Determinants of Exports of Hungary: Trade Theory and the Gravity Model[1]

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Abstract
The end of the Communist regime brought about great changes in the economies of Central and Eastern Europe; the restructuring of foreign trade was one of the biggest challenges for these countries. After the transition period, Hungary has become a very open country with its trade to GDP ratio around 1.5, while trading with more than 190 countries in 2014. The central aim of this paper is to analyze the determinants of exports for this small Central European country in the period of 1993-2014, with an emphasis on the impact of factor endowments. According to our results, economic size, common border and free trade agreements have a statistically significant positive effect on the exports of Hungary, while the coefficient of distance has the expected negative sign. We measured factor endowments with several approaches and our results show that exports of Hungary correspond to the Linder hypothesis, i.e. Hungary tends to trade more with countries having similar factor endowments, and thus its trade is based on differentiated products.
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1. Introduction

Hungary is a small, Central European country which only became a market economy in 1989, after the end of the Communist regime. The last 25 years greatly differ from the Communist era in both political and economic terms; one of the most noticeable changes has been the

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structural change in the foreign trade as Hungary started to trade with more advanced economies. This paper analyses the determinants of foreign trade of Hungary after the transition period, and its purpose is to determine which trade theory corresponds to the trade flows of Hungary regarding factor endowments.

Empirical studies on trade theory became widespread after the famous statement of *Leontief (1953)* on trade and factor endowments in the United States which was in contradiction with the Heckscher-Ohlin model. *Leamer (1980)* suggested that Leontief just misinterpreted the H-O model, hence there was no paradox; however, since then a great number of empirical studies (see e.g. *Krugman and Obstfeld, 1988*; *Trefler, 1993*) have focused on the validity of trade theories and found evidence against the H-O model. One question still remains: whether the H-O model is inconsistent with the foreign trade of small, open transition countries as well. In our analysis we used the gravity model of trade which lies at the center of recent international trade researches. Similar studies include *Rahman (2003)*, *Schumacher (2003)* and *Sohn (2005)*; and we followed the methodology of *Eicher et al. (2012)* and *Shirotori et al. (2010)*. Our empirical results confirm the previous findings: the greater the differences in the factor endowment variables, the less the trade volume between Hungary and its trading partner, therefore the H-O model is inconsistent also in the case of Hungary.

The remainder of this paper is organized as follows. Section 2 discusses the theoretical background of the relationship between factor endowment and trade theory and the evolution of the gravity model, Section 3 gives an overview of the foreign trade of Hungary. Section 4 presents the methodology and data of the empirical analysis along with the results, and Section 5 concludes.

2. Factor Endowment, the Linder hypothesis and Trade Theory, the Evolution of the Gravity Model

Empirical analyses of international trade in most of the cases aim to discover the structure and volume of trade flows and their sectorial breakdown. This paper aims to identify the underlying trade model in Hungary's trade flows. When we refer to Heckscher-Ohlinian or Linder-type trade models we differentiate between the traditional and new explanations of international trade. From the chronological point of view, the classical Ricardian theory that explains international trade with technological differences between countries was the first of the traditional models which contain the foundations of international trade theory. Although this model is more than 200 years old, the multi-country and multi-product versions were born much later and were subjected to deeper empirical testing only recently (*Eaton and Kortum, 2002*; *Costinot et al., 2012*). We may follow inter alia *Hausmann et al. (2014)* to consider the Ricardian model as a reduced form of the more general Heckscher-Ohlin-Vanek (*Vanek, 1968*) model where labor productivities are the consequences of the availability of other factors of production. The original Heckscher-Ohlin model in its most basic forms stresses the differences in factor endowments as the cause of international specialization. Different relative marginal costs of production caused by factor endowment differences make

countries tend to export goods which require their abundant and import those which contain their scarce factors. The contradictions of the traditional Ricardian and Heckscher-Ohlinian trade to real world trade flows made an impetus to further developments in the field. *Leamer (1992)* stresses two important empirical findings leading to new discoveries, i.e. the Leontief paradox which showed that US imports were more capital intensive than exports, and the other was the emergence and growing volumes of intra-industry trade. These findings led to alterations and amplifications of the Heckscher-Ohlin model (e.g. the reformulation by Vanek in terms of factor content of trade; *Trefler, 1993, 1995*; *Davis at al., 1997*; *Davis and Weinstein, 2001*; *Antweiler and Trefler, 2002*; *Trefler and Zhu, 2010*) and at the same time made at least a strong partial push to the development of new trade theory models based on imperfect competition with differentiated products and increasing returns to scale which we will refer to as Linder-type models acknowledging the original insight of *Linder (1961)* which is the oldest theory of product quality in international trade. Linder hypothesized that potential exports are determined by domestic demand, since strong local demands for a good are required for investors to induce investments in a sector, which would lead to exports to countries with similar consumption patterns. Almost two decades later new trade theory models based on the works of *Spence (1976), Dixit and Stiglitz (1977), Krugman (1979, 1981), Lancaster (1979, 1980), Helpman and Krugman (1985)* were able to explain horizontal and vertical intra-industry trade (for the origins of the latter see *Falvey, 1981*; *Falvey and Kierzkowski, 1987*; *Flam and Helpman, 1987*; *Shaked and Sutton, 1984*).

Although empirical research shows a steady upward trend of global intra-industry versus inter-industry trade even in the case of some lower-income (mostly Asian) countries (see inter alia *Brülhart, 2009* for a comprehensive analysis) the relationship between factor endowment differences and trade types (i.e. inter-industry, horizontal, and vertical intra-industry trade) remains imperfectly explained. While there is a broad, theoretically and empirically supported consensus for long decades that relative factor endowment differences enhance or are the very reason of inter-industry trade (except for the case of possible factor intensity reversals) and also that the stronger prevalence of horizontal intra-industry flows can be expected between countries with more similar relative endowments, there is not an unquestionable monotonic relationship between the share of vertical intra-industry trade and factor endowments (see *Gabszewicz et al., 1981, Shaked and Sutton 1984, Motta 1992, 1994, Lutz and Turrini, 1999, Gabszewicz and Turrini, 1997, Haucap et al. 2000, and Cabral et al. 2013* for at least some slightly different approaches compared to the former 'consensus' on the existence of that).

