Impact of Industrial Processing on Hungarian Agro-Export Trade
-Gravity Model Approach-

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Abstract

In this thesis, a gravity model approach was used in order to analyze the main factors affecting the trade flow of Hungarian agro-commodity and food export to its twenty most important partner countries. The thesis created three individual product categories; differentiated according to the level of processing: raw material, firstly processed products and secondarily processed products. The empirical model was applied using panel datasets for each category for the period 2005-2012 (from the first entire year after EU accession until the latest observed year). The gravity estimates implied the importance of economy size effects, distance, exchange rate and a set of dummy variables as determinants of Hungary’s agro-export trade. Furthermore, the study analyzed one-way fixed effects in the model, which accounted for heterogeneity in time. With this specification, the individual effects of time periods were evaluated on the created categories and revealed that the secondarily processed products were the most resistant against trade shocks in the international market environment.

In order to calculate unbiased and consistent estimates, the datasets were econometrically tested for choosing the most appropriate regression procedure. Groupwise heteroskedasticity, contemporaneous correlation and first-order autocorrelation were found in the panel datasets, which were controlled by Panel-Corrected Standard Error estimates, where the parameters were estimated by Prais-Winsten regression. The datasets were analyzed by the same estimation procedure for comparing the results and evaluating the effect of industrial processing. The basic gravity estimates (effect of economic sizes and economic distance) of the differentiated product categories were found statistically significant with their expected signs. The GDP increase of the host countries stimulated the market for twice as much as the Hungarian GDP increase. The estimates showed that the structure of raw material export and secondary processed product export were more closely resembled than the firstly processed products.

These results are important for trade policy formulation to promote processed Hungarian food products to the World market to strengthen the food processing sector by providing jobs and establishing economic improvement in the rural region.
Table of Contents

Abstract ........................................................................................................................................ iv
Table of Contents .......................................................................................................................... v
List of Figures .................................................................................................................................. vii
List of Tables ................................................................................................................................... viii
Acknowledgements ....................................................................................................................... ix
Dedication ........................................................................................................................................ x
Chapter 1 - Introduction................................................................................................................ 1
Chapter 2 - Evolution of Hungarian trade of agriculture over the period of 1990-2013 .............. 6
  The transition decade, new challenges .......................................................................................... 6
  Effects on bilateral trade of Hungary ........................................................................................... 8
  The divided export performances ................................................................................................. 10
  Arising investment problems ....................................................................................................... 13
  Regional position of Hungarian agriculture towards increasing trade prosperity ..................... 14
Chapter 3 - Literature review on theory and methodology of Gravity model .............................. 16
  Origin of the ‘Gravity Model’ and its evolution .......................................................................... 16
  Commonly measured explanatory variables and dummy extension .......................................... 19
  Panel data econometrics associated with gravity model ............................................................ 20
  How gravity models utilized panel data econometrics in recent literature ............................... 24
Chapter 4 - The analyzed datasets .............................................................................................. 27
  Data context of the study .............................................................................................................. 27
  Data sources and description ....................................................................................................... 28
  Preliminary analysis ...................................................................................................................... 31
Chapter 5 - Methodological framework ...................................................................................... 33
  Unit root tests ............................................................................................................................... 34
  The models .................................................................................................................................. 37
  Estimation .................................................................................................................................... 38
  Testing the datasets ...................................................................................................................... 39
    OLS versus One-way Fixed effect model (time effect) .............................................................. 39
Misspecification tests .............................................................................................................. 39
Linear regression with panel-corrected standard errors .................................................. 42
Chapter 6 - Results ............................................................................................................. 43
Chapter 7 - Conclusion ..................................................................................................... 50
References ........................................................................................................................ 54
Appendix A - Figures ....................................................................................................... 61
Appendix B - Pictures ...................................................................................................... 64
Appendix C - Tables .......................................................................................................... 66
List of Figures

Figure 1 Evaluation of the External Trade of Hungarian Agricultural Commodity Market .......... 9
Figure 2 Evaluation of Hungary's export categories in terms of processing .......................... 11
Figure A.1 International imports and exports of goods and services in 2011 .......................... 61
Figure A.2 Growth of GDP and international trade in percentage of GDP (2004-2011) ..........61
Figure A.3 Annual change of arable land between 1999 and 2011 .................................62
Figure A.4 Average annual cereal yield in the CEE region and in Hungary .......................62
Figure A.5 Average annual cereal yield in Western Europe and in Hungary .....................63
List of Tables

Table 1 Descriptive data of explanatory variables........................................................................32
Table 2 Results of panel unit root tests.........................................................................................37
Table 3 Probability results of the applied tests on the individual datasets .................................42
Table 4 Results obtained for Panel corrected standard error (PCSE) regression ......................49
Table C.1 Segmentation system of individual traded products....................................................66
Table C.2 Export trade partners, analyzed in the sample.............................................................73
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Dedication

This thesis is dedicated to the memory of my beloved grandfather,

Dr. Tibor Marton
Chapter 1 - Introduction

Historically agriculture has always been a key sector in the Hungarian economy. Hungary has outstanding makings in production of agricultural products. Excellent soil quality, no extreme weather conditions and democratic political system contribute to successful appearance in the highly competitive agro-food and commodity World market. Through many decades, Hungary was one of two European countries which could preserve its net exporter position in the agro-commodity and food market in the Central and Eastern European region (Fertő et al. 2006). Generally, small economies have more significant export/import shares of their gross domestic product (GDP) than larger economies. In comparison the international imports and exports of goods and services in the OECD countries (see Figure A.1.; OECD¹, 2013), Hungary had one of the largest share of its GDP, which indicates that the national economy was highly dependent on international trade. On Figure A.2 was pointed out that the trade flows of Hungary were growing faster than its GDP in the period of 2004-2011. This registered an increase in openness of the economy as a whole in the past few years. The agricultural commodity and food products’ share of international exports and imports were between 5-7% depending on the annual productivity and market conditions. Agricultural trading took a small share of Hungary’s international trade, it is still not insignificant, because the corresponding employment rate of the whole society was 5-5.5% in this sector (KSH², 2014). Agricultural production is located in the rural region, creates jobs and livelihood. Every country has the elementary interest to develop and invest into agriculture. Those investments should open new possibilities to farmers to assure food safety and food security for the nation.

Countries in Europe are suffering from migration, and especially of the depopulation of rural area. In order to stop the trend, the European Union (EU) endeavored to make people interested in agriculture, initiated prosperous offers to the workers in the agro-sector. The EU introduced the Common Agricultural Policy (CAP) among the member states in 1962 which has

undergone many changes since then. In 1999 the Agenda 2000 reform created the second pillar, the rural development goal (funded by EAFRD, European Agricultural Fund for Rural development) besides production support. These programs specifically subsidized young farmers, small farms and aimed to shorten the supply chain in the EU in order to increase food quality and vitalize indoor market environment (European Commission, 2011).

Hungary joined to the EU in 2004 with nine other Central and Eastern European countries (CEE) and since they have undergone significant changes especially in the field of agriculture. Due to the 2004 expansion, EU membership made those countries new individual parts of a large market; hereby these countries faced a new market situation and a new market structure. In such an enlarged, competitive environment, the role of high quality, region-specific (see shorten supply chain) products had measurably increased (Török and Jámbor, 2012). One of the major impacts of the enlargement was that the intra-EU agro-commodity and food trade significantly increased and the trading structure as well as the partner relations of the countries also changed.

The motivation of this thesis was to analyze the main factors influencing Hungary’s agricultural export performance to its major trading partners after the enlargement for the period of 2005 and 2012. Many studies were published about the effects of the Communist and Post-Communist period on agricultural trade of Central Eastern European countries (CEE) including Hungary (Csáki, 1990, 2000; Csáki and Lerman 1996) and about the anticipatory effects of the Eastern Enlargement of the EU (Baldwin et al., 1997; Münch et al., 2000; Keuschnigg and Hohler, 2002). The thesis intended to contribute to the growing literature that evaluates the effects of the 2004 EU accession and the market development since then. Hungary’s agro-export trade performed successfully during the past decades and became a key sector in the national economy. The Hungarian agro-trade has been analyzed by comparative and sensitivity analyses of the individual traded products (Fertő, 2008; Bojnec and Fertő, 2008; Csáki and Jámbor, 2010), as well as investigated by price and quality competition (Bojnec and Fertő, 2009).

The thesis evaluated continuous eight years after the accession and employed the gravity model for detecting the influence of trade determinants of Hungary’s agro-export. The gravity model has been extensively used in international trade research for the last 40 years because of its considerable empirical robustness and explanatory power (Kepaptsoglou et al., 2010). Applying gravity model allows the evaluation of aggregated trade flows such as import and
export or both and even bilateral trade not just between country pairs, but also between groups of countries. Hungary’s agro-export trade as a whole has never been analyzed by the gravity model approach, that is why it was important to evaluate the most important trade determinants and factors (e.g. home and host countries GDP growth effect, economic distance effect and border effect) with its most prosperous trading partners. The so-called gravity equation in international trade has proven surprisingly stable over time and across different samples of countries and methodologies. It stands among the most stable and robust empirical regularities in economics (Chaney, 2011).

The innovation of the thesis was that the Hungarian agro-export flow was differentiated according to the presence of industrial processing. The Hungarian Research Institute of Agricultural Economics developed the methodology, for creating product groups according to the degree of processing. Three individual categories were built, where the agricultural commodity and food products were identified as raw materials, firstly processed products (considered as semi-finished products) and secondary processed products (as finished products). Due to the divided databases, we were allowed to investigate the effects of industrial processing. In order to gain group-specific coefficients of the determinants, the same gravity model was applied in all three categories. Therefore, the coefficients of the determinants became comparable to each other and we may infer to the effects and role of processing on agricultural export trade. The databases were established and considered as cross-section time-series (i.e. panel) datasets, which infer many advantages for calculating heterogeneity in time and making measurable annual effects on trade.

The thesis intended to answer the following questions:

- How the agricultural and food industrial processing influenced trade patterns?
- What was the most influential trade determinant in raw material, firstly processed and secondary processed products export-category?
- How the industrial processing affected the annual changes of trade after the 2004 EU enlargement in Hungary?

The differentiated export flows as dependent variable were collected from the UN Comtrade Database and in each category the most influential 20 trading partner countries were represented. As the set of partner countries changed between the created groups on different levels of processing, the associated country-specific details in the datasets were altered
accordingly. One of the most important research decisions was to determinate the most relevant trade influential features. In traditional gravity models the analyzed explanatory variables were the GDPs of the trading countries as the gravitation masses, the geographical distance as trade cost and a set of dummy variables (Feenstra et al., 1998). From a Central European country perspective and as an EU member, it was important to determinate the EU related connections, such as EU membership and euro-zone; then the effects of contiguity and OECD membership. In an extended gravity model (Kafle and Kennedy, 2012), it was common in the literature to evaluate the national currency performance of the detected country by introducing exchange rate against US dollar ($) or Euro (€).

In each category, the export trade to the top-20 partner countries came to be roughly 90% of the total export trade value (raw material, 93.34%; firstly processed products, 90.73%; secondary processed products, 89.14%). In the estimation process the export to those 20 partners was considered as the total export trade in order to avoid zero observations. During the interpretation of the results, we had to take into consideration the 10% omission; however the advantage of eliminating zero observations made the estimations easier and more reliable. This correction could be regarded as a negative marginal externality.

By analyzing panel datasets, several hypotheses needed to be taken into consideration to find the best fitted regression methodology and gain unbiased estimates. Databases were econometrically tested to learn about their possible drawbacks and limitations. Panel datasets were built with time dimension which allows us estimating a time-varying elasticity of trade with respect to distance. Furthermore, panel data econometric prevents bias from omission of relevant variables by considering what is known as unobservable heterogeneity (Angulo et al., 2011). In econometrics, the diagnostic hypotheses help to make appropriate research decisions. The datasets were tested for stationarity, heteroskedasticity, contemporaneous correlation and serial autocorrelation in order to detect the best econometric regression model, which controlled the occurred problems.

After the 2004 enlargement the raw material export was found the most significant. The estimation results expected to show an excessive demand increase for raw material. The basic gravity determinants were expected to be significant and reveal how the national and partner countries GDP growth invigorated the agro-export trade of Hungary; furthermore how the impact of economic distance (as trade cost) negatively affected the export trade. It was presented in the
thesis, that the geographical distance of the raw material and firstly processed product categories was similarly high compared to the secondarily processed products category. That is why the negative effect on trade was expected to be also higher. Heterogeneity in time was included in the models; in the examined period of 2005-2011, two trade shocks were marked in the international market. The increasing food demand caused the 2007-2008 food crisis and the World financial crisis in 2008-2009 also affected the export trade. The thesis intended to measure those effects on Hungary’s agro-export trade and found out which product category performed better resistance against trade shocks.

The thesis focused on Hungary’s agricultural export trade and intended to model the influence and the role of processing on international trade. In order for Hungary to remain a successful net exporter in the region, there is a need for increasing competitiveness and efficiency in production. The commodity structure should be transformed from raw material export to high value-added products export (i.e. processed animal products, fruits and vegetables). By assessing the influence of industrial processing on export trade, we expect to gain category-specific results from one side of Hungary’s agro-trade. However, for understanding international trade movements of a nation, the import demand also should be detected by the same methodology. In the future it would be interesting to evaluate the import demand of Hungary by focusing on industrial processing and compare the results to the export trade. Such a comprehensive analysis could infer effective policy implications in order to increase productivity and establish dynamically developing rural areas.

In the following, the thesis will discuss the evolution of Hungarian trade of agriculture in a broader sense. In order to understand the current movements of trade, it was important to detect the legacy and declare Hungary’s regional position and its perspectives to the future. The third chapter presented a brief literature review of gravity model, where the advantages of panel data estimation procedure were also demonstrated. In the fourth chapter, the established datasets were presented and the descriptive data were analyzed. In the fifth chapter the applied methodological framework was detected by ran diagnostic hypotheses and misspecification tests of the datasets. The sixth chapter performed the estimation results and the last chapter concluded the findings of the thesis.
Chapter 2 - Evolution of Hungarian trade of agriculture over the period of 1990-2013

The transition decade, new challenges

At the end of the communist regime (1990) Hungary and other Central Eastern European countries (CEEC) faced a transition period from central planning to ground market economy in the region. After decades of communism, these countries’ agricultural sectors were characterized by large, inefficient farms with high production costs; heavier food consumption than in market economies of comparable prosperity and an excess demand for food at subsidized prices. As it matters the macroeconomic status of CEEC could be described by permanently increasing inflation, state monopoly in food processing and distribution, budget deficits and huge foreign debt. In order to stop the adverse run of the market, significant actions had to be made. To create a new agricultural structure based on private ownership, which is led by market economy, the following challenges had to be accomplished: the creation of a new agricultural policy that emphasized efficient production and income parity among agricultural producers, which meant developing a new legal framework, including land law that defined the processes for distributing ownership titles, handling former owners’ claims, and the transfer of land and other assets of cooperatives to private ownership; the development of a real agricultural market that encouraged fair competition, in order to eliminate food subsidies; alteration of agriculture’s structure to emphasize medium-size private agricultural ventures and various cooperatives together with state or communal farms; the change of the government’s role, reassessing the agricultural sector as part of the macroeconomic framework by extending liberalization on consumer and producer food prices and simultaneously providing a supporting consultant service and network (Csáki, 1992; Banse et al. 1999). The comprehensive changes significantly affected the agricultural sector. Substantial differences characterized the CEEC in comparison to the EU-15 countries before the enlargement of 2004, and those differences still have not been demolished. For example, the support policy and the farm-gate prices were lower, whilst the employment rate in
agro-sector and the agricultural share of GDP were higher compared to EU-15 countries. That is why reshaping the agricultural sector became the most controversial issue on the accession negotiations between EU-15 and Central Eastern European countries. The Common Agricultural Policy (CAP) codified the different national agricultural policies which intended to create transparent and predictable agriculture in Europe with its common institutional background. At that time, the CAP came out at almost half of the whole European Union (EU) budget. The most important objectives of CAP were: to increase agricultural productivity, stabilize food market and ensure the suitable and honored living conditions for farmers. The CAP established the uniform regulatory principle: one size fits all, which has not proven effective, since it has not taken into account the structural differences between countries. In the future, more appropriate agricultural policy programs are required to be developed by shaping for local needs and allowing individual (country specific) creations (Csáki and Jámbor, 2013).

