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Application of the gravity model on the exports of the Hungarian food economy

Katalin Székelyhidi

The last few decades have been characterized by deepening trade connections and the elimination of trade barriers. There are more and more trade agreements among countries, and their integration is becoming deeper and deeper. This process is continuous as ongoing negotiations between countries and regional blocs proceed, for example between the EU and third countries. These processes make it important to identify and examine those factors that influence foreign trade flows (like distance, income and trade barriers) and to analyse the effects of integration, as nowadays, deeper forms of integration eliminate not only tariffs, but non-tariff barriers as well.

In this study I model trade flows of the Hungarian food economy with a gravity model. Gravity models are widely used for ex-post analysis in order to examine the effects of agreements, and to model trade flow. The results of this study suggest that distance, tariffs and non-tariff barriers are serious obstacles to trade. They seem to confirm many countries' efforts to establish deeper cooperation, not just to reduce tariffs but also non-tariff barriers, which often remain present after eliminating tariffs as well.

Keywords: gravity model, foreign trade, food economy

1. Introduction

Nowadays there are only a few countries which are not integrated in the global economy. Experience from past decades shows that economies around the world have recognised the benefits of foreign trade, so more and more trade agreements and regional integration have been created. This phenomenon makes it important to identify those factors that influence foreign trade and quantify the extent of their influence, especially as far as agricultural and food products is concerned, which are very sensitive products in trade negotiations. Gravity models are generally used for this purpose. On the one hand, they are used to determine factors influencing trade flows (both export and import), and on the other hand, they are suitable for analysing the effects of agreements and integration that have already been established for some time, so their effects can be evaluated. Gravity model was derived from Newton's law of gravity. It has been widely used in the social sciences over the past decades, and although its theoretical foundations are well established, there is no general modelling framework which could be used in all types of commercial relations.

In this study I model the factors that influenced Hungary's export of agrarian and food products for 2013 with the gravity model. In doing so, I have applied a new explanatory variable in the model which has never been used before in similar models.

This indicator is called the 'Trade Freedom index', as it measures the effects of tariffs and non-tariff barriers. Before presenting the results of the model, I shall summarize the relevant literature on integration from early regionalism, both in connection with tariffs and with the effects of their elimination to new regionalism, which is a more adequate theory for integration as it typically occurs today. Integration is much more thorough going nowadays, and going beyond the simple elimination of tariffs, it has special characteristics which are better described by new regionalism. In the next part of this study, I present the gravity model and its statistical background. Then I sum up those empirical models in the literature that have been made for analysing agrarian and food trade flows in order to identify models and explanatory variables successfully used in explaining foreign trade. In the last section of this study, I present my model of the Hungarian food economy's trade flows.

2. Integration theories

Over the past few decades, countries all over the world have recognised that the benefits of foreign trade can be enhanced by simplifying the process of trading with each other. Acting on this insight, they have signed agreements, creating and joining trading groups in order to decrease or eliminate tariffs, and even further-reaching forms of integration have been established to eliminate other barriers to trade as well. Such integration is often referred to as regionalism, which can be any form of regional agreements. Integration can be defined as the institutional linking-up of separate national economies into larger economic blocks or communities (Robson 2002). Integration can take different levels, which can create even closer relationship between countries. Moreover, integration increases foreign trade even in cases where a free trade agreement has previously been signed and been in force before subsequent integration entered into force, meaning that there is more to increasing trade flows than merely the elimination of tariffs. Hungary already had a free trade agreement with the EU before 2004, and there were zero or close to zero tariffs on many products, but after EU accession foreign trade still managed to increase. The elimination of administrative barriers to trade further deepened trade relations in the case of those products where tariffs had been eliminated well before 2004 (Kürti et al. 2007). The history of integration is divided into two parts. The 1950's and 1960's was the first significant period of integration, which mainly involved European integration. This period is called regionalism, the first wave of regionalism being characterized mainly by the establishment of the principle of customs union. The second wave was the era of new regionalism from the middle of the 1980's. From this time on, regionalism was considered to be global, and integration interpreted much more widely than simply the elimination of tariffs, as it had become clear that integration had much deeper economic effects.