As far as the latest developments are concerned, while traditional trade theory adopted a country as its basic unit of analysis, new trade theory focused on industries. "New new trade" theories of the last decade stressed the importance of firm level differences within industries (see *Melitz, 2003*; *Bernard et al., 2003*; *Bernard et al., 2007*) producing differentiated goods.

The trade policy changes and the proliferation of trade agreements after World War II triggered a rise in the number of theoretical models evaluating trade as well. One of the most important and empirically most successful models of these is the gravity model of trade which is at the center of our analysis. The basic gravity model tries to explain the volume of trade between two countries or regions by their economic size and distance. The augmented or extended gravity model contains other variables as well (e.g. common language, common border, historical ties, trade agreement etc.) which can be also important at explaining the

volume of trade, however, sometimes the use of these variables does not have a theoretical foundation. The gravity model became popular in the last 30 years for being a quite simple instrument at explaining trade patterns; the values predicted by the model fit the data quite well, while the R square usually ranges from 60 to 80 percent.

As the name of the model suggests, the gravity model of trade derives from the gravity model known from physics. *Jan Tinbergen (1962)* was the first to use the gravity model for assessing trade, he concluded that the most determining factors of the optimal level of trade are the size of the two countries (GNP) and the distance between them. The economic size of the importing country reflects the size of the country's demand and the diversity of its products. Regarding these two effects we expect a smaller than unity effect of economic size on trade since the more diversified the products produced are in a given country, the less import it will need, i.e. parallel to the increase in the importer countries GNP, *ceteris paribus* the volume of its imports will increase by less than unity. The economic size of the exporter country reflects its ability to produce export products, and thus the increase of GNP in the exporter country will also increase the volume of its trade. The geographical distance affects trade since the shipment of goods between countries is costly. In addition, the more a product is moved, the more costs incur regarding transportation, therefore geographical distance has a negative impact on imports. Following the work of *Tinbergen (1962)* several empirical studies – such as *Linnemann (1966)* and *Aitken (1973)* – applied the gravity model of trade; however, these models did not have sound theoretical foundations. It was *Anderson (1979)* who laid down the theoretical foundations of the model: the starting point was an ordinarily gravity equation and he then derived the gravity equation from the properties of expenditure systems. The gravity model of *Anderson (1979)* is the following:

$$(1) \qquad M_{ijk} = \propto_k Y_i^{\beta_k} Y_j^{\gamma_k} N_i^{\varepsilon_k} N_j^{\epsilon_k} d_{ij}^{\mu_k} U_{ijk},$$

where M_{ijk} the flow of good or factor k from country or region i to country or region j expressed in dollar, Y_i and Y_j are the income of country or region i and j, N_i and N_j are the population of country or region i and j, d_{ij} is the distance between country or region i and j, while U_{ijk} is a lognormally distributed error term with an expected value of 0.

According to the gravity equation, bilateral trade depends on the economic sizes and the bilateral barriers between country or region i and j. Considering given bilateral trade barriers, the higher the barriers between j and its other trading partners, the more the reduction in the relative price of products from country i, and thus the import from country i increases. Based on the gravity equation, trade between two countries are determined by the *relative trade barriers*: bilateral trade depends on the relationship of bilateral barriers between these two countries and the average trade barriers with other trading partners. This average trade barrier is called *multilateral resistance*. Trade is more important for smaller countries, therefore trade barriers have a greater impact on their multilateral resistance *(Anderson-van Wincoop 2001)*.

The gravity model can be considered as a representation of the supply and demand forces as well. In this context, let country i be the origin, then M_i shows the total amount it is willing to supply to consumers, while M_j represents the total demand of destination country j. Distance causes a lower equilibrium trade because it creates a wedge between supply and

demand in a form of trade costs *(Head, 2003)*. In this approach trade costs also include the differences in the demand between countries, such as home bias, i.e. people tend to consume more domestically produced goods than imported ones, causing a distortion in supply and demand *(Anderson, 2010)*.

After the appearance of the theoretical foundations, the gravity model of trade became the most successful empirical method of foreign trade analyses. Empirical analyses focused on several factors influencing trade, such as borders (*McCallum (1995); Wei (1996); Anderson-van Wincoop (2001); Mayer-Zignago (2005)*), factor endowment (*Rahman (2003)*; *Schumacher (2003*); *Sohn* (2005); *Eicher et al. (2012)*; *Shirotori et al. (2010)*), common language and colonial linkages (*Hutschinson (2002); Head et al. (2010); Oh et al. (2011); Felbermayr-Toubal (2006); Martinez-Zarzoso (2003)*); institutions and corruption (*Anderson-Marcouiller (2002); de Groot et al. (2004)*); free trade agreements and regional integrations (*(Martinez-Zarzoso (2003); Baier-Bergstrand (2007); Carrere (2006); Soloaga-Winters (2001); Jugurnath et al. (2007); Coulibaly (2009); Anderson-Yotov (2011); Rose-van Wincoop (2001); Vicard (2009); Frankel-Wei (1998)*).

According to *Anderson (2010)*, a typical gravity model contains the logarithm of bilateral trade as the dependent variable, and the explanatory variables are the logarithm of GDP, population and distance. Additional variables may be necessary depending on the purpose of the analysis, although some of them might have a great explanatory power without theoretical grounds. In order to understand the results of our empirical analysis, a brief explanation of the variables is needed here.

Income is one of the most important explanatory variables. High income of the exporter country indicates high level of production which increases the amount of exportable goods thus the coefficient of the variable is expected to have a positive sign. On the other side, high income in the importer country indicates higher level of import because higher income causes higher demand; so again, the coefficient is expected to have a positive sign *(Martinez-Zarzoso, 2003)*. Generally, empirical results show a coefficient of income close to unity, however it is not unusual to get results in a range between 0.7 and 1.1 *(Head, 2003)*.

The second explanatory variable in the model of *Anderson (1979)* was the population. The sign of the coefficient can be positive and negative as well depending on which effect prevails: a big country can either export more than small countries due to economies of scale, or less when the absorption effect prevails, i.e. if the country consumes what it produced resulting in fewer products to be exported *(Martinez-Zarzoso, 2003)*.