The EU-15 countries were apprehensive due to the enlargement of the organization and the subsequent increase of budget responsibility to meet the needs in the integration of new member states. Former scientific literature phrased the following expectations from an economic point of view, as it had significance to the future development of agriculture: production system would develop, external food trade as well as competitiveness of agriculture would increase in the joining countries; the agricultural output would shift towards crop production (due to the grain intervention system of the CAP, which increased feed prices, created a difficult situation for poor-capital livestock farms), furthermore, the sectorial aid and the agricultural earnings would also significantly change after the enlargement (Nagy, 2011). The general transaction raised an expectation that the CEE countries might become major agricultural exporters inside Europe, which could significantly affect the internal market of EU-15. Previous research highlighted that the reason for the suspected rapid increase was because of the extension of the CAP to CEEs (Tangermann and Josling, 1994; Banse et al., 1998).

The export increase after the 2004 enlargement in CEEC proved the forecast at the beginning of the 90’s to be significant, however those countries’ imports also rapidly increased. By turning it all round, the import increased more than the export in the region of Central and Eastern Europe, which eventually led to increased prosperity of the EU-15 and to the new member states also, since new products had begun to appear. Between 1992 and 2002 Poland and Hungary were leading agro-commodity exporters in the region, although only Latvia and
Hungary could reach positive trading balance of their external agricultural trade (Fertő et al. 2006). This was explained by maintaining more developed production system, good product quality and quicker adjustment to EU standards during the period of accession preparation in comparison the other member states that joined at that time.

Significantly different trading structures characterized the processed and non-processed agricultural products of the CEE countries. In retrospect, it could be concluded that the raw agricultural products dominated in export trading, whilst in import trading processed agricultural products had greater importance. The cause behind the significant raw products export was primarily the lack of competitiveness generally in CEEC. Industrialization could not rapidly develop during the communist regime and after the gates of the competitive markets opened, the occupied countries faced a strongly competitive market in Europe. Fertő (2008) revealed by employing Balassa-indices, that, however the EU enlargement increased the trading intensity in the region, the comparative advantages of every examined CEE countries were found to be negatively affected. This indicated further research, which examined the decisive determinants of the competition of price and quality. Bojnec and Fertő (2009) found, that the gap was closing due to competition of quality, but they revealed unsuccessful development in terms of price competition. The EU had not just accelerated the market performances, but also had an industrial developing effect on its member states and indicated greater openness to trade. The increased openness may have caused economies to be vulnerable to volatility due to trade shocks, but more openness generally enabled specialization and scale economics (Kristjánsdóttir, 2005).

After a basic summary of CEEC expectations and performance over the transition period, as well as the most dominant influences of the EU enlargement in 2004, the thesis will attempt to demonstrate the changes of the Hungarian agro-industrial sector.

**Effects on bilateral trade of Hungary**

Trade liberalization, general economic and food products import growth around the World and the end of the transition decade all contributed to the prosperous integration to the World markets. As it was mentioned above, Hungary was one of the two countries, which could achieve a positive balance of the export and import accounts in the agricultural sector (see Figure
1). A broader spectrum of the examined period (1999-2013) was needed to identify and properly locate the investigation interval of the thesis, which was from the first complete year after the 2004 EU accession until the most recent data available (2005-2012). By analyzing the extended time period, the comparison of export and import performance showed that the increase of import exceeded the export achievement. If 1999 is considered as the base year of trading, relatively to the spot, the import/export-run increased by 6.15 and 4.75 times, respectively. However, from another point of view, the annual average growth of export exceeded the import (5752.22 million and 3490.25 million US dollars, respectively). The more than two-fold difference at the starting point (1999) was hiding the opportunity for a faster growth path for the import, which actually occurred between 2003-2006 when as a new member state could not immediately adjust to the expectations of the market and in the newly opened 500 million population economy it needed to find its place to become successful. In 2005 and 2006 was the worst ratio of export and import from the national perspective and from 2007 the export was almost always expanding at a faster pace than the import.

**Figure 1 Evaluation of the External Trade of Hungarian Agricultural Commodity Market**

![Graph](figure1.png)

Source: UN Comtrade\(^3\) (2014), own calculation

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\(^3\) UN Comtrade: International Trade Statistics Database. The data was downloaded from UN Comtrade website: http://comtrade.un.org/db/dqQuickQuery.aspx
In 2010, the new political leadership carried out structural reforms in many segments of the national economy as well as the legal basis of Hungary (New Constitution). The National Bank largely reduced the base rate several times, as a mechanism to drive the inflation rate down close to zero; however the national currency (Hungarian Forint, HUF) was substantially weakened as a consequence. The weak national currency made interest on revenues of exports which reacted immediately and invigorated the external trading. As Figure 1 shows, from 2010 the charts diverged from each other which influenced the Account Balance (AB) to increase. In the future, if the AB were fortunately to intersect the import-run, the export would be exactly twice as the imported value as a result. This already occurred during the time period between 1999 and 2002. It was also striking, that the import- and export-runs closely followed and correlated with each other until 2010. Furthermore, as visible on Figure 1, a market shock effect was observed between 2008 and 2009. The price of nearly every agricultural commodity sharply increased in 2007 and 2008, creating a global food price bubble. At the peak, in the second quarter of 2008, World prices of wheat and maize were three times higher than at the beginning of 2003 and the price of rice was five times higher (von Braun, 2008). Although on Hungary’s international agricultural commodity market the export and import correlated with each other, the crises more severely affected the export performance than the import. The export relapse was more significant than the import, which meant that the Hungarian agro commodity exports had greater exposure to negative market changes. In order to reduce the effects of negative market changes on the national economy, the competitiveness of the exported goods individually needed to be increased by innovation, launching new products, creating stronger economic relationships. This could set up a higher-level resistance against the excessive price volatility on international food market.

The divided export performances

This chapter not just inferred the export- and import-run and their relations; it also investigated specifically the determinants of the divided export groups according to the level of processing. In the following, the exported value was split in terms of processing and three
individual groups were created in order to assess the impact of industrial processing on international trade.

All existing agricultural and food products were classified in the Harmonized Commodity Description and Coding System (HS), which was an internationally standardized system of names and numbers for categorizing trading products (which was developed and maintained by the World Customs Organization). Aggregate levels between 01 and 24 of HS summarized all the agricultural and food commodities. The study focused on these aggregated levels and divided the sub-aggregated levels according to the level of processing into raw material (e.g. live animals; live trees and other plants; cereals), firstly processed products (e.g. meat and edible meat offal; coffee, tea, mate and spices; milling industry products) and secondary processed products (e.g. edible preparation of meat, fish, crustaceans; preparations of vegetables, fruits and nuts; beverages, spirits and vinegar). The segmentation system of the individual traded products was developed by the Hungarian Research Institute of Agricultural Economics (AKI) (see Table C.1). The growth run of those charts was drawn on Figure 2. The data treated from the first entire year in the EU (2005), until the most recent available observations (2012).

**Figure 2 Evaluation of Hungary's export categories in terms of processing**

![Graph showing the evaluation of Hungary's export categories in terms of processing from 2005 to 2012.](source: UN Comtrade (2014), own calculation)

Source: UN Comtrade (2014), own calculation
The figure showed that the access to the EU substantially affected the proportions of the specific charts. In the initial state, the secondarily processed products were favored, which was closely followed by the exported raw and firstly processed products values. Two years after the accession, in 2006 the raw product export rapidly increased and stepped away from the other two. The processed products charts also showed a discrete positive increase. However, after 2010 higher demand occurred for the firstly processed products. Up to 2012 the export-market structured unfavorably for Hungary (the order of the charts changed; raw material had the highest demand on the market, then the firstly processed products and lastly the secondary processed product groups), but the market growth could compensate the supposedly temporal changes. It has been already stated that the open market revealed the major disadvantages in productivity which could be explained by lower development level of the joining country in comparison to EU-15 in 2004. From the perspective of a historically exporting country like Hungary, it was found that the increase in value-added products would be more beneficial for the national economy, since it would energize the origin country due to production, reduction of unemployment rate, and could contribute to rural development by providing jobs and respectful living for families.

The Hungarian food and commodity trade was heavily concentrated on the intra-EU market, especially on the top five partner countries (60.6%). Intra-EU trade accounted for 75.21% of Hungarian agro export in 2005 and 85.57% in 2012. As a result of the Eastern enlargement of the EU in 2004, the share of intra-EU trade increased by 10.36% in the period of 2005-2012. In an 8 year average, the 67% of the exported raw material was sold in its top five export destinations in Italy, Germany, Romania, Austria, and the Netherlands; 59% of the firstly processed products in Romania, Germany, Slovak Republic, Italy and Austria; and 54% of the secondarily processed products in Germany, Romania, Austria, Slovakia and Poland. In all cases, heavily skewed distributions were observed, however significant differences were found in the deflections. Comparing the cases and detecting the effect of industrial processing, on Picture B.1, B. 2 and B. 3 were drawn the annual average exported value of the top five countries and on an aggregated chart the rest 15 countries. The charts representing the top 5 countries were found roughly in the same range; however the aggregated average flow reclined significantly beneath them. The ‘stata-generated’ pictures also showed that in the case of raw products export the top 5
countries were the most influential compared to the other categories, which implied that the commodity export was highly dependent on the demand of those five partner countries.

**Arising investment problems**

As an effect of EU accession the new member states could open up easier to the trade of intra-EU market and were faced with high demand of agricultural products, especially of raw material commodities. The pulling market structure increased rapidly the raw product export of Hungary. The export of processed products also increased; however on the highly competitive market those were not successful. From Hungary’s perspective, in order to change the structure of export expansion in favor of the processed products, capital investments should have been allocated to the industrial sector in order to maintain and develop the rural area. Hungary is suffering from migration, which is especially true for the country side. The society is ageing and cannot produce the basis of future investments. In general, it can be declared that the necessary investments failed during the communist regime and the transition period. Clear investment policy should be elaborated and led by the government, which could differentiate the agro investments from other sectorial investments. There is no conventional market-based venture investment in Hungary regarding low innovation competence, lower than average profitability, combined with variable influencing factors planning (e.g. weather). It is very difficult to achieve the investors’ expectation, namely to produce dynamic growth in this sector. For example, in case of bankruptcy it is very difficult to liquidate particular assets (e.g. livestock farms, buildings), which makes the agro-sector more insecure. These negative sectorial features could be controlled, if the government would create improved conditions and less risky environment for business. The venture capital investment could gain ground in related sectors to agriculture, such as investment to produce bioenergy and biogas. Hungary has promising possibilities for the future to create the above mentioned developments, since apparently it has a very strong government, which is responsible for vitalizing the rural area.

Other issues also complicate the re-industrialization of the agro-food production sector. Since the CEE countries could not afford to cover the expenses of technological innovation and research & development, there is now more emphasis on management issues (e.g. cross
compliance, diversification, quality control etc.), which are also very important, but the sequencing of the future performed work could be better controlled (Nemes, 2013).

Regional position of Hungarian agriculture towards increasing trade prosperity

To evaluate the performance of agricultural commodity export of Hungary, some important influencing factors related to productivity needed to be identified and compared to the regional competitors.

The role of the agricultural sector in the national economies could be characterized by its contribution to the national GDP. These indicators were decreasing all over the World and the accession accelerated this trend in the new member states. In the V-4 countries this number was 2.4% in the Czech Republic, 3.54% in Poland, 3.86% in the Slovak Republic and 3.53% in Hungary in the year 2010 (World Bank database). Despite the small contribution to the GDP, the expanded agriculture-related food industry had a significant weight in all countries (Csáki and Jámbor, 2012).

The employment rate of agriculture also showed a decreasing trend. On one hand the increasing migration from rural areas caused difficulties in the pursuit of developing agricultural production and on the other hand the slow industrialization and mechanization induced human work force. The employment rate in the agro-sector generally decreased in Hungary over the period 1999-2012. In 1999 it was more than 7% of the total employment and it changed to 5.2% turning to 2012. In 2008 it reached its minimum at 4.3%. In the region Hungary had one of the smallest ratios with two other countries over a 14-year-average in period of 1999-2012: Slovak Republic (4.8%), the Czech Republic (4%) and Hungary (5.3%). The other CEE countries had significantly higher rates, such as Romania (33.4%), Poland (16.1%), Croatia (15.1%) and Slovenia (9.3%). More developed countries in Western Europe, mostly had even smaller employment rates than the least amount in CEE, for example: France (3.5%), Germany (2.1%) and the United Kingdom (1.3%) (World Bank database). The available arable land differs in each

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4 V-4: Visegrád Group is an alliance of four Central European states: Czech Republic, Poland, Slovak Republic and Hungary.
country which fundamentally defines the opportunities of agricultural production. Countries could be measured and compared by the indicator of arable hectares per person, which includes land defined by the FAO as land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. Land abandoned as a result of shifting cultivation is excluded (World Bank data, 2014). Hungary’s biggest advantage was that it had outstanding ratio of arable land in relation to population, which equated to less than 0.5 hectares per capita. With this contribution, Hungary had one of the highest ratios in Europe. The European average was nearly 0.2 hectares per person. This application means that Hungary has a potentially greater capacity for production, which indicates higher level export capability than the vast majority of its competitors in the region (on Figure A.3 the annual change of arable land between 1999 and 2011 of eight European countries and Hungary was drawn). The reason why Hungary could not enforce advantage on the international market of the size of arable land was that the average production yields per hectares just ran to the European mean. Less efficient production technology, lack of innovation and slow knowledge diffusion caused drawbacks in agro commodity production. On Figure A.4 and A.5, the average annual cereal yields were drawn in the period of 1999-2012. For a better comparison, the displayed countries were separated in order to see the differences between Western Europe and Central and Eastern Europe. On Figure A.4 the Czech Republic, Poland, Slovenia, Slovak Republic, Romania and Hungary were examined, while on Figure A.5 Germany, Italy, Austria, Spain, France and Hungary. In the first comparison Hungary had relatively high annual productivity, while in the second comparison with the Western EU countries, Hungary showed significant drops from the leaders. Despite that the Western European countries had smaller ratio of arable land per capita, they could reach higher cereal yields and thereby their disadvantage was compensated.

It is a common goal for Central European countries to increase their efficiency of productivity. For example, launching National and EU programs for increasing agricultural knowledge diffusion from Western Europe towards Central Europe, better co-operation and utilization of the CAP and technological investments could contribute to an increase of cereal production yields.

Hungary’s trading position in the region could be summarized as good, however compared to the EU as a whole, many development opportunities appear. Hungary was
successful in the intra-EU market, since 82.57% of its agricultural export was sold in this market in 2012 (Eurostat\(^5\), 2014).

