Mendel University in Brno
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Infrastructure and time to trade as barriers

Bachelor Thesis

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Abstract

TÓTHOVÁ, P. Infrastructure and time to trade as barriers. Bachelor thesis. Brno: Mendel University, 2016.

Bachelor thesis is oriented on analysing of the impact of time, infrastructure and logistics on international trade. Time and the quality of infrastructure do not influence only trade volumes, but what is even more important, the long procedures for export and import and disorganized infrastructure contribute to the reduction of the probability that companies or a countries will enter time-sensitive products markets, where for instance consumer electronics and clothing belong to. In the practical framework, the application of the gravity equation for bilateral trade was used in order to find out whether it is significant on given sample of European Union countries in the year 2012. By means of using statistical and econometric tests such as Fisher´s test, RESET test or Test of a Goodness of Fit, the overall significance of the model and individual variables was proved.

Keywords

Time, infrastructure, logistics services, trade barriers, gravity model.

Abstrakt

TÓTHOVÁ, P. Infraštruktúra a čas na obchodovanie ako bariéry. Bakalárska práca. Brno: Mendelova Univerzita, 2016.

Bakalárska práca je orientovaná na analýzu vplyvu času, infraštruktúry a logistiky na medzinárodný obchod. Čas a kvalita infraštruktúry neovplyvňujú len objem obchodu, ale čo je omnoho dôležitejšie, dlhé procedúry pre import a export a zle zorganizovaná infraštruktúra prispievajú k znižovaniu pravdepodobnosti že spoločnosti alebo krajiny vstúpia na trhy s časovo senzitívnymi produktmi. Medzi takéto patria napríklad trhy so spotrebiteľskou elektronikou alebo oblečením. V praktickom rámci bola použitá aplikácia gravitačnej rovnice na bilaterálny obchod na zistenie, či je rovnica významná pre danú vzorku vybratých krajín Európskej Únie v roku 2012. Za použitia štatistických a ekonometrických testov ako napríklad Fisherov test, RESET test alebo testu dobrej zhody celková významnosť modelu a aj jednotlivých premenných bola dokázaná.

Kľúčové slova

Čas, infraštruktúra, prepravné služby, obchodné bariéry, gravitačný model.

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1 Introduction

It is not a coincidence that industrial centres and cities are located in the proximity of harbours and other infrastructural networks. The reasons are quite logical: the access to inputs, proximity to markets and well developed logistics in such places. Because of these, it makes it convenient locations for trade and also helps to decrease the time for the shipment. Many people would assume that the innovation in transport and communication technologies have helped to the increase of economic activities and their spread evenly all around the world. Unfortunately it is not the truth. This only contributed to the state that the rich and developed countries became even richer and more developed, while the poor and remote countries became poorer and more remoted than before. This is because the infrastructure and logistics are mainly improved only in those industrial centres with convenient location for trading such as in ports, where there is high concentration of investments and only what is left is given for the development of remote locations. Moreover, high level of administration and transport costs make it even more difficult for developing places and countries to compete and to be integrated to the markets. That is the reason why the removing of unnecessary barriers to time delivery is of utmost importance for developing countries.

In the theoretical framework of the thesis I will explain the relations of the time and infrastructure towards the trade. Time as a trade barrier is most commonly understood in the form of lead time, just-in-time and time variability together with the time to import, export and the length of administrative procedures. Also very crucial is the role of infrastructure in trading, because the countries with highly developed and well organized infrastructure are seen as more attractive and reliable when trading. In addition, I will provide a case study of Kenya and its cut flowers industry, because it is a very good example of how a well-organized infrastructure and the length of time are important for trading, regarding the products with short-term duration of time.

Following is the practical framework, which includes the data inevitable for the simple gravity model. In this part I will verify the overall significance of the gravity model function and individual variables by means of statistical and econometric tests. The gravity model is applied to the selected countries of the European Union where the variables like GDP, distance, Logistics Performance Index are included for the period of time for the year 2012.

2 Objectives and Methodology

2.1 Objectives

The main aim of the bachelor thesis is to investigate and provide better overview on the topic of time and infrastructure as basic barriers to trade and also their impact on this issue. The main aim is fulfilled by means of the partial aim, which is based on the principle of the gravity equation adjusted to the needs of trade to show, whether these two factors play either significant or non-significant role in trading.

2.2 Methodology

From the structural point of view this thesis may be divided into two parts: theoretical background and practical framework.

Theoretical background is dedicated to the explanation and description of time and infrastructure related to the international trade and why these two terms deserve to be marked as trade barriers. Furthermore, the way how these two factors influence the ability to trade on international level mainly with time-sensitive products is also described. All the necessary information and literature review needed for the theoretical framework was collected from the series of professional articles from Scopus or Google Scholar databases.

When speaking about practical framework, for this part the collection of data for further processing was needed. The most suitable source for data was Eurostat and its databases. However, the choice of the data was limited by the publishing of the Logistics Performance Index, which was used as one of the variables in gravity equation, because it is published by the World Bank every two years. For this reason I decided to use year 2012 because to this year also other variables needed for processing are available to be assessed.

Another important step was to choose the selected sample of the European Union countries. This was done by the percentage share of the volume of export from Slovakia to another member states countries, with the condition chosen that Slovakia has to have at least 1 percentage share of the export.

Because of the fact, that the data are for one year (2012), so it means that the data is cross-sectional and the regression analysis was needed in order to process it. Following, the data was applied to the simple version of the gravity equation used by Matyás László and analysed by means of the method of Ordinary Least Squares in computer software Gretl. For further testing, whether the model is significant from statistical or econometric point of view, several tests available in Gretl were used. The actual process of the verification consisted of the determination of null and alternative hypothesis and it was followed by the rules of the given test. Additionally, the significant level of α 5% was chosen because it is most commonly used level. For example, the significance of the individual variables in the model (GDP, Language, LPI and Distance) was tested by means of Student test, the correct specification of the overall model was proved by Fisher distribution or Ramsey´s RESET test. Even though there are many tests in order to identify either homoscedasticity or heteroskedasticity of residuals, the one I decided to choose for the gravity model was White test because it is available in Gretl and it is considered to be one of the most useful tests for its detection.

Finally, all the results are summarized and the single conclusion that variables and model are significant, well specified and relevant in the model.

3 Theoretical background

Artificial trade barriers were introduced to control and regulate international trade and protect domestic environment and producers. However, the basic barrier that has to be struggled with is time which is directly proportionate to the quality of infrastructure. The relation can be expressed that, the higher quality the infrastructure is, the less time for the trading can be considered. That is the basic reason why these two factors are so important in bilateral trade, especially when we are talking about the food, electronics or fashion industries, which have to be delivered and transported exactly on time from various reasons. For instance, in electronics the time plays and important role because of its quick development – today's absolute innovation may become obsolete in couple of weeks. This is also one of the main reasons why the importance of time should not be underestimated.

3.1 Time as a trade barrier

3.1.1 The relation between time and trade

According Nordås, Pinali and Grosso (2006), the time to trade is crucial factor in trading because its length influences the overall tradability of a country. Time to trade has two possible effects on trade. The first one is whether or not a producer or a manufacturer will enter a particular foreign market in order to sell there the products or services. This can result in two possible outcomes – enter or not enter (and consequently find another suitable market for trading). The second effect influences the volume of trade once a market is entered. Hummels (2001) defined the difference between these effects in a detailed study on practical example of U. S. imports. His results were interesting mainly because he found out that even one-day increase in shipping time reduces the likelihood that a country will export products or goods to the USA by 1.5%. We can assume that there are also other delays which will have the common effect on the expected export to a certain market as already mentioned shipping time. These are for instance: delays due to bureaucratic procedures related to import and export, delay associated to certification and testing of goods and delays on the domestic transport routes. All of these represent the time as a trade barrier in general, but when we are discussing the time as a trade barrier more specifically, the three aspects are needed to be considered:

- Lead time
- Just-in-time
- Time variability

Lead time can be defined as the length of time between the processing of the order and the receipt of the ordered goods. The nature of the product also depends because whether it was made to be ordered or "from the shelf" product needs to be considered. Lead time is also bounded by logistics services, distance to customers and suppliers and supply chain and planning management. If the demand is stable and delivery predictable, long lead time does not need to be taken as a problem. This means that if demand has been known months in advance, quantity demanded in orders could be processed months in advance too, and lead time does not matter much. But if this does not hold and the future demand is not certain, long lead time becomes costly even though the customer is completely informed about the arrival of the merchandise. There are two possible situations, which may occur when the demand is uncertain: underestimation and overestimation of the future demand. If the future demand has been underestimated, the consequences are in the form of foregone sales and the possibility of losing customers. On the contrary, if the future demand has been overestimated, the excess stocks must be sold at discount in order to get rid of them. Moreover, the competitiveness in lead time is a dynamic concept. It means that once a certain firm is capable of shortening the lead time, others must respond quickly in order not to be excluded from the process or punished in terms of selling at reduced prices.