Distance is a variable applied to approximate trade costs. The expected sign of the coefficient is negative meaning that distance has a negative effect on trade: empirical studies have shown that if distance is doubled, then trade is halved. Distance is a relatively good approximation of trade costs, the time elapsed during loading, and various transaction and communication costs which are not easy – if possible at all – to measure directly *(Head, 2003)*. Geographical distance is used in the gravity model, usually great circle distance between the capitals of the countries, but there are cases when it may be wiser to use the distance data between the most important economic areas, e.g. in the case of the USA. Although it is an easily calculated variable, the approximation of trade costs by distance is far from perfect, so it can lead to significant distortions, therefore other variables affecting trade

costs (e.g. common language, trade agreement, variables for political and legal system, etc.) should be used in the model.

Recently, more and more studies highlight the fact that cultural proximity has a great impact on trade between countries. Linguistic proximity, colonial linkages, ethnic similarities, common religion are the most widely used variables capturing cultural proximity. According to *Felbermayr and Toubal (2010)*, cultural proximity affects bilateral trade through two main channels. First, cultural similarities reduce the direct and indirect costs of trade, for example, common language directly reduces transaction costs, because there is no need to use an interpreter at contracting. Similar legal and institutional environment of the seller and the buyer will also reduce the costs of contracting. The second channel is related to consumer preferences: cultural proximity may be reflected in the similar preferences of consumers as well, thus may directly increase the volume of bilateral trade. *Martinez-Zarzoso (2003)* showed that in 1999, two countries having a common language traded by 242 percent more with each other than with other language speaking countries, so in certain cases common language has a great impact on the volume of trade. Cultural variables are usually expressed as dummy variables, e.g. the variable equals to 1 if two countries have a common language, and zero otherwise.

Contiguity is also a dummy variable which equals to 1 when two countries share a common border. The sign of this coefficient is positive, generally, having a common border leads to 65 percent higher trade than otherwise *(Head, 2003)*. However, having a geographically common border is not enough to enhance bilateral trade: there is a need to be able to transport through the border as well, so a border in the middle of a rainforest without rails or roads will not have an impact on the volume of trade.

There is a wide literature that deals with the impact of regional/bilateral trade agreements on trade (see for example *Kepaptsoglou et al., 2010*). Trade agreements are also dummy variables in the gravity model usually equaling to 1 when two countries are members of the same agreement, although several studies apply different dummies for intra-FTA and extra-FTA trade capturing the trade creation and trade diversion effects. The variable is expected to have a positive sign since trade agreements reduce barriers and facilitate trade thus increase the volume of trade. Still, a great number of empirical studies do not confirm this statement. For example, *Frankel et al. (1995)* found insignificant effect of the European Community, while previously *Aitken (1973)* and *Abrams (1980)* showed positive significant effect when analyzing the effect of the European Community on trade of member states. Later, *Frankel (1997)* found significant positive effect for Mercosur, insignificant effect for the Andean Community, and significant negative effect for the European Community. Distortions deriving from the sample size, sample period, omitted or endogenous variables can lead to these mixed results so caution is needed when interpreting negative trade agreement coefficients, i.e. it cannot mean that bilateral trade decreased after signing the agreement. *Carrere (2006)* studied 7 regional trade agreements and after correcting for the endogeneity of the income, size, infrastructure and intra-RTA trade variables found that the intra-regional trade increased beyond the levels predicted by the gravity model, meanwhile export and import with the rest of the world showed evidence of trade diversion. *Baier and Bergstrand (2007)* focused on the endogeneity of trade policy and found that a free trade

agreement will on average increase two member countries' trade by about 86 percent after 15 years.

The main aim of this study is to determine which trade theory holds when assessing the foreign trade of Hungary, thus the gravity equation needs to be augmented by adding variables capturing factor endowment. One variable that indicates the factor endowment of a country is the per capita income calculated as the ratio of income and population. Adding GDP per capita to the model reveals the link between a country's trade and its stage of development. *Bergstrand (1989)* applied the gravity equation in a multi-industry world and found that if the elasticity of substitution exceeds unity, then the positive coefficient for the exporter's per capita income indicates the industry to be capital intensive, while a positive coefficient for the importer's per capita income indicates that the industry's output is a luxury in consumption. Negative coefficient for the exporter's per capita income refers to labor intensity, while negative coefficient for the importer's per capita income reveals that the industry's output is a necessity in consumption.

Montenegro and Soto (1996), Rahman (2003) and *Batra (2006)* used the absolute value of difference of the two countries' income per capita to determine whether the H-O model or the Linder hypothesis explains the pattern of bilateral trade flows. The Heckscher-Ohlin model states that countries with dissimilar levels of output will trade more than countries with similar levels, while the Linder hypothesis says that countries with similar levels of income per capita will have similar preferences and thus will trade more with each other. The positive sign of the coefficient refers to the H-O model, while the negative sign refers to the Linder hypothesis. *Montenegro and Soto (1996)* found evidence supporting the Linder hypothesis for the foreign trade of Cuba in the period of 1980-1991. Similar result was found by *Batra (2006)* in the case of India for the year 2000. In contrast, *Rahman (2003)* analyzed foreign trade of Bangladesh for the period of 1972-1999 and got positive coefficients for the variable capturing the per capita differential between the two countries; and thus foreign trade of Bangladesh corresponds to the H-O model.

Baskaran et al. (2011) augmented the gravity equation by adding the absolute difference of capital-labor ratio of country *i* and *j* from Penn World Table, and analyzed the trading system as a scale-free network for 28 product groups for the period of 1980-2000. They found negative coefficients for the factor endowment variables rejecting the H-O model, however augmenting the model with the interaction between the factor differential and the network variable resulted in much more favorable coefficients with regard to the H-O model. *Sohn (2005)* applied the trade conformity index (TCI) measuring trade complementarities between two countries to determine whether Korea's trade patterns reflect the H-O model of inter-industry trade (positive sign) or the differentiated product model with intra-industry trade (negative sign).