Chapter 3 - Literature review on theory and methodology of Gravity model

Origin of the ‘Gravity Model’ and its evolution

Gravity modelling has been one of the most successful empirical models in econometrics. It became very popular among researchers and has been extensively used for assessing trade policy implications over the last 40 years, because of its inherent empirical robustness and explanatory power (Kepaptsoglou et al., 2010). The gravity equation has been long recognized explaining many different types of flows, such as migration, commuting, tourism and commodity shipping (Bergstrand, 1985). The gravity model is a macro model by its nature, since it was designed for capturing volume, rather than the composition of bilateral trade (Appleyard and Field, 2001). First, gravity was derived by Tinbergen in 1962, in order to explain trade flows. Since then, the model has been significantly improved and has acquired a primary importance in empirical analysis of trade patterns. Gravity model has been utilized not only to gain understanding of trade flows in general, but also to assess the role of particular determinants of trade between countries, such as distance, currency union, contiguity, trade organization membership or identical languages.

Gravity model is distinguished from other (e.g. Absolute, Comparative Advantage Theories; Krugman’s New Trade Theory; or Heckscher-Ohlin (H-O) model) trade models by its parsimonious and tractable representation of economic interaction in a many country world. Most international theories have concentrated on two country cases, occasionally extended to

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\(^5\) Eurostat: http://epp.eurostat.ec.europa.eu/portal/page/portal/international_trade/data/database
three country cases with special features (Anderson, 2011). These features made gravity to become a workhorse model to explain factor movements as Origin-Destination (OD) flows, such as international or regional commodity trade, population migration, foreign direct investments and tourism. Furthermore, most recent studies have focused on the examination of regional trade agreements, currency unions and common markets, trade policy implications, such as natural border effect (Nitsch, 2000), monetary union impacts (Buch and Piazolo., 2001), domino effect (Sapir, 2001), foreign direct investment (Gopinath and Echeverria, 2004), rules-of-origin (Augier et al., 2005) and transportation costs (Egger, 2008).

Gravity model is built on the analogy between trade and physical force of gravity. Traditional gravity allowed the coefficients of one applied to the mass variables and of two applied to bilateral distance to be generated by data to fit a statistically inferred relationship between data on flows and the mass variables and distance. In the original version by Tinbergen, the model was expressed in log-log form, so that the parameters become the elasticity of the trade flow with respect to the explanatory variables. Tinbergen also involved two dummy variables; one took the value 1, if the trading countries shared a common land border (contiguity), 0 otherwise. The other one was described as the political factor which indicated that goods traded received a preferential treatment if they belonged to the some unilateral or system of preferences (Salvatici, 2013). Tinbergen’s work inspired Linnemann (1966), who realized that the half trade of the world is zero. This finding began to resolve the problem of zero value trading. Only after 30 years this critical issue has been addressed, not without discrepancies on how to treat zero trade data appropriately (Felbermayr and Kohler, 2006; Helpman et al., 2008; Silva & Tenreyro, 2006; Egger et al., 2011; Westerlund and Wilhelmsson, 2011).

After building the idea and improving a few applications of gravity, there was a need for formal representation of the role of technology, factor endowments, demand differences of any of the underlying structural differences and the determinants of trade which have to be recognized. That shortcoming has been addressed by a series of papers beginning with Anderson (1979) and Bergstrand (1985, 1989), Helpman and Krugman (1985), Deardorff (1998), Eaton and Kortum (2001) and Anderson and van Wincoop (2003).

The microeconomic ground of the gravity equation lies in the imperfect competition theory applied to international trade, in particular to intra-industry trade. Anderson (1979) formalized a general equilibrium model for the gravity equation for trade. His model assumed
product differentiation as well as homothetic preferences and a frictionless economy. It used the properties of expenditure systems with a maintained hypothesis of identical homothetic preferences across regions. The gravity model constrained the pure expenditure system by specifying that the share of national expenditure accounted for by spending on tradable goods (openness to trade) was a stable unidentified reduced-form function of income and population. The share of total tradable goods expenditure accounted for by each tradable good category across regions was treated (through preferences) as a function of transit cost variables.

Bergstrand (1985; 1989) also explored the theoretical determination of bilateral trade in a series of papers, in which gravity equations were associated with simple monopolistic competition models. He concluded that price indices influenced trade flows. Furthermore, Bergstrand acknowledged the multilateral resistance term and dealt with inherent time-series implications, but was unable to deal with the cross-section aspects which were crucial for proper treatment of bilateral trade barriers.

Helpman and Krugman (1985) made assumptions that prevented the adjustment of prices (frictionless trade and factor price equalization), so all adjustments happened in the number of varieties that each nation had to offer. This implied that nations with large GDPs exported more to all destinations, since they produced more varieties. Since each firm produced one variety and each variety was produced only by one firm, adjustment was stated from taking place at the level of where varieties equated to stating that the number of firms in each country adjusted endogenously. This was enough to lead to the standard gravity results. Furthermore, Helpman and Krugman (1985) justified the gravity equation in the frame of differentiated product with increasing returns.

In 2003 Anderson and van Wincoop derived an operational gravity model based on the manipulation of the CES expenditure system that could be easily estimated and helped to solve the so-called border puzzle. According to them, particularly transportation costs, trade policies, cultural differences, geographical characteristics, limited overlap in consumer preference schemes, regulatory bottlenecks, etc. National borders are among these impediments, even for industrialized countries.

In the following, the review will subject to similar studies analyzed by gravity model approach. Through the studies we can look into the huge variety of statistical and econometric techniques used for estimating the parameters of the gravity model specification. Furthermore, in
this section, the widely used variables will be discussed and the background of some important research decisions of applying gravity model will be demonstrated. Established practice (with its pros and cons) was found in the literature regarding panel data approach, existence of heteroskedasticity or autocorrelation. Thanks to econometrics and computer developments it became possible to analyze enormous size of data bases, evolve and apply multiple analyzing techniques. Despite of the established practice, more and more ideas appear in order to shape the model to best fit reality.

**Commonly measured explanatory variables and dummy extension**

The theory is based on the concept of where the volume of trade (or the examined movement) between countries is directly proportional to their economic masses and inversely proportional to their distance (considered as trade barriers). Exports and bilateral trade flows were the most widely analyzed dependent variables in trade flow gravity models. The commonly used indicators for measuring market size are: gross domestic product (GDP), population, GDP per capita, or the gross national income (GNI). The geographical element may be classified as the physical distance between the markets, usually measured in kilometers between the capitals of the trading partners. In order to provide precise estimation of the gravity model parameters, a set of ‘dummy variables’ can be included to describe more accurately the trading situation, where more robust and reliable estimates of trade costs are afforded. Trade cost have been described in the literature as follows: common border, language, and history, common currency, quality of infrastructure, economic integration and affiliation. Kepaptsoglou et al. (2010) pointed out that their explanatory variables could be distinguished in the following two groups: (i) Factors indicating demand and supply of trading countries; (ii) Factors representing the impedance imposed on a trade flow between countries. Common proxies for demand and supply are measures of a country’s economic and market size; income level, population, area size and GDP per capita are variables included in most gravity model specifications. In particular, GDP per capita indicates the purchasing power of importing and exporting countries (Sohn, 2005); two countries with considerably different populations may have similar GDPs but totally different economic development. According to Bergstrad (1985), many studies explicitly
consider GDP and GDP per capita as explanatory variables, with GDP per capita serving as a proxy for the capital-endowment ratio.

The description of trade patterns by improving the data (better specification of the performing countries) is just half the bottle, the other is to find the good application of the gravity model from an econometric point of view. During the last decades many methodologies have been developed with many adjustments made. In the following paragraphs the panel data econometrics will be detailed in relation to gravity model, furthermore the main econometric specifications and technical improvements will be discussed that connect to the issue of examining export trading towards several countries.

**Panel data econometrics associated with gravity model**

Historically, the gravity equation in international trade has been estimated using cross-section data either for a single year (Oguledo and MacPhee, 1994) or for multiple years (Aitken, 1973); only around the millennium was the gravity equation estimated by using panel data techniques (Egger, 2002; Baltagi et al., 2003). The longitudinal econometric methods became popular in research where a short-term perspective was introduced and thereby complementing the discussion of long-term relationships in cross-sectional studies.

Mátyás (1997) argued that the properly formulated econometric specification of a gravity panel with time variation would be one in three ways with main time, exporter and importer effects. Therefore, excluding an important source of variation such as time, could lead to inconsistent modeling results. The exporter and importer effects control for all time-invariant observable and unobservable country characteristics. Time effects capture cyclical influences commonly shared by all involved countries. Panel data with time dimension allow estimating the time-varying elasticity of trade with respect to distance. As it is well known, one important advantage of the panel econometric framework is the reduction of the “risk of obtaining biased results” (Baltagi, 2001). On the other hand, the interpretation of the coefficients estimated from panels with time variation is different from the cross-section outcome. Whereas cross-section estimates represent long-term relationships, their panel counterparts should be interpreted as short-term, within group effects. Angulo et al. (2011) concluded the main advantage of panel
data econometric was that bias from the omission of relevant variables was prevented by the consideration of what is known as unobservable heterogeneity. Furthermore, panel models prevented such bias by considering the individual effects related to cross-sectional, generally the countries involved in trade, and/or time units (Mátyás, 1997, 1998). For panel specific applications, many approaches exist e.g. Prais-Winsten regression with Panel Corrected Standard Errors (PCSE), which assumed that the disturbances were heteroskedastic (each country had its own variance), and contemporaneously corrected across countries (each country had its own covariance) (Papazogulou, et al. 2006; Marques, 2008; Brodzicki, 2008) or simply only contemporaneous correlation was detected, where generalized least squares (GLS) regression would be applied with correlated disturbances. The mentioned data distorting effects should be econometrically tested and find remedies to mitigate the bias (Chapter 5.). Linear panel models, by using feasible GLS estimation allowed the regression in the presence of AR(1) autocorrelation within panels and cross-sectional correlation and heteroskedasticity across panels (Glick and Rose, 2002; Antonucci and Manzocchi, 2006; Kalirajan, 2007; Lampe, 2008).

The fundamental advantage of a panel data set over a cross section was that the panel data allow great flexibility for the researchers in modeling differences in behavior across individuals. In the following is the basic framework of the regression model of the panel data form (Greene, 2003):

\[ y_{it} = x_{it}'\beta + z_{i}'\alpha + \varepsilon_{it} \]

\[ = x_{it}'\beta + c_{i} + \varepsilon_{it}. \]

There are K regressors in \( x_{it} \), not including a constant term. The heterogeneity, or individual effects is \( z_{i}'\alpha \) where \( z_{i} \) contains a constant term and a set of individual or group specific variables that may be observed or unobserved heterogeneity of which are taken to be constant over time \( t \). As it stands, this model is a classical regression model. If \( z_{i} \) is observed for all individuals, then the entire model can be treated as ordinary linear model and fit by least squares. The complications arise when the individual and group specific variables \( c_{i} \) are unobserved, which will be the case in most applications.
The main objective of panel data analysis is to gain consistent and efficient estimation of the partial effects: \( \beta = \frac{\partial E[y_{it}|x_{it}]}{\partial x_{it}} \). Whether this is possible depends on the assumptions about the unobserved effects. Exogeneity of the independent variables \( E[\varepsilon_{it}|x_{i1}, x_{i2}, ...] = 0 \) is the first assumption. That is, the current disturbance is uncorrelated with the independent variables in every period, past, present and future. The crucial aspect of the model concerns the heterogeneity and serial correlations within and between the panels. A particularly convenient assumption would be mean independence; \( E[c_i|x_{i1}, x_{i2}, ...] = \alpha \).

The scientific literature developed three varieties of different models for panel data. The **Pooled Regression**, when \( z_i \) contains only a constant term, then ordinary least squares provides consistent and efficient estimates of the common \( \alpha \) and the slope vector \( \beta \). The **Fixed effects model**, when \( z_i \) is unobserved, but correlated with \( x_{it} \), then the least squares estimator of \( \beta \) is biased and inconsistent as a consequence of an omitted variable. However, in this instance, the model:

\[
y_{it} = x'_{it} \beta + \alpha_i + \varepsilon_{it},
\]

where, \( \alpha_i = z'_i \alpha \), embodies all the observable effects and specifies an estimable conditional mean. This fixed effects approach takes \( \alpha_i \) to be a group-specific constant term in the regression model. It should be noted that the term “fixed” as used here signifies the correlation of \( c_i \) and \( x_{it} \), not that \( c_i \) is non-stochastic. The last one is the **Random effects model**, when the unobserved individual heterogeneity can be assumed to be uncorrelated with the included variables, then the model may be formulated as:

\[
y_{it} = x'_{it} \beta + E[z'_i \alpha] + \{z'_i \alpha - E[z'_i \alpha]\} + \varepsilon_{it} \\
= x'_{it} \beta + \alpha + u_i + \varepsilon_{it},
\]
that is, as a linear regression model with a compound disturbance that may be consistently, albeit inefficiently, estimated by least squares. This random effects approach specifies that \( u_i \) is a group-specific random element, similar to \( \varepsilon_{it} \) except that for each group, there is but a single draw that enters the regression identically in each period. This model might be viewed as applying only to the cross-sectional units in the study, not to additional ones outside the sample. If the individual effects are strictly uncorrelated with the regressors, then it might be appropriate to model the individual specific constant terms as randomly distributed across cross-sectional units. Again, the crucial distinction between fixed and random effects is whether the unobserved individual effect embodies elements that are correlated with the regressors in the model, not whether these effects are stochastic or non-stochastic.

Since one of the objectives of the thesis was to analyze the year specific effects over the examined period to detect common trade shocks, one-way fixed effect in time was introduced into the regression procedure as dummy variables, which embodies all the observable effects of the evolution of time. That is why the random effect can be excluded in further estimations.

As it was shown in the regression model of the panel data form, a panel data set consisted of \( n \) sets of observations on individuals, denoted as \( i=1, \ldots, n \). If each individual in the dataset is observed the same number of times, denoted \( T \), the dataset is called balanced panel. The thesis examined three balanced panel data sets, each with 20 sets of observations on individuals and 8 time periods (years) over every panel, this took 160 \((= n \times T = 20 \times 8)\) observations in every single case of value flow of Hungarian agro-export.

In panel estimation techniques, applying gravity model for assessing trade flows, the detected variables assumed to be stationary in time, which means that the variables do not contain unit root in the dataset. The current estimation introduced eight explanatory variables in order to catch precisely the trade movements. If the variables are stationary, then the traditional estimation can be used to eliminate the relationship between the variables (pooled, fixed or random). If they contain a unit root or are non-stationary, a co-integration test should be performed (Hadri, 2000; Faruqee, 2004). Detecting stationary characteristics of variables are well developed in the literature (Maddala and Wu, 1999; Levin et al. 2002; Im et al. 2003). Most commonly the LLC, IPS and Fisher-type tests are performed in order to prove that the variables contain unit root or not (Barenjee, 1999). The estimations were detailed in Chapter 5.
How gravity models utilized panel data econometrics in recent literature

De Benedictis and Vicarelli (2004) through a panel data specification built a comparative analysis starting from a static linear equation, and moving subsequently to a static linear equation with fixed effects, and finally to a dynamic linear system with fixed effects. They found two main pieces of evidence resulting from the analysis. First, when they estimated a gravity equation through a dynamic estimator instead of a static one, generally obtained that the fitted values were closer to those found historically. It followed that a potential trade index derived from a dynamic specification gave more accurate indications on the spread between actual and potential trade. Secondly, the choice of the estimator (static or dynamic) was very important if some policy guidelines were needed to be drawn from a gravity equation. The same “standard” gravity equation could give very different results in terms of potential trade index if a static estimator were to be estimated instead of a dynamic one. Filippini and Molini (2003) also used a fixed effects model, which assumed that heterogeneity was correlated with the regressors and noted that long-run data allowed any endogeneity problems to be disregarded and the fixed effect model to be applied without any bias.