Just-in-time specifies a way of organizing a production where the inventories, both inbound and outbound, are kept to a minimum level and inputs arrive to the factor exactly at the time when they are needed to enter the production process. Moreover, when just-in-time technology is used, delayed delivery of a component can stop the whole production and cause the rise in the costs, which may even exceed the market price of the component. That is the reason why no reduction in price can compensate the customer for unreliable time of delivery.

The last but not the least is time variability. It is measured by delivery time variation. There is a relation between the reserve stock and time variability and it is that the more variable deliver time is, the larger reserve stocks are needed in order to have a safeguard for unexpected demands. Because of this reason even if the average lead time is low, a high variability can mark suppliers as unable to compete and therefore it can have even more damaging impacts than long, but on the other hand, predictable lead times.

Whilst lead time mainly influences the volumes of trade, time variability present in just-in-time production processes has significant impact on the supplier and his ability to fulfil contracts. Although lead time can be prohibitively long and might reduce trade volumes to zero. From this point of view the distinction of three aspects of time correspond generally to costs that are independent of trade volume (e.g. waiting time for testing) mainly affect market entry, while time costs that are proportional to trade volume or value mainly affect these issues.

3.1.2 Time as an entry barrier

There has not been done much empirical research to assess time as a barrier to entry. Fortunately, there exist several theoretical developments that make this topic more clear and understandable. Kremer (1993) describes production as a sequence of several tasks and operations performed subsequently and which are essential. To be more specific, if one operation task is performed in a wrong way or a particular input is missing, the product cannot be finished and does not generate requested revenue. Consequently, the missing input or task will negate the value of the work that has been done in previous stages of production. Another version of this theory, the less extreme one, assigns quality to the final products. It supposes that for the product to possess the required parameters and quality, also all the operations and inputs must have or be performed at required level of quality. Si the time as an entry barrier mean that once a producer is not able to keep all the inputs and parts of the production process on the same quality because of financial or capacity reasons, it should not enter the market and produce it.

For better and practical explanation of this theory I would like to present several examples. A producer of luxurious clothing with fabric of a top quality and fancy design would not choose buttons, thread, zippers or other accessories of a low quality, because it may put the whole product in the jeopardise of not having luxurious status. In the same way, upmarket car producer would not fit into hundred thousand dollars car with a plastic dashboard or cheap equipment. Another example can be provided from fashion industry where there is no point in using high-quality fabric in T-shirt of bright pink made for a short period of time while this colour is fashionable.

To sum it up, an optimal strategy for producers is to choose and work with the same quality inputs in order to reach required quality of the final product. This theory can be also applied to just-in-time production systems. This means that if just-in-time is introduced at one stage of production process, it is convenient to harmonize the entire supply chain, so it can operate smoothly. It is assumed that the strength of the chain is measured by its weakest link and it is the reason why the link should have as high strength as possible or at least that all the links should have the same strength.

3.1.3 Time as a trade cost

A sharp fall in the costs for air transport, faster ships and more effective and better connected world transport have helped to reduce time costs. For example, the relative cost of air transport declined by more than 40 % between 1990 and 2004. A decrease in transaction costs results in higher transaction intensity of doing business. For instance, as communication and transport costs decline, exporters in machinery industry find it profitable to produce machines of higher quality, what requires more frequent interactions among producers and customers. Another example can be found in just-in-time management techniques, which have been extended to international production sharing networks. International production networks include the location of different production stages in many countries and the components in a product have crossed the international borders many times before it reaches the final consumer in the form of final product.

Even though from this we can assume, that distance and time do not play crucial role in trading anymore because of improvements in communication technologies and transportation, some authors are still not identified with this statement. I suppose that it is important to mention James E. Anderson and Eric van Wincoop

(2004), according to whom the death of distance is exaggerated. Trade costs are large, even aside from above mentioned improvements in communication and transport and even between apparently highly integrated economies. Despite many difficulties in measuring and inferring the height of trade costs and their decomposition into economically useful components, the outlines of a coherent picture emerge from recent developments in data collection and especially in structural modelling of costs. Furthermore, trade costs are obviously still highly variable across goods and countries. Trade barriers in developing countries are higher than those reported for developed and industrialized countries and high value-to-weight goods are less penalized by transport costs. The value of timeliness varies across goods, explaining modal choice. Poor institutions and poor infrastructure penalize trade differently across countries.

From many other reliable sources we can assume, that it is the matter of the fact that some countries benefit more from the current development in communication technologies, transportation facilities or integration among the countries, which consequently lead to the decline of the trade costs than others. Obviously, it is the problem mainly concerning developing countries; however, also many developed countries are still not able to import or export effectively.

Fortunately, currently there is offered a solution for the reduction of time for the shipment and transportation of goods and it is 3D painting. However, this novelty of the technology is only in its basis, but I assume that in the future this technology will definitely help to decrease the time and it will be no more trade barrier or at least will decrease the amount of costs for the transportation of goods.

3.2 Logistics services

"United States International Trade Commission defined in the report from 2005 that logistic services involve a range of related activities intended to ensure the efficient movement of production inputs and finished products. Global logistics services include for instance supply-chain consulting and transportation management services (storage and warehousing, cargo handling, transport agency services and customs brokerage). Additional service include, but are not limited to, packing services, trade financing, equipment rental services, freight insurance services, data message transmission services, express delivery, courier services etc."

In comparison, the view of the logistics according to the Nordås, Pinali and Grosso (2006) is more general and they describe logistics as a factor for whether or not firms will enter international markets and the price they receive for their product. For better illustration, the role of logistics is according to these authors illustrated in the following figure.

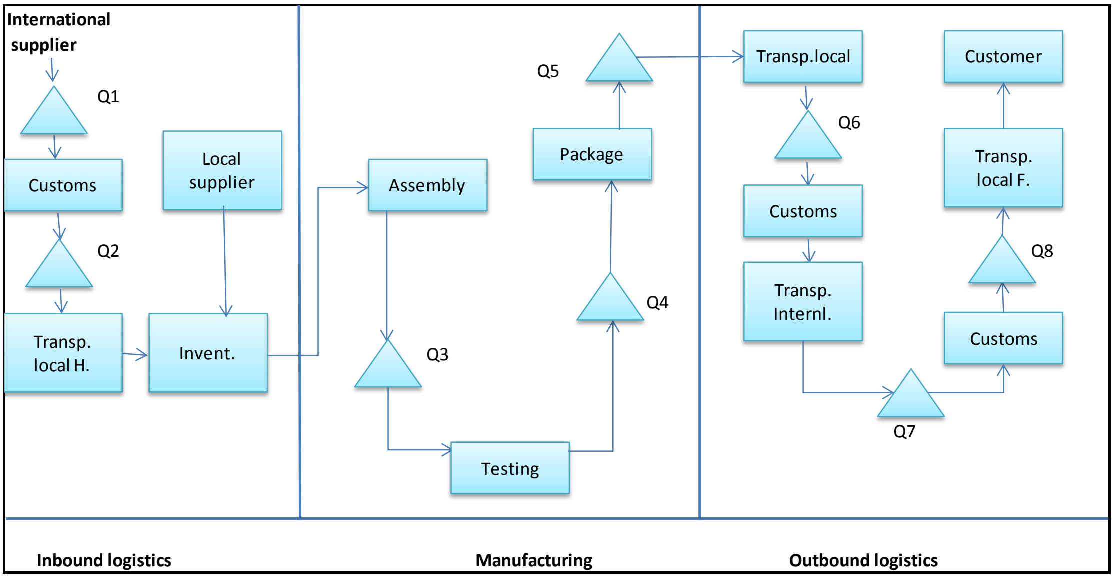

Fig. 1 Material Flow
Source: Nordås, Pinali and Grosso, 2006

Description Q1-Q8: Queue for inventory processing, H and F represent home and foreign country respectively

"The material flow chart starts at the point when imported inputs have been loaded off the ship in the country of destination. Within international production sharing systems, the inbound material flow and related logistics are repeated for a large number of supplies. These are often synchronised by means of sophisticated supply chain management tools, but the less they are synchronised, the larger the inbound inventory needs to be. "

Testing is another critical service in the manufacturing section in the Figure 1. The occurrence of accredited test laboratories can be scarce mainly in the developing countries and Q3 can from this reason be quite long. In some cases, the satisfaction of the customer from testing facilities may simply not exist in shallow and small markets.

In developing countries, the logistics services depicted in the manufacturing section of the figure are often undertaken in-house. The main reason is that in such countries the market for these services is considered to be shallow. The consequence of this is that the quality of the services is limited since the majority of firms cannot afford to employ specialists in each of the mentioned services. Much lower fixed costs level but somewhat higher variable costs than from in-house production may be attained by purchasing services from outside. Therefore, small firms would benefit from rich abroad logistics services market which would allow them to purchase only the amount of expert services they need, saving the fixed costs of in-house logistics provision. It is the matter of the fact that a well-developed logistics services market reduces the entry barriers for medium and small sized companies in local but also international levels.

3.3 Infrastructure as a trade barrier

Infrastructure is considered to be one of the most important determinants of transport costs, especially when we are talking about landlocked countries. Many researches of bilateral trade confirm the significance of infrastructure and its level of organization.

