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ABSTRACT OF DIPLOMA THESIS
Gravity model and its application in international trade

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Souhrn

Svět se v současné době mění rychlým tempem a mezinárodní obchod je považován za klíčový 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 zakotvený v fyzikálním 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 součástí Evropské unie, tak mimo ni.

Klíčová slova

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

1 Introduction

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 method, 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.

2 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

3 Methodology

The first part of research was to develop the suitable and applicable of gravity theory in economic theory. The importation and exportation 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. The trade resistance were also replaced by dummy variables of currency,

common border, languages, landlocked location and regional trade agreement (RTA). Therefore the gravity model of trade was formulated as below:

$$\ln X = a_0 + a_1 \ln_{GDP_{cz}} + a_2 \ln_{GDP_j} + a_3 \ln d + b_1 \text{Currency} + b_2 \text{cmbd} + b_3 \text{lang} + b_4 \text{RTA} + c \text{year} + \varepsilon$$

Where

$\ln X$ 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 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 second part was based on quantitative approach to analyze the international trade of Czech Republic in the case study. Six linear regression models were generated to carry out the application of gravity model in interpretation the trade flows between Czech Republic (CR) with specific group of countries in the period from 2000 to 2014:

Linear regression models of importation and exportation between CR and European Union group – EU28 (27 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 – 405 observations)

Linear regression models of importation and exportation between CR and outside European Union group – non-EU28 (18 countries - China, US, Russia, Azerbaijan, Belarus, Israel, India, Japan, Kazakhstan, Mexico, Malaysia, Singapore, Thailand, Turkey, Ukraine, Vietnam – 270 observation)

Linear regression models of importation and exportation between CR and all countries from EU28 and non-EU28 (45 countries – 675 observations)

Multicollinearity testing:

Before putting the dataset into the model, the research created the correlation matrix to check the intercorrelation between independent variables, and compare the generated value with ± 0.8 . The dataset must be modified to eliminate the multicollinearity if the generated value exceed the criteria ± 0.8 .

Verification of statistically significant coefficient of independent variables

Comparing the generated p-value with level of significance 5%, if p-value $< 5\%$, its related independent variable is statistically significant and influence the trade flows. Other wise, the independent variable is statistically insignificant and being consider as null value.

Econometrical verification

Interpretation of coefficient of determination R^2 and standard error ϵ aimed to indicate the fitness of regression model. How much % of dependent variable can be explained by the linear regression models.

4 Evaluation of the regressions:

In the case of exportation, GDP of partner was statistically significant in all three models. The GDP of CR was statistically insignificant in model of non-EU28 exportation. And the coefficient of GDP_{CZ} was less effective when compared to GDP of partner ($0.48 < 0.78$ and $0.44 < 0.68$). The GDP of partner countries was more decisive in the gravity model. The larger economic size of partner country is, the larger volume of trade CR can export. The distance between countries is statistically significant and has negative effect to the exportation. The highest coefficients are the variables of common border (1.24 and 0.93). And RTA was not statistically significant in all three models. The coefficient of determination in three export models were very high (0.87, 0.87, 0.86). Therefore these three model can be used to interpret the exportation of CR with all group of countries.

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

<i>Generated model of export</i>	<i>Export EU28</i>	<i>Export non-EU28</i>	<i>Overall export</i>
<i>Independent variable</i>	<i>Regression coefficient</i>	<i>Regression coefficient</i>	<i>Regression coefficient</i>
<i>const</i>	4.37***	9.15***	7.83***
<i>lnGDPcz</i>	0.48***	0.019	0.44***
<i>lnGDP</i>	0.78***	0.62***	0.68***
<i>ln_distance</i>	-0.58***	-0.98***	-1.05***
<i>currencyEU</i>	-0.92***	<i>Not available</i>	-0.55***
<i>cmbd</i>	1.24***	<i>Not available</i>	0.93***
<i>landlock</i>	0.2**	0.22	-0.21***
<i>lang</i>	-0.67***	0.07*	0.19**
<i>RTA</i>	-0.13	9.15	-0.04
<i>year</i>	0.05**	0.02***	0.05***
<i>R²</i>	0,87	0,87	0,86
<i>Standard error ε</i>	0,67	0,50	0,66
	<i>Accepted</i>	<i>Accepted</i>	<i>Accepted</i>

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

In the importation case, the GDP of CR was statistically insignificant in all three model. But the GDP of partner countries was statistically significant and has positive impacts upon the importation. The importation of CR was not influenced by GDP of CR but mainly by GDP of exporting countries. The dummy variable of languages also has huge impact in three models. However the distance may provide some conflict with theory of gravity model. In the theory, the distance between countries has the negative effect to the trade flow. But in the model of importation from non-EU28, the coefficient of distance has positive sign. Also the model has relatively low R2 0.65. These two reasons evaluate that the regression model of importation from non-EU28 was insufficient in interpretation the trade flows of CR with non-EU28. The regression models of import EU28 and overall import were generated successfully according to theory of gravity model.

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

<i>Generated model of import</i>	<i>import EU28</i>	<i>import non-EU28</i>	<i>Overall import</i>
<i>Independent variable</i>	<i>Regression coefficient</i>	<i>Regression coefficient</i>	<i>Regression coefficient</i>
<i>const</i>	8.99***	-3.80*	2.80***
<i>lnGDPcz</i>	0.07	0.70	0.26
<i>lnGDP</i>	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
	Accepted	Rejected	Accepted

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

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 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 bilateral trade resistance and created a solid gravity model in interpretation of trade flows movement.

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. From the theory of gravity model: *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*

- Model: Export EU28: accepted
- Model: Export non-EU28: accepted
- Model: Overall export: accepted
- Model: Import EU28: accepted
- Model: Import non-EU28: rejected
- Model: Overall import: accepted

Model: Import non-EU28: was explained by the limitation of the thesis. The constructed gravity model was unable to control the bilateral trade resistance. The main reason is the divergence of East Asian countries (differences in size of economy, population, culture and trade barrier). And the chosen dummy variables were unable to capture these factors.

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 disadvantage 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 30th 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. However, the international trade of CR was dominated by trade within EU region (80% of total export and 70% of total import). The trade surplus in EU could overcome the total trade performance.

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