Silva and Tenreyro (2006) observed that whilst under heteroskedasticity, the parameters of log-linearized models estimated by OLS lead to biased estimates of the true elasticities. They argued that the gravity equation and more generally, constant-elasticity models, should be estimated in their multiplicative form and proposed a simple pseudo-maximum-likelihood (PML) estimation technique. Besides being consistent in the presence of heteroskedasticity, this method also provided a natural way to deal with zero values of the dependent variable. They ran a comparative analysis using Monte Carlo simulation on the performance of PML estimator with that OLS. The outcome of the Monte Carlo simulation indicated that when there was evidence of heteroskedasticity, the PML should be used as a substitute for the standard log linear model. After Silva and Tenreyro (2006), Siliverstovs and Schumacher (2009) confirmed the suggestion of Silva and Tenreyro, namely the assumption that ensured OLS consistency was very likely to be violated and at the same time, found no serious departures from assumptions underlying PML regressions.
In a recent paper, Tripathi and Leitao (2013) examined India’s trade flows using gravity model for the period 1998-2012. They selected India’s 20 major trade partners and found evidence that political globalization and cultural proximity positively influenced the bilateral trade of India. The results were important for policy implications for India’s recent bilateral trade direction and were implied to reduce the uncertainty in the decision making process. Their study made differentiation between static and dynamic panel data models. The static panel data had some problems in serial correlation, heteroskedasticity and endogeneity of some explanatory variables. However in the case of the dynamic panel data, after a small sample standard error correction (Blundell and Bond, 1998, 2000; Windmeijer, 2005), the GMM-system estimator became consistent if there were no second order serial correlations in the residuals. The dynamic panel data model became valid if the estimator was consistent and the instruments were valid. Dynamic panel model was also used in Angulo et al. (2011) research, besides OLS and spatial models. The introduction of dynamic model needed to consist of the above mentioned, System Generalized Methods of Moments, which combined the moments conditions for the first difference model with the moments conditions for the level model. With the addition of dynamic flow to the model, the parameter associated to the export volume can be obtained, if the previous period variable was significant.

Simakova (2012) investigated the effects of exchange volatility on international trade flows of Czech Republic to its major 17 trading partners. In order to add the exchange rate volatility into the gravity equation, Tichy (2007) and Baldwin et al. (2005) indicated that this relationship was not linear but convex and so to avoid error due to rounding during data transformation, the volatility measure should be used in the exponent. Logarithmic transformation helped to reduce skewness and heteroskedasticity and to stabilize variability. By analyzing panel data, the estimation of Breusch-Pegan Lagrange multiplier test revealed random effects and further calculations showed that the nominal exchange rate volatility of Czech Crone had a negative, but weak effect on bilateral trade over the sample period. This meant that, for example, an active future exchange rate policy aimed to influence exchange rate development, was not supposed to promote any notable improvements of Czech international trade.

Kristjánsdóttir (2005) published a very comprehensive paper, where the model specifications tested allow for sector and trade bloc estimation. She divided the Icelandic economy into four different sectors (fishing industry, manufacturing industry, power intensive
industry and other industries) in order to make distinctions and estimations on one another. The basic gravity specification was applied, for different functional forms: *natural logarithm of exports and inverse hyperbolic sine (IHS)*. The advantage of using IHS function rather than the natural logarithm function was that IHM function could be applied to zeros. With the contribution of the sector specific fixed effects estimation (in that case, power intensive industry was holding constant as sector 3) it could be presented as positive effects that meant the other sectors had significantly more weight in goods exports than sector 3. In the following, the fixed difference was measured between trade blocs receiving exports from Iceland. Trade blocs are: EU, NAFTA, EFTA and non-bloc member countries. The EU trade bloc held constant. The results indicated that the EFTA and non-bloc member countries estimates had positive effects on exports, when they were compared to the EU.

Brodzicki (2009) investigated the determinants of the pattern of aggregated bilateral trade flows of Poland with its major trade partners with the use of trade gravity model in a panel data framework. In order to obtain unbiased results he utilized the *Prais-Winsten regression with Panel Corrected Standard errors (PCSE)*. The analysis was performed on a pooled panel of data with time effects and estimated heteroskedasticity-adjusted OLS method.

Taking into consideration the manifold panel data specifications estimated by gravity model, it can be concluded that the research objectives and the shape of the dataset determine the regression procedure and not the other way around. Furthermore, there is no standardized and commonly used estimation technique that performs unified and unbiased estimates. In Chapter 5 the thesis fulfilled the obligation of detecting trade distorting effects (stationary tests, misspecification tests) and developed the methodological framework of analyzing industrial processing effect on trade by dint of similar previous studies.
Chapter 4 - The analyzed datasets

Data context of the study

The empirical analysis of the study will be conducted with panel datasets that cover Hungary’s agro-commodity and processed food exports to its 20 major export trading partners over the period 2005-2012 with yearly observations (giving a potential total of 160 observations). The exported goods were sorted into three separate groups according to the degree of processing: raw material, firstly processed products and secondarily processed products groups were differentiated. The product or commodity differentiation was made according to methodology of Hungarian Research Institute of Agricultural Economics (Table C.1), which was built on the HS. The value data (i.e. dependent variable) on trade flows over the period 2005-2012 were obtained from UN Comtrade Database, summarized and sorted manually to the related country and year. Since the study investigated the individual effects of the created groups, it was necessary to reshape the major 20 export destinations in each group (Table C.2 provides a separated full list of export trade partners included in the sample.) The countries included in the sample had a share of 93.34%, 90.73% and 89.14% in total Hungarian export volume of agricultural commodity and food raw material, firstly processed and secondarily processed products, respectively. In order to avoid missing or zero observations and gain balanced panel datasets, this average 90% will be considered as total export trade flows. The nominal UN COMTRADE data was transformed into real terms by dividing the country-specific Consumer Price Index\(^6\) (CPI). The CPI was set equal to 100 of the base year, in 2005.

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\(^6\) The country-specific CPI was gained from the World Bank. (http://worldbank.org)
Data sources and description

In gravity model, we had to be able to measure and identify fundamentally the economic mass (i.e. referred to the size of the listed countries’ economy) and the economic distance, which corresponded to the transport costs.

The size or strength of an economy was usually characterized by some aggregate product (GDP, GNI, GNP, etc.), population or product per capita. According to gravity model theory, the volume of trade between countries depended on the conditions of supply of the exporting country (defined by Hungarian GDP) and demand conditions in importers country (determined by the importer GDP), which was in the context of trade theory (Nastic, 2012). This thesis measured the economic mass (also known as gravity force) by GDP of Hungary and the trading partner countries. The GDP data was downloaded from the online World Bank database. GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2005 U.S. dollars. Dollar figures for GDP are converted from domestic currencies using 2000 official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used (worldbank.org, 2014).

In the analysis we expected to gain positive signs for the proxies of economic masses for both coefficients (GDP\textsubscript{HUN,t}; GDP\textsubscript{i,t} – real GDP of Hungary and of a trading partner i), because according to the literature (Kabir and Salim, 2010; Tripathi and Leitao, 2013) it has been proven that larger economic dimension increases trade.

The other fundamental gravity determinant was the economic distance. A common practice in literature related to economic distance referred to the geographical distance between the countries, which was measured in kilometers between the capitals. Although broadly a reasonable idea, does not take sufficient account of a whole series of trade impediments that surely matter, such as tariff and non-tariff barriers, or actual real transport cost. Goods were transported by sea, by road, by rail or over inland waterways (Christie, 2001). In international commodity trade analysis one of the most important determinants is the cost of distance. It is
very difficult to gain quantified datasets, since every country or every region has different capability to transport, as it was mentioned before.

Venables (2001) classifies the costs of distance into four types: first, the cost of moving goods internationally (direct shipping costs); second, searching costs (the cost of identifying potential trading partners); third, control and management costs and finally, the cost of time involved in shipping goods. From this perspective, it is obvious that the only measurable type is the cost of moving goods by actual distance which is a good proxy for transport costs at aggregate level. However it is not clear that this good performance remains at more detailed levels (Hummels, 2001). In order to decrease the trade torturing effects by the existence of the other above-listed four types of distance cost, the thesis propose a specific distance measure using city-level data to access the geographical distribution of population inside each nation. The basic idea is to calculate distance between two countries (Hungary and its trading partner) based on bilateral distances between the biggest cities of those two countries, those inter-city distances being weighted by the share of the city in the overall country’s population. This procedure can be used in a totally consistent way for international distances. The data was used from World Gazetteer web site, which provides current population figures and geographic coordinates for cities, towns and places of all countries. The general formula developed by Head and Mayer (2002) and used for calculating distances between countries $i$ and $j$ is:

$$d_{ij} = \sum_{k \in i} \left( \frac{pop_k}{pop_i} \right) \sum_{l \in j} \left( \frac{pop_l}{pop_j} \right) \theta d_{kl},$$

where $pop_k$ designates the population of agglomeration $k$ belonging to country $i$. The parameter $\theta$ measures the sensitivity of trade flows to bilateral distance $d_{kl}$ (Mayer and Zignago, 2006).

As it matters the expected sign of economic distance between trading countries, it has been also proven that trade increases when partners are geographically close (Tripathi and Leitao, 2013). This implies that the increasing distance between Hungary and the partner country groups affects the trade negatively. That is why economic distance is considered as trade cost.

The third influential explanatory variable, which was also taken into consideration in many research papers (Kafle and Kennedy, 2012; Suvankulov and Guc, 2012) is the evolution of the
exchange rate. It has been already discussed, how the exchange rate influences trade (in section 3). The thesis counts with real effective exchange rate, which is the nominal effective exchange rate (a measure of the value of a currency against a weighted average of several foreign currencies) divided by a price deflator or index of costs\(^7\).

The indices show the evaluation of Hungarian Forint (HUF) over US Dollars (USD). The mostly increasing data indicates over time HUF has been depreciated against USD, which indicates a trade increasing effect, since there is an inverse relationship between appreciation and depreciation of currencies and international trade. That is why we expect to gain positive sign for the coefficient.

Apart from these various attempts in the literature at using alternatives for the fundamental economic mass, distance and volatility in exchange rate, the main thrust of the model was to introduce a set of dummy variables to isolate country groups of interest. Six dummy variables have been included in the model. For trade flow categories in order to measure specific influential factors the thesis implements four dummy variables either facilitating or restricting trade between pairs of counties:

- European currency union \(d_{y_{EUR}}\): equals 1, if partner country is a member of the euro zone; 0 otherwise. This is a time variant variable, since some of the partner countries for example Slovenia and the Slovak Republic adopted the euro in 2007 and 2009, which is in the examined period.
- Common border (contiguity) \(d_{y_{contig}}\): equals 1, if partner country shares a common border with Hungary; 0 otherwise.
- European Union membership \(d_{y_{EU}}\): equals 1, if partner country is a member of the EU; 0 otherwise. This is also a time variant variable, since some of the partner countries - Romania and Bulgaria - joined to the EU in 2007 that is why in the data the first two examined years (2005-2006) are considered as 0, the following years after the enlargement as 1.

\(^7\) Source: International Monetary Fund, International Financial Statistics.
OECD membership \( p_{OECD} \): equals 1, if the partner country is a member of the Organization for Economic Co-operation and Development; 0 otherwise. There are no newly joined member states in the data, so this is a time invariant variable.

Another type of dummy variable was generated, in order to get scientific answer to the research question of the effects of individual time periods. In spatial trading we seek to identify the influential variables, but agricultural commodity trade there is a different market, because some determining variables cannot be predicted such as weather conditions. If we are interested in specific effects of the individual time units (years), we needed to introduce year specific dummy variables. The panel structure of the data allowed calculating the year specific effects over the period of 2005-2012 individually. The significant coefficients show the annual percentage change of the exported value compared to the initial year (2005). Since the following years’ export trade exceeded the base year export value, positive sign were expected for all year specific dummy variables. With this specification, we allowed to compare the annual evolution and the exported flows become separately comparable to one another.

**Preliminary analysis**

In the previous sub-chapters the evaluated determinants were explained and their expected influence on trade revealed. As trade flow categories: the GDP mass of destination and origin countries, EU membership, Euro currency union, OECD membership, contiguity and geographical distance between trading countries were taken into account. Two other specifications were also introduced in order to gain one-way fixed effect of annual changes in all the three cases and market analysis by the effect of industrial processing.

In this sub-chapter the descriptive statistics which are used to quantitatively characterize the datasets were analyzed. Table 1 included the most important characteristics of trade flow variables of the examined cases: mean, minimum and maximum.

Some important implications could be concluded from the pure statistics. First of all, comparing weighted distances we could consider that the mean of geographical distance was the same in the cases of raw material and firstly processed products. In terms of secondary processed products, a huge decrease was perceived which indicated that the finished food products were
sold significantly closer to Hungary that is why a smaller negative coefficient was expected in that case.

Table 1 Descriptive data of explanatory variables

<table>
<thead>
<tr>
<th></th>
<th>Raw material</th>
<th>Firstly pr.</th>
<th>Secondary pr.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weighted distance (km)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1228,4</td>
<td>1289,5</td>
<td>864,37</td>
</tr>
<tr>
<td>Min</td>
<td>204,83</td>
<td>204,83</td>
<td>204,83</td>
</tr>
<tr>
<td>Max</td>
<td>8395,54</td>
<td>8943,9</td>
<td>2334,33</td>
</tr>
<tr>
<td><strong>Real GDP destination (in billion $)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1290</td>
<td>997</td>
<td>705</td>
</tr>
<tr>
<td>Min</td>
<td>11</td>
<td>10,9</td>
<td>22,5</td>
</tr>
<tr>
<td>Max</td>
<td>13800</td>
<td>6000</td>
<td>3400</td>
</tr>
<tr>
<td><strong>Real GDP Hungary (in billion $)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>112</td>
<td>112</td>
<td>112</td>
</tr>
<tr>
<td>Min</td>
<td>108</td>
<td>108</td>
<td>108</td>
</tr>
<tr>
<td>Max</td>
<td>116</td>
<td>116</td>
<td>116</td>
</tr>
<tr>
<td><strong>Real exchange rate (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>103,98</td>
<td>103,98</td>
<td>103,98</td>
</tr>
<tr>
<td>Min</td>
<td>95,42</td>
<td>95,42</td>
<td>95,42</td>
</tr>
<tr>
<td>Max</td>
<td>110,22</td>
<td>110,22</td>
<td>110,22</td>
</tr>
<tr>
<td><strong>EU member</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0,625</td>
<td>0,675</td>
<td>0,725</td>
</tr>
<tr>
<td>Min</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Max</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Contiguity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0,35</td>
<td>0,3</td>
<td>0,35</td>
</tr>
<tr>
<td>Min</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Max</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>EUR currency</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0,4125</td>
<td>0,4125</td>
<td>0,3625</td>
</tr>
<tr>
<td>Min</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Max</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>OECD member</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0,6125</td>
<td>0,6625</td>
<td>0,6125</td>
</tr>
<tr>
<td>Min</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Max</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: own calculations, Stata 12 package
Furthermore, if we accept that EU countries are closer to Hungary than others, than the previous assumption was enhanced by the results of EU membership as well, since it indicates that 15 partner countries are in the EU. The means of dummy variables showed the number of countries belonged to the specific examined group. Since in each category the total number of countries was 20, the mean factor showed the percentages of belonging to the dummy specific group. It was also interesting that despite of the highest number of EU member states in the secondary processed product group, we could make further differentiations about features of those countries. The mean value of EUR currency dummy was the smallest in the finished product group compared to the other two, so the 36.25% of countries (i.e. 7 export destinations) were in the euro-zone. This revealed that the countries in the secondary processed products group belonged to the EU, but not to the euro-zone unlike the raw material and firstly processed product groups. These features are true for countries similar to Hungary; those are that joined the EU in 2004 or after, and have still not adopted the euro. The significantly lower geographical distance also supported the preconception that the countries in the secondary processed products were mostly CEE countries relative as opposed to the other groups.

