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Application of the gravity model of trade in analysing Hungary's foreign trade of agricultural and food products

Theses of doctoral dissertation

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Contents

1. Relevance of the topic

Global export of goods and services was 25,2 trillion dollars in 2018 based on World Bank data. It shows the importance of foreign trade that in the same year global export constituted almost one-third of the world's GDP. In 1995 this ratio was only 21,9 percent. In the 1980s countries of the world recognised that the benefits of foreign trade could be increased if they decreased the barriers among themselves. Despite that, negotiations under the World Trade Organization (GATT, later WTO) failed due to opposite interests. Then countries started bilateral negotiations, as a result of which the number of free trade agreements has grown rapidly since the beginning of the 1990s. Besides, in most continents much deeper forms of integrations were formed that went far beyond the simple abolition of tariffs.

In case of Hungary, first the regime change in 1989, then the EU accession in 2004 were milestones regarding the country's foreign trade, not only concerning the abolition of tariffs and non-tariff barriers, but concerning the country's international target markets. In a sense, the group of trade partners became evident. While in 1999, Hungary's export to the 27 member countries of the EU constituted 73 percent of its total agricultural and food exports, this ratio grew to 86 percent by 2018. So, Hungary's exports to the EU27 countries increased by 13 percent between 1999 and 2018.

Since the accession, Hungary has become an active participant of the EU's trade policy. As a small country, this fact has been a major influence concerning Hungary's foreign trade prospects. Hungary has become a beneficiary of the EU's formerly signed agreements as well as agreements yet to come. Besides positive effects, disadvantages can also arise as a result of the growing competition in the EU's market.

In connection with these facts, many questions arise. Why do countries trade with each other? What factors influence trade between two countries? Why do countries sign free trade agreements? What are the advantages and disadvantages of free trade? What are the effects of these integration efforts on a country's foreign trade and target market orientation?

I examine these questions in case of Hungary and agricultural and food products. The reason for choosing this sector as the main focus of my dissertation is that the agricultural and food products are generally the most sensitive parts of free trade negotiations, therefore understanding the key drivers of the sector's trade is of high importance. Besides, such a research that focuses on the trade effects of the EU accession, especially in case of Hungary

and agricultural and food products, hasn't been conducted yet. Therefore, my research has novel results that could be useful in evaluating integration processes.

2. Research objectives, theoretical background and hypotheses

The main goal of my research is to identify those factors that influence the foreign trade of Hungarian agricultural and food products. After identifying these factors, I quantify the magnitude of their effects on trade. I examine the effects of Hungary's EU accession in particular. I focus on how it changed the amount of trade and Hungary's international trade relations.

To answer my research questions, I collected trade data between 1999 and 2018 and applied the gravity model of international trade to analyse it. Analysis of the motivations of international trade has a long history, it has been examined since the 16th century. Since the creation of the European Economic Community in the 1950s and the increasing number of free trade agreements in the past decades, there has been a growing interest towards the key drivers of international trade. Economics has been applying gravity model for this purpose since the 1920s. The basic concept of the model derives from Newton's law of gravity which states that the force of attraction between two objects is directly proportional to the masses of the two objects and inversely proportional to the square of the distance between their centres. In international trade the attraction of the objects is the trade flow between two countries, the masses of the objects are the economic masses of the countries while the distance between the objects is the geographical distance between two countries. The gravity model became very popular in the second half of the 20th century, it has been used to examine a wide range of phenomena such as migration, FDI, but it is mainly used to analyse international trade flows (Yotov et al. 2016). The gravity model is basically applicable for the two purposes. First, it can be used to analyse a country's foreign trade in general, identifying those factors that influence its trade. On the other hand, it's widely applied to quantify the effects of trade policy, especially free trade agreements and other forms of integrations (Clausing 2001).