2.1. Theory of customs union

Early theories of integration concentrated on the elimination of tariffs between countries. Jacob Viner introduced his idea of eliminating tariffs in 1950, and his theories completely changed established thinking on the subject. His thoughts were at the core of integration theory for decades. According to his theory, customs union has two effects: trade creation and trade diversion. The first one appears when, after the elimination of tariffs, countries import in order to substitute high cost domestic production with cheaper foreign products. The theory states that this is a positive process as foreign producers with cheaper products get the chance to supply the market and a new trade connection comes into being. Trade creation is obviously advantageous for the exporting country. For the importing country it can be both advantageous and disadvantageous as well. Consumers benefit from trade creation because they can buy cheaper products instead of the domestic products, but cheaper foreign products may squeeze domestic producers out of the market. Trade diversion, on the other hand, means that, after customs union, a new partner becomes the exporter of a product, even though the former partner could produce the product more efficiently. As the former partner is not a member of the union, it has to pay customs, meaning the price of its products is higher than that of the new partner created by integration. It is advantageous for the partner country resulting from integration, because it seizes a market, but it is also beneficial for the importing country as it is supplied with cheaper products. But it is only partly beneficial for the latter, because the less effective country will supply the importing country, and it also loses an old, well-functioning business relationship and the associated customs revenues. In Viner's theory the scale of trade creation and trade diversion compared to each other represents integration's true effects on the welfare of a national economy (Clausing 2001). The benefits of the elimination of tariffs derives from the balance of trade creation and trade diversion. This balance depends on many factors such as:

- The scale of tariffs eliminated: The higher the value of the tariffs, the higher the degree of trade creation within the integration, as the main purpose of customs was to protect a less effective industry;
- The economic size and geographical area of the integration: The larger the size of the union, the larger the benefits of integration. In contrast, the smaller the size of the union, the larger the scale of trade diversion.
- Transport costs deeply influence trade between two countries and it is also connected to the size of integration. It is extremely important in the context of larger unions because transport cost can be very high where integration involves a large geographical area. In this case closer partners are more likely to trade with each other. Many researchers draw attention to the fact that transport costs are larger obstacles to trade in many cases than tariffs (Limao–Venables 2001, Clark et al. 2004, Hummels 2007).

The effect of distance, which is a decisive part of transport costs, is generally used as a proxy for transport costs in gravity models. Research proved that there is a negative correlation between trade flow and distance between two countries. Moreover, 23 percent of world trade by value is conducted between countries who share a common border.

- Economic structure of countries: Similarity in product structure between two countries, on the one hand, and difference in their production costs make the customs union more profitable (Palánkai 2004).

The effects of customs unions mentioned above are the static effects but there are dynamic effects as well, like economies of scale, increased competition (companies may fold), investment stimulation and the better utilisation of resources. The effects of these are predicted to be larger than static effects (Michalopoulos–Tarr 2004, Scitovsky 1958).

2.2. New regionalism

Viner's theory of customs unions has been used to explain foreign trade for many decades, but the past decades of dynamically increasing trade and deepening integration cannot be explained by trade creation and trade diversion alone. Former theories had been created at the same time as the creation of the European Union mainly to explain and justify the EU. On the other hand, new types of integration have emerged from the 1980s onward, and these former theories could not explain these new forms. There are many reasons for this, foremost of which, the fact that trade in processed products between industrialised countries had become much more deeply intertwined. During the old regionalism, less developed countries were closed to trade and to the flow of capital, but in the past few decades they have been taking steps to play a part in the global multilateral system of trade. The third characteristic of the new international economic world is the intense flow of FDI between developing and developed countries. Regionalism has become worldwide and has different characteristics in different parts of the world and different types of integration come into being (Söderbaum 2003, Hettne 2005).