As it matters the contiguity, there is no significant differences or trends over the examined groups. Hungary exported commodities and food products to all its 7 neighboring countries of raw material and secondary processed products; however the firstly processed products were exported with one exception. Finally, OECD members were obtained with 12 or 13 countries in the examined cases.

**Chapter 5 - Methodological framework**

In order to set out the methodology that performed unbiased estimates and analytically provided proper answers to the research questions, it was important to apply hypotheses tests on the datasets to reveal their weaknesses, testify the violations of the assumptions and find remedies to them. The thesis dealt with three different, but similarly structured (same set of
explanatory variables) panel datasets in the interest of being able to evince the effect of industrial processing and its market influential power. The circumstance of evaluating three panel datasets increased the importance of selecting a suitable model that fits to all cases and enable comparisons. In classical linear panel data regression in order to gain unbiased coefficients the dataset should fulfill some decisive assumptions (e.g. stationarity, homoskedasticity, non-autocorrelation). By applying hypotheses tests in econometrics we could infer to the favored model. Furthermore, with empirical hypotheses testing, we allowed to investigate the fulfillment of the above mentioned assumptions. The econometric literature developed several different tests for detecting the same violation (e.g. stationarity tests, heteroskedasticity tests, and time or cross-sectional dependence tests). In some cases, those various tests were marked in this chapter.

**Unit root tests**

In order to define proper specification of the models as described in Chapter 3, the statistical properties of the data also have to be analyzed. The consideration of fully modified estimation techniques, to take account of endogeneity of the regressors, correlation and heteroskedasticity properties of the residuals and the use of methods for fixed or random effects estimation, developed in the literature on panel data with stationary variables (Banerjee, 1999). Therefore, testing for stationary unit roots in all variables included in the models was necessary. If the regression variables would not be stationary, then it could be proved that the standard assumptions for asymptotic analysis would not be valid. The analysis of unit roots and cointegration in panel data was a well-developing area of study in turn of the Millennium.

Panel based unit root tests were developed by Quah (1994), Choi (2001) Fisher-type, Levin, Lin and Chu (LLC) (2002) and Im-Pesaran-Shin (IPS) (2003), among others. The tests proposed by Quah do not accommodate heterogeneity across groups such as individual specific effects and different patterns of residual serial correlations. This limitation has been overcome by the three other tests (LLC, Fisher-type and IPS).

The LLC proposed tests for the null of non-stationarity imposing the restriction that all panels share the same autoregressive parameter, which means that the unit-specific fixed effects
were an important source of heterogeneity here, since the coefficient of the lagged dependent variable was restricted to be homogenous across all units of the panel; that is:

\[ H_0 : \phi = 0 \]

\[ H_A : \phi < 0 \]

In the following first-order autoregressive regression:

\[ \Delta y_{it} = \delta_i + \phi y_{i,t-1} + \sum_{j=1}^{p} \phi_{ij} \Delta y_{i,t-j} + \epsilon_{it} \]

where \( i = 1, \ldots, N \) indexes panels; \( t = 1, \ldots, T \); \( y_{it} \) is the variable being tested; the \( \delta_i \) term can represent panel-specific means; and \( \epsilon_{it} \) is a stationary error term. To calculate this test, the data is pooled before fitting into the equation (common autoregressive parameter) and compute a test statistic based on the pooled regression results. The LLC test is derived as following:

\[ T \sqrt{N_\theta} \sim N(0, 2) \]

This test is recommended for “moderate” sized panel datasets, which the authors describe as having between 10 and 250 panels and 25 to 250 observations per panels (Levin et al., 2002). The main theorems in Levin and Lin relate to deriving the asymptotic distributions of the panel estimator of \( \phi \) under different assumptions on the existence of fixed effects or heterogeneous time trends (Banerjee, 1999). Due to the fact that the null hypothesis and the alternative hypothesis are so strict (not realistic in practice) (Hoang and Mcdown, 2006), we will complement this test with more flexible ones.

Fisher-type and IPS tests set the null hypothesis for all panels containing a unit root and while the alternative was that a fraction of panels follows stationary process:

\[ \begin{align*}
H_0 : \phi_i = 0 ; \quad & \forall i \\
H_A : \phi_i < 0 ; \quad & i = 1, \ldots, N_1 \\
\phi_i = 0 ; \quad & i = N_1 + 1, \ldots, N
\end{align*} \]

The main extension by IPS of the LLC framework was to allow heterogeneity in the value of \( \phi_i \) under the alternative hypothesis and that the errors are serially autocorrelated with different serial correlation (and variance) properties across units. The Fisher-type and IPS tests were calculated combining individual evidence in a joint test as follows. Firstly, they used
separate unit root tests for the N panels (instead of pooling the data, as the LLC test). Hence, both allow the autoregressive parameter to be panel-specific:

$$\Delta y_{it} = \delta_i + \phi_i y_{i,t-1} + \sum_{j=1}^{p_i} \phi_{ij} \Delta y_{i,t-j} + \epsilon_{it}$$

Then, the IPS statistic is calculated by averaging the resulting $t$ statistics:

$$\overline{t}_{N,T} = \frac{\sum_{i=1}^{N} t_{i,T}}{N} \Rightarrow \sqrt{N} \left[ \frac{\overline{t}_{N,T} - \mu}{\sigma} \right] \sim N(0,1)$$

while, the Fisher-type test combines the individual significance levels $\pi_i$ ($i=1,2, ..., N$) as follows:

$$\lambda = -2 \sum_{i=1}^{N} \ln \pi_i \chi^2(2N).$$

Maddala and Wu (1999) describe the IPS test, as follows: “... the IPS test is a way of combining the evidence on the unit-root hypothesis from the N unit-root tests performed on the N cross-section units”, while Fisher-type panel unit-root tests make this approach explicit.

The estimation results for the three explained tests were presented in Table 2. As it is shown, nearly all of them rejected the null hypothesis of unit root for all variables in favor of the alternative which indicated the variables were stationary (The linearized real GDP of Hungary was found insignificant in the IPS case. The reason for investigating unit roots by three types of application was to avoid misleading results and prove the stationary feature at least with one type of model. The linearized real GDP of Hungary and the real exchange rate were constant in terms of processing levels; it was expected to have unchanged coefficients.) Since all variables were found stationary, the co-integration tests were not required and the standard assumptions for asymptotic analysis will be valid (Hatab, 2010).
Table 2 Results of panel unit root tests

<table>
<thead>
<tr>
<th>Estimated variables</th>
<th>Raw material</th>
<th>Firstly processed</th>
<th>Secondary processed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LLC</td>
<td>IPS</td>
<td>Fisher</td>
</tr>
<tr>
<td>Lnreexp</td>
<td>-21.3***</td>
<td>-9.8***</td>
<td>141.3***</td>
</tr>
<tr>
<td>lnGDPred</td>
<td>-12.5***</td>
<td>-4.4***</td>
<td>124.6***</td>
</tr>
<tr>
<td>lnGDPreo</td>
<td>-2.6***</td>
<td>0.34</td>
<td>71.1***</td>
</tr>
<tr>
<td>Lnreexch</td>
<td>-40.0***</td>
<td>-19.8***</td>
<td>223.2***</td>
</tr>
</tbody>
</table>

Note: *** denotes that the null hypothesis was rejected at a 1% level of significance.

Source: own calculations, Stata 12 package

The models

The specifications of the gravity equations employed in the thesis largely follow the above (Chapter 3) presented studies of Feenstra et al. (1998, 2004), Bergstrand (1985, 1989) and Anderson and van Wincoop (2003). Taking into account the previous results of unit root tests, a log-linear relationship between data on flows and the mass variables, distance and set of dummy variables is specified, as follows:

Raw products export:

\[ \ln \lambda_{Hij}^{\text{Raw}} = \beta_1 + \beta_2 \ln Y_{Ht} + \beta_3 \ln Y_{it} + \beta_4 \ln Dist_{Hi} + \beta_5 \ln RER_{H5} + \beta_6 \ln Y_{zone_{it}} + \beta_6 \ln Y_{EU_{mem_{it}}} + \beta_6 \ln Y_{OECD_{mem_{it}}} + \beta_6 \ln Y_{Contig_{Hi}} + \lambda_t + \varepsilon_{hit} \]

Firstly processed products export:

\[ \ln \lambda_{Hij}^{\text{Firstly}} = \beta_1 + \beta_2 \ln Y_{Ht} + \beta_3 \ln Y_{it} + \beta_4 \ln Dist_{Hi} + \beta_5 \ln RER_{H5} + \beta_6 \ln Y_{zone_{it}} + \beta_6 \ln Y_{EU_{mem_{it}}} + \beta_6 \ln Y_{OECD_{mem_{it}}} + \beta_6 \ln Y_{Contig_{Hi}} + \lambda_t + \varepsilon_{hit} \]
Secondary processed products export:

$$\ln X_{Hjt}^{Secondary} = \beta_1 + \beta_2 \ln Y_{Ht} + \beta_3 \ln Y_{it} + \beta_4 \ln Dist_{Hi} + \beta_5 \ln RER_{Ht} + \beta_6 dy\text{ezone}_{it}$$

$$+ \beta_6 dyEU\text{mem}_{it} + \beta_6 dyOECD\text{mem}_{it} + \beta_6 dyContig_{Hi} + \lambda_t + \varepsilon_{Hit}$$

where, the subscript H represented Hungary, the i were the importing trading partners of Hungary (i = 1, 2, ..., 20) and the t = 2005, 2006, ..., 2012 time period; the dependent variables represented by $X_{Hjt}^{Raw}$, $X_{Hjt}^{Firstly}$, $X_{Hjt}^{Secondary}$ the divided Hungarian food and agro-commodity export flows in value (constant US$ 2005=100%) to the top-20 export destinations in each category during the examined period; $Y_{Ht}$ and $Y_{it}$ marked the real GDP of both Hungary and the importing country, in constant 2005 US dollars; $Dist_{Hi}$ denoted the population weighted distance in kilometers which associated with the economic cost of trade; $RER_{Ht}$ was the real exchange rate between Hungarian Forint (HUF) and the trade flow currency (2005US$=100%); and the set of dummy variables if the partner country adopted Euro, member of the EU and the OECD and had a common border with Hungary equals 1, 0 otherwise one at a time; $\lambda_t$ was the time-effect dummy variable which represented the business cycle effect (Mátyás, 1997) and the $\varepsilon_{Hit}$ was a white noise disturbance term.

**Estimation**

Panel data estimation technique was employed in the models. Given that, since the thesis was interested in the individual year effects (especially in 2007-2008 during the world food crisis), formally it can be named as fixed unknown parameter (Matyas, 1997). Hence, we apply a fixed effect one-way panel data model, also known as Least Squares Dummy Variables (LSDV) model, which considers the variations of time (individual years). In standard econometric notation, it can be expressed as follows:

$$y_{it} = x_{it}' \beta + \lambda_t + \varepsilon_{it}, \text{ where } \varepsilon_{it} \sim IID(0, I_{f_2})$$
This model emphasized the time-specific effects by the inclusion of additional T-1 dummy variables in the datasets. One of the time effects must be dropped to avoid perfect collinearity. Plausibly the first time period (2005) will become the base period and fixed effect parameters will measure differences in the respective year with respect to 2005 period.

Testing the datasets

**OLS versus One-way Fixed effect model (time effect)**

To find out whether the fixed effects model or the OLS estimator is more appropriate to analyze the datasets, the F-test (Greene, 2000) was performed. The null hypothesis supports the pooled OLS model while the alternative gives evidence in favor of the fixed effects model. The results of the test showed (Table 3.) significance in all cases. That is, we rejected the null hypothesis in favor of the alternative and fixed effect model is found more appropriate than the OLS estimation for the three cases. In other words, tests revealed that the regressors were correlated with specific time effects and the model could not be consistently estimated using pooled OLS.

**Misspecification tests**

Classical assumptions about properties of the model error terms (denoted, in the standard econometric expressions as $e_{it}$) are being independent over $i$ and $t$, and/or homoskedastic. However, in reality the errors are frequently serially correlated (i.e., correlated over $t$ for a given $i$) and/or heteroskedastic (Cameron and Trivedi, 2005). The violation of those assumptions cause bias of the standard errors and this could result in less efficient estimates, which mislead the researcher. Valid statistical inference requires controlling for both of these factors. However, in order to find the proper remedies, first those had to be detected in the datasets.
Testing for heteroskedasticity

In classical linear panel regression the error term was assumed to be homoskedastic, which meant constant variance of error terms across observations. To detect for groupwise heteroskedasticity the modified Wald statistic was applied. The classical assumptions that the error process is independently and identically distributed may be violated in several ways in the pooled cross-section. The error process may be homoskedastic within cross-sectional units, but its variance may differ across units. This condition is known as groupwise heteroskedasticity.

The null hypothesis specifies that $IF_i^2 = IF^2$ for $i = 1, 2, ..., N$, where $N$ is the number of cross-sectional units (in the examined cases those are equal 20). Let $\hat{\sigma}_i^2$ be the estimator of the $i^{th}$ cross-sectional unit’s error variance, based upon the $T_i$ residuals $e_{it}$ available for that unit. Then define

$$V_i = T_i^{-1}(T_i - 1)^{-1} \sum_{t=1}^{T_i} (e_{it} - \hat{\sigma}_i^2)^2$$

as the estimated variance of $IF_i^2$. The modified Wald test statistic, defined as

$$W = \sum_{i=1}^{N} \frac{(\hat{\sigma}_i^2 - \sigma^2)^2}{V_i}$$

will be distributed as $X^2[N]$ under the null hypothesis (Baum, 2001). Greene’s discussion of the Lagrange multiplier, likelihood ratio and standard Wald test statistics points out that these statistics are sensitive to the assumption of normality of the errors.

The second deviation from independently and identically distributed errors may arise in the context of contemporaneous correlation of errors across cross-sectional units. In the examined cases $N>T$ (20 cross-sectional units $> 8$ time-series) the literature suggested to apply the cross-sectional dependence (CD) test by Pesaran (2006), Friedman’s statistic (1937) and Frees (1995) statistic. The impact of cross-sectional dependence in estimation naturally depends on a variety of factors, such as the magnitude of the correlations across cross sections and the nature of the cross-sectional dependence itself. If we assumed that cross-sectional dependence
was caused by the presence of common factors which were unobserved (and the effect of these components was therefore felt through the disturbance term) but uncorrelated with the included regressors, the standard fixed-effects (FE) and random-effects (RE) estimators were consistent, although not efficient, and the estimated standard errors were biased (Hoyos and Sarafidis, 2006). The above indicated tests were valid for $N>T$, otherwise ($T>N$) the Lagrange multiplier test would be performed, developed by Breusch and Pagan (1980).

