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Country- and industry-specific determinants of intra-industry trade in agri-food products in the Visegrad countries

The article analyses country- and industry-specific determinants of horizontal and vertical intra-industry trade (IIT) in agri-food products between the Visegrad countries (Czech Republic, Hungary, Poland and Slovak Republic) and the European Union in the period 1999-2013. The results show that IIT is mainly of a vertical nature in the Visegrad countries, though the majority of their exports consist of low quality/value-added agri-food products to European markets. The results obtained by generalised method of moments (GMM) panel model estimations suggest that factor endowments and distance are mainly negatively related to IIT, while product differentiation was found not to foster two-way trade of quality-differentiated goods. All model runs show a negative relationship between productivity as well as foreign direct investment and IIT.

Keywords: intra-industry trade, agri-food trade, Visegrad countries, determinants

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Introduction

During recent decades, intra-industry trade (IIT) has become a widespread phenomenon with an increasing role in international trade (Brülhart, 2009). The formation of stronger economic ties due to the creation and expansion of the European Union (EU) has contributed to an increase in IIT between European countries.

Despite the importance of the topic, most literature is focused on IIT of industrial products, with agricultural produce usually neglected in empirical works (McCorriston and Sheldon, 1991), possibly because agricultural markets are assumed to be competitive. However, recent studies support the view that agricultural markets can be characterised by imperfect competition (Sexton, 2013) and IIT has an increasing role in agricultural trade for both developed and developing countries (e.g. Wang, 2009; Leitão, 2011; Rasekhi and Shojaee, 2012; Varma, 2012; Fertő, 2015). Moreover, most research is focused on a single country and simply neglects the importance of horizontal/vertical distinction of IIT.

The aim of this article is to identify both the country- and the industry-specific determinants of horizontal and vertical IIT agri-food products between the Visegrad countries (Czech Republic, Hungary, Poland and Slovak Republic) and the EU in the period 1999-2013. This approach aims to contribute to the literature in four ways: (a) analysing a group of countries instead of a single country, (b) focusing on agri-food products, (c) distinguishing between horizontal and vertical IIT, and (d) analysing both country- and industry-specific determinants.

A review of the theoretical literature in the next section is followed by a summary of recent empirical evidence, then by a review of measurement methods. After a demonstration of the basic patterns of agri-food IIT in the Visegrad countries, hypotheses and econometric specifications are outlined. The results of model runs and the discussion of these follow, while the last section concludes.

Theoretical framework

Traditional trade theories assume constant returns to scale, homogenous products and perfect competition, and aim to explain inter-industry trade based on comparative advantages. However, a significant portion of the world trade since the 1960s has taken the form of *intra*-industry trade rather than *inter*-industry trade. Consequently, traditional trade models have proved to be inadequate in explaining this new trade pattern as there is no reason for developed countries to trade in similar but slightly differentiated goods.

In the 1970s, an increasing amount of research dealt with this issue, providing a theoretical basis for IIT, defined as the simultaneous export and import of products belonging to the same statistical product category. The first synthesising model of IIT was developed by Helpman and Krugman (1985), creating a framework for IIT theory by using the Chamberlin monopolistic competition theory. This model combines monopolistic competition with the Heckscher-Ohlin (HO) theory, incorporating factor endowments differences, horizontal product differentiation and increasing returns to scale. It pointed out that comparative advantages drive *inter*-industry trade through specialisation, while economies of scale drive *intra*-industry trade.

Owing to the pioneering work of Falvey (1981), notions of horizontal and vertical product differentiation have come into existence in the literature. *Horizontal* intra-industry trade (HIIT) refers to homogenous products with the same quality but with different characteristics, while *vertical* intra-industry trade (VIIT) means products traded with different quality and price. Following the author's work, three types of bilateral trade flows may occur between countries: inter-industry trade, HIIT and VIIT.

Horizontal differentiation is more likely between countries with similar factor endowments while vertically differentiated goods occurs because of factor endowment differences across countries (Falvey and Kierzkowski, 1987). The amount of capital relative to labour used in the production of vertically differentiated goods indicates the quality of the good. Higher-quality products are produced in capital-abundant countries while lower-quality products are produced in labour-abundant countries. VIIT occurs as the capital-abundant country exports higher-quality products and the labour-abundant country exports lower-quality ones. It is therefore predictable that the share of VIIT will increase as countries' income and factor endowments diverge.

Empirical evidence

There is an increasing interest in studying agri-food trade patterns. The first strand of the literature concentrates on identifying analysing *country specific determinants* of IIT. Fertő (2005) found a positive relationship between factor endowment and VIIT in agri-food products between Hungary and the EU-15, while a negative correlation was identified in the case of the distance between the countries. Fertő (2007) showed that for IIT in agri-food products between Hungary and the EU-15 the determinants for HIIT and VIIT differed. HIIT was negatively associated with differences in per capita income, average gross domestic product (GDP), distance and distribution of income, while income and distance were found to be positively related to VIIT.