In my dissertation I examined the effects of Hungary's EU accession at first. These integration effects are mostly analysed by the two most important concepts of Integration Theory: trade creation and trade diversion. Trade creation occurs after the creation of a customs union as a result of which countries replace expensive domestic products by cheaper foreign products. According to theory, this is a positive process as new trade relations are formed. On the other hand, trade diversion is a negative process because custom union members replace

old trading partners (who are not members of this new union) in their import by countries from the customs union even if old trading partners produce the same product with lower costs (Bhagwati 1996). Literature results suggest that integration enhances trade significantly (especially in case of integrations in Europe and the American continent) while it is also proven that trade diversion exists in many cases (Tang 2005, Montenegro – Soloaga 2006, Egger – Larch 2011, García et al. 2013, Ravishankar – Stack 2014, Pietrzak – Lapinska 2015). Trade creation is examined through a country's export to its trading partners while trade diversion is analysed through its imports from its supplier countries. To quantify these two effects, I constructed a hypothesis:

Hypothesis I *The EU accession had a significant trade creation and trade diversion effect on the trade of Hungarian agricultural and food products.*

Second, I examined Hungary's agricultural and food product exports in general to identify those factors that influence its trade. To analyse this question, I collected data for all the variables of interest, first the basic variables of gravity models: GDP, population and distance. The main concept of the gravity model is that the import of trading partners increases as their income increases while decreases as the distance between the exporting country (in this case Hungary) and the importing country increases. The effects of population are not so obvious. Generally, we assume that a country imports more if its population increases, but its opposite can also happen. It is called absorption effect when a country imports or exports less compared to its large population (Martinez-Zarzoso – Nowak-Lehmann 2003). I formed a hypothesis for the basic variables of the gravity model:

Hypothesis II *The economic size and population of the partner country have a significant positive while distance between Hungary and trade partners have a significant negative effect on Hungary's exports of agricultural and food products.*

Besides the EU accession, I had other explanatory variables to access the effects of integration processes. I also examined whether the accession to the Schengen Area in 2007 had any further trade enhancing effects. This was another milestone in Hungary's integration to the EU because border controls were abolished as well as administration burdens for exporters (Felbermayr et al. 2018a). I also examined whether WTO membership had any effects on

Hungary's exports of agricultural and food products. For these two factors, I constructed the following hypothesis:

Hypothesis III *Accession to the Schengen area and WTO membership have a significant effect on Hungary's exports of agricultural and food products.*

I applied many control variables in my gravity model such as common language, common border and common history. These variables are supposed to have significant effects on trade according to literature results (Paiva 2008, Angulo et al, 2011, Serrano – Pinilla 2012, Cheptea 2013, Melece – Hazners 2014, Said – Shelaby 2014, Bojnec – Fertő 2015). Common language and common border are supposed to have positive effects. Common language in case of Hungary is measured on the basis of the share of language minority which is present in case of Romania and Slovakia. Regarding common history, colonial past or being a member of the former Soviet bloc may have a significant effect on a country's trade decades after its disintegration. Common historical past in case of Hungary is measured by a variable that consists of those countries which were the member of the former Soviet bloc as well as Hungary. For these control variables I formulated the following hypothesis:

Hypothesis IV *Common language, common border and common history have a significant effect on Hungary's exports of agricultural and food products.*

Trade costs play an important part in explaining international trade. Countries set up barriers themselves to protect their markets and sensitive sectors while natural barriers like distance also exist (Anderson – Wincoop 2003). Besides, business activity also has its costs such as remoteness, poor transport, bad communication infrastructure etc. (Limao – Venables 2001). In my dissertation, I measure these trade cost by distance on one hand, but on the other, I applied an index calculated by the Heritage Foundation which has never been used before in gravity models. This is the Trade Freedom Index which quantifies the two main groups of artificial trade costs, tariffs and non-tariff barriers. The higher the value of this index is, the more liberalised a country's trade will be. The following hypothesis is formulated based on this:

Hypothesis V *Trade freedom of the partner country have a significant effect on Hungary's exports of agricultural and food products.*

Finally, I have some assumptions concerning the estimation methods applied in my thesis. There is an argument among researchers regarding the estimation methods of the gravity model. At the beginning, the traditional Ordinary Least Squares (OLS) regression was the golden rule when running a gravity model. Later, it was realised that the OLS method gives biased estimates because of its assumptions that are often violated (endogeneity, heteroskedasticity, multicollinearity, autocorrelation), but most importantly it ignores that the gravity model dataset is a panel dataset and often suffers from heterogeneity as well. While the above-mentioned assumptions often violated in case of other estimation methods as well, panel data needs other estimation methods that can handle the specific characteristics of this type of data. Random (REM) and Fixed Effect (FEM) Models are better choices for panel data. An advantage of these models is that they take into consideration that country and country-pair specific fixed effects exist. On the other hand, they exclude zero trade flows as they are loglinear models, but zero trade flows are frequent in international trade data and they give important information about the trade relationship between two countries. Therefore, REM and FEM also result biased estimates. In the past years, Poisson Pseudo Maximum Likelihood (PPML) estimation method has been recommended because this method doesn't ignore zero trade flows as it uses the gravity equation in its original multiplicative form, making the estimation unbiased and consistent (Silva – Tenreyro 2006, Cheng – Wall 2005):