Indeed, the deepest form of integration in which countries establish full economic, political and regulatory integration cannot be explained by Viner's theory. That is in fact why new regionalism was created, and its main area of research is the examination of deep forms of integration, especially with regard to the following aspects (Burfisher et al. 2004):

- standardisation and protection of investments in order to promote the mobility of financial and real capital;
- ensuring the free flow of labour;
- harmonisation of domestic tax and subsidy policies especially in case of production and trade;

- harmonisation of fiscal and monetary policies including exchange rate policies;
- establishment of institutions in order to enhance the operation of the integration;
- development of transport and communication infrastructure for ensuring the free movement of labour and capital;
- harmonisation of product and factor markets' regulations;
- creation of an integrated monetary and exchange rate policy for the introduction of the common currency.

The characteristics mentioned above can be interpreted as steps towards the deepest integration. These kinds of integration have the following characteristics:

- One or more small countries become integration partners or sign a regional agreement with a large country. For example, in the case of NAFTA, Mexico and Canada are small countries compared to the USA, or one might cite the EU and its enlargement eastwards. In case of MERCOSUR, Brazil plays the decisive role in the integration;
- Small countries introduce reforms in many areas, for example the system change of Central and Eastern European countries, and all the efforts they have made since then to harmonise with the EU;
- There are no drastic steps to reaching free trade, usually it is a matter of a series of smaller steps towards liberalising trade. For example, with regard to agricultural products there are smaller reductions in tariffs, sometimes in several steps over a number of years, or for sensitive products, protection is even maintained. This also shows mistakes in Vinerian theory, tariffs not needing to be eliminated immediately and completely in many cases (Burfisher et al. 2004, Ethier 1998);
- In many cases, agreements are one-sided as small countries take steps towards liberalisation. These typically involve granting preferences not only in terms of tariffs but also with regard to institutional systems. The same applied to the EU's eastern enlargement, when the accessing countries adapted to the EU's system. Mexico and Canada also granted more preferences to the USA than the USA to them. It must be noted that the larger country often has lower tariffs well before the integration;
- In the era of new regionalism, deeper forms of integration are also established in which the elimination of tariffs is not the only target but the harmonisation of economic policies;
- Regional agreements and integration are regional in the geographical sense as well meaning that the participants are typically neighbouring countries (Ethier 1998).

3. The gravity model

There are two main methods to model foreign trade flows. Computable General Equilibrium (CGE) models are used for ex-ante analysis, which means that the possible effects of integration and agreements can be estimated. The other modelling tool is the gravity model, which is used for ex-post analysis, with the help of which one can evaluate the effects of instances of integration that had already come into force. Coincidently, Tinbergen and Pöyhönen developed the model virtually simultaneously, and completely independently from each other. It was introduced in 1962 and it has become a very popular tool for analysing many types of flows, for example migration, foreign investments, but more typically foreign trade flows. The model is basically a regression model which is used to identify factors that can explain trade flows between regions. With the gravity model one can capture the causal relationship between the explanatory factors and the trade flow. On the other hand, it can be used to estimate the effects of integration and agreements on foreign trade with the help of panel data (Garcia et al. 2013).

The basic gravity model explains trade flow between two nations with the size of the countries and the cost of transportation. The size of the country is captured by income, and the transport cost is measured by the distance between country pairs. The higher the income of the countries, the higher the trade flow between them will be, and the larger the distance between two countries, the smaller the trade flow between them. Linnemann added population to the explanatory variables in 1966 (Cheng–Wall 2005). The model seemed to fit observations very well, and it was widely used over the next few decades, even though it lacked a theoretical foundation. Work on this was begun in the 60s and nowadays it has a solid theoretical background as well.