Leitão (2011) found that the agricultural IIT of the United States was positively influenced by average GDP, foreign domestic investment (FDI) and trade imbalance, while it had a negative relationship with differences in per capita GDP. Rasekhi and Shojaee (2012) showed that VIIT between Iran and its main trading partners and was positively influenced by land endowments, but negatively affected by the economic size of trading partners. Caetano and Galego (2007) found that determinants of HIIT and VIIT also differed within an enlarged Europe, although both had a statistically significant relationship with a country's size and FDI. Income per capita differences and geographic distance were also found to be important factors for IIT, especially for HIIT.

Jensen and Lüthje (2009) identified production size, geographical proximity, average income per capita and income distribution overlap as the major driving forces of VIIT in Europe. They showed that countries characterised as being on a high economic level and as having large economies had a higher bilateral VIIT with each other than with other countries. Furthermore, countries with large income distribution overlap tended to have a large VIIT, while countries far from each other had lower VIIT than those close to each other.

Gabrisch (2009) found country-pair fixed effects to be of high relevance for explaining VIIT between 'old' and 'new' EU Member States (EU-10). Technology differences were positively, while differences in factor endowment were negatively, correlated with VIIT. Moreover, changing bilateral differences in personal income distribution during the transition of the 'new' EU Member States were found to contribute to changes in VIIT.

Fainštein and Netšunajev (2011) showed that market size was positively related to IIT in the Baltic States. However, a negative relationship between distance and the share of IIT was found, together with a negative correlation between difference in human capital and IIT. Ambroziak (2012) found that FDI stimulated not only VIIT in the Visegrad countries but also HIIT. Differences in country size and income were positively related to IIT as is FDI, while distance and IIT showed a negative relationship. Jámbor (2014) and Fertő and Jámbor (2015) analysed country-specific determinants of IIT for agri-food products for the post-socialist EU Member States and found that factor endowments are ambiguously related to HIIT and VIIT in agri-food products. Economic size was found to be positively and significantly related to both types of IIT, while distance and IIT were found to be negatively related in both cases.

The other strand of the literature searches for *industry specific determinants* of IIT. Loerstcher and Wolter (1980) were among the first to analyse industry-specific determinants of IIT, for 13 OECD countries. A positive correlation between product differentiation and IIT was found, as well as a statistically significant negative relationship between economies of scale and IIT. They also demonstrated that IIT was explained by monopolistic competition and a large number of enterprises.

Hartman *et al*. (1993) analysed IIT for food processing with thirty-six trading partners of the United States in 1987. Using the ordinary least squares (OLS) model for their estimations, they showed that product differentiation and economies of scale were positively related to IIT while industrial concentration had a negative impact. The empirical study of Kim and Marion (1997) shows that physical capital endowments (K/L), economies of scale (MES), FDI and research and development (R&D) costs promote IIT in the agri-food sector.

IIT for 14 OECD countries was investigated by Bergstrand (1983) by using a cross-section analysis for 1976. Economies of scales were negatively correlated with IIT, indicating that this type of trade is explained by imperfect competition. Balassa and Bauwens (1987) found a positive effect of product differentiation and FDI on IIT.

Lee (1989) investigated IIT of 13 Pacific countries for 1970 and 1980, and concluded that product differentiation and FDI are positively correlated with IIT. The author also found a negative relationship between industrial concentration and IIT. For the UK, Greenaway *et al*. (1995) considered three equations. The first analysed IIT and the others considered HIIT and VIIT. Scale economies and product differentiation were shown to be negatively correlated with IIT, not as *a priori* expected. For the HIIT equation, they demonstrated that product differentiation (PD), industrial concentration (CONC) and FDI met theoretical expectations. In other words, similar quality of products (HIIT) was explained by these determinants. As to the VIIT equation, vertical product differentiation (VPD) had a positive impact on VIIT while FDI was negatively correlated with VIIT, showing that these variables are not complementary.

Faustino and Leitão (2007) used static and dynamic panel data to analyse the determinants of IIT for the Portuguese economy for the period 1995-2002. The explanatory variables used were horizontal and vertical product differentiation, economies of scales, productivity and intensity of physical capital. Physical capital was found to have a negative impact on VIIT, meaning that Portugal produced and exported lower-quality products to the EU.