Hypothesis VI. *PPML model is the most reliable and consistent estimation method among those applied in my dissertation in both specifications.*

3. Structure of the dissertation

The main goal of my research is to identify those factors that influence the foreign trade of Hungarian agricultural and food products. I examine the effects of Hungary's EU accession in particular focusing on how it changed the amount of trade and Hungary's international trade relations. For this purpose, I studied the relevant literature (Chapter 2-5) and summarised its connection with my hypotheses (Table 1.)

Table 1. Literature reference of the hypotheses

Hypothesis	Literature reference
Hypothesis I *The EU accession had a significant trade creation and trade diversion effect on the trade of Hungarian agricultural and food products.*	Chapter 4
Hypothesis II *The economic size and population of the partner country have a significant positive while distance between Hungary and trade partners have a significant negative effect on Hungary's exports of agricultural and food products.*	Chapter 2, 3, 5.
Hypothesis III *Accession to the Schengen area and WTO membership have a significant effect on Hungary's exports of agricultural and food products.*	Chapter 4
Hypothesis IV *Common language, common border and common history have a significant effect on Hungary's exports of agricultural and food products.*	Chapter 5
Hypothesis V *Trade freedom of the partner country have a significant effect on Hungary's exports of agricultural and food products.*	Chapter 3, 5
Hypothesis VI *PPML model is the most reliable and consistent estimation method among those applied in my dissertation in both specifications.*	Chapter 5

Source: own construction

In *Chapter 2,* I reviewed International Trade Theory which lays down the theoretical foundation for the gravity model. I examine why countries trade with each other and what advantages and disadvantages derive from international trade.

In *Chapter 3,* I summarise theories of trade costs. Classical International Trade Theory often ignores the fact that though it is a basic interest of countries to trade with each other, in reality they often don't because of trade costs. In this chapter I summarise those trade costs that are essential elements of gravity models.

In *Chapter 4,* I deal with Integration Theory to examine the effects of free trade agreements and deeper integrations on trade with member countries and third countries as well. I also present results of gravity models to discover how integration effects are modelled in the literature and what results they have. Besides trade, integrations have effects on other aspects of a country's economy such as growth, dispersion of business activity, FDI etc. that I also present in this chapter.

In *Chapter 5*, I focus on the gravity model itself. I summarise its methodological background and all aspects that must be considered when running a gravity model. I present its equation, its basic variables and its estimation methods. I also review the experiences of its application with particular focus on the group of explanatory variables applied in the model. In the rest of this chapter, I also present gravity models conducted on agricultural and food products.

In *Chapter 6,* I present my own research explaining first the definition of the food economy, measurement of international trade flows and then the process of Hungary's EU accession. Then, I proceed to my gravity model summing up first the construction of the model, then the results of the estimations and main conclusions.

4. Research methodology

As a first step of my primary research I collected data of the dependant variable which was Hungary's agricultural and food product exports and imports (based on 2-digit HS codes) for the years between 1999 and 2018 to all its partner countries. I used the STATA statistical software to structure and analyse data. After collecting trade data, I created all the possible year and country pairs to include zero trade flows which must be considered when analysing international trade.

Then I collected data for the explanatory variables of my gravity model starting with the 3 basic variables: GDP and population of the importing country and distance between Hungary and the trading partners. My database also contained dummy variables which were the following:

- *common border*, that is contiguity where 0 means the two countries are not adjacent and 1 means they are;
- *common language*, which seems irrelevant in case of Hungary, but the CEPII database contains a variable which builds on language minorities. If the share of language minority (in this case Hungarian) is at least 9 percent, the variable takes the value of 1 and zero otherwise (in this case in Romania and Slovakia);
- *EU membership*, which takes the value of 1 if the two countries are both EU members and zero otherwise,
- *Third country partner,* which takes the value of 1 if the partner country is a third country and zero otherwise,

- *WTO membership,* which takes the value of 1 if the two countries are both WTO members and zero otherwise;
- *Schengen Area membership,* which takes the value of 1 if the two countries are both Schengen Area members and zero otherwise;
- *Former Soviet bloc membership,* which takes the value of 1 if the two countries are both members of the former Soviet bloc and zero otherwise;

The main focus of Integration Theory is the examination of trade barriers. Many of the gravity models I presented in the literature review attempted to build in tariffs and non-tariff barriers, but many problems occurred. In case of non-tariff barriers, it is nearly impossible to construct a database of 20 years, almost 200 countries and of 24 commodity groups because the available databases are not suitable for collecting a large amount of data. On the other hand, it is recommended to analyse non-tariff barriers only for one specific product at a time because there is a wide range of non-tariff barriers in case of agricultural and food products and they differ from product to product.