The gravity model of trade explains the export between countries with income, population, distance and other dummy variables. The basic equation of the gravity model is the following:

$$X_{ij} = \beta_0 Y_i^{\beta_1} Y_j^{\beta_2} P_i^{\beta_3} P_j^{\beta_4} {D_{ij}}^{\beta_5} A_i A_j A_{ij} \epsilon_{ij}, \quad (1)$$

where X_{ij} is the export from country i to country j, Y_i (Y_j) is the income of the countries, which is captured by GDP, P_i (P_j) is the population of the countries, D_{ij} is the distance between the countries, and β are the coefficients of the explanatory variables. Meanwhile, A_i,A_j,A_{ij} are dummy variables characterising country i, j and their relationship. These are used to capture qualitative, specific features of countries. With dummy variables one can examine the effects on trade of common language, common border, colonial past, participation in an agreement or in an organization, whether one or both of the country pair is a landlocked country or enjoys access to a coastline. The dummy variable has the value of 1 if the country or the country pair

has the given characteristic, and zero if otherwise. For example, if the countries have the same language, then the value of the dummy variable will be 1.

The basic equation of the gravity model is a multiplicative equation for trade flows and if we take the logarithm of it, we get the linear form of the equation. The result is a simple loglinear regression equation which can be analysed with the tools of the basic regression model. The basic loglinear form of the gravity model is:

$$lnx_{ij} = \ln\beta_0 + \beta_1 \ln Y_i + \beta_2 \ln Y_j + \beta_3 \ln P_i + \beta_4 \ln P_j + \beta_5 \ln D_{ij} + A_i + A_j + A_{ij} + \mu_{ij} \quad (2)$$

According to the model, if the income of the exporting country increases its production will increase as well, and its potential for export will be greater. Hence the coefficient of β_1 is expected to be positive. The logic is the same in case of β_2, because if the income of the importer country increases, it can purchase more products from abroad. The coefficient of population is not as obvious as for the former variables, because β_3 and β_4 can be both positive and negative according to absorption effect or economies of scale. In case of absorption effects a country's exports are low compared to its high population, and the sign of the coefficient will be negative. On the other hand, if a country has a large population and it exports a lot, then the economies of scale prevails (Martinez-Zarzoso and Nowak-Lehman 2003).

Gravity model had been used for cross-section data only for a long time, so the gravity equation was estimated only for one year. A few years before the millennium, panel data began to be used, because the estimation is more accurate when analysing many years.

4. Application of the gravity model in the foreign trade of a food economy

The application of gravity models has become widespread in explaining foreign trade flows and estimating the effects of integration measures that have already come into force. It has been also widely used in agriculture and the food industry since the beginning of century. The reason for that lies in the many agreements and instances of integration that were established about 20 years before the millennium, meaning that by 2000 there was enough data from many years on which the effects of this integration could be examined.

The effects of agreements on the continent of America has been widely analysed, among other things pertaining to the food economy (Table 1). The results of this research prove that the market opening of Mexico in the 1980s increased US exports to Mexico much more than to other countries. The effects of NAFTA seemed to be much less, it was only significant in the case of a few products. With the establishment of MERCOSUR, trade flows between the USA and Brazil fell sharply, especially those of milk, sour cream, legumes and wheat (Zahniser et al. 2002).

Another research dealt with the trade creation and trade diversion effect of NAFTA as it affected six agricultural products (meat, cereals, vegetables, fruits, sugar and oil seeds). The results showed that for 5 products out of the 6 categories examined, NAFTA decreased the openness of the countries, and that after NAFTA had entered into force, trade among member states had increased (Jayasinghe–Sarker 2007).