Regarding comparative advantage, *Ciuriak and Kinjo (2006)* used the Trade Specialization Index (TSI) measured as the net exports in a given sector divided by total trade in that sector, then they calculated the simple correlation between two trading partner's TSIs. They found that, according to the principle of comparative advantage, country pairs that have a positive TSI correlation tend to be natural competitors in international trade, while the negative sign indicates that the country pair tends to be natural trading partners. *Nicita et al. (2013)* examined the interaction between the H-O model and the chances of export survival of

the least developed countries using the gravity model. They applied the distance from comparative advantage as an explanatory variable which means that a product is distanced from a country's comparative advantage when the product is not utilizing the resources relatively abundant in the country. They found the coefficient greater than unity, thus as a product becomes further away from the exporting country's comparative advantage, the export survival period becomes shorter. *Schumacher (2003)* pointed out the importance of geography in the pattern of comparative advantage in total trade showing that two countries with similar factor endowments and same level of per capita income will differ significantly comparing the commodity patterns of trade according to the stage of development of their neighboring countries.

3. Foreign Trade of Hungary: An Overview

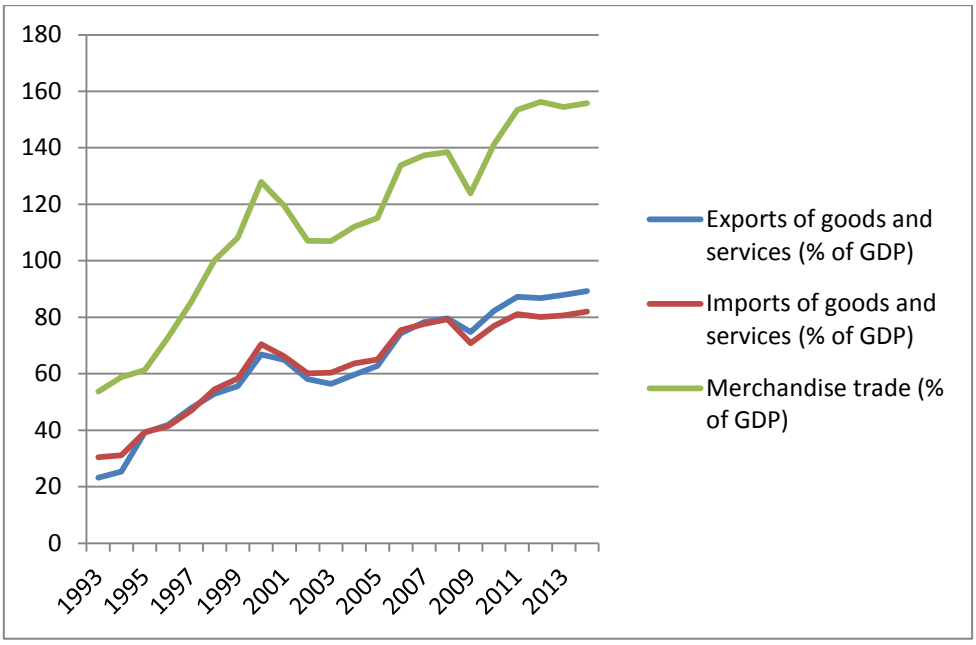
Research, inter alia *Köves (2003)* demonstrates that World Wars I and II and the post-socialist transition, starting in the end of the 1980s and the beginning of 1990s deeply changed the geographic structure of Hungary's international trade. On the eve of World War, I Hungary's most important trading partner was Austria. After about 25 years, in 1938 Hungary's most important trading partners were Germany and its allies Italy and Austria. The period after World War II was dominated by the Soviet Union with about the same role of other Eastern-European COMECON countries.

From the middle of the 1990s we can witness an era characterized by very dynamically increasing trade volumes with only two shortfalls in 2004 and 2009. The former might be partly due to methodological changes and the second obviously emerged as an impact of the financial crisis[2].

In spite of increasing trade volumes, Hungary's trade openness (exports/GDP, imports/GDP or trade turnover/GDP ratios) indices were slightly decreasing from the middle of the 1970s until the beginning of the high trade dynamism era from the middle of the 1990s (Figure 1).

Figure 1. Indices of Hungary's trade openness, 1993-2014 (%)

[2] Once trade data reported by the Hungarian Central Statistical Office (HCSO) is concerned, it must be noted that there were two important changes in the compilation of external trade data. Since the 1997 review trade between industrial free zones and foreign markets was taken into account. From 2004 the compilation has been adapted to the methodology of the EU.
See http://www.ksh.hu/docs/eng/modsz/modsz35.html, accessed 05/16/2014.



Source: World Bank, World Development Indicators

Merchandise trade (as a percentage of GDP) was 82% and shrinking until 1993, surpassed its starting level only in 1997. From that time on dynamism seemed almost unstoppable reaching 155% by 2014 making Hungary one of the most open countries in the world economy.

The last 20 years deeply changed the geographical structure of Hungary's foreign trade as well. Foreign economic liberalization was very fast and deep[3] creating the basis for today's trade structure. The reorientation of trade was greatly facilitated by the Europe Agreement – removing protectionist measures for most of Hungary's trade with the EC (EU) – and the creation of the Central European Free Trade Agreement. Turning towards developed markets at the same time was coerced by the transformational recession and liberalization of the former socialist countries which significantly decreased the demand for products imported from Hungary.

The reorientation can be assessed undoubtedly successful. Along with liberal policies towards foreign direct investment linked the country to the global production system of multinational companies. The shifting geographic structure of trade reflects these changes[4]. Between 1991 and 2003 the share of developed countries in Hungarian exports and imports quickly reached 70% and 80% respectively. At the same time the EU (first twelve and from 1995 15 countries) became the most important trading partner dominating Hungarian trade flow destinations and sources.

Between 2003 and 2006 the share of EU-25 (the 25 countries constituting the EU from 2004 to 2007) slightly decreased from 76% to 68% in imports and from 81% to 74% in exports with the growing share of extra-EU, mostly Asian countries (the growth of China's

[3] See for example *Bock (1995)*, *Nagy (1995)* and *WTO (1998)*.

[4] The following section contains the authors' own calculations based on HCSO data.

share was more than twofold). The last period analyzed in this paper between 2007 and 2014 is characterized by the share of the EU-27 around 2/3 of imports growing to 3/4 and a stable 3/4 of exports, with a slightly decreasing role of the core-EU members (EU-15 of 1995) and the growing share of the newly joined member states. Taking a look at the country level, Germany's role is unquestionable once again after the interbellum period in the history of foreign economic relations. Germany is responsible for roughly 1/4 of the Hungarian trade turnover.