3.3.1 Definition of term infrastructure

Infrastructure is critical to our community, economy and pursuit of sustainable environment. There are hundreds of terms for defining infrastructure, which vary from author to author. The one I choose is provided by Larry Beeferman and Allan Wain(2013) in their work Infrastructure : Defining matters. "According to them, the infrastructure refers to facilities, structures, equipment, or similar physical assets – and the enterprises that employ them – that are vitally important if not absolutely essential to people having the capabilities to thrive as individuals and participate in social, economic, political, civic or communal, household or familial, and other roles in the ways critical to their own well-being and that of their society, and the material and other conditions which enable them to exercise those capabilities to the fullest."

3.3.2 Infrastructure and trade

The significant determinants of the ability to trade and fully participate in the world economy events for a particular country are the real costs of trade – the transports costs and other costs connected with doing business on the international level. Low quality transport and communications infrastructure with the remoteness isolates countries and prevent them from participation in global production networks. Therefore it is crucial matter to consider the indicators of transport costs and their geographical dependence and level of infrastructure. When taking into the account geographical measures, it is necessary to focus on distance between countries and whether they share common border and whether they are landlocked or islands. The distance is often involved in the gravity model as a variable and also it will be the practical part of the thesis, but because of the reason that the model was applied to the selected European Union countries, which are located only on the European continent, I found it useless to apply landlocked country variable in the model. And also because nowadays there is Schengen area valid in the EU, the variable common or shared border owns also the lack of importance.

The measures of infrastructure are related to the level of development of communication infrastructure and transport. Even though the meaning of infrastructure for transport costs is well established on regional (or local) level, it is quite common phenomenon that it is neglected on international level which can be influenced by overall geographical characteristics and the ability to trade with other countries. The quantitative importance of infrastructure is the most obvious in determining of transport costs and finding suitable reasons for infrastructure investments. The level of transport costs, the quality of the transport networks and the overall infrastructure development are the basic criteria whether two countries will trade with one another or not. That is why the infrastructure in its sense can be considered as very binding and meaningful and can decide whether two countries will trade or not and that is why it can be considered as a barrier for trading (Limão and Venables 2001).

3.3.3 Transport costs

Transport costs are financial measure of what the provider of transport must pay in order to produce transportation services. They are dependent on wide variety of conditions such as geography, quality of infrastructure, administrative barriers or energy. The main significance of transport costs is that they have direct influence on the structure of economic activities as well as on international trade. There is proved empirical evidence that raising transport costs reduces trade volumes. However, for the increase in transport costs is responsible the general quality of infrastructure because it is responsible for the half of the changes in transport costs.

When talking about the infrastructure, this term is directly linked to the transport costs. The relation between infrastructure and transport costs is that with the higher capacity and effectivity of transport terminals and modes has direct influence on the height of transport costs. Logically, low quality of infrastructure results in higher transport costs, delays and overall negative consequences on economy. It is the matte of the fact that more developed systems of transport a particular country possesses, the lower transportation costs are because the country is considered to be more reliable in handling more movements. All in all, high quality of infrastructure and developed connection of transportation nodes make the country more attractive to trade with.

The importance of the transport costs is not only in their connection to the infrastructure as a barrier to trade but also to time as a trade barrier. The transport time component is also inevitable to be included as it is connected to service factor of transportation. This involves the timing, frequency, the order time, the transport time and punctuality. All of these are recommended to have the shortest length of time as possible, so the country or company is seen as reliable and suitable for trading (Rodrigue and Comtois 2013).

3.4 Logistics Performance Index (LPI)

The infrastructure can be viewed from different kinds of aspects and perspectives. When considering all the possibilities how to apply the infrastructure variable into the gravity model, I needed one single indicator or variable in order to have included this variable in the model. The one such variable is the Logistics Performance index, which was developed by the World Bank and is issued every two years since 2007. In this one indicator the overall quality of countries infrastructure consider for instance customs clearance, the frequency of shipments or the quality of transport infrastructure are included, so it gives simple and easily understandable overview of the countries quality of infrastructure services in only one indicator.

Primarily, the efficiency of trade supply chain or logistic performance is measured by LPI and it includes 160 countries all over the world. Actually, the importance of good logistics performance for poverty reduction, diversification and economic growth are firmly based. The LPI and its elements aid countries to recognize the challenges that they and also their trade partners have to struggle with in order to trade with one another. The main reason for this is to make national logistics to perform in strong and reliable way. The LPI allow the more convenient assessment of the competitive advantage created by good level of logistics. Additionally, to make the logistics performance better is the core value for the economic growth from several obvious points of view. One of them is that inefficient logistics and infrastructure increases trade costs together with the reduction of the potential development of global integration.

The significance of effectively working logistics is currently appreciated by policy-makers all over the world. Trade and commerce, both of them are now moved within and across the borders. What LPI and its components actually measures is the logistics performance or in other words, the efficiency of those supply chains.

In order to obtain the rank of LPI, the survey with standardized questionnaire is spread among the respondents. Consequently, the respondents assess six key areas of logistics performance. These six key areas include:

- The efficiency of customs and border clearance – customs
- The quality of trade and transport infrastructure – infrastructure
- The ease of arranging competitively priced shipments
- The competence and quality of logistics services – trucking, forwarding, and customs brokerage – quality of logistics services
- The ability to track and trace consignments – tracking and tracing
- The frequency with which shipments reach consignees within scheduled or expected delivery time – timeliness

The calculation of LPI is quite demanding process, so I will simplify it in order to make it understandable for the needs of the thesis. To every key element of the index the weighted average is assessed. Then by means of standard statistical techniques (e.g. confidence intervals and average) the data is processed into one single indicator, which can be used to compare countries, regions and income groups (Connecting to Compete 2014).

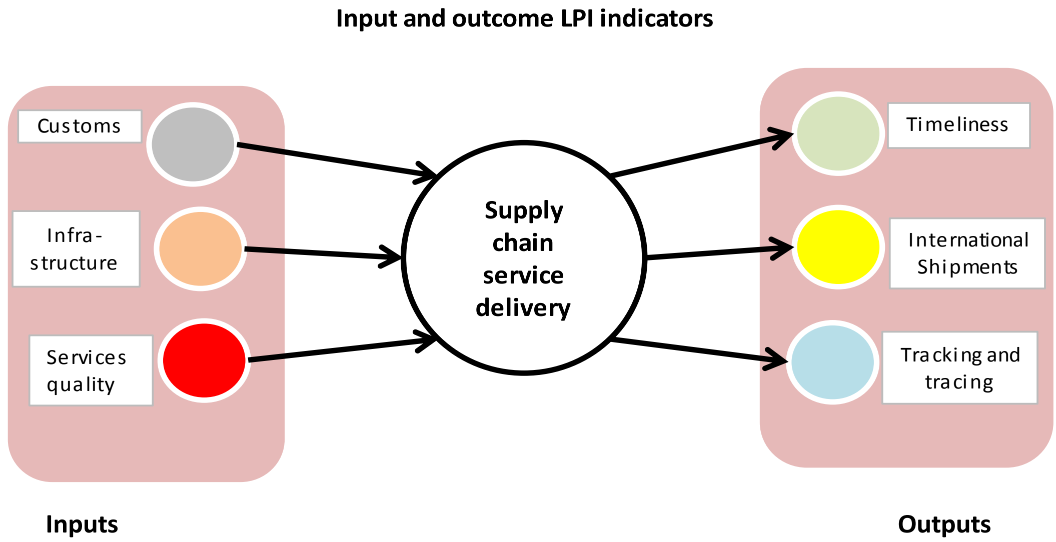

Fig. 2 Input and outcome LPI indicators
Source: Arvis et al. 2014

3.5 Case Study : Cut flowers in Kenya

In order to provide a real example for the connection of time-sensitive products and the importance of quality of infrastructure and logistics, there is a case study of cut flowers in Kenya provided by the World Bank in 2004. The reason why I consider this case study suitable to mention is that Kenya´s cut flower production represents 4.3 % of the world market share for cut flowers. Moreover, the country is the largest exporter to the European Union, where it supplies 62 % of all roses sold.

When trading with cut flowers on international level, the required transportation facilities, cold storage and good organization of inland and air-freight delivery systems are needed for flowers to remain fresh. Fulfilment of these requirements have been a main challenge for Kenyan exporters because they have to face inadequate infrastructure, limited capacity of air routes and air freight, the overall high cost of transport and transport and storage facilities at airports.

Kenya´s logistics and transportation services have been affected by the sustainable worsening of the economic situation. This is also transferred to the opinions of Kenyan companies, which find transport infrastructure and long administrative procedures to be a much more serious obstruction than do companies in other countries of the world. However, the main discontent originates with the transport infrastructure which seems to be dramatically deteriorated in quality of roads. This subsequently increased the costs for vehicles maintenance and wrecked firm profitability and competitiveness. For example, when the firms were surveyed by the World Bank, almost three-quarters of firms reported roads to be "poor", "very poor" or "not available".