The research also dealt with agricultural trade in general, and tried to explain the tendencies of its foreign trade (Table 2). In 2008 a study stated that the agricultural trade increased between 1990 and 2002, but trade among less developed countries increased much more slowly than that of OECD and EU countries. Moreover, developed and developing countries had become closed to each other. The results of the study proved that if a rich country was a member of NAFTA or the EU, then it exported much more than other countries, a phenomenon which could admittedly be the result of the huge subsidies paid to producers. Latin America and Africa were seriously affected by the protectionist behaviour of rich countries, they had become relatively closed and imported less than their size and other explanatory variables would have predicted (Paiva 2008).

According to another piece of research, foreign trade of manufactured products (light industry, heavy industry, and food industry altogether) increased in the second half of the 20th century, but if we examine only the food economy, then data shows that the share of products of the food economy actually declined. In 1951 their share was 43% in world trade but it had fallen back to 6.7% by 2000. It also decreased in terms of quantity, by 20 percentage points. The results of the gravity model showed

Table 1 Some characteristics of gravity models used to analyse foreign trade flows of America

Period	Author(s)	Target	Target variable	Explanatory variable(s)
1980-1999	Zachniser et al. (2002)	Examination of the effects of interactions created in the continent of America	Export	GDP, distance, participation in the agreement
1985-2000	Jayasinghe and Sarker (2007)	Examination of the trade creation and trade diversion effects of NAFTA in case of 6 agricultural products	Export	GDP, distance, participation in the agreement, openness

Source: Own construction

Table 2 Some characteristics of gravity models used to analyse the foreign trade flows of the food economy in general

Period	Author(s)	Target	Target variable	Explanatory variable(s)
1990-1993, 1999-2002	Paiva (2008)	Examination of the unequal liberalisation of trade comparing developed and developing countries	Export	GDP, distance, participation in an agreement, remoteness, the size of the countries, population density, the share of agriculture in GDP, landlocked country, common border, common language, common currency, colonial past, regional classification, income categories
1963 - 2000	Serrano and Pinilla (2012)	Examination of the decreasing share of the exports of the food economy in world trade in long time-series and comparing it with manufactured products	Export	GDP, distance, distance weighted by income, GDP per capita, participation in an agreement, common border, common language, exchange rate

Source: Own construction

that income played an important role in the tendencies of trade, but whereas for manufactured products income was in positive correlation with trade, for agricultural and food products, the correlation showed a negative sign in the 40 years examined. The research refers to the income elasticity of food products, i.e. because they are inferior products, their consumption decreases as the income increases. The model also proved that the products of the food economy are more sensitive to trade agreements, especially true of the EU (Serrano–Pinilla 2012).

Gravity model has also been used for the examination of the food economy of a single country (Table 3). Among these the trade connection of the EU with Mediterranean countries is the subject of much of the research. The reason for this could be that they play an important role in EU foreign policy, not only because of their proximity, but the colonial past of some EU countries also affecting trade (Crescimanno et al. 2013). For example, Germany's import of olive oil was significantly influenced by partnership agreements between Mediterranean countries and the EU (Kavallari et al. 2008). In the case of Italy, these agreements were less significant, whereas agreements signed with potential candidate countries significantly influenced exports because of the fewer barriers to trade (Crescimanno et al. 2013).

Gravity models have been used to analyse foreign trade with the Middle East, mainly with Egypt, which has experienced a fall in exports of agricultural products over the past few decades. Research has shown that common language is very important in Egypt's trade connections, as it clearly exports more to the Arab countries. On the other hand, agreements with Arab countries do not play a significant

Table 3 Some characteristics of gravity models used to analyse the foreign trade flows of specific countries

