. Available at:http://www.econ.ku.dk/nguyen/teaching/Anderson%20van%20Wincoop%202003%20Gravitas.pdf [last retrieve 03/2015]
11. Andreas Maurer, Christophe Degain. Staff Working Paper: "Globalization and trade flows: what you see is not what you get!" World Trade Organization: Economic Research and Statistics Division. 2010. Available at: https://www.wto.org/english/res_e/reser_e/ersd201012_e.pdf [last retrieve 03/2015]
12. I.Bernard Cohen and Anne Whitman, translators: "Isaac Newton, The Principia: Mathematical Principles of Natural Philosophy". Preceded by A Guide to Newton's Principia, by I.Bernard Cohen. University of California Press 1999 ISBN 0-520-08816-6.
13. Index of Economic Freedom: Outline of Czech Republic. 2015. Internet source. Available at: http://www.heritage.org/index/country/czechrepublic [last retrieve 03/2015]
14. International Monetary Fund, 2012. 'Czech Republic – 2012 Article IV Consultation Concluding Statement', IMF News : IMF website. Available at: http://www.imf.org/external/np/ms/2012/022712.htm [last retrieve 03/2015]
15. Irena Pekarskiene. The Assessment of Manifestation of Economic Globlaization: the international trade factor. Procedia – Social and Behavioral Sciences (2014).E-book. ELSEVIRE publication. ISSN: 1877-0428. Volume 156
16. Jan Bruha, Jiri Podpiera, Stanislav Polak. The convergence dynamics of a transition economy: The case of Czech Republic. Economic Modelling. Volume 27, 2010. ISSN: 0264-9993. E-book. Available at: http://www.sciencedirect.com/science/article/pii/S0264999309001394# [last retrieve 03/2015]
17. Jana Simkaova, Daniel Stavarek. Exchange-Rate impact on Industry-Level trade flows in the Czech Republic. Procedia Economics and Finance. ELSEVIER publication (2014). E-book. ISSN: 2212-5671.
18. Joao Santos Silva, Silvana Tereyro. Article: "The Log of Gravity".The Review of Economics and Statistics. November 2006. E-book. E-ISBN: 1530-9142. Available at: http://personal.lse.ac.uk/tenreyro/jensen08k.pdf [last retrieve 03/2015]

19. John M. Letiche, International economic policies and their theoretical foundations. 2nd edition. Academic Press, Inc. 1992. ISBN: 0-12-444281-1. Term of trade. Chapter 4: Development of gain from trade theory: Classical to modern literature. E-book. Available at: http://www.sciencedirect.com/science/book/9780124442818 [last retrieve 03/2015]
20. Juan M. Ruiz, Josep M. Vilarrubia. "The wise use of dummies in gravity models: export potentials in the Euromed region". Unidad Publication, Madrid. ESBN: 1579-8666. E-book. Available at:http://www.bde.es/f/webbde/SES/Secciones/Publicaciones/PublicacionesSeriadas/DocumentosTrabajo/07/Fic/dt0720e.pdf [last retrieve 03/2015]
21. Keith Head. Article: "Gravity for beginners" Handbook of International Economics Volume 2 edition. Gopinath, Helpman, Rogoff. Available at:http://web.efzg.hr/dok/me_gravity%20for%20begin.pdf [last retrieve 03/2015]
22. Marc Bacchetta, Cisuni Beverelli, Olivier Cadot, Roberta Piermartini. A Practical Guide to Trade Policy Analysis. WTO publications. 2012. WTO ISBN 978-92-870-3812-8. E-book. Available at: https://www.wto.org/english/res_e/publications_e/wto_unctad12_e.pdf [last retrieve 03/2014]
23. Marie-Lise E.H. van Veenstra, Mina Yakop, Peter A.G van Bergeijk. "Economic Diplomacy, the Level of Development and Trade."Discussion papers in Diplomacy. Netherlands Institute of International Relations 'Clingedael'. ISSN 1569-2987. Available at:http://www.clingendael.nl/sites/default/files/20101000_cdsp_artikel_%20van%20Veenstra,%20Yakop%20and%20van%20Bergeijk.pdf [last retrieve 03/2015]
24. Marina Mastrostefano, Lewis Dijkstra, Hugo Poelman. Regions 2020. Globalistion challenges for European Regions. Commission of the European Community (2009). Online article. Available at: http://ec.europa.eu/regional_policy/sources/docoffic/working/regions2020/pdf/regions2020_globalisation.pdf [last retrieve 03/2015]
25. Micheal Moffett, Arthur Stonehill, David Eiteman; Fundamentals of multinational finance, 2nd edition. Pearson Education publisher. ISBN: 0-321-28031-8