The impact of infrastructure and time for logistics is of a huge importance regarding the value chain analysis on medium sized producers of cut flowers. It is known that transport and marketing are very cost demanding parts of this value chain. Furthermore, also packing accounts for the large share of post-harvest handling because when flowers are sold directly to supermarkets, this service has critical importance.

When all the controls of the goods are done the seasonal master plan is collaborated with the schedule of the airlines. Also the convenient conditions for the transportation of flowers are required. One of them is for instance refrigerated trucks, where flowers are kept at a temperature range of between 2-4 degrees during the delivery in order to keep them fresh till they reach the final destination.

Most of developing countries, which are exporting cut-flowers, sell their products via large wholesale auction markets in the Netherlands. However, such wholesales require the flowers to be properly packed and bar-coded products and increasingly demanding source directly from the producers. That is why many producers in developing countries are trying to integrate their systems through locally established offices in the key markets, so they can respond quickly to the market needs. Unfortunately, not all of them are able to do so for financial and other reasons, which again confirm that the time for the transportation and the quality of infrastructure are barriers, which influence trading.

Lessons learned regarding time-sensitive products from this case study are following:

- Time-sensitive products require the availability of reliable transport services and performance to be done on-time
- State of freshness at the time when they reach the final market or consumer is critical
- Suitable transport conditions are also crucial part- in this case these conditions are for instance refrigerated trucks or good quality and organization of infrastructure
- Design, packaging, presentation and appropriate labelling are needed to enter markets.

4 Gravity Model

In this practical part of the thesis I will apply the simple gravity equation for the data of European Union countries and Slovakia. I will analyse, whether such model is significant for this purpose or not. All data will be processed in computer software Gretl, where also the verification of the model and other tests for the specification of the function form, significance of individual variables or detection of heteroskedasticity will be done. The reason why I decided to use the simple version of the model is because it is the basic one and here can be easily and briefly depicted whether in the future the extended version may be applied for the same sample of countries. Also it is important to mention that all the data in the model is sourced from Eurostat databases.

4.1 Background of the gravity model

Gravity has been for a long period of time one of the most successful empirical models in economics, which depicts very well the observed variation in economic interaction in factor movements and trade. The theory of gravity in trade is based on the Newton´s law of gravitation used in physics, which was adopted to the economic theory and adjusted to its needs. Traditional gravity can be explained as a mass of factors of production (labour, land, capital or goods) at origin i is attracted to a mass demand for these factors at another destination j. However, it is important to mention that the distance reduces the potential flow between them. Applying the strict analogy gives the predicted movement of factors of production between these two countries. Because there are many origins and many destinations in any applications, a theory of bilateral flows must account for the relative attractiveness for the origin-destination pairs. Generally, each sale has multiple numbers of possible destinations and each purchase has multiple numbers of origins. In addition, in 19th century the gravity as used only for the prediction of migration patterns in the United Kingdom. But it was the credit of Jan Tinbergen in 1962, who was the first one to use the gravity to explain trade flows (James E. Anderson 2010).

According to Baldwin and Taglioni (2006) the gravity model is an essential device in a wide variety of empirical fields. It is frequently used in order to judge the influence of currency unions, trade agreements, and common or related language usage. Furthermore, it has even more exotic range of application for instance the impact of religion on trade or the impact of the trade on the probability of war outbreak. His explanation of the popularity of the gravity model is that it rests on the three pillars. The first one is that the data necessary to estimate the model are available for the researches. The second pillar is that number of highly professional papers have been written and contributed to gravity model respectability worldwide. The third one, international flows of trade are the main factor in economic relations, so there is a demand for the knowledge of what the level of normal trade flows is.

In order to analyse the infrastructure (or logistics) and time as trade barriers, the gravity model is considered to be the most suitable form for analysing. This approach can be seen also in the work of Nordås, Pinali and Grosso from the year 2006 and that is why I assume it is the right decision. However, there exist many interpretations and equations of the gravity model which are derived from different theories and authors. For my bachelor thesis I decided to apply the equation used by Mátyás László in his work Proper Econometric Specification of Gravity model in 1997. The reason why I decided to use this method is that I would like to apply it into the year 2012 and analyse the trade of selected countries of the European Union. The correct econometric representation of gravity model takes the form of triple-indexed model:

$$\ln \mathrm{EXP}_{\mathrm{ijt}} = \alpha_{\mathrm{i}} + \gamma_j + \lambda_t + \beta_1 \ln Y_{it} + \beta_2 \ln Y_{jt} + \beta_3 DIST_{ij} + ...u_{ijt} \quad (1)$$

Where:
EXP_{ijt} is the volume of trade (exports) from country i to country j at time t,
Y_{it} is the GDP in the country i at time t, and the same Y_{jt} for the country j at time period t,
$DIST_{ij}$ is the distance from country i to country j ,
i=1 (Slovakia)
j= 2,3,4 (Germany, Czech Republic, Bulgaria)
α_i…local country effect
γ_j…target country effect
λ_t…period of time or phase of the business cycle
u_{ijt}…element of the white noise.

This model or gravity equation should be viewed as a general model for all gravity equation. If we want to obtain the model, that is more specific and represents the best either the country i or country j current trade situation, it is convenient to use more extended form of the gravity equation. The main purpose of these is to represent the effects, which influence the behaviour of the volume of exports beyond those, which are explained by the GDP and distance. When the specific effects are large, this can be the sign of the openness of the economy as a target country and it covers two economies simultaneously. On one hand it indicates that there are not any administrative obstacles that may cause any foreign trade difficulties and that there are no potential financial problems keeping imports down. Local country effect describes how effective a given country can be in comparison to other countries from the sample but with the respect to its size. When both ‚local and target effects' are large for majority of the countries inside of the trading block in comparison to the countries which are not members of the block, we can mark this as a significant trading block.

Many previous analyses showed that adding more specific parameters into the gravity equation really makes difference, for example the extended model of the gravity equation may have this form:

$$\ln \mathrm{EXP}_{\mathrm{ijt}} = \alpha_{\mathrm{i}} + \gamma_j + \lambda_t + \beta_1 \ln Y_{it} + \beta_2 \ln Y_{jt} + \beta_3 POP_{it} + \beta_4 \ln POP_{jt} + \beta_5 \ln FCR_{jt} + \beta_6 RER_{ijt} + \ldots u_{ijt} \quad (2)$$

Where:
EXP_{ijt} is the volume of trade (exports) from the country i to the country j at time t,
Y_{it} is the GDP of country i at time t, the same for Y_{jt} for the country j at time t,
POP_{it} is the population of country i at time t, and the same for POP_{jt} for country j at time t,
FCR_{jt} is the number of foreign country reserves of country j at time t,
RER_{ijt} is the real exchange rate between countries i and j in time t,

The specification parameters are considered to be significant and providing better overview into the country i and j position within the trading block. But opinions on whether to use restricted or extended version of the gravity model differs. For example, Hummels (2001) states that the additive specification of coefficients of the gravity model may be more sensible.

As the gravity equations vary, it is always a problem which observables should be included. It is especially valid for abstract trade barriers such as information costs. The reason is that it is quite unclear of what exactly the variable is meant to capture in the model. Even though when the specific theory is not present for the trade costs specification and also variable in the model, a need for careful specification of the relationships between trade barriers and observed variable. To give an example it is suitable to relate language. For gravity equations it is quite common to include language variable. If two countries speak the same or common language, it is give value 1. This is also show in the practical part of my thesis, where the Slovakia and Czech Republic are given 1 variable, because the languages are very similar. Otherwise, the value 0 is submitted into the model.

Another example to be given is distance. It is common to state distance as Great Circle distance (the shortest distance between two capitals on the surface or spheres disregarding highways, roads, etc) between capitals. However, in countries where the capital city differs from commercial centres it is sometimes recommended to use the distances between commercial centres (Anderson and Van Wincoop 2004).

4.2 Selection of countries

Firstly I had to choose the countries for the further processing and analysing. I used the data in the Table from Eurostat databases and depicted the volume of export from Slovak republic to other 27 European Union member states: Italy, France, Germany, Belgium, Luxembourg, Netherlands, the United Kingdom, Ireland, Denmark, Greece, Spain, Portugal, Austria, Sweden, Finland, Slovenia, Czech Republic, Hungary, Poland, Malta, Cyprus, Estonia, Latvia, Lithuania, Romania, Bulgaria and Croatia. Also the total export represents the total volume of Slovak export to the countries of European Union

Tab. 1 Volume of Export and percentage share of Slovak export to EU countries

Country	Volume of Export	Share on the total export in %
Italy	2 884 335 746	5,47%
France	3 336 660 547	6,33%
Germany	13 275 854 303	25,17%
Belgium	922 182 410	1,75%
Luxembourg	74 136 743	0,14%
Netherlands	1 407 189 796	2,67%
UK	2 460 120 196	4,67%
Ireland	84 916 228	0,16%
Denmark	536 618 676	1,02%
Greece	151 399 033	0,29%
Spain	1 061 402 731	2,01%
Portugal	138 731 513	0,26%
Austria	4 135 423 461	7,84%
Sweden	975 726 634	1,85%
Finland	175 982 491	0,33%
Slovenia	467 867 662	0,89%
Czech Republic	8 796 058 546	16,68%
Hungary	4 523 722 260	8,58%
Poland	5 238 072 720	9,93%
Malta	20 116 016	0,04%
Cyprus	6 015 860	0,01%
Estonia	51 461 873	0,10%
Latvia	165 494 898	0,31%
Lithuania	111 103 381	0,21%
Romania	1 152 638 401	2,19%
Bulgaria	344 924 576	0,65%
Croatia	236 858 325	0,45%
Total export of Slovakia	52 735 015 026	100,00%

Source: Eurostat, 2016

For the needs of my thesis I decided to select the countries according to the condition that Slovakia has to export at least 1 % share to the particular country. For this purpose, I had to calculate the % share for each country and apply that condition. After this condition I got fourteen countries, which are also highlighted in the Table 1: Germany with the highest share of more than 25 %, following is Czech Republic, Poland, Hungary, Austria, France, Italy, UK, Netherlands, Romania, Sweden and the last one is Denmark.