Period	Author(s)	Target	Target variable	Explanatory variable(s)
1995 – 2006	Kavallari et al. (2008)	Examination of German olive oil imports, particularly the effects of partnership agreement with Mediterranean countries	Import	GDP, distance, employees coming from the partner country to Germany, EU membership, Euro-Mediterranean partnership membership, presence of German tourists in the partner country, direct supply, labelling
1996 – 2010	Crescimanno et al. (2013)	Examination of the exports of Italy to Mediterranean countries	Export	GDP, distance, participation in an agreement, colonial past, share of land used in for agricultural production, regional classification (Balkan, Machrek, Maghreb country)
2001 - 2009	Angulo et al. (2011)	Examination of Tunisian olive oil exports with the tools of spatial econometrics	Export	GDP, distance, common language, HDI index
2002 - 2012	Melece and Hazners (2014)	Examination of Latvia's food trade flows	Export	GDP, distance, EU membership, colonial past, common border, landlocked country
1994 - 2008	Hatab et al. (2010)	Examination of the decreasing share of Egypt's agricultural exports in total exports, especially in the case of its largest importers	Export	GDP, distance, openness, participation in an agreement, exchange rate, common language, common border
1995-2010	Said and Shelaby (2014)	Examination of the decreasing share of Egypt's agricultural exports in total exports, only exports to other Arab countries	Export Import	GDP, distance, number of foreign capital investments, common border
2012	European Parliament (2014)	Examination of tariffs and non-tariff barriers in trade of agricultural products between the EU and the USA	Export	GDP, distance, common border, common language, presence of non-tariff barriers, tariffs

Source: Own construction

role in the exports of Egypt, which is due to the similar comparative advantages, the lack of harmonisation of regulations and the low level of private sector activity. The infrastructure is not modern either, and rather represents a serious barrier to trade which limits the transportation of large shipments (Hatab et al. 2010, Said–Shelaby 2014).

Many gravity models have tried to estimate the effects of tariffs and non-tariff barriers, which are very difficult to quantify because of the many types of tariffs and non-tariff barriers. The results of a gravity model proved that tariffs and non-tariff barriers in trade of agricultural and food products also affect trade relations. Looking at the trade connection between the EU and the USA, trade flows were negatively affected by these trade barriers but the effects of non-tariff barriers were much larger and more serious than the effects of tariffs.

Much research has been conducted with gravity model for modelling food economy trade flows, but no standard modelling framework or general specification has been created. Income and distance have been part of every gravity models, but the other variables depend on the country examined or the integration being modelled. The reason for this is likely the many factors influencing the trade of a country or a group of countries like language, common borders, history or being party to an agreement.

5. Gravity model of the Hungarian food economy

5.1. Data

The gravity model of the Hungarian food economy was a cross-section analysis for 2013 seeking to identify and quantify the main factors influencing the exports of the food economy. The target variable of the model was the export value (HS 01-24) in dollars, as taken from the database of the Central Statistical Office. Explanatory variables were the GDP of the importing country, population from the World Bank, and the distance between country pairs as quoted in the CEPII database. The data was collected in the Research Institute of Agricultural Economics as part of a research started in 2015 examining foreign trade relations. The reason for using cross-section analysis instead of panel data was to test potential variables that might be applied in later models using panel data. The database also contained the share of agriculture in GDP as listed by the World Bank. The model used variables that have not been applied by other researchers so far:

- *Trade Freedom index*, which was collected from the Heritage Foundation (2017a). This variable quantifies the tariffs and non-tariff barriers and its value is between 1 and 100. If the value of the indicator is higher for one country compared to another country, its trade is more liberalized. This indicator is very useful as tariffs and non-tariff barriers are of crucial importance in trade, but they are very difficult to quantify and it can be a simpler way to model tariffs and non-tariff barriers;
- *Corruption Freedom index* from the same source (Heritage Foundation 2017b). It is also an indicator with values between 1 and 100 and the higher the value of the Corruption Freedom index, the lower the corruption is in a given country;

- *Trading Across Borders index* from Doing Business (World Bank 2017). This indicator measures logistical and bureaucratic barriers (documents needed for export, import, days necessary for export and import, transport costs) excluding tariffs. It ranks countries starting from a country with the lowest barriers to the highest.