The commodity structure of trade reflects a developed country setup. In the COMECON division of labor system Hungary was an important exporter of manufactured goods and machinery but this meant relatively low quality goods exported mostly to the Soviet Union in return this partner was the largest supplier of fuels, minerals and other crude materials. By the end of the period, once again, the most important commodity groups in both imports and exports are machinery and transport equipment (46% and 54% respectively in 2014), and manufactured goods (34% and 32%). The difference this time is that the Hungarian products are sold in competitive markets of developed countries. On the import side fuels and electric energy are significant, as well (12%).

The final part of this section aims to analyze some major characteristics of Hungary's intra-industry/two-way trade after the transition[5]. Firstly, we calculated the Grubel—Lloyd (1975) indices at two different aggregation level using SITC Rev 3. 3-digit level for sections 0-8 (257 product groups, excluding the high trade volatility commodities and transactions not classified according to kind) and at HS92 6 digit levels (4959 products) to reduce the aggregation bias. We deliberately choose not to control for the geographical bias coming from using bilateral trade between Hungary and the "rest of the world" to get a picture about the general pattern of inter- and intra-industry trade, however we are aware of the fact that this choice might cause some slight overestimation of the indices compared to those calculated aggregating the weighted bilateral data with each trading partner. Then we disentangled the trade flows into one-way, horizontal, and vertical two-way (intra-industry, HIIT and VIIT respectively) trade using the Fontagné—Freudenberg—Gaulier[6] (2005) and the Azhar—Elliott[7] (2004) method. The indices are reported in *Table 1.*

The first three columns of the table clearly show a markedly growing tendency of the share of intra-industry flows in Hungary's trade which became a dominant part even at high levels of disaggregation of the country's international merchandise exchange. High GL indices demonstrate evidence for a growing economic similarity to its major trading partners. Two-way trade can be disentangled into two parts. Horizontal intra-industry trade is the two-way trade of similar versions of the same product that are differentiated by secondary attributes (i.e. design etc.) but not primarily by quality and price. In the case of vertical intra-industry trade we may observe and measure the two-way flows of product versions differing in quality and price. The growing indices of the horizontal type suggest that consumption patterns of Hungary and its major trading partners became more similar and the country enhanced its ability to exploit agglomeration and economies of scale effects in the production. High and stable shares of vertical two-way trade are in line with increased levels of

[5] The source of data was DESA/UNSD, *United Nation's Comtrade database*.
[6] With γ=10% and α=25% parameters.
[7] With γ=10% and α=15% parameters.

transnationalisation of the Hungarian economy, that is the supply side of the economy became a highly integrated part of international production network of multinational companies.

4. Empirical Analysis with the Gravity Model

Hungary is a very open country at the heart of Europe, in 2014 it traded with more than 190 countries, but due to data availability, our analysis consists of 79 countries[8] accounting for around 90 per cent (93.7 per cent in 2014) of total exports. The time period of this analysis is from 1993 to 2014[9] due to several reasons. Hungary's transition started in 1989 and in the spring of 1990 was the first free and democratic election after 43 years of communism. Although the country's economy was market-based by that time and trade data is available for Hungary, our analysis starts in 1993 because several trading partners' transition took more time and there was no trade data available for the previous years. 2014 is the upper bound of data availability for most of our variables.

4.1. Model

Our approach for this analysis was to apply an augmented gravity model not only to capture the usually measured effects on the trade of Hungary but also to analyze the effect of factor endowments on trade. In the previous section we discussed various methods revealing factor endowment effects, and in order to be able to find strong evidence supporting one of the trade theories, we applied 3 different approaches capturing factor endowments.

4.1.1. Model I: Factor endowment and GDP per capita

GDP per capita reflects the stage of development and is a good proxy of factor endowment; according to *Reimer and Hertel (2010)* if GDP per capita rises by 1 per cent, the capital-labor ratio rises by 0.9 per cent, on average. However, we cannot decide between the H-O model and the Linder hypothesis by using this variable *per se*. As mentioned in the previous section, many authors applied the difference of GDP per capita which reflects the per capita similarity and thus the factor endowment similarity of the countries. *Antonucci and Manzocchi (2006)* and *Yip (2012)* called this variable relative factor endowment. We followed *Eicher et al. (2012)* calculating the variable in absolute term:

$$AbsRelendow_{ijt} = \left|\ln GDPpcap_{it} - \ln GDPpcap_{jt}\right|$$

[8] Albania, Argentina, Australia, Austria, Bangladesh, Barbados, Brazil, Bulgaria, Cambodia, Canada, Chile, China, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Finland, France, Gabon, Germany, Ghana, Greece, Guatemala, Honduras, Hong Kong, Iceland, India, Indonesia, Ireland, Italy, Japan, Jordan, Kazakhstan, Kenya, Korea, Latvia, Lithuania, Malaysia, Malta, Mauritius, Mexico, Moldova, Morocco, Mozambique, Nepal, Netherlands, New Zealand, Norway, Panama, Peru, Philippines, Poland, Portugal, Romania, Russia, Saudi Arabia, Singapore, Slovakia, Slovenia, Spain, Sweden, Switzerland, Thailand, Tunisia, Turkey, Uganda, Ukraine, United Kingdom, Uruguay, USA, Venezuela, Vietnam, Zimbabwe.

[9] Due to data availability time period for Model II is 1993-2011 and 1993-2007 in the case of Model III.