The computed modified Wald statistics were found significant in all the three cases, so we allowed to reject the null hypothesis of homoskedasticity across observations in favor evidence of groupwise heteroskedasticity. Since the error terms performed not constant variances, those need to be treated in the model. For testing cross-sectionalal dependence, three indicated tests were applied on the datasets. In all cases it showed insignificance, so we failed to reject the null hypothesis of cross-sectional independence, which meant no presence of common shocks and unobserved components that ultimately could become part of the error term (Hoyos and Sarafidis, 2006). (Results of testing groupwise heteroskedasticity and cross-sectional independence were performed in Table 3.)

**Testing for serial correlation**

Serial correlation was needed to be detected in linear panel models, because ignoring the serial correlation in the error, would result in consistent, but inefficient estimates of the regression coefficients and biased standard errors (Baltagi et al., 2007). While a number of tests for serial correlation in panel-data models have been proposed (Baltagi and Wu, 1999; Baltagi, 2001; among others), an innovative test was developed by Wooldridge (2002). This test is very attractive because it requires relatively few assumptions, it directly detect first-order autocorrelation and is easy to implement. The Wooldridge method uses the residuals from the regression under analysis, expressed in first-differences. Such transformation removes all time-invariant covariates from the model (Drukker, 2003) and, under the null of no autocorrelation in the original error term, the error of the first-differenced model follows a MA(1) process. The null hypothesis of no correlation in the original error term is tested using the equivalence on testing that the first value of the autocorrelation function of the MA(1) error term in the first-difference equation equals 0.5. By contrast, evidence in favor of the alternative would show evidence in favor of first-order serial correlation. As shown in Table 3., in our application the null hypothesis of no serial correlation was strongly rejected in favor the evidence of first-order autocorrelation,
for the three types of material (raw, firstly and secondary processed). This also could be treated in the models by clustering at the panel level as discussed by Baltagi (2001) and Wooldridge (2002).

<table>
<thead>
<tr>
<th>Investigation of:</th>
<th>Test</th>
<th>Raw material</th>
<th>Firstly processed</th>
<th>Secondary processed</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLS vs. FEM</td>
<td>F-test</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>Heterosk.(Groupwise)</td>
<td>Wald statistic</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>Cross-sectional dep.</td>
<td>Pesaran test</td>
<td>0.1960</td>
<td>0.0708</td>
<td>0.1351</td>
</tr>
<tr>
<td>Cross-sectional dep.</td>
<td>Friedman test</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
</tr>
<tr>
<td>Cross-sectional dep.</td>
<td>Frees test</td>
<td>1.426</td>
<td>1.382</td>
<td>2.481</td>
</tr>
<tr>
<td>Serial correlation</td>
<td>Wooldridge test</td>
<td>0.0000</td>
<td>0.0002</td>
<td>0.0002</td>
</tr>
</tbody>
</table>

Source: own calculations, Stata 12 package.

**Linear regression with panel-corrected standard errors**

In this section the datasets become detected and the most important influential factors are revealed. We needed to find a regression model which corrected the above mentioned problems of heteroskedasticity, contemporary correlation and autocorrelation. In the literature (Egger, 2002; Papazogulou et al., 2006; Marques, 2008; Serrano and Pinilla, 2011), estimating by gravity model, those problems were frequently controlled by the panel-corrected standard errors (PCSE) estimates for linear panel models. When computing the standard errors and the variance-covariance estimates, the model itself assumes that the disturbances are, by default, heteroskedastic and contemporaneously correlated across panels. The panel-corrected standard errors estimates are estimated by OLS when no autocorrelation is specified, however in another case, when evidence was found for serial correlation and it was specified as first order autocorrelation, the standard errors are estimated by Prais-Winsten procedure (Beck et al., 2012).
The Prais-Winsten procedure estimates the elements of \( \sum \) as \( \sum \) where \( \varepsilon_i \) and \( \varepsilon_j \) are the residuals for panels \( i \) and \( j \), respectively, that can also be matched by period and where \( T_{ij} \) is the number of residuals between the panels \( i \) and \( j \) that can be matched by time period. When the panels are balanced (just like in the apparent cases, which means each panel has the same number of observations and all periods are common to all panels), \( T_{ij} = T \), where \( T \) is the number of observation per panel (Beck et al., 2012). The Prais-Winsten method is an efficient procedure that incorporates serial correlation into the estimation process (Cheung et al., 2007).

In order to obtain estimates of the models that are statistically correct in the presence of heteroskedasticity and contemporary correlation, the thesis applied the panel corrected standard error regression. Moreover, to treat first-order autocorrelation AR(1) within panels, the Prais-Winsten procedure was utilized. In the following section, the obtained results were represented, when the gravity model was calculated by Panel-corrected standard errors (PCSE) estimates where the parameters were estimated by Prais-Winsten regression.

**Chapter 6 - Results**

In this chapter the empirical results of the estimations were presented and the influence of industrial processing was analyzed. The differentiated groups according to the level of processing were estimated by the same methodology in order to make valid comparisons and reveal the influences of the investigated trade determinants and annual market changes.

The estimation results of the gravity equations calculated by panel-corrected standard error regression were presented in Table 4. The explanatory trade determinants explained outstandingly well Hungary’s agro-commodity and food export flow, the R-squared values were found above 95% in all cases. The investigated datasets carried out the major 20 export destinations of Hungary (individually selected and sorted for the differentiated groups) which added up to roughly 90% of the total export trade flows in each category. That is why the
revealed coefficients performed with high trade explanatory power, which is above 85% if we take into consideration the approximate 10% truncation of the total export trade.

The basic gravity determinants, home country and host countries GDPs and economic distances were found with the predicted signs and statistically significant in all cases. One percentage increase in Hungary’s GDP improved its trade, especially the export of raw materials and secondary processed products and implied 27% and 30% export increase, respectively. The same relation occurred when the influence of the host countries were detected in their GDP change. The raw materials and secondary processed products responded better to market demands than the firstly processed products group. In comparison to the estimated coefficients of home and host countries’ GDP growth effects on Hungary’s export trade, the results revealed that the partner countries economic growth stimulated the trade exactly twice more than Hungary’s national growth. Since the host countries’ economic power was found more influential than that of Hungary; it inferred that the Hungarian agro-export trade was more like a pulled value flow, where the demand was higher than the supply.

The third basic gravity determinants, the economic distance (defined by geographical distance in kilometers) performed unexpected results, namely the most negative impact on trade was found in the cases of raw material and secondary processed products. The high negative influence on secondary processed products export was not expected compared to the other groups, because in that case the average geographical distance was significantly lower (864.37 km) than the raw material (1228.4 km) and the firstly processed products (1289.5 km). The idea of gravity modeling assumed that the trading volume would decrease when the geographical distance between trading partners increases. The coefficient of the firstly processed products was relatively small (in absolute value) compared to the other cases, however it was supposed to be the highest, because the associated geographical distance was the largest. By interpreting the results it is important to find explanations and connections to the reality why the value of coefficients did not accede with the expected values. As it was argued previously, economic distance has many determinants which are not quantifiable. That is why, in gravity model, the economic distance was only associated with the geographical distance in kilometers. However, as the structure of transporting goods were not identified in the calculation, the measure of economic distance could show differences and the outstandingly high (in absolute value) raw material and secondary processed products coefficients could indicate two different explanations
of those values. In the raw case, the coefficient could be high, because 40% of the agro-trade export was sold as raw material, which physical volume was extensive and heavy; furthermore the average of the transported kilometers was also large. In the secondary processed product case, as value-added products, indicate higher-level compliance with safety regulations, where mostly more expensive transportation equipment is needed to be used (e.g. refrigerated trucks, airplane) in order to shorten the shipping time, because these products deteriorate easier. All these extra expenses could cause higher costs on transporting goods, which led to the relatively high (in absolute term) coefficient of economic distance.

The impact of the exchange rate was also evaluated in the models, which performed strong significance in the estimations. Trade vitalizing power was expected of the evolution of exchange rate (positive signs of the coefficients), because the strongly depreciated national currency (Hungarian Forint) against the US dollars favored the export market. The highest influence of changing the value of the national currency was found in the firstly processed products case. The raw products showed moderate response, compared to the firstly processed case. Finally, the secondary products indicated small trade increasing effect due to exchange rate growth. There was no observed comprehensive trend where the influence of industrial processing could be demonstrated. Each group reacted significantly different to the fluctuation of the exchange rate, however, it can be concluded that each group showed notable response.

In the estimations four dummy variables were assessed in order to reveal specific advantages or disadvantages of the created groups and be able to conclude the influences of the Euro-zone; EU and OECD membership and the effect of contiguity. Prominent among these was the EU membership of the partner countries, because that was the only variable which was found statistically significant of all dummy variables. Tendency could be observed in this case, since the related coefficients were decreasing as the level of processing increased. This implied that the major partner countries importing raw material products from Hungary were decisively members of the EU. However, from the descriptive data it was already obtained that the number of the EU member partner countries were 13, 14 and 15 of the raw product, firstly and secondary processed product groups respectively. This circumstance would have caused an inversed way of decreasing the coefficients. The valid explanations of the results are two-fold. On one hand, the difference between the examined country groups is not so important. On the other hand, in the raw material category the EU members were more influential than those in the other cases. It
means that the EU member countries’ rank of the raw material export were more prominent in comparison to the other categories. That is why the more exported value flow overwrites the number of the presented countries.

The border effect of Hungarian export trade was found significant where industrial processing appeared. Hungary has seven neighboring countries. In the examined period, the estimates revealed that those countries imported more of firstly processed products than secondary processed products. The Euro-zone and the OECD-member dummy variables were included in the models and those were expected with positive sign in the estimation as trade increasing determinants. Of six the coefficients three was found insignificant and the other three with an unexpected negative sign. Hungary is not a member of the Euro-zone, however it was assumed that those countries who already adopted the Euro were more developed countries and able to perform more import. Similar assumption was made with the OECD countries (though Hungary is a member), nevertheless, the results were negative or insignificant.

In summary, the explanatory variables performed realistic estimates of the divided Hungarian agro-commodity and food export. The basic gravity determinants were found strongly significant with the expected signs in all categories. The negative impact of economic distance was found as the most relevant trade determinant of raw material and the secondary processed products, while the evolution of exchange rate affected mostly the firstly processed products as a trade increasing influence. By analyzing the explanatory variables, the similarity of the coefficients between the raw material and the secondary processed products was conspicuous especially of the basic gravity determinants. Most of the determinants had only a few hundredths difference comparing those two cases. It means that in the examined period, the raw and the secondary processed products export flows were affected similarly by the basic trade determinants.

The panel specification of the datasets allowed us to investigate the individual time effects and introduce heterogeneity of time periods. Originally, T-1 years were considered in the datasets, however the first year dummy (2006) was not significant and as a consequence the homogenous two years at the beginning of the sample (2005-2006) became the base categories. The annual growth of export trade was dependent on production performance and efficiency of Hungary, as well as the market condition. In the examined period of 2005-2012 the market was instable (2007-2008 food crisis and 2008-2009 world financial crisis). The presence of market
shocks can divert the attention of evaluating production increase, because the market effects on trade are significantly stronger than the slowly but steadily increasing productivity improvement. In agricultural production the other important component of annual effects were the changing weather conditions, which are not measurable. Those could strengthen or stultify the effects of market shocks.

The coefficients of the individual years showed the percentage of export growth compared to the homogenous base periods. The first observed year was 2007, where an outstanding 25.8% expansion was detected in the raw material export. The processed products export increased slightly by 1-3%. In 2008 further excessive expansion was revealed despite the contemporaneous food crises and each export category increased by an additional approximate 20%. The following year (2009) demonstrated the presence of market shocks. Significant setback was observed in the market; substantially the export of raw material was affected by a 30% decrease. The other categories were also affected by the market shocks, however not to the same extent as the raw material. The exports of the firstly processed products and the secondary processed products shrunk by 4% and 1.6%, respectively. The effects of the food crises did not cause any setbacks in Hungary’s agro-export trade in 2007-2008, however the global financial crises which spilled over to Hungary in 2009 caused a large decrease in agro-commodity and food export of Hungary. The analysis revealed that the secondary processed products had the highest resistance against the market shocks, because its reduction was found the smallest compared to the other cases. After the negative impact of the financial crisis, the Hungarian agro-export turned to growth again. A year later the firstly and secondary processed products growths reached the same export increase that those performed in 2008 before the crisis. The raw material could reach in two years its pre-crisis growth and in 2011 the exported value of raw material became the most significant export category. In the last analyzed year, in 2012, the raw and the firstly processed products increased by similar percentages (57.7% and 55.6%, respectively), while the growth of secondary processed products fell slightly behind (43%).

The estimation results supported previous findings (Jámbor and Törők, 2012) that the EU accession accelerated trade, especially the intra-EU trade. The underdeveloped countries such as Hungary compared to EU-15 could significantly increase its agro-export trade. In the performed 8-year estimation the order of the exported product categories completely changed. Initially, in 2005 the categories had largely similar standing points, where the secondarily processed
products had the leading role, then the raw material products and eventually the firstly processed products with their exported value of 1350, 1200 and 1100 million US dollars, respectively. Up to 2012 the raw material export strengthened and became the most valued product category in the market. The processed product categories increased basically by the same amount; however in 2011 the firstly processed products outran the secondary processed products’ export and established the new order of product categories (raw material, firstly processed products and secondary processed products). The average annual individual increases, calculated from the obtained coefficients between 2007-2012, were 36.1%, 27% and 26.2%, respectively to the new order. Taking into consideration the massive increase in each category, Hungary has no reason to complain about its agro-trade performance. However, from another point of view, Hungary’s elementary interest is to push the export of the value-added products, since by producing those goods, the agro- and food processing sector could better contribute to the national economic growth. By enhancing the food processing sector, as a “by-product” the quality of life generally increases due to creation of jobs, which decelerates urbanization and migration out of the country.
### Table 4 Results obtained for Panel corrected standard error (PCSE) regression

<table>
<thead>
<tr>
<th>Variable</th>
<th>Label</th>
<th>Raw material</th>
<th>Firstly processed</th>
<th>Secondary processed</th>
</tr>
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<tr>
<td>Home country GDP</td>
<td>$lnY_{Ht}$</td>
<td>0.2664***</td>
<td>0.1517**</td>
<td>0.2963***</td>
</tr>
<tr>
<td>Host country GDP</td>
<td>$lnY_{it}$</td>
<td>0.5654***</td>
<td>0.4632***</td>
<td>0.6633***</td>
</tr>
<tr>
<td>Distance</td>
<td>$lnDist_{Hi}$</td>
<td>-1.0651***</td>
<td>-0.6184***</td>
<td>-1.0562***</td>
</tr>
<tr>
<td>Exchange-rate</td>
<td>$lnRER_{Hs}$</td>
<td>0.6515***</td>
<td>1.1398***</td>
<td>0.1563***</td>
</tr>
<tr>
<td>Euro-zone</td>
<td>$dy€zone_{it}$</td>
<td>0.3821</td>
<td>-0.0151</td>
<td>-0.2714*</td>
</tr>
<tr>
<td>EU-member</td>
<td>$dyEU_mem_{it}$</td>
<td>0.5210*</td>
<td>0.4075**</td>
<td>0.3349***</td>
</tr>
<tr>
<td>OECD-member</td>
<td>$dyOECD_mem_{it}$</td>
<td>-0.7621**</td>
<td>-0.0730</td>
<td>-0.6881***</td>
</tr>
<tr>
<td>Border</td>
<td>$dyContig_{Hi}$</td>
<td>-0.0219</td>
<td>0.5201**</td>
<td>0.2001***</td>
</tr>
<tr>
<td>Annual effect of 2007</td>
<td>$\lambda_{2007}$</td>
<td>0.2579***</td>
<td>0.015</td>
<td>0.0331*</td>
</tr>
<tr>
<td>Annual effect of 2008</td>
<td>$\lambda_{2008}$</td>
<td>0.4003***</td>
<td>0.1945***</td>
<td>0.2527***</td>
</tr>
<tr>
<td>Annual effect of 2009</td>
<td>$\lambda_{2009}$</td>
<td>0.0864**</td>
<td>0.15523***</td>
<td>0.2360***</td>
</tr>
<tr>
<td>Annual effect of 2010</td>
<td>$\lambda_{2010}$</td>
<td>0.2986***</td>
<td>0.2392***</td>
<td>0.2763***</td>
</tr>
<tr>
<td>Annual effect of 2011</td>
<td>$\lambda_{2011}$</td>
<td>0.5389***</td>
<td>0.4358***</td>
<td>0.3601***</td>
</tr>
<tr>
<td>Annual effect of 2012</td>
<td>$\lambda_{2012}$</td>
<td>0.5779***</td>
<td>0.5525***</td>
<td>0.4304***</td>
</tr>
<tr>
<td>R-squared</td>
<td>$R^2$</td>
<td>0.9624</td>
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<tr>
<td>Constant</td>
<td>$\beta_1$</td>
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<td>0 (omitted)</td>
<td>0 (omitted)</td>
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<tr>
<td>Rho</td>
<td>$\rho$</td>
<td>0.6989</td>
<td>0.7945</td>
<td>0.7211</td>
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</tbody>
</table>

Notes: The first analyzed time dummy variable (2006) was found insignificant, as a consequence, the homogenous two years at the beginning of the sample (2005-2006) are the base categories.