The database also contained dummy variables such as common border with Hungary, whether the partner country applied tariffs, and whether the country was a member of the EU. After the construction of the database, I took the logarithms of all variables except for the dummy variables. Hungary exported its agricultural and food products to 153 countries in 2013. The model consisted of 133 observations, as certain countries had to be excluded for lack of data for the Trade Freedom index. 20 observations were excluded from 153 observations, which constituted less than 1 per cent of the total exports of Hungary's food economy. The model was constructed with SPSS software.

5.2. Factors influencing the exports of the Hungarian food economy

The first step in modelling is the examination of linear correlations between the pairs of variables in order to determine which variables are connected to the target variable, and to what extent. On the other hand, in regression models, multicollinearity may be present causing bias to the estimation. Multicollinearity means that there is a significant correlation between the explanatory variables, which is a problem because in a regression model the main target is the estimation of partial effects of explanatory variables on the target variable. If multicollinearity is present, the results are biased by the correlation of independent variables, and they explain each other. The correlation matrix and the VIF indicator are used to identify this phenomenon. The VIF indicator is the variance inflation factor which measures the extent of multicollinearity among variable groups. If the value of the indicator is higher than 5, multicollinearity is considered disruptive and the estimation will be biased (Kovács 2008).

When we construct the correlation matrix, the relationship between the logarithms of the original variables can be examined. The matrix showed that that there was no significant connection between export and the population, but all other variables proved to be significantly related to export. The link was the weakest for the presence of a common border ($r = 0.349$). There was medium-level correlation with the Corruption Freedom index ($r = 0.466$), the share of agriculture in GDP ($r = -0.560$), GDP ($r = 0.569$), the application of tariffs ($r = -0.590$), EU membership ($r = 0.603$) and distance (r=-0.655). Export proved to be strongly related to the Trade Freedom index ($r = 0.702$) which quantifies the tariffs and non-tariff barriers applied by the partner country. The negative sign of the correlation means that the two variables move in the opposite direction. For example, as the distance between two countries increases, the trade flow between them will decrease. It is the same with the

share of agriculture in GDP and the presence of tariffs in the partner country variables as well. There is a positive sign in the case of Trade Freedom index, because as previously mentioned, if the value of the indicator is higher for a country compared to another country, its trade is more liberalized and export will increase as well.

Besides the examination of the relationship between export and all other variables, it is important to identify the connection between the explanatory variables in order to prove the presence or the lack of multicollinearity. GDP and population are strongly related to each other ($r = 0.627$) and there is a significant relationship between the distance and the presence of tariffs ($r = 0.501$), the distance and EU membership ($r = -0.582$), the presence of tariffs and EU membership ($r = -0.916$). These relationships seem to be logical, as for example in the latter, EU member countries are those partner countries of Hungary where there are no tariffs applied at borders. The Trade Freedom index, the Trading Across Borders index and the Corruption Freedom index also correlated with each other. The correlation matrix showed that multicollinearity could cause serious bias in the regression model, which will be tested with the VIF indicator.

For the first step, I ran a model which contained most of the variables in order to observe multicollinearity and partial effects. The first model proved what could have been seen from the matrix as well, namely that the presence of tariffs, the EU partnership, GDP and population, and the trade barrier indexes are strongly connected to each other and thus violate the requirement of the lack of collinearity among the explanatory variables in a regression model. In the next steps, I excluded those variables that violated this requirement, namely the presence of tariffs, the EU partnership, population, the Trading Across Borders index and Corruption Freedom index. Their exclusion depended on their importance to the model explaining export. According to this, Trade Freedom index remained in the model instead of the presence of tariffs because although both variables influenced export, the former had a much more significant role in accounting for it. The inclusion of Trade Freedom index thus resulted in a model with a much higher explanatory power. Similarly, the exclusion of population increased the explanatory power of the model as well, which is no surprise as it did not seem to be in connection with export at all according to the correlation matrix. Moreover, Trade Freedom index seemed to be the most important factor in the model among the three variables quantifying barriers to trade.