Table 1: Hungary-World inter- and intra-industry trade indices, 1993-2014

Year	GL (0-8)	GL (0-98)	FF OWT 10-25 (0-98)	FF NS 10-25 (0-98)	FF HTWT 10-25 (0-98)	FF VTWT 10-25 (0-98)	AE OWT 10-15 (0-98)	AE NS 10-15 (0-98)	AE HTWT 10-15 (0-98)	AE VTWT 10-15 (0-98)
1993	0.53	0.33	0.48	0.00	0.12	0.40	0.48	0.00	0.20	0.32
1994	0.54	0.34	0.45	0.00	0.17	0.38	0.45	0.00	0.20	0.34
1995	0.55	0.35	0.41	0.00	0.20	0.38	0.41	0.00	0.25	0.34
1996	0.54	0.36	0.43	0.00	0.16	0.41	0.43	0.00	0.21	0.37
1997	0.57	0.36	0.39	0.00	0.26	0.35	0.39	0.00	0.31	0.30
1998	0.59	0.39	0.37	0.01	0.21	0.42	0.37	0.01	0.26	0.37
1999	0.59	0.40	0.34	0.01	0.23	0.43	0.34	0.01	0.32	0.34
2000	0.63	0.43	0.32	0.00	0.22	0.45	0.32	0.00	0.31	0.37
2001	0.64	0.44	0.26	0.00	0.30	0.44	0.26	0.00	0.36	0.38
2002	0.64	0.44	0.27	0.00	0.28	0.45	0.27	0.00	0.36	0.37
2003	0.66	0.45	0.26	0.00	0.28	0.46	0.26	0.00	0.35	0.39
2004	0.67	0.47	0.25	0.00	0.26	0.49	0.25	0.00	0.31	0.43
2005	0.69	0.49	0.20	0.01	0.32	0.48	0.20	0.01	0.40	0.39
2006	0.70	0.49	0.19	0.01	0.37	0.44	0.19	0.01	0.44	0.36
2007	0.70	0.50	0.20	0.01	0.34	0.45	0.20	0.01	0.43	0.36
2008	0.71	0.50	0.18	0.01	0.38	0.43	0.18	0.01	0.45	0.36
2009	0.69	0.48	0.18	0.01	0.36	0.44	0.18	0.01	0.44	0.37
2010	0.69	0.47	0.18	0.01	0.38	0.43	0.18	0.01	0.42	0.39
2011	0.69	0.50	0.17	0.01	0.40	0.42	0.17	0.01	0.49	0.33
2012	0.69	0.51	0.20	0.01	0.35	0.44	0.20	0.01	0.42	0.36
2013	0.70	0.53	0.18	0.01	0.38	0.43	0.18	0.01	0.46	0.35
2014	0.70	0.53	0.19	0.01	0.37	0.43	0.19	0.01	0.43	0.37

GL (0-8): Grubel-Lloyd indices, SITC, Rev 3. 3-digit level, GL (0-98): Grubel-Lloyd indices HS92 6-digit level, FF: Fontagné-Freudenberg-Gaulier method using HS92 6-digit level, AE: Azhar-Elliott method using HS92 6-digit level, OWT: one-way (inter-industry) trade, NS: Not specified part of trade due to the lack of trade quantities, HTWT: horizontal two-way trade, VTWT: vertical two-way trade

Adding commonly used variables to the basic gravity model and augmenting it by the factor endowment variable, our first equation is the following:

$$(2) \quad \ln X_{ijt} = \alpha_0 + \alpha_1 \ln GDP_{it} + \alpha_2 \ln GDP_{jt} + \alpha_3 \ln DIST_{ij} + \alpha_4 AbsRelendow_{ijt} + \beta_1 CONT_{ij} + \beta_2 FTA_{ijt} + e_{ijt},$$

where X_{ijt} means bilateral export between country *i* and *j*, i.e. between Hungary and its trading partner in period *t*. GDP_{it} and GDP_{jt} are income of Hungary and its trading partner in dollar, $DIST_{ij}$ is distance between Hungary and its trading partner (distance of capitals). $CONT_{ij}$ is the dummy variable for common border, FTA_{ijt} is a binary variable capturing the effect of a common trade agreement, and e_{ijt} is the error term with expected value of 0.

4.1.2. Model II: Factor endowment following the approach of *Eicher et al. (2012)*

According to *Eicher et al. (2012)*, proxies based on GDP per capita, population density and schooling can capture the difference in factor endowments. In their paper they applied all three variables in the same model capturing the effect of factor endowment, and therefore we augmented our first model by adding the other two variables.

Besides per capita GDP, education is another factor which reflects the development of countries, and we can create variables that show the differences or similarities of countries trading with each other. We applied the index of human capital from the Penn World Table as a proxy for factor endowment and calculated its absolute difference form similar way as before:

$$AbsHumancapDiff_{ijt} = \left|\ln Humancap_{it} - \ln Humancap_{jt}\right|,$$

where *Humancap* is the index of human capital per person, based on years of schooling and returns to education. As 2011 is the upper bound for data availability on the index of human capital, time period for Model II is 1993-2011.

Population density does not necessarily reflect stage of development but refers directly to the factor endowment of a country, as it is measured as population divided by the area of a country. The difference of two country's population density is calculated as follows:

$$AbsPopdensDiff_{ijt} = \left|\ln Popdens_{it} - \ln Popdens_{jt}\right|.$$

We added these two proxies to our previous equation:

$$(4) \quad \ln X_{ijt} = \alpha_0 + \alpha_1 \ln GDP_{it} + \alpha_2 \ln GDP_{jt} + \alpha_3 \ln DIST_{ij} + \alpha_4 AbsRelendow_{ijt} + \alpha_4 AbsHumancapDiff_{ijt} + \alpha_4 AbsPopdensDiff_{ijt} + \beta_1 CONT_{ij} + \beta_2 FTA_{ijt} + e_{ijt}.$$

4.1.3. Model III: Factor endowment with UNCTAD variables

UNCTAD has a database of factor endowment variables available for 135 countries for the period of 1970-2007. Due to data availability, for the period of 1993-2007our third model contains 75 countries[10] still accounting for more than 90 per cent (93.28 per cent in 2007) of total exports. The three variables are physical capital per worker, human capital capturing the average years of schooling, and land area per worker. More information about these variables is available in *Shirotori et al (2010)*.

We calculated the absolute difference of these variables in the same way as before and to avoid confusion, we renamed the variable for human capital to *AbsSchoolDiff*:

(5) $ln\, X_{ijt} = \alpha_0 + \alpha_1\, ln\, GDP_{it} + \alpha_2 ln\, GDP_{jt} + \alpha_3\, ln\, DIST_{ij} + \alpha_4\, AbsPhyscapDiff_{ijt} + \alpha_4\, AbsSchoolDiff_{ijt} + \alpha_4\, AbsLandDiff_{ijt} + \beta_1\, CONT_{ij} + \beta_2\, FTA_{ijt} + e_{ijt}.$

4.2. Hypothesis

All three model specifications of ours aim to capture the effect of factor endowments on the foreign trade of Hungary. Our hypothesis is the following: if the coefficients of the factor endowment variables are *(1) positive:* they support the Heckscher-Ohlin model, i.e. if the difference in the factor endowments of two countries increases, then trade between them will increase as well; *(2) negative:* the bigger the difference in the factor endowments of the countries, the less they trade with each other, or the more similar these countries' factor endowments are, the more they will trade with each other; in case of negative coefficients foreign trade corresponds to the Linder theorem.