For the better illustration and overview of the Slovak export I used pie chart of the Slovak export to EU member states.

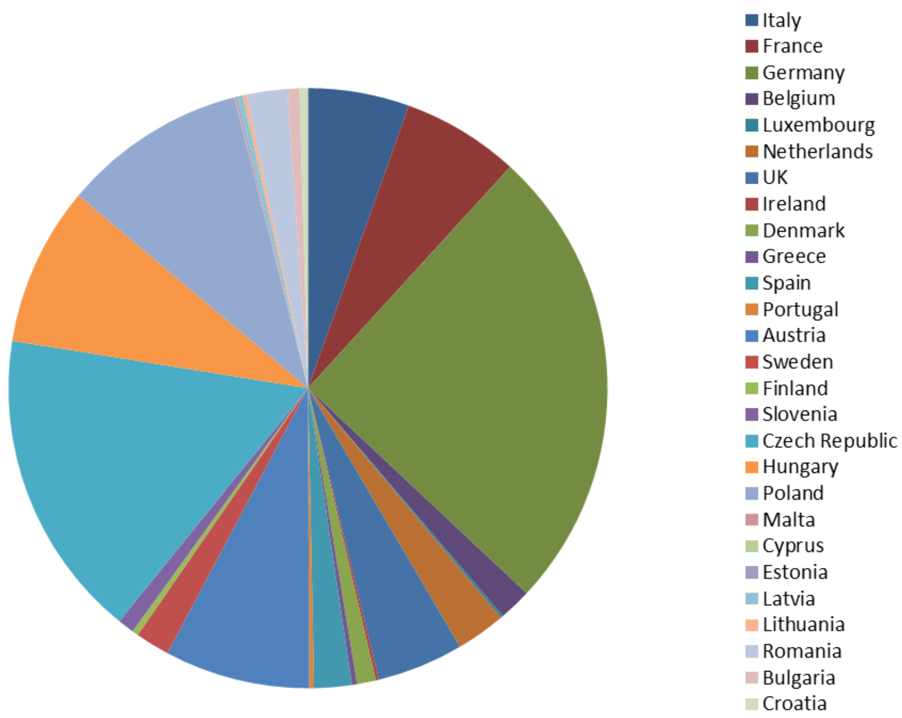

Fig. 3 Volume of export from Slovakia to EU countries in 2012

4.3 Description of data for analysis

The data set consists of sample of 15 countries of European Union, which are divided into I and J for the needs of the analysis of the gravity model. It is because I will examine the trade effect from Slovakia (I) to the other countries (J). Because all the countries are located in Europe and none of them is island, I found it useless to add landlocked country or island variable into the gravity equation as can be found in some versions of this model. Furthermore, in the literature review in the part dedicated to the infrastructure, there was mentioned the borders of the countries as important factor for infrastructure as a barrier to trade. However, these are the countries of European Union that is why I do not consider this variable to be fitted into the model because under the current situation of Schengen area (even the Romania is still candidate country and the UK belongs to non-Schengen countries of the EU), the borders of the countries do not matter anymore. Time period is the year 2012 from the reason that the LPI index, which is crucial for the analysis is issued every 2 years by the World Bank. I am aware that the year 2014 is also available, but other data which I used in the analysis of extended model are still not available. Gross domestic product is in current prices in the value of euro currency. Another variable distance is in kilometres and it was measured by the great circles distances. Language is considered as a dummy variable and it has value 1 if there is no language barrier (or minimal) as in the case of Czech Republic or 0, when there are needed the services of translators in order to intermediate communication between countries I and J(the rest of the countries). The last, but not the least is Logistics Performance Index, which express the overall state and quality of the infrastructure and logistics of the particular country.

4.4 OLS model

Quantification of the model

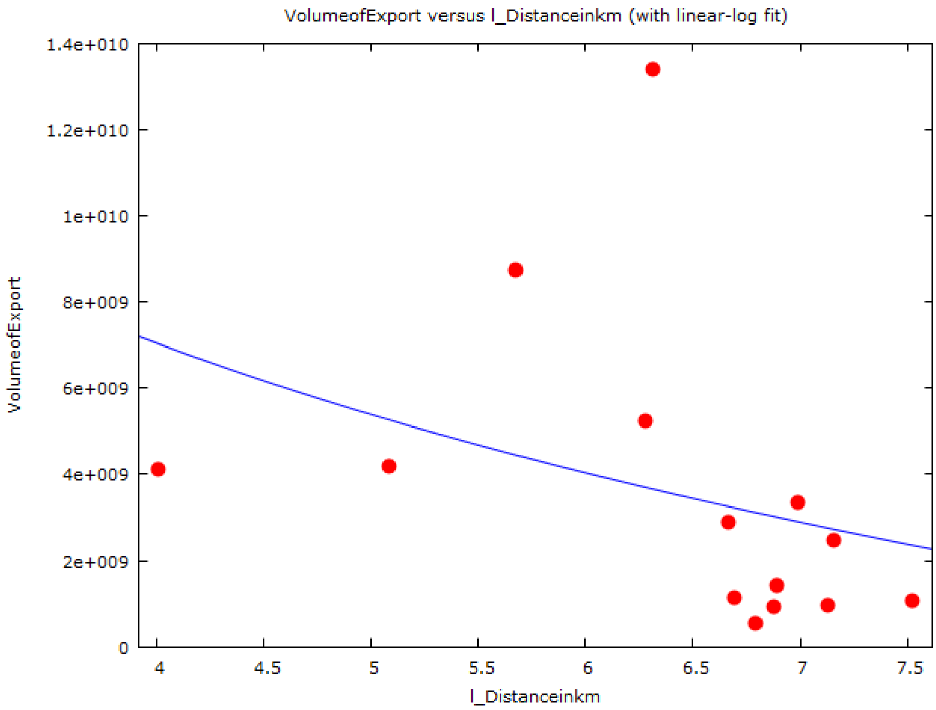

Fig. 4 Scatter Plot

Because the gravity equation is explained by the GDP, distance, LPI and language, it was quite difficult to find appropriate relation between two variables to do scatterplot. After several trying I found lin-log relationship between the volume of export and distance. Lin-log function was the best fitting one from all possibilities, even though the fit is not perfect. This relation can be interpreted by means of OLS model, where 1 % change in distance (increase in distance) will cause 1.01655 decrese in the volume of export.

OLS model of the gravity equation

For the quantification of the model for the regression analysis of the gravity equation for year 2012 I applied Ordinary Least Square method and achieved the values of the coefficients.

Tab. 2 OLS model number 1

Model 1: OLS, using observations 2-15 (n = 14)					
Dependent variable : l_Volume of Export					
	Coefficient	**Standard Error**	**t-ratio**	**p-value**	
constant	5.21076	3.06694	1.699	0.1235	
l_GDP	0.801799	0.135811	5.904	0.0002	***
Language	0.905450	0.456363	1.984	0.0785	*
LPI	- 1.07901	0.407657	-2.647	0.0266	**
Distance in km	- 0.00160061	0.000257619	-6.213	0.0002	***
Mean dep. variable	21.59868	S.D. dependent variable		0.938516	
Sum squared resid	1.353360	S.E. of regression		0.387780	
R-squared	0.881808	Adjusted R-squared		0.829279	
F (4,9)	16.78690	P-value (F)		0.000333	
Log-likelihood	-3.509873	Akaike criterion		17.01975	
Schwarz criterion	20.21503	Hannan-Quinn		16.72396	
Log-likelihood for Volume of Export = -305.891					

The value of R^2 is 0.881808 which means that the model explains 88, 18 % of the variability. This value can be considered as good one because in economic sciences the value of 60 % is usually assumed to be the highest attainable. The value of R^2_{adj} is 0,829279 and so the rule that $R^2_{adj} \leq R^2$ is valid. This coefficient adjusted to the number of degrees of freedom explains 82, 92 % of the variability.