The results of the model correlated to the results of the models constructed in the literature. The food economy exports of Hungary are influenced by the GDP of the partner country, the distance between the two countries and the tariffs and non-tariff barriers to trade.

$$\ln Export_{ij} = -16.891 + 0.879 \ln GDP_i - 2.012 \ln Distance_{ij} + 7.026 \ln TFI_i \quad (3)$$

The model explained 79 (R^2) per cent of the differences in the exports, and there was a strong relationship between exports and sum of the explanatory variables ($R = 0.889$). According to the goodness of fit, the model can be used with confidence for the examination of Hungary's food economy exports. The VIF indicator proved that the constructed model is free of multicollinearity, so the explanatory variables are uncorrelated. When explaining the coefficients of the variables we have to consider that we have taken the logarithms of the variables. In practice that means that the linear relationship is between the logarithms of the variables, so when we speak about the original variables the regression coefficients must be interpreted as elasticities. According to this, the model suggests if the GDP of the importing country increases by 1 per cent from any level, the exports of Hungary increases by 0.88 per cent. The relationship of the export and distance is of negative direction. If Hungary exports to a country which is 1 per cent more distant, export decreases by 2.01 per cent. Tariffs and non-tariff barriers have the largest influence on export. The connection with the index suggests that if the level of these barriers falls by 1 per cent from any level, the export of food products of Hungary increases by 7.03 per cent (Table 4).

Table 4 The results of the gravity model of Hungary's food economy exports (n=133)

Parameters	**Coefficients of the parameters (β)**	**level of significance**	**VIF indicator**
Constant	-16,891	0.004	
GDP of the importer country	0.879	0.000	1.212
Distance	-2.012	0.000	1.356
Trade Freedom index	7.026	0.000	1.131
Correlation (R)		0.889	
Explanatory Power (R^2)		0.789	
Adjusted Explanatory Power (adjusted R^2)		0.785	

Source: Own construction

In the gravity model of Hungary's food economy, I applied an indicator which has not been used before in gravity models. This is the Trade Freedom index, which seemed to be applicable in explaining foreign trade flows. Tariffs and non-tariff barriers are very difficult to quantify as there are many types of tariffs in different countries for most of the products in question, if we model aggregate trade flows, it is very hard to define the average level of tariffs. On the other hand, non-tariff barriers are even harder to measure. This index thus provides a simpler way to quantify the effects of tariffs and non-tariff barriers to trade. The results of the model suggest that distance and especially tariffs and non-tariff barriers are serious obstacles to trade. This proves the importance of the integration efforts being conducted around the world. Countries close to each other must make efforts to create forms of integration concentrating not only on the elimination of tariffs, but also on the creation of deeper

alliances that eliminate all those regulatory, administrative barriers that seem to be even larger obstacles to trade than tariffs.

6. Conclusion

The gravity model of Hungary's food economy verified the results of gravity models presented in the literature. Export is negatively influenced by the distance of countries and positively affected by the GDP of the importer country. The contribution of this model is the application of variables that have not been used in gravity models before, but can be useful in quantifying trade barriers when exporting to a country. These indicators are the Corruption Freedom index, Trade Freedom index and Trading Across Borders. Trade Freedom index proved to be the most important factor in explaining food trade flows. The index measures the ease of trading with a country by quantifying the freedom of a country from tariffs and non-tariff barriers. Tariffs and non-tariff barriers are difficult to quantify directly, so this index could be useful in measuring the aggregate effects of these barriers to trade. The significant effect of tariffs and non-tariff barriers to trade suggest that forms of integration that aim to eliminate both types of barriers between partner states foster foreign trade as far as agricultural and food products are concerned. Hungary exports a significant part of its food economy products to the European Union, the effect of which is indisputable according to the results of the model in connection with proximity and barriers to trade. The model presented here can be developed by using panel data in order to determine country pair specific effects, and to make the estimation more accurate.

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