*Significance at 10% level (p-value <0.1); **Idem, 5% (p-value <0.05); ***Idem, 1% (p-value <0.01)

In the parenthesis are the t-ratios.

Source: own calculations, Stata 12 package.
Chapter 7 - Conclusion

Recognizing the importance of agricultural commodity and food exports in the Hungarian economy, the thesis attempted to empirically analyze the impact of industrial processing on Hungarian agro-export trade covering the period 2005 to 2012. Gravity model was employed in order to identify the factors influencing agro-export trade, which is considered as one of the most efficient models in explaining export trade flows. The aggregated Hungarian agro-commodity and food export flow was divided into three individual product categories. It was differentiated according to the level of processing into raw material, firstly processed products and secondarily processed products. In each category Hungary’s 20 major trading partners were represented.

Despite that the gravity model has been frequently used for explaining international trade movements, it has never been applied for specifically evaluating the determinants of Hungary’s agro-export trade. However the pioneering idea of the thesis was to analyze the influence of industrial processing by creating the three differentiated datasets and evaluating those by the same methodology. Panel datasets were built, where the basic explanatory variables were the real GDPs of home and host countries and the geographical distance between the traders. The traditional gravity model was extended with the measure of real exchange rate and with a set of dummy variables (EU & OECD membership, € adoption and contiguity). Furthermore, the thesis investigated the individual year effects to measure the impact of trade shocks on export trade that is why annual dummy variables were introduced to the datasets. Panel data estimation allowed calculating heterogeneity in time and the obtained coefficients became comparable across the product categories and revealed that the secondary processed products export was the most resistant against the 2009 World financial crisis.

The aim of the thesis was to build a methodology from former literature that performed consistent and unbiased estimates. The datasets were econometrically tested for heteroskedasticity, contemporaneous correlation and serial correlation. All the misspecification tests rejected the null hypothesis and found evidence to the above mentioned problems. To resolve those difficulties, the panel corrected standard error estimates were calculated, where the parameters were estimated by Prais-Winsten regression. In the literature, the feasible generalized
least squares (GLS) estimates were also used for analyzing linear panel data models, which corrected the misspecifications. By applying GLS estimation procedure we could gain different estimates. Further research should decide which regression methodology fits better to reality.

By investigating trade patterns it is always better to analyze huge datasets because it would correspond better to reality. One of the problems with the analyzed sample was that it took into consideration only 8 years (the period of 2005-2012) instead of 12 or 16 years. As a consequence, obtaining individual year effects, the thesis could infer to the influence of the 2004 EU accession on trade. Although, the massive increase was represented well in the model, it could have been better demonstrated, if the examined period would have been extended and the analysis started from 2000, when the accession negotiations formally started or from 1996 when a 16-year-period could have been analyzed with the 2004 EU accession in the midpoint. This way the research would show how the trade evaluated 8 years before and after the accession. For such a comprehensive analysis 6 months (from my point of view) would not be enough, because the data downloading and formatting (long form in Stata) process, the selection and sorting of the values of the exported product categories related to the respective countries would take excessive time. Creating new panel datasets, where the dependent variable is so complex, even the independent variables could be extended for a better trade explanatory power, might be better to start with a smaller set of sample (i.e. 8 years) and if the estimation looks promising, then expand the analyzed time periods.

The major findings of the estimated time periods were:

- The inner economic growths (GDP increase) of the importing countries were found more influential on Hungary’s export trade, than Hungary’s economic growth (GDP increase). By comparing the related estimates of the different categories it could be concluded that the trade stimulating effect of host countries’ GDP growths was approximately twice as influential, as the effect of Hungary’s GDP growth. This implied that the international export trade was more like a pulled-market, where the trading partners appreciated the competitive products and performed high demand on the market.

- The influences of economic distance were significant across the categories and in two cases (raw material and secondary processed products) it revealed the most influential power on trade.
• The exchange rate volatility affected the product categories differently and performed the strongest influence on the firstly processed products group.

• The measured explanatory dummy variables have not developed entirely as it was expected, however the results obtained that the influence of EU membership decreased on processed products categories.

• The introduction of heterogeneity in time revealed that the secondary processed products were the most resistant against trade shocks, because the 2009 World financial crisis caused the smallest (2%) temporal decrease on its trade.

• Finally, former findings (Jámbor and Török, 2012) have been empirically proven that the EU accession significantly invigorated the agro-export trade of Hungary. Furthermore, the coefficients of the raw material export proved that it had the most significant demand on the intra-EU trade compared to the other categories, because it performed the highest coefficient of the EU-member dummy and it had the most massive annual trade increase.

The thesis investigated the effects of heterogeneity in time as a one-way estimation; however panel data econometric would also allow determining the individual specific effects of the trading partners as a two-way estimation. For further research it is also suggested to investigate the effects of the 5 most relevant trading countries since it has been proven that those countries import more than 60% of the Hungarian agro-commodities and analyze the differences between the differentiated product categories.

Furthermore, as gravity modeling is widely utilized for explaining bilateral trade (import and export in the same model), it is advisable that if we would like to comprehensively understand Hungary’s agro-trading patterns, the import trade evaluation also should be performed, in order to make valid comparisons between the international trade flows. Although, Hungary performed a positive agricultural account balance, it does not mean that in all product categories the export overran the import flows. Since the significant raw material export increase overcompensated the processed products’ export increase, it kept the aggregated export value above the import value, but presumably the import of processed products increased more than the raw material import in the examined period.

The new government in 2010 targeted to strengthen the export of processed products by creating new and transparent land law and subjected the leasing of state land to specific
conditions for farmers (e.g. mandatory livestock production and expanding the production area of fruits and vegetables). In the future, when the latest trade data will be available, it would be very interesting to evaluate the real effects of those attempts by expanding the examination period.

Hungary has great opportunity to become an important agro-commodity and food exporter in Europe compared to its size. However the necessary investments should be made in the food processing sector and in enhancing productivity on land (to develop the annual production yields which were achieved in Western Europe). Those investments should be controlled and maintained by the subsequent governments, since in the last 20-25 years after the collapse of the Communist regime, the market could not entirely produce the developing surplus. It does not mean re-nationalization, but greater state involvement in order to increase the retaining power of rural areas by creating jobs, which improve the national budget. This conformation cannot happen in a short period of time, but with accurate continuous work a prosperous rural region with strong agricultural background could be developed in the future.
References


54


Appendix A - Figures

A. 1 International imports and exports of goods and services in 2011

A. 2 Growth of GDP and international trade in percentage of GDP (2004-2011)
A. 3 Annual change of arable land between 1999 and 2011

A. 4 Average annual cereal yield in the CEE region and in Hungary
A. 5 Average annual cereal yield in Western Europe and in Hungary
Appendix B - Pictures

B. 1 Annual average raw products export

B. 2 Annual average firstly processed products export
B. 3 Annual average secondary processed products export

Annual average Secondary Processed Products export
- top 5 destinations and the aggregated 15 countries -

Linearized export value
17 5 18 5 19 5 20

2004 2006 2008 2010 2012 Years

DEU ROM
AUT SVK
POL 15 countries

Edited by the author, UN Comtrade database
Appendix C - Tables

C. 1 Segmentation system of individual traded products

<table>
<thead>
<tr>
<th>AKI classification</th>
<th>4 digit code</th>
<th>HS classification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aggregate level</strong></td>
<td>01</td>
<td>Live animals</td>
</tr>
<tr>
<td>Raw products</td>
<td>0101</td>
<td>horses, asses, mules and hinnies, live</td>
</tr>
<tr>
<td>Raw products</td>
<td>0102</td>
<td>bovine animals, live</td>
</tr>
<tr>
<td>Raw products</td>
<td>0103</td>
<td>swine, live</td>
</tr>
<tr>
<td>Raw products</td>
<td>0104</td>
<td>sheep and goats, live</td>
</tr>
<tr>
<td>Raw products</td>
<td>0105</td>
<td>chickens, ducks, geese, turkeys, and guineas, live</td>
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<tr>
<td>Raw products</td>
<td>0106</td>
<td>animals, live, nesoi Nesi - not elsewhere specified of indicated.</td>
</tr>
<tr>
<td><strong>Aggregate level</strong></td>
<td>02</td>
<td>Meat &amp; edible meat offal</td>
</tr>
<tr>
<td>Firstly processed products</td>
<td>0201</td>
<td>meat of bovine animals, fresh or chilled</td>
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<td>Firstly processed products</td>
<td>0202</td>
<td>meat of bovine animals, frozen</td>
</tr>
<tr>
<td>Firstly processed products</td>
<td>0203</td>
<td>meat of swine (pork), fresh, chilled or frozen</td>
</tr>
<tr>
<td>Firstly processed products</td>
<td>0204</td>
<td>meat of sheep or goats, fresh, chilled or frozen</td>
</tr>
<tr>
<td>Firstly processed products</td>
<td>0205</td>
<td>meat of horses, asses, mules, hinnies fr, chld, fz</td>
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<tr>
<td>Firstly processed products</td>
<td>0206</td>
<td>ed offal, bovine, swine, sheep, goat, horse, etc.</td>
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<tr>
<td>Firstly processed products</td>
<td>0207</td>
<td>meat &amp; ed offal of poultry, fresh, chill or frozen</td>
</tr>
<tr>
<td>Firstly processed products</td>
<td>0208</td>
<td>meat &amp; edible offal nesoi, fresh, chilled or frozen</td>
</tr>
<tr>
<td>Firstly processed products</td>
<td>0209</td>
<td>pig &amp; poultry fat fresh chld frzn salted dried smkd</td>
</tr>
<tr>
<td>Firstly processed products</td>
<td>0210</td>
<td>meat &amp; ed offal salted, dried etc. &amp; flour &amp; meal</td>
</tr>
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<td><strong>Aggregate level</strong></td>
<td>03</td>
<td>Fish and crustaceans</td>
</tr>
<tr>
<td>Raw products</td>
<td>0301</td>
<td>fish, live</td>
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<td>Firstly processed products</td>
<td>0302</td>
<td>fish, fresh or chilled (no fillets or other meat)</td>
</tr>
<tr>
<td>Firstly processed products</td>
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<td>fish, frozen (no fish fillets or other fish meat)</td>
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<tr>
<td>Firstly processed products</td>
<td>0304</td>
<td>fish fillets &amp; other fish meat, fresh, chill or froz</td>
</tr>
<tr>
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<td>0305</td>
<td>fish, dried, salted etc, smoked etc, ed fish meal</td>
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<tr>
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<td>molluscs &amp; aquatic invertebrates nesoi, live etc</td>
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<td>0403</td>
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<td>whey &amp; milk products nesoi, flavored etc. or not</td>
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<tr>
<td>Secondary processed</td>
<td>0405</td>
<td>butter and other fats and oils derived from milk</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
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<tr>
<td>0406</td>
<td>cheese and curd</td>
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<tr>
<td>0409</td>
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<tr>
<td>0410</td>
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**Products of animal origin**

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<tr>
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<tr>
<td>0501</td>
<td>human hair, unworked and waste of human hair</td>
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<tr>
<td>0502</td>
<td>hogs' hair etc, badger hair etc, waste hair etc.</td>
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<tr>
<td>0503</td>
<td>horsehair and horsehair waste</td>
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<tr>
<td>0504</td>
<td>animal (not fish) guts, bladders, stomachs &amp; parts</td>
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<td>0505</td>
<td>bird skins &amp; other feathered parts and down</td>
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<tr>
<td>0506</td>
<td>bones &amp; horn cores, unworked etc, powder &amp; waste</td>
</tr>
<tr>
<td>0507</td>
<td>ivory, tortoise-shell, whalebone, horns etc, unwrk</td>
</tr>
<tr>
<td>0508</td>
<td>coral, shell of molluscs etc unworked powder/waste</td>
</tr>
<tr>
<td>0509</td>
<td>natural sponges of animal origin</td>
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<tr>
<td>0510</td>
<td>ambergris, castoreum etc, glands etc for pharmacy</td>
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<tr>
<td>0511</td>
<td>animal products nesoi, dead animals, inedible etc.</td>
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**Live trees & other plants**

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<tr>
<td>0601</td>
<td>bulbs, tubers etc, chicory plants &amp; roots nesoi</td>
</tr>
<tr>
<td>0602</td>
<td>live plants nesoi, cuttings etc., mushroom spawn</td>
</tr>
<tr>
<td>0603</td>
<td>cut flowers &amp; buds for bouquet etc., prepared</td>
</tr>
<tr>
<td>0604</td>
<td>foliage, grasses etc for bouquets etc, prepared</td>
</tr>
</tbody>
</table>

**Edible vegetables**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0701</td>
<td>potatoes (except sweet potatoes), fresh or chilled</td>
</tr>
<tr>
<td>0702</td>
<td>tomatoes, fresh or chilled</td>
</tr>
<tr>
<td>0703</td>
<td>onions, shallots, garlic, leeks etc, fr or chilled</td>
</tr>
<tr>
<td>0704</td>
<td>cabbages, cauliflower, kale etc, fresh or chilled</td>
</tr>
<tr>
<td>0705</td>
<td>lettuce and chicory, fresh or chilled</td>
</tr>
<tr>
<td>0706</td>
<td>carrots, turnips &amp; other edible roots, fr or chill</td>
</tr>
<tr>
<td>0707</td>
<td>cucumbers and gherkins, fresh or chilled</td>
</tr>
<tr>
<td>0708</td>
<td>leguminous vegetables, shelled or not, fr or chill</td>
</tr>
<tr>
<td>0709</td>
<td>vegetables nesoi, fresh or chilled</td>
</tr>
<tr>
<td>0710</td>
<td>vegetables (raw or cooked by steam etc), frozen</td>
</tr>
<tr>
<td>0711</td>
<td>vegetables, temporarily preserved, not now edible</td>
</tr>
<tr>
<td>0712</td>
<td>vegetables, dried, whole, cut etc., no added prep</td>
</tr>
<tr>
<td>0713</td>
<td>leguminous vegetables, dried shelled</td>
</tr>
<tr>
<td>0714</td>
<td>cassava arrowroot etc fresh or dry: sago pith</td>
</tr>
</tbody>
</table>