4.3. Data

Since the main focus of this paper is to present a thorough empirical analysis of exports of Hungary, discussion on the type and nature of the trade data and thus the limitation of the results is unavoidable. Although empirical research suggests the ever increasing share of services in global trade up to 20 per cent of total global exports *(WTO, 2015)*, there are still limits on data availability of trade in services which poses constraint on trade related research (see e.g. *Miroudot et al., 2013*). In order to avoid serious limitation on the sample size the dependent variable in our analysis is the export in goods.

Another limitation of the calculations and conclusions derives from the application of gross trade data. Evidence shows that due to production fragmentation and the emergence of global value chains (GVCs) foreign content of exports has become significant in the last decades. In parallel, as the result of the OECD and WTO joint initiative a database has become available on trade in value-added (TiVA). Value-added trade data suggests that the larger a country the higher the share of domestic content in its export *(Ahmad 2013)*: while

[10] There was no sufficient data for the Dominican Republic, Hong Kong, Moldova and Singapore; data availability starts in 1994 for Kazakhstan, Latvia, Lithuania and Ukraine.

domestic content of the export of the United States is around 87%, Eastern European countries have on average 30% foreign content in their export, and the share of foreign content of Hungary is even higher, reaching 45% on average for period 1995-2011 and 48% in 2011. Since accounting for the content of domestic contribution in foreign trade is quite problematic, data on value added trade is still very limited and therefore in our analysis we used gross trade data from the UN Comtrade database.

Table 2 contains more information about the variables and the data sources.

Table 2: Variable description and data sources

Variable	Description	Data Source
X	Export in goods	UN Comtrade database (SITC Rev 3.)
GDP	Gross domestic product	World Bank database and IMF WEO April, 2016[11]
Dist	Distance	CEPII database
AbsRelendow	Absolute relative factor endowment	authors' calculation based on the World Bank database and IMF WEO April, 2016[12]
AbsHumancapDiff	Absolute difference of human capital	authors' calculation based on the World Bank database
AbsPopdensDiff	Absolute difference of population density	authors' calculation based on the World Bank database
AbsPhyscapDiff	Absolute difference of physical capital per worker	authors' calculation based on the UNCTAD database
AbsSchoolDiff	Absolute difference of human capital	authors' calculation based on the UNCTAD database
AbsLandDiff	Absolute difference of land area per worker	authors' calculation based on the UNCTAD database
CONT	Common border	CEPII database
FTA	Free trade agreement	WTO database

4.4. Empirical results

We carried out panel analysis for bilateral exports using STATA 13.0, *Table 3* and *Table 4* contain the regression results.

By using simple OLS regression *(Table 3)* the R-squared reaches 0.80 which means that our models fit the data quite well; the explanatory variables explain up to 80 per cent of the variability in the dependent variable. Coefficients of the income variables are statistically significant at 1 per cent level and show positive sign: a 1 per cent increase in the GDP of Hungary or its trading partners increases bilateral export by 0.81-0.96 per cent. While GDP

[11] GDP data from World Bank database was expanded by IMF WEO data for Venezuela (2013-2014) and Malta (2014).

[12] GDP data from World Bank database was expanded by IMF WEO data for Venezuela (2013-2014) and Malta (2014).

growth has positive impact on trade, bilateral distance has significantly negative effects; a 1 per cent increase in the bilateral distance decreases bilateral trade by 1.39-1.50 per cent, *ceteris paribus*. Sharing a common border or a common free trade agreement has a positive but rather small effect on bilateral export, although the results for these binary variables are not statistically significant in all cases.

Turning our focus to the effects of the factor endowment variables, Model I shows a statistically significant negative value at 1 per cent level, meaning that if the difference in GDP per capita between Hungary and its trading partner increases, bilateral exports between them will decrease. In case of Model II and Model III only 2 out of the 3 factor endowment variables give statistically significant results at 10 per cent level; however, these significant results all have negative signs. Model II confirms the negative result of Model I of the GDP per capita differences, while the variable capturing the effect of the difference in human capital also shows statistically significant negative results; the effect of population density is insignificant. In case of Model III, the coefficient of physical capital is insignificant, while the differences in human capital and land area also have statistically significant negative coefficients. Consequently, based on simple OLS regressions we found that differences in factor endowments result in less bilateral trade, therefore we can reject the H-O model and conclude that bilateral exports of Hungary corresponds to the Linder theorem.

Table 3: OLS regression results

	Model I	**Model II**	**Model III**
ln GDP$_{it}$	0.96***	0.95***	0.91***
	(11.10)	(9.95)	(6.45)
ln GDP$_{jt}$	0.89***	0.81***	0.81***
	(37.49)	(29.34)	(24.49)
ln DIST$_{ij}$	-1.50***	-1.40***	-1.39***
	(-51.37)	(-37.07)	(-28.85)
CONT$_{ij}$	0.20**	0.16*	0.23**
	(2.01)	(1.66)	(2.07)
FTA$_{ijt}$	0.04	0.08	0.31**
	(0.50)	(0.87)	(2.44)
AbsRelendow$_{ijt}$	**-0.29*** **	**-0.09***	
	(-6.11)	**(-1.93)**	
AbsHumancapDiff$_{ijt}$		**-2.17*** **	
		(-9.67)	
AbsPopdensDiff$_{ijt}$		**0.04**	
		(0.86)	
AbsPhyscapDiff$_{ijt}$			**0.03**
			(0.43)
AbsSchoolDiff$_{ijt}$			**-0.99*** **
			(-6.77)
AbsLandDiff$_{ijt}$			**-0.13***
			(-1.88)
Constant	-16.67***	-15.21***	-14.35***
	(-7.84)	(-6.33)	(-4.08)

Number of obs.	1738	1501	1121
Number of var.	6	8	8
R-squared	0.8028	0.7993	0.7953

*Note: T-statistics in the parenthesis; *, **, *** denotes to significant at 10, 5, 1 percent level, respectively.*

However, regression results of simple OLS tend to be biased (see e.g. *Mátyás, 1996*; *Baldwin-Taglioni, 2006*), therefore in order to get less biased results and control for multilateral resistance we expanded our model specifications with country and time fixed effects. These dummy variables control for country and time specific fixed effects, therefore results of the original explanatory variables are more accurate. *Table 4* contains the results for the expanded model.