In case of tariffs, there are such databases from which you can collect a large amount of data for many years, countries and commodities. The difficulty of analysing tariffs is the huge amount of missing data and aggregation bias (Anderson és Wincoop 2003). Countries often fail to report the applied tariffs therefore the coverage of databases is not satisfactory especially in case of panel data with many years. I collected tariff data from two databases and the share of missing data was at least 75 percent.

In order to build in the effects of these barriers without actually using tariff and non-tariff data, I applied an index which is constructed by *Heritage Foundation*. This index has never been used before in gravity models. It quantifies the two main groups of artificial trade costs, tariffs and non-tariff barriers. The higher the value of this index is, the more liberalised a country's trade will be.

I applied two model specifications in my dissertation. *Hypothesis I* examines whether the EU accession had a significant trade creation and trade diversion effect on the trade of Hungarian agricultural and food products. Trade creation measures an integration's trade enhancing effect while trade diversion quantifies the extent of which a country replaces third country suppliers by integration partner countries in its imports. Trade creation is analysed through a country's export. In this case I applied the *EU membership* dummy variable which takes the value of 1 if both countries are members of the EU and zero otherwise. Trade diversion on the other hand is analysed through a country's import. In this case I applied the *Third country partner* dummy variable which takes the value of 1 if the partner country is a third country and

zero otherwise. Therefore, in the first specification I used only one explanatory variable in both cases to estimate these two effects.

In the second model specification I examined Hungary's exports of agricultural and food products in general with many explanatory variables. This specification is connected to the *Hypotheses II-V*.

In both specifications, I used many estimation methods that I presented earlier. The OLS method which gives biased estimates is still applied by many researchers, mainly to compare its results with other methods. For this purpose, I also applied OLS method. Besides I run several gravity models with fixed effect (FEM) and random effect estimation (REM). The advantage of FEM is that is builds in country and country pair specific and time fixed effects. On the other hand, by doing so time invariant explanatory variables (such as distance) are excluded from the model. This method is often applied when only a few, time variant explanatory variables are of interest (Chevassus-Lozza et al. 2008, Balta – Delgado 2009, Manchin – Pinna 2009, Mika 2017, Rault et al. 2007). If the research question focuses on the effects of time invariant variables such as distance, REM model could be applied but it doesn't quantify fixed effects (and so multilateral trade resistance) rather consider them as part of the error term (Martinez-Zarzoso – Nowak-Lehmann 2003). Besides OLS, REM and FEM model I also applied PPML model because it corrects one of the most serious faults of the above-mentioned estimation methods which is, they exclude zero trade flows. PPML model uses the original multiplicative form of the gravity equation while the other methods use its loglinear form which eliminates zeros. *Hypothesis VI* is constructed for the comparison of these estimation methods.

5. Main results of the dissertation

In the above-mentioned specifications, I examined the relationship between a set of explanatory variables and Hungary's agricultural and food exports. Based on the results of the estimations I made decisions about the hypotheses after which I constructed the theses.

The main target market for Hungarian agricultural and food products had been the EU well before the accession to the integration, but after 2004 Hungary's market orientation became even more EU centred. According to the results of the least unbiased gravity model Hungary's EU membership ceteris paribus increased Hungary's value export of the sector's products by 80-100 percent between 2004 and 2018. Based on this, I constructed the following thesis:

Thesis I *The EU accession had a significant positive effect on the export of agricultural and food products; EU membership enhanced trade towards EU members. It also caused trade diversion; Hungary replaced third country suppliers by EU countries in its imports.*

According to the literature review of gravity models, trade costs that are often proxied by distance, have a negative, GDP and population of the partner country have a positive effect on trade. These relationships are confirmed for Hungary by my research results as well: a 1 percent increase in the distance between Hungary and its trading partner decreases trade by 1,7 percent on average. In addition, a 1 percent increase in the partner's income and population increases trade by 0,7 and 0,4 percent on average, respectively. I constructed the following thesis for the three basic variables of the gravity model:

Thesis II *The distance between Hungary and its trading partners, GDP and population of the importer country had a significant effect on Hungary's export of agricultural and food products. Hungary's export of the sector's products increases as the income and the population of the trading partner increases, but it decreases as the distance grows between Hungary and its trading partners. The latter tends to have a greater effect on trade than income and population.*

Another result of my gravity model is that besides the EU accession, accession to the Schengen Area in 2007 had a further trade creation effect. In addition, WTO membership also had a significant effect on the export of agricultural and food products of Hungary. Based on these results, the following thesis can be formulated:

Thesis III *Accession to the Schengen Area had a significant, trade creating effect on Hungary's export of agricultural and food products. WTO membership also had a significant, but surprisingly negative effect on Hungary's export of the sector's products. The latter phenomenon could be the result of the fact that in the past decades WTO has lost its ability to negotiate meaningful agreements. On the other hand, the examined period of the research may also cause this negative connection as Hungary was a member of the organisation through the whole examined period as well as his most important trading partners. Besides, only a few accessions took place between 1999 and 2018 and these were mainly countries which aren't notable trading partners of Hungary.*

According to my research results, common language, common border and common history have no significant effect on the Hungarian export of agricultural and food products which was drawn up in the following thesis:

Thesis IV *Language minority in the partner country, contiguity and membership in the former Soviet bloc have no significant effect on Hungary's trade of agricultural and food products.*

Besides distance, I applied another variable to quantify the effects of trade costs, especially those that are applied by the government. Tariffs and non-tariff barriers have a significant, negative effect on the trade of Hungarian agricultural and food products. I constructed the following thesis for this result:

Thesis V *It significantly increases Hungary's export of agricultural and food products if the partner country applies less tariffs and non-tariff barriers, so the more liberalised a trading partner's trade is, the more Hungary's exports of the sector's products will be to this trading partner.*

My research also had useful results regarding the methodological issues of the gravity model. The classical OLS estimation ignored the panel characteristics of my data resulting in extreme values for parameter coefficients. The loglinear REM and FEM models improved the results of the gravity model, but they excluded zero trade flows which causes information loss. PPML model eliminated this problem as it uses the original multiplicative form of the gravity model, but it only results in reliable and unbiased estimation if it applies country fixed effects. Based on these results, the following thesis could be formulated:

Thesis VI *PPML model is the recommended estimation method when applying a gravity model because it doesn't ignore zero trade flows like other estimation methods. Besides, application of country and country-pair fixed effects is a must to obtain unbiased and consistent results.*

My research had numerous novel results. I presented the results of several gravity models synthesizing them by many aspects. In *Chapter 5,* I summarised the outcome of gravity models regarding the effects of integrations first on trade, then I organised gravity models by the applied explanatory variables. Finally, I presented gravity models applied for agricultural and food products.

There are some examples of gravity models applied in Hungary, but its application is not even close to frequent. This is especially true in case of agricultural and food products and no

gravity model has been created for quantifying the effects of Hungary's EU accession, especially for the above-mentioned sector.

Another novelty of my research is the application of a variable that hasn't been applied before in gravity models. This is the *Heritage Foundation's* Trade Freedom Index which measures the level of trade liberalisation of countries based on the applied tariffs and non-tariff barriers.

Besides, there are several deficiencies of my research as well. The aggregate analysis of agricultural and food products excludes the possibility of considering the specific characteristics of subsectors of the food economy. In the future, subsectoral analysis should be considered. It is especially important if the research focus is on trade costs such as tariffs and non-tariff barriers as different subsector apply different protectionist tools. The index I used to measure these costs is not perfect either as it is also an aggregate index for the whole economy, not only for agriculture and food products.

My research could also be improved in methodology as well. I focused on the general analysis of Hungary's foreign trade applying many time-variant and time-invariant explanatory variables. The classical estimation methods have two types. OLS and REM model can handle time-invariant variables (such as distance), but they can't handle country and country-pair fixed effects which is a serious deficiency. On the other hand, FEM and PPML model include these fixed effects, but exclude time-invariant variables. In my research my primary goal was to examine Hungary's trade in general and quantify the effect of such basic variables as well as distance. In the future, it should also be considered to analyse the effect of only one or two time-variant phenomenon (such as Russian embargo) and leave out the basic variable that I have already analysed in this research.

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