**Ed. Fruits & nuts, peel of citrus/melons**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0801</td>
<td>coconuts, brazil nuts &amp; cashew nuts, fresh or dry</td>
</tr>
</tbody>
</table>
Raw products 0802 nuts nesoi, fresh or dried
Raw products 0803 Bananas and plantains, fresh or dried
Raw products 0804 dates, figs, pineapples, avocados etc, fr or dried
Raw products 0805 citrus fruit, fresh or dried
Raw products 0806 grapes, fresh or dried
Raw products 0807 melons and papayas, fresh
Raw products 0808 apples, pears and quinces, fresh
Raw products 0809 apricots, cherries, peaches, plums & sloes, fresh
Raw products 0810 fruit nesoi, fresh
Firstly processed products 0811 fruit & nuts (raw or cooked by steam etc), frozen
Firstly processed products 0812 fruit & nuts temporarily preserved, not now edible
Firstly processed products 0813 fruit dried nesoi, mixtures of nuts or dried fruit peel, citrus or melon, fresh, frozen, dried, provsl pres.
Firstly processed products 0814 coffee, coffee husks etc, substitutes with coffee
Firstly processed products 0901 mate
Firstly processed products 0902 pepper, genus piper, genus capsicum or pimenta
Firstly processed products 0903 vanilla beans
Firstly processed products 0904 cinnamon and cinnamon-tree flowers
Firstly processed products 0905 cloves (whole fruit, cloves and stems)
Firstly processed products 0906 nutmeg, mace and cardamoms
Firstly processed products 0907 seeds, anise, badian, fennel, coriander, cumin etc
Firstly processed products 0908 ginger, saffron, tumeric, thyme, bay leaves etc
Firstly processed products 0910 Cereals
Raw products 1001 wheat and meslin
Raw products 1002 rye in the grain
Raw products 1003 barley
Raw products 1004 oats
Raw products 1005 corn (maize)
Raw products 1006 rice
Raw products 1007 grain sorghum
Raw products 1008 buckwheat, millet & canary seed, cereals nesoi
Firstly processed products 1101 Milling industry products
Firstly processed products 1102 wheat or meslin flour
Firstly processed products 1103 cereal flours, except of wheat or of meslin
Firstly processed products 1104 cereal groats, meal and pellets
Firstly processed products 1105 cereal grains, worked etc nesoi, cereal germs, wrk
Firstly processed products 1106 flour, meal and flakes of potatoes
Firstly processed products 1107 flour & meal of dry, legum vegs, sago, fruit etc.
malt, whether or not roasted
Firstly processed products 1108
Firstly processed products 1108 starches, inulin
Firstly processed products 1109 wheat gluten, whether or not dried

**Aggregate level 12 Oil seeds/ misc. Grains/med. Plants/straw**

Raw products 1108 soybeans, whether or not broken
Raw products 1109 peanuts (ground-nuts), raw
copa
Raw products 1203
Raw products 1204 flaxseed (linseed), whether or not broken
Raw products 1205 rape or colza seeds, whether or not broken
Raw products 1206 sunflower seeds, whether or not broken
Raw products 1207 oil seeds & oleaginous fruits nesoi, broken or not
Raw products 1208 flour & meal of oil seed & olea fruit (no mustard)
Raw products 1209 seeds, fruit and spores, for sowing
Raw products 1210 hop cones, fresh or dried, lupulin
Raw products 1211 plants etc for pharmacy, perfume, insecticides etc
Raw products 1212 locust beans, seaweed, s beet & cane: fruit pits etc.
Raw products 1213 cereal straw & husks unprep w/n chop etc or pellet
Raw products 1214 rutabagas, hay, clover & other forage products

**Aggregate level 13 Lac, rums, resin, etc.**

Firstly processed products 1201 lac, natural gums, resins, gum-resins and balsams
Firstly processed products 1202 veg saps & extracts: pectates etc: agar-agar etc.

**Aggregate level 14 Vegetable plaiting materials**

Raw products 1301 vegetable plaiting materials (bamboos, reeds etc.)
Raw products 1302 veg materials (kapok etc) for stuffing or padding
Raw products 1303 veg materials (broom corn etc) for brooms & brushes
Raw products 1304 vegetable products nesoi

**Aggregate level 15 Animal or vegetable fats, oil & waxes**

Firstly processed products 1401 lard, other pig fat and poultry fat, rendered
Firstly processed products 1402 fats, bovine, sheep or goat, raw or rendered
Firstly processed products 1403 lard stearin/lard oil/etc not emulsified or preprd
Firstly processed products 1404 fats & oils, their fractions, fish & marine mammal
Firstly processed products 1405 wool grease & fatty substances derived therefrom
Firstly processed products 1406 animal fat & oil & reaction nesoi not chem modified
Firstly processed products 1407 soybean oil & its fractions, not chemically modified
Firstly processed products 1408 peanut oil & its fractions, not chemically modified
Firstly processed products 1409 olive oil & its fractions, not chemically modified
Firstly processed products 1410 olive-residue oil & blends (1509 & 1510) not chem mod
Firstly processed products 1411 palm oil & its fractions, not chemically modified
Firstly processed products 1412 sunflower-seed, safflower or cottonseed oil, not ch mod
Firstly processed products 1413 coconut, palm kernel or babassu oil etc, not ch mod
Firstly processed products 1414 rapeseed, colza or mustard oil etc, not chem modif
Firstly processed products 1415 fixed veg fats & oils nesoi etc, not chem modified

70
<table>
<thead>
<tr>
<th>Category</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firstly processed products</td>
<td>1516</td>
<td>an or veg fats &amp; oils, hydrogen etc, not fur prep</td>
</tr>
</tbody>
</table>
| Secondary processed products                                           | 1517 | margarine, edible mixtures etc an or veg fat & oilhold/iodeseed/iodine/  
| Firstly processed products                                             | 1518 | animal/veg fats & oils chem modified, inedible mix etc                                                                                       |
| Firstly processed products                                             | 1520 | glycerol (glycerine), glycerol waters and lyes                                                                                            |
| Firstly processed products                                             | 1521 | veg waxes nesoi, beeswax etc and spermaceti                                                                                                 |
| firstly processed products                                             | 1522 | degras, residues from fatty substances/animal/veg wax                                                                                       |
| Aggregate level                                                        | 16    | Prep of meat fish and crustaceans, etc.                                                                                                      |
| Secondary processed products                                           | 1601 | sausages, similar prdt meat etc food prep of these                                                                                        |
| Secondary processed products                                           | 1602 | prepared or preserved meat, meat offal & blood nesoi                                                                                    |
| Secondary processed products                                           | 1603 | extracts etc. of meat, fish, crustaceans, etc.                                                                                               |
| Secondary processed products                                           | 1604 | prep or pres fish, caviar & caviar substitutes                                                                                              |
| Secondary processed products                                           | 1605 | crustaceans molluscs etc prepared or preserved                                                                                            |
| Aggregate level                                                        | 17    | Sugars and sugar confectionery                                                                                                               |
| Firstly processed products                                             | 1701 | cane or beet sugar & chem pure sucrose, solid form                                                                                         |
| Firstly processed products                                             | 1702 | sugars nesoi, incl chem pure lactose etc, caramel                                                                                        |
| Secondary processed products                                           | 1703 | molasses from the extraction or refining of sugar                                                                                           |
| Aggregate level                                                        | 18    | sugar confection (incl white chocolate), no cocoa                                                                                        |
| Secondary processed products                                           | 1801 | Cocoa and cocoa preparations                                                                                                                |
| Firstly processed products                                             | 1802 | cocoa beans, whole or broken, raw or roasted                                                                                            |
| Firstly processed products                                             | 1803 | cocoa shells, husks, skins and other cocoa waste                                                                                           |
| Firstly processed products                                             | 1804 | cocoa paste, defatted or not                                                                                                                |
| Secondary processed products                                           | 1805 | cocoa butter, fat and oil                                                                                                                   |
| Aggregate level                                                        | 19    | cocoa powder, not sweetened                                                                                                                 |
| Secondary processed products                                           | 1806 | chocolate & other food products containing cocoa                                                                                           |
| Aggregate level                                                        | 19    | Preparations of cereals, flour, starch, or milk                                                                                             |
| Secondary processed products                                           | 1901 | malt ext, food prep of flour etc un 50% cocoa etc                                                                                           |
| Secondary processed products                                           | 1902 | pasta, prepared or not, couscous, prepared or not                                                                                         |
| Secondary processed products                                           | 1903 | tapioca and substitutes from starch in flakes, etc                                                                                         |
| Secondary processed products                                           | 1904 | foods prep by swell cereal, cereal nesoi, grain fm                                                                                         |
| Aggregate level                                                        | 20    | bread, pastry cakes etc: comm wafers, empty caps etc                                                                                       |

71
<table>
<thead>
<tr>
<th>Aggregate level</th>
<th>21</th>
<th>Misc. edible preparations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary</td>
<td>2101</td>
<td>extracts etc of coffee, tea or mate, roast chicory</td>
</tr>
<tr>
<td>Secondary</td>
<td>2102</td>
<td>yeasts, dead sing-cell micro-org nesoi, baking powder</td>
</tr>
<tr>
<td>Secondary</td>
<td>2103</td>
<td>sauces &amp; prep,mixed condiments, mustard flour etc</td>
</tr>
<tr>
<td>Secondary</td>
<td>2104</td>
<td>soups, broths &amp; preps, homogenized comp food preps</td>
</tr>
<tr>
<td>Secondary</td>
<td>2105</td>
<td>ice cream and other edible ice, with cocoa or not</td>
</tr>
<tr>
<td>Secondary</td>
<td>2106</td>
<td>food preparations nesoi</td>
</tr>
<tr>
<td>Aggregate level</td>
<td>22</td>
<td>Beverages, spirits &amp; vinegar</td>
</tr>
<tr>
<td>Secondary</td>
<td>2201</td>
<td>waters, natural etc, not sweetened etc, ice &amp; snow</td>
</tr>
<tr>
<td>Secondary</td>
<td>2202</td>
<td>waters, sweetened etc &amp; other nonalc beverages nesoi</td>
</tr>
<tr>
<td>Secondary</td>
<td>2203</td>
<td>beer made from malt</td>
</tr>
<tr>
<td>Secondary</td>
<td>2204</td>
<td>wine of fresh grapes, grape must nesoi</td>
</tr>
<tr>
<td>Secondary</td>
<td>2205</td>
<td>vermouth &amp; other wine of fresh grapes spec flavored</td>
</tr>
<tr>
<td>Secondary</td>
<td>2206</td>
<td>fermented beverages nesoi (cider, berry, mead etc)</td>
</tr>
<tr>
<td>Secondary</td>
<td>2207</td>
<td>ethyl alcohol, undenat, n/un 80% alc, alcohol, denat</td>
</tr>
<tr>
<td>Product Category</td>
<td>Code</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Secondary processed products</td>
<td>2208</td>
<td>ethyl alcohol, undenat, und 80% alc, spirit bev etc</td>
</tr>
<tr>
<td>Secondary processed products</td>
<td>2209</td>
<td>vinegar &amp; substitutes for vinegar from acetic acid</td>
</tr>
<tr>
<td><strong>Aggregate level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firstly processed products</td>
<td>2301</td>
<td>flour, meal etc of meat etc, not for human: greavs</td>
</tr>
<tr>
<td>Firstly processed products</td>
<td>2302</td>
<td>bran, sharps etc from working cereals &amp; leg plants</td>
</tr>
<tr>
<td>Firstly processed products</td>
<td>2303</td>
<td>residues of starch mfr or sugar mfr or brewing etc</td>
</tr>
<tr>
<td>Firstly processed products</td>
<td>2304</td>
<td>soybean oilcake &amp; other solid residue, wh/not ground</td>
</tr>
<tr>
<td>Firstly processed products</td>
<td>2305</td>
<td>peanut oilcake &amp; other solid residue, wh/not ground</td>
</tr>
<tr>
<td>Firstly processed products</td>
<td>2306</td>
<td>oilcake etc nesoi, from veg fats &amp; oils nesoi</td>
</tr>
<tr>
<td>Firstly processed products</td>
<td>2307</td>
<td>wine lees, argol</td>
</tr>
<tr>
<td>Firstly processed products</td>
<td>2308</td>
<td>veg material, waste etc for feeding animals nesoi</td>
</tr>
<tr>
<td>Secondary processed products</td>
<td>2309</td>
<td>preparations used in animal feeding</td>
</tr>
<tr>
<td><strong>Aggregate level</strong></td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Raw products</td>
<td>2401</td>
<td>tobacco, unmanufactured, tobacco refuse</td>
</tr>
<tr>
<td>Secondary processed products</td>
<td>2403</td>
<td>cigars, cigarettes etc., of tobacco or substitutes</td>
</tr>
<tr>
<td>Secondary processed products</td>
<td>2405</td>
<td>tobacco &amp; tobacco subst mfrs nesoi, tob proces etc</td>
</tr>
</tbody>
</table>
## C. 2 Export trade partners, analyzed in the sample

<table>
<thead>
<tr>
<th>Raw material</th>
<th>Firstly processed</th>
<th>Secondary processed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Italy</td>
<td>Romania</td>
<td>Germany</td>
</tr>
<tr>
<td>2 Germany</td>
<td>Germany</td>
<td>Romania</td>
</tr>
<tr>
<td>3 Romania</td>
<td>Slovak Republic</td>
<td>Austria</td>
</tr>
<tr>
<td>4 Austria</td>
<td>Italy</td>
<td>Slovak Republic</td>
</tr>
<tr>
<td>5 Netherlands</td>
<td>Austria</td>
<td>Poland</td>
</tr>
<tr>
<td>6 Slovak Republic</td>
<td>Czech Republic</td>
<td>Russian Federation</td>
</tr>
<tr>
<td>7 Greece</td>
<td>France</td>
<td>Czech Republic</td>
</tr>
<tr>
<td>8 Poland</td>
<td>Japan</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>9 Turkey</td>
<td>Poland</td>
<td>France</td>
</tr>
<tr>
<td>10 Russian Federation</td>
<td>United Kingdom</td>
<td>Croatia</td>
</tr>
<tr>
<td>Bosnia and Herzegovina</td>
<td>Netherlands</td>
<td>Ukraine</td>
</tr>
<tr>
<td>12 Slovenia</td>
<td>Belgium</td>
<td>Slovenia</td>
</tr>
<tr>
<td>13 Ukraine</td>
<td>Slovakia</td>
<td>Netherlands</td>
</tr>
<tr>
<td>14 Croatia</td>
<td>Switzerland</td>
<td>Italy</td>
</tr>
<tr>
<td>15 France</td>
<td>Croatia</td>
<td>Bulgaria</td>
</tr>
<tr>
<td>16 Czech Republic</td>
<td>Russian Federation</td>
<td>Belgium</td>
</tr>
<tr>
<td>17 Spain</td>
<td>Spain</td>
<td>Serbia</td>
</tr>
<tr>
<td>18 Bulgaria</td>
<td>Bosnia and Herzegovina</td>
<td>Lithuania</td>
</tr>
<tr>
<td>19 United States</td>
<td>Bulgaria</td>
<td>Switzerland</td>
</tr>
<tr>
<td>20 Serbia</td>
<td>Ukraine</td>
<td>Sweden</td>
</tr>
</tbody>
</table>