In the original gravity equation there is distinguished between GDP of the i country (Slovakia) and j country (other countries of EU). However in my equation I do not distinguish these two for the practical reason. If I wanted to distinguish between them, the value of Slovak GDP would be the same for all the countries in the Excel and it would not make sense for my regression analysis. This would be the solution in case of time-series; however I will not do my practical part for time-series or panel data because I want to process it from the regression point of view.

On the first viewpoint, the variables of the gravity equation are all statistically significant varying from one to three stars, so it means that all the variables have the reason to be included in the equation. However, two of the variables have negative signs and those are Logistics Performance Index and Distance in kilometres. The negative sign in the variable Distance in kilometres is supported by the theory that the decrease in distance will support the increase in the volume of export, because the countries, which are located closer to each other, are more willing to trade (e. g. lower level of transport costs). On the other hand, the negative sign of LPI is quite surprising, because I expected that with the higher value of LPI (higher quality of infrastructure, lower level of customs etc.) the volume of export will increase. That is why I consider this from the logical point of view bad explanation of the model, which needed to be changed in order to make sense.

For this reason I had to find the way how to cope with the negative LPI value in the model. The best solution to this situation was to create new variable, which would include the positive relation of LPI. That is why I decided to name the new variable LPId, which I got by the multiplication of the Logistics Performance Index by the Distance in kilometres. This variable will explain the relation that with the longer distance between the countries which want to trade with one another LPI plays more significant role. This step included to define new variable in Gretl and consequently to include this variable in the gravity equation and verification in the OLS model.

After adding new variable into the equation, the OLS model changed and I can compare whether the new variable is significant or not, the sign of the variable and its logical interpretation in relation to the volume of export.

Tab. 3 OLS model number 2

Model 2: OLS, using observations 2-15 (n = 14)					
Dependent variable : l_Volume of Export					
	Coefficient	**Standard Error**	**t-ratio**	**p-value**	
constant	5.03762	3.58111	1.407	0.1898	
l_GDP	0.661687	0.136383	4.852	0.0007	***
Language	1.23453	0.502006	2.459	0.0337	**
LPId	-0.000442884	7.87357 e-05	-5.625	0.0002	***
Mean dep. variable	21.59868	S.D. dependent variable		0.938516	
Sum squared resid	2.006285	S.E. of regression		0.447916	
R-squared	0.824787	Adjusted R-squared		0.772223	
F (4,9)	15.69116	P-value (F)		0.000413	
Log-likelihood	-6.265732	Akaike criterion		20.53146	
Schwarz criterion	23.08769	Hannan-Quinn		20.29484	
Log-likelihood for Volume of Export = -308.647					

This model with the new variable explains 82.47% of the variability. The value of adjusted R-squared is 0,772223 so it means that it explains more than 77 % of the variability and also the rule that $R^2_{adj} \leq R^2$ is present. Even though these two indicators are better in the first OLS model, but still they explain variability by high percentage, so I assume to have a good fit.

All the variables are statistically significant so they have meaning in the gravity equation. If we look at the variable LPId, it has negative sign and this can be interpreted that with the the longer distance the LPI plays more important role in considering the trade between countries and so the longer distance between Slovakia and particular country ,the higher LPI of this country will encourage the increase in the volume of trade. From this point of view this variable has the logical explanation in the gravity equation and also statistically is more significant.

The comparison of the Akaike, Hannan-Quinn and Schwarz information criteria is also important. Generally it holds that the better criterion is the one, which produces minimum value of that criterion. From this view point, the values of criteria are better for the first OLS model because they are lower, but still it is good also for the model with the new variable.

4.5 Statistical verification

4.5.1 Fisher´s distribution test

F –test is used for the testing of statistical significance of either one or several regression coefficients, but more frequently it verifies the significance of all model parameters. The results of F –test are summarized in the Analysis of Variance, or generally used abbreviation ANOVA table.

First of all, it is necessary to set the hypothesis H_0 and the alternative one H_1. H_0 refers that the overall model is not statistically significant, so its variables and the function are incorrectly specified. Contrary, if the H_0 is rejected, it means that the model is statistically significant and the function form and the regression variables are specified in a right way. However, before the actual analysis I have to set the significance level for the model. In the literature, these values vary from 1% to 10%, but the most commonly used one is 5%, that is also why I decided to use this value for the statistical and econometric testing.

$H_0 : \beta_1 = \beta_2 = ... = \beta_n = 0$

H_1 : not H_0

Tab. 4 ANOVA Table

Analysis of Variance					
Source of Variation	**Sum of Squares**	**Degrees of Freedom**	**Mean Squares**	$F_{empirical}$	$F_{critical\ 0,05(3;10)}$
Regression	9.44428	3	3.14809	15.6912	3.70826
Residual	2.00629	10	0.200629		
Total	11.4506	13	0.880813		

From the Anova table we can see the detailed analysis of the model and the share of sources of variation. From the econometric point of view, we reject H_0 when $F_{empirical}$ is greater number than $F_{critical}$ value. In the case of gravity model, this rule is valid because 15.6912 >3.70826, so I reject H_0. This confirms that the model is statistically significant and also that the regression variables are specified in a right way. Furthermore, P-value obtained from the Anova table is 0.0004, which is lower than the significance level 5% so also from this view point we reject H_0.

4.5.2 Student´s test

I found using T-test very essential because it examines the significance of every regression coefficient in the model. For the model I have four coefficients, including the constant variable, logarithm of GDP, added variable LPId and language. For every variable I will run the statistical verification and find out, whether they are correctly placed in the model or not. As far as I am concerned, I am about to use two sided tests, because I want to test the significance of the coefficients not their sign (either positive or negative). For this reason I have to divide the level of significance 0.05 by two so the level of significance is 0.025 for the both sides of the test. For all the variables will be the following hypothesis:
$H_{0:}$ $\beta_0 = 0$ (variable is not significant)
$H_{1:}$ $\beta_0 \neq 0$ (variable is significant)

Constant variable β_0
By using the formula:

$$t = \frac{\beta_j - \beta_{H0}}{SE(\beta_j)} \sim t_{n-p} \tag{3}$$

I calculated the value of t is 1.407, which can be also found in the OLS model. However, for the calculation of the value of $t_{critical}$ is inevitable to know the value n-p. Because the sample size consists of 15 countries and there are 3 parameters in the model, the number is 15-3=12. After this, I found the value of $t_{critical}$ is 2.17881. From the econometrics rule, the H_0 is rejected only in the case when $t_{calculated} \geq t_{critical}$. However, in this case it is vice versa, so 1.407 <2.36462, that is why I do not reject H_0. The constant variable in the model is not significant. However, sometimes it is of a little relevance whether the constant is significant or not, because it only interprets the number of export if all the other variables in the model are equal to zero, that is why I will not assess it so high importance to non-significance of this variable.

Gross Domestic Product variable
This variable is in the gravity model in the form of logarithm. Even from the OLS model it is obvious that this variable is significant on the highest level, because it contains three asterisks. But for the better statistical ground I will test this variable. The same formula will be applied for the calculation of t-value, which is 4.852. By means of tool in Gretl, I found the value of $t_{critical}$, which is 2.17881. Because 4.852 is greater than 2.17881, the null hypothesis is rejected, so this variable is significant in the model.

Moreover, according to the Nordås and Piermartiny (2004) in the paper Infrastructure and trade, the quality of infrastructure is highly correlated with GDP. Thus the quality model that incorporate GDP and find it positive and significant coefficient may well pick up the quality of infrastructure. In this case the GDP variable is significant and also positive coefficient, so I can assume that the model depicts the quality of infrastructure, so the GDP variable is legitimate in the equation.

Language variable

This variable has the number of sample size 14, because from the logical point of view it would be useless to analyse the language barrier within Slovak republic and its influence over the export to the selected countries. The value of $t_{calculated}$ is 2.459 and the value of $t_{critical}$ is 2.20099. The null hypothesis is rejected and this variable is significant in the model.

Logistics Performance Index multiplied by the distance

This variable was added into the equation because of its logical interpretation and I will test its significance and presence in the model. The same as in the case of language variable applies here, the size of the sample is 14 because the rate of LPI within Slovakia will not influence its export to the other countries. $T_{calculated}$ is -5.625 and the $t_{critical}$ is 2.20099, so the null hypothesis is rejected and the variable is significant.

4.6 Econometric testing

4.6.1 Ramsey´s Reset Test

The RESET test was proposed by Ramsey in 1969 and it is a general misspecification test, which is designed to determine omitted variables in the function and inappropriate functional form. It´s background is based on the principle of Lagrange Multiplier and uses F-distribution´s critical values.

The definition of the null and alternative hypothesis H_0 and H_1:
H_0 : model specification is correct
H_1 : model specification is incorrect

H_0 is rejected in the case when $F \geq F_{critical}$ and so the alternative hypothesis that the model is specified correctly is valid. I will apply this test in order to find out whether the gravity model applied in this thesis is correctly specified.