Adding country and time specific dummy variables results in higher R squared values and more statistically significant (and less biased) results. The effect of Hungary's GDP on its export is much greater than in the case of the OLS regression and for Model II it is almost twice as much as the effect of the trading partner's GDP, while Model I shows an even greater difference. Since after controlling for factor endowments the major difference between our models lies in the time periods, this result suggests that in the post-crisis era the impact of Hungarian GDP on its export has grown significantly. In contrast, fixed effects had smaller impact on the size of the coefficients of distance, but the effect of a common border (which factor is related to geographical proximity) increased significantly. Based on the results of the expanded model, sharing a common border increased Hungary's bilateral export in the period of 1993-2007 by 480 per cent which effect multiplied in the case of the sample for 1993-2014[13]. In the meantime, having a common trade agreement had a smaller positive (23-48 per cent) impact on trade for the period following the EU accession of 2004.

Results for the factor endowment variables are very similar to those in the simple OLS regression. Absolute relative endowment shows significant negative values in both Models I and II, and differences in human capital have significant negative effects on bilateral export in both Models II and III. Coefficients for population density, physical capital and land area are insignificant in the expanded model.

Table 4: Regression results with country-and-time fixed effects

	Model I	**Model II**	**Model III**
ln GDP$_{it}$	1.93***	1.22***	1.05***
	(13.51)	(8.52)	(5.97)
ln GDP$_{jt}$	0.16***	0.63***	0.71***
	(2.62)	(8.04)	(6.90)
ln DIST$_{ij}$	-1.51***	-1.50***	-1.24***
	(-13.63)	(-6.87)	(-5.96)
CONT$_{ij}$	3.35***	1.92***	1.71***
	(18.28)	(7.95)	(4.55)
FTA$_{ijt}$	0.21***	0.26***	0.38***

[13] Calculated as 100*[exp(VALUE)-1].

	(3.56)	(4.14)	(4.10)
AbsRelendow$_{ijt}$	**-0.15*** **	**-0.23*** **	
	(-3.03)	**(-2.89)**	
AbsHumancapDiff$_{ijt}$		**-2.06** **	
		(-2.19)	
AbsPopdensDiff$_{ijt}$		**0.27**	
		(0.83)	
AbsPhyscapDiff$_{ijt}$			**-0.29**
			(-1.25)
AbsSchoolDiff$_{ijt}$			**-1.71** **
			(-2.38)
AbsLandDiff$_{ijt}$			**0.01**
			(0.02)
Constant	-24.97***	-17.87***	-16.86***
	(-7.85)	(-5.36)	(-4.67)
Number of obs.	1738	1501	1121
Number of var.	102	101	93
R-squared	0.9518	0.9524	0.9485

*Note: T-statistics in the parenthesis; *, **, *** denotes to significant at 10, 5, 1 percent level, respectively.*

Concluding the results of the empirical analysis we can state that we found strong evidence supporting that bilateral export of Hungary is more significant with countries with similar factor endowments, and therefore we can reject the Heckscher-Ohlin model.

5. Conclusions

The purpose of this paper was to highlight the most important factors affecting foreign trade of Hungary with an emphasis on factor endowments. Although today Hungary trades with more than 190 countries, complete data is available for only 79 of them for the period of 1993-2014. Therefore, this paper did not analyze the total export of Hungary, but those permanent trade linkages that have existed for 19 years without cease, therefore our results are not biased by those trade relations that lasted for just a couple of years including only a few product groups. However, limitations of the results arise from the fact that we applied gross merchandise data due to limited data availability on both value-added trade data and data on trade in services.

Our empirical results show that regarding the permanent trade relations of Hungary, the increase in the national income of Hungary or its trading partner has a positive effect on the export of Hungary. In contrast, distance as a proxy of trade costs has negative effect on foreign trade; on average a 1 per cent increase in distance decreases bilateral trade by 1.4-1.5 per cent. Sharing a common border increases trade significantly, while free trade agreements have a positive effect on trade as well; according to our results, Hungary trades about 30 per cent more with countries who signed a trade agreement, although in order to have a more accurate calculation on the effect of FTAs, refinement on the variable would be needed as the literature of trade agreements suggests.

We managed to find a convincing answer to our research question about which trade theory corresponds to the foreign trade of Hungary. Although having a 45-50 per cent foreign factor content in export as seen in the case of Hungary would support the Heckscher-Ohlin model as foreign value-added comes from countries having dissimilar factor endowments, our results unanimously support the Linder type models. In all three model approaches it was clearly outlined that Hungary tends to trade more with similar countries and that high differences in factor endowments cause less bilateral trade between Hungary and its trading partners. Therefore, the Heckscher-Ohlin model is rejected regardless of the fact that foreign content is quite high in the case of Hungarian export.

The results are well in line with recent findings in the theoretical and empirical literature of intra-industry trade (see inter alia *Cabral et al, 2013*) which reinforce the importance of relative endowment similarities in two-way trade of horizontally differentiated goods and also point to the fact that as opposed to some former quite "monotonic" explanations of vertical intra-industry trade the share of vertical two-way flows grows with differences in factor endowments only until these differences remain limited.

Our findings not only contribute to the literature of the empirical studies on trade theory but may also have further implications for policy makers. In a country where foreign trade is one of the most important drivers of the economy, the increase in trade volumes may have a trickle-down effect. If a country's foreign trade corresponds to the Linder theorem, then closer trade relations with similar countries may have a positive effect on the volume of trade and thus on the economy. Governments recognizing this phenomenon may redirect their trade policies and focus on pursuing trade and investment negotiations with countries that have similar factor endowments.

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