26. Min Zhou. Intensification of geo-cultural homophily in global trade: Evidence from the gravity model. Social Science Research. Volume 40. E-book.ELSEVIER publication. ISSN: 0049-089X.
27. Norman J. Glickman, Edwin S. Mills. Econometric Analysis of Regional systems. Academic Press, Inc. 1997. ISBN: 0-12-286550-2. Chapter 2: Methods of regional economic analysis. E-book. Available at:http://www.sciencedirect.com/science/book/9780122865503[last retrieve 03/2015]
28. Raj Aggarwal, Jenny Berrill, Elaine Hutson, Colm Kearney. What is a multinational corporation? Classifying the degree of firm-level multinationality. International Business Review (2011). E-book. ISSN: 0969-5931. ELSEVIER publication.
29. Raul Prebisch, Economic theory and Mathematical Economics. (1972). Academic Press, Inc. United Kingdom Edition. ISBN: 72-87230. Chapter IV. Economic policy, foreign trade and development.
30. Reinhard Schumacher. Adam Smith's theory of absolute advantage and the use of doxographu in the history of economics. Erasmus Journal of Philosophy and Economics. Volume 5, Issue 2. ISSN: 1876-9098.
31. Robert J. Corker, Craig Beaumont, Rachel van Elkan, Dora M. Iakova. Exchange rate regimes in selected advanced transition economies – Copingwith Transition, Capital inflows and EU accession (2000). IMF publication. ISSN: 1934 – 7456.
32. Salvatore, Dominick, Introduction to International Economics (1st edition.), Hoboken, NJ: Wiley, ISBN 0-471-20226-6.
33. Scott L. Baier, Jeffrey H. Bergestrand. "Do free trade agreement actually increase members' international trade?" Journal of International Economics. 2007. Volume 71.Available at: http://www.sciencedirect.com/science/article/pii/S0022199606000596
34. Sonia, Taylor. Business Statistics. 3rd ed. 2007; Plgrave Macmilan publisher. 2007; ISBN: 978-0-230-50646-6
35. Steve Suranovic. International trade: Theory and Policy. George Washington University. 2010, ISBN 13: 978-1-9361264-4-6.

36. Tatyana P. Soubbotina, Katherine A. Sheram. Beyond Economic Growth: Meeting the Challenges of Global Development. The international Bank for Reconstruction and Development/The World Bank. ISBN: 0-8213-4853-1.
37. United National Statistics Division: National Account Main Aggregates Database. Available at: http://unstats.un.org/unsd/snaama/dnllist.asp [last retrieve 03/2015]
38. United National Statistics Division: National Account Main Aggregates Database. Available at: http://unstats.un.org/unsd/snaama/dnllist.asp [last retrieve 03/2015]
39. Vincent Vicard. Determinants of successful regional trade agreements. Economics Letter. Volume 68. ISSN: 0165-1765. E-book. Available at: http://www.sciencedirect.com.infozdroje.czu.cz/science/article/pii/S0014292114000208 [last retrieve 03/2015]
40. W.Charles Sawyer, Richard L. Sprinkle; International Economics, 2nd edition. Pearson Education publisher. ISBN 0-13-170416-8
41. World Bank Summary Report. Czech Republic: Toward EU Accession. World Bank publication (1999). ISBN: 0-8213-4589-3.
42. Shoiw-Mei Tseng, Trade flows between Czech Republic and East Asia. Online magazine: Review of Economic Perspectives. Masaryk University, Brno, Czech Republic Publisher. ISSN 1213-2446. Volume 13 (2013).