Tab. 5 RESET specification test

Auxiliary regression for RESET specification test				
OLS, using observations 2-15 (n = 14)				
Dependent variable: l_Volume of Export				
	Coefficient	**Standard Error**	**t-ratio**	**p-value**
Constant	403.410	897.762	0.4494	0.6651
l_GDP	-115.487	272.670	-0.4235	0.6831
Language	-215.550	508.661	-0.4298	0.6829
LPId	0.0772739	0.182483	0.4235	0.6831
yhat^2	8.00071	19.0271	0.4205	0.6852
yhat^3	-0.121448	0.292659	0.4150	0.6891
Warning: data matrix close to singularity!				
Test statistic: F = 0.182732,				
with p-value = P (F(2,8) > 0.182732) = 0.836				

By means of Gretl I used Reset test and the following results were available. From the F statistics the value is 0.182732. The value of $F_{critical}$ is 3.41053 so the F is lower than $F_{crtitical}$ value, so the null hypothesis is not rejected which means that the model specification is considered to be correctly specified. Moreover, p-value 0.836 > 0.05 which also contributes to the approval of correct form specification. All in all, the model is correctly specified.

4.6.2 Lagrange Multiplier test of specification

This test is used to identify incorrect function form of the regressors in the gravity equation. It can be in two forms: polynomial or logarithmic. However, the correctly specified form of the model can be already indicated from the Reset test, because it is quite often that the results of these two tests are similar.
LM test hypotheses are:
H_0 : model is correctly specified, function form is correct
H_1 : model is incorrectly specified, function form is wrong

Tab. 6 Non-linearity test

Auxiliary regression for non-linearity test (squared terms)				
OLS, using observations 2-15 (n=14)				
Dependent variable: uhat				
	Coefficient	**Standard Error**	**t-ratio**	**p-value**
Constant	116.102	91.6488	1.267	0.2409
l_GDP	-8.58014	6.76490	-1.268	0.2403
Languae	-0.152523	0.454126	-0.3359	0.7456
LPId	-0.000281450	0.000209200	-1.345	0.2154
sq_l_GDP	0.158655	0.124538	1.274	0.2384
sq_LPId	4.72628e-08	2.83600e-08	1.667	0.1342
Unadjusted R-squared = 0.361621				
Test statistic : TR^2 = 5.06269				
with p-value = P (Chi-square(2) > 5.06269) = 0.0795518				

From this I can compare the p-value with the significance level of 5%. P-value from LM test is 0.0795518, which is greater than the significance level so it implies that the linear function form in the examined model is correctly specified. This result also confirms the similarity of the results with the RESET test, where also the model specification outcome was that the model can be marked as correctly specified.

4.6.3 White´s test for the detection of heteroskedasticity

Heteroskedasticity is unfavourable state, when the error term is variably distributed for individual observations or groups of observations. Generally, the testing heteroskedasticity is done by White´s test, which is also considered to be one of the most useful tests for its detection among all the others available.

In this part I will identify either the homoscedasticity or heteroskedasticity of the error term for the gravity equation. The White´s test is available in Gretl and it is based on the hypotheses:

H_0 : error term is homoscedastic

H_1 : error term is heteroskedastic

Tab. 7 White´s test

White´s test for heteroskedasticity				
OLS, using observations 2-15 (n = 14)				
Dependent variable: uhat^2				
Omitted due to exact collinearity: X2_X3 X3_X4				
	Coefficient	**Standard Error**	**t-ratio**	**p-value**
Constant	11.4005	53.1323	0.2146	0.8362
l_GDP	-0.837537	4.00695	-0.2090	0.8404
Language	-0.221321	0.230131	-0.9617	0.3682
LPId	0.000420434	0.00158068	0.2660	0.7979
sq_l_GDP	0.0157106	0.0755561	0.2079	0.8412
X2_X4	-1.79486e-05	6.16798e-05	-0.2910	0.7795
sq_LPId	9.05043e-09	2.06228r-08	0.4389	0.6740
Warning: data matrix close to singularity!				
Unadjusted R-squared = 0.175132				
Test statistic: TR^2 = 2.451848,				
with p-value = P (Chi-square(6) >2.451848) = 0.873817				

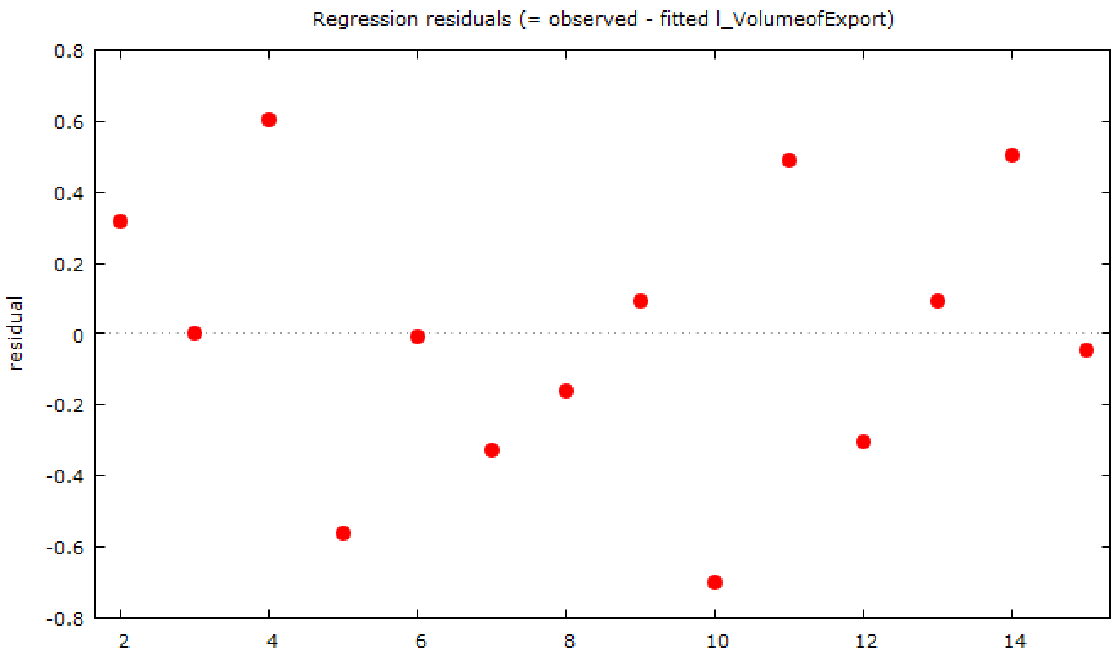

Fig. 5 Regression Residuals

As it is depicted in the Tab.7, the p-value of the test is 0.873817, which is greater value than the significance level of α 5%. From this I can conclude that there is no occurrence of heteroskedasticity. In order to have it even more examined and to exclude any possibility of heteroskedasticity of error term in the model, I decided to use the residual graph.

Residual graph in Fig. 5 confirms that there is no problem with heteroskedasticity. The variability of standard error term does not change. The variance of residuals is not dependent on other variables.

4.6.4 Test of a goodness of fit

There exist many different methods of how to verify normality of the error term. These methods include procedures, which are based on statistical tests, plots or charts. From the statistical tests the most common ones are for instance Chi-square test of goodness of fit, Shapiro-Wilk test or Jarque-Bera test. For the testing of goodness of fit for the gravity equation I apply Chi-square test, because it can be easily interpreted and used.

The null hypothesis is the same for all normality tests:

H_0 : error term is normally distributed

H_1: normality does not hold

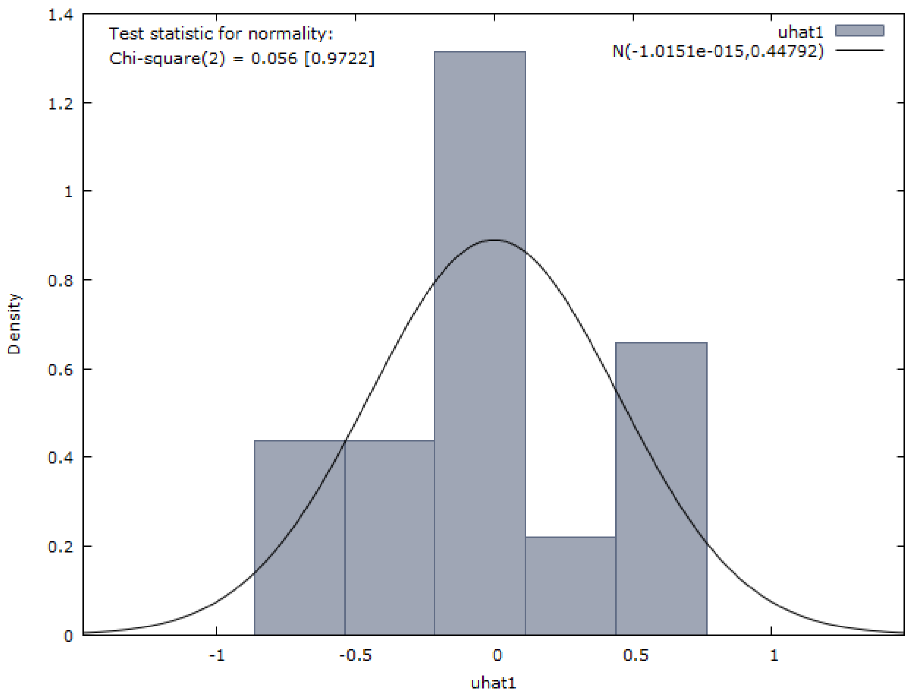

Fig. 6 Test of error distribution

The normality test graph indicates that the error terms are normally distributed among the 0, so from this I expect that the normality of the error term holds for the gravity equation. In order to have it even more backgrounded with the evidence, I decided to compare the p-value with the significance level of α = 5 %. P-value from the gretl output of residual distribution is 0.97220, which is greater than 0.05, so I do not reject H_0. The result is that the error term of the gravity equation is normally distributed.

Tab. 8 Test of a Goodness of fit

Frequency distribution for uhat1, obs 2-15					
number of bins = 5, mean = 2.28389e-015, sd = 0.447916					
Interval		**Midpt**	**Frequency**	**Rel.**	**Cum.**
	< - 0.53774	-0.70066	2	14.29 %	14.29 %
- 0.53774	- -0.21191	-0.37483	2	14.29 %	28.57 %
-0.21191	- 0.11392	-0.048999	6	42.86 %	71.43 %
0.11392	- 0.43974	0.27683	1	7.14 %	78.57 %
	> = 0.43974	0.60266	3	21.43 %	100.00 %
Test for null hypothesis of normal distribution:					
Chi-square (2) = 0.056 with p-value 0.97220					

4.7 Summary of results

Tab. 9 Results of testing

Test	Statistics	P-value	Conclusion
Fisher´s Distribution Test	15.6912	0.0004	Model is statistically significant
RESET Test	0.182732	0.836	Model specification is correct
Lagrange Multiplier Test	5.06269	0.0795518	Model is correctly specified, function form is correct
White´s Test	2.451848	0.873817	No occurrence of heteroskedasticity
Test of goodness of fit	0.0563885	0.97220	Normal distribution of the error term

To finalize this part of the thesis, I would like to summarize the results of the econometric and statistical verification of the gravity equation applied to trade of Slovakia with other European Union countries. All the statistical verification tests outcomes prove, that the equation is correctly specified with the correctly defined function form. Moreover, the error terms is normally distributed with no occurrence of heteroskedasticity, which is a favourable state. As far as the statistical significance of individual coefficients is concerned, the coefficients Language, logarithm of GDP and added variable LPId are statistically significant, so their presence in the model is relevant. However, the constant variable resulted not to be significant, but this is not of a huge importance for the model, as the constant variable is allowed not to be significant. Because all of this factors and testing I can conclude, that the gravity equation applied in the bachelor thesis possesses correctly specified function, model and individual coefficients.

5 Discussion

The usage of the gravity model is very disputable in terms of literature and also in terms of practice. There were held numerous researches which proved its validity but still there are some factors which may prove it to be inadequate. A large amount of gravity model studies require serious errors. Unfortunately, some of them have been repeated so often, that they have penetrated into the acceptable practice. Some of these are for instance silver and bronze medal mistakes, which may be responsible for non-significance of the gravity models or for its biased results. Bronze medal mistake is the inappropriate deflation of nominal trade values. Since there are global trends in inflation rates, the infusion of these terms creates biases, which may misrepresent the gravity model.

Silver medal mistake is connected with the direction of the trade. The gravity equation can be depicted as expenditure function, because it represents the spending of one nation on other nation´s goods. This means that the gravity equation explains uni-directional bilateral trade. However, many gravity equations are not estimated on uni-directional base for instance the exports from Slovakia to Czech Republic. They rather use the average of two-way exports, for example the average exports from Slovakia to Czech Republic and the average exports from Czech Republic to Slovakia. In plain, this may not be big mistake for countries, which have bilaterally balanced trade but it can be really terrible for the countries with unbalanced trade. Since this error ends up in the residuals, it will bias the point's estimates if the error is correlated with other variables. If the error is evenly or randomly distributed, as in the case of the gravity equation applied in the bachelor thesis, the silver medal mistake would have minimum effect. However, in the case of bilaterally very imbalance trade between countries, this can bias the results very significantly.

The partial goal of the bachelor thesis was to identify, whether the gravity model used was proved to possess significant function form, specification and variables relevant for the model according to the economic theory. By means of numerous statistical and econometric verifications it was proved to be right without biases of any of the medal mistakes. The impact of my study is positive in the sense that if the simple version of the model was marked to be right and significant, I can assume that also its extended version may be proved to be significant too. However, according to the working paper written by Richard Baldwin and Daria Taglioni (2006), where they studied the extended model on the APEC (Asia-Pacific Economic Cooperation) trading bloc countries. According to the F statistics, the overall model resulted to be significant with the statistics 49.63, which clearly rejected the null hypothesis about the incorrect specification of overall model. However, during testing of the individual variables, the variable level of foreign currency reserves of the importing country appeared to have only small effect and the estimated standard error term, suggesting it should be considered as insignificant. However, what is even more surprising is the non-significance of the real exchange rate variable, so the relevance of these two variables in the current period of time may be doubted. The adequate solution to this may be the replacement of these variables by the more relevant ones into the model.

I am completely aware of several limitation factors that the gravity equation in the bachelor thesis has. The first one is that the gravity equation was applied to the sample of 15 countries of the European Union. It may be extended by the larger amount of countries of the whole European Union or also third countries may be included. Moreover, the data used was cross-sectional, so it may be quite interesting to watch it on the panel data and provide time series analysis on the gravity model. This may also include the prediction of the influence of the individual variables on the international trade for the future periods of times or business cycles. Another place for the further development is that the extended equation by variables such as population, exchange rate and foreign country reserves may be tested. Furthermore, the testing and comparing of the simple and extended model may be used in order to test whether other variables will provide better results on gravity equation, or on the other hand will make it over specified.

6 Conclusion

The goal of the bachelor thesis was on the basis of the acquired theoretical and practical knowledge to analyse and depict time and infrastructure as trade barriers. The secondarily or auxiliary aim was to prove the main aim by means of the application of the gravity model on the sample of European Union countries, where Slovak Republic exports at least 1 % of its share towards member states.

For the achievement of these aims I used the parts of the literature review, processing of the data in the OLS model and following testing of the model by tests available in computer software Gretl. By means of this testing I identified the significance of the model and individual variables used, which confirmed the significance of time and infrastructure as trade barriers. This structurally divides bachelor thesis into the theoretical and practical part.

I assume the fulfilment of the main goal of the thesis, because in the theoretical part I examined time and infrastructure and their impact on tradability of the certain countries and firms. The length of time for export and import together with the long administrative procedures and lead time may influence the tradability of the country. Moreover, also the quality and the connection of individual nodes of the infrastructure plays important role in considering the country to be reliable partner for trading.

In the practical part I applied well-known gravity model adjusted to the needs of the bilateral trade and proved its correct specification and meaning in the economic theory. First of all the OLS was applied to the data and the overall significance of the model was proved. However, one variable, LPI had negative sign, which from the logical point of view is irrational. This would mean that with the lower LPI the country would be more attractive for trading and it is wrong, because the higher LPI indicates better quality of the infrastructure and logistics. That is why I decided to add new variable, LPId (LPI multiplied by the distance) and after using OLS it was fine.

Than by statistical and econometric testing, such as Fisher´s distribution test, Student´s test, White´s test or RESET test the significance of the gravity equation was proved, that is why I consider the aim of the thesis to be met. However, there is still the occurrence of the biased results of the gravity model in the literature and it is also the reason why there should be held a complex research oriented on this topic and to prove for once either its importance or lack of significance.

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Appendix

A Data for gravity equation

Data for the simple gravity equation						
Countries	**Time**	**Volume of Export (from i to j)**	**GDP**	**Distance in km**	**Language**	**LPI**
Slovakia (i)	2012		72 134 100 000			3.03
Germany (j)	2012	13 392 495 248	2 737 600 000 000	552,65	0	4.03
Czech Republic (j)	2012	8 755 276 340	149 491 100 000	291,06	1	3.14
Hungary (j)	2012	4 204 582 557	97 948 000 000	161,41	0	3.17
Italy (j)	2012	2 884 335 746	1 566 911 600 000	783,49	0	3.67
France(j)	2012	3 336 660 547	2 032 296 800 000	1088,45	0	3.85
Belgium (j)	2012	922 182 410	375 852 000 000	967,63	0	3.98
Netherlands (j)	2012	1 407 189 796	599 338 000 000	985,65	0	4.02
UK (j)	2012	2 460 120 196	1 921 904 900 000	1287,83	0	3.90
Denmark (j)	2012	536 618 676	245 252 000 000	892,65	0	4.02
Spain (j)	2012	1 061 402 731	1 029 002 000 000	1858,06	0	3.70
Austria (j)	2012	4 135 423 461	307 003 800 000	54,88	0	3.89
Sweden (j)	2012	975 726 634	407 820 300 000	1245,21	0	3.85
Poland (j)	2012	5 238 072 720	381 479 700 000	532,06	0	3.43
Romania (j)	2012	1 152 638 401	131 578 900 000	804,77	0	3.00

Source: Eurostat, 2016