Regarding IIT for food processing, Leitão and Faustino (2008) found that economies of scales had a positive, while industrial concentration had a negative, relationship with IIT for the period 1995-2003. Ekanayake and Veeramacheni (2009) analysed the impact of product differentiation, economies of scales and industrial concentration on IIT, HIIT and VIIT between US and NAFTA partners for the period 1990-2007 and found a positive impact of product differentiation on IIT. The variables of industrial concentration and economies of scales were negatively correlated with IIT, which is in accordance with the dominant theory, explaining IIT by larger number of firms. The VIIT model found a positive relationship between vertical product differentiation and VIIT, while VIIT was negatively related to economies of scales and industrial concentration.

Cernosa (2009) identified product differentiation, economies of scale, industrial concentration and multinational firms as the main industry-specific determinants of IIT in Slovenia. The study showed that multinational firms had a positive impact on HIIT and VIIT while economies of scales were positively correlated with HIIT and VIIT. Andresen (2010) found that economies of scale and industrial concentration were negatively, while vertical product differentiation was positively, related to VIIT between USA and Canada. The empirical study of Sotomayor (2012) analysed IIT for Mexican non-*maquiladora* industry, covering the period 1994-2006. On the one hand, the results showed that FDI and economy of scale had a positive impact on IIT, HIIT and VIIT. On the other hand, product differentiation was found to be negatively related to both sides of IIT.

In short, studies have highlighted the increasing role of IIT in agri-food trade. In addition, in line with recent empirical evidence, papers confirm that horizontal and vertical IIT are influenced by different factors and therefore the distinction makes sense.

Measuring vertical and horizontal intra-industry trade

Several methods exist to measure IIT. One is the classical Grubel-Lloyd (GL) index, which is expressed formally as follows (Grubel and Lloyd, 1975):

$$GL_i = 1 - \frac{|X_i - M_i|}{(X_i + M_i)} \quad (1)$$

where X_i and M_i are the value of exports and imports of product category i in a particular country. The GL index varies between 0 (complete *inter*-industry trade) and 1 (complete *intra*-industry trade) and can be aggregated to level of countries and industries as follows:

$$GL = \sum_{i=1}^{n} GL_i w_i \text{ where } w_i = \frac{(X_i + M_i)}{\sum_{i=1}^{n}(X_i + M_i)} \quad (2)$$

where w_i comes from the share of industry i in total trade. The high level of IIT between two countries refers to higher degree of economic integration (Qasmi and Fausti, 2001). However, several authors have criticised the GL index, for five main reasons: (a) aggregate or sectoral bias, (b) trade imbalance problem, (c) geographical bias, (d) inappropriateness to separate HIIT and VIIT, (e) inappropriateness for treating dynamics (see Fertő, 2004).

The fourth problem of the GL index is caused by the joint treatment of HIIT and VIIT. There are several possibilities for solving this problem, the most widespread of which is based on unit values developed by Abd-el Rahman (1991). The underlying presumption behind unit values is that relative prices are likely to reflect relative qualities. According to the widespread view in the literature based on this presumption, horizontally differentiated products are homogenous (perfect substitutes) and of the same quality, while vertically differentiated products have different prices reflecting different quality (Falvey, 1981). According to Greenaway *et al*. (1995), a product is horizontally differentiated if the unit value of export compared to the unit value of import lies within a 15 per cent range at the five digit SITC level. If this is not true, the Greenaway-Hine-Milner (GHM) method refers to vertically differentiated products. Formally, this is expressed for bilateral trade of horizontally differentiated products as follows:

$$1 - \alpha \leq \frac{UV_i^X}{UV_i^M} \leq 1 + \alpha \quad (3)$$

where UV means unit values, X and M means exports and imports for goods i and $\alpha = 0.15$. Furthermore, Greenaway *et al*. (1994) added that results obtained from the selection of the 15 per cent range do not change significantly when the spread is widened to 25 per cent. Blanes and Martin (2000) developed the model further and defined high and low VIIT. Low VIIT means that the relative unit value of a good is below the limit of 0.85, while unit value above 1.15 indicates high VIIT. Based on this logic, the GHM index becomes formally as follows:

$$GHM_k^p = \frac{\sum_j [(X_{j,k}^p + M_{j,k}^p) - |X_{j,k}^p - M_{j,k}^p|]}{\sum_j (X_{j,k} + M_{j,k})} \quad (4)$$

where X and M stand for export and import, while p distinguishes horizontal or vertical IIT, j is the number of product groups and k is the number of trading partners (j, k = 1, ... n).

The FF method is another popular way to distinguish HIIT and VIIT. Fontagné and Freudenberg (1997) categorise trade flows and compute the share of each category in total trade. They defined trade to be 'two-way' when the value of the minority flow represents at least 10 per cent of the majority flow. Formally:

$$\frac{Min(Xi, Mi)}{Max(Xi, Mi)} \geq 10\% \quad (5)$$

If the value of the minor flow is below 10 per cent, trade is classified as inter-industry in nature. If the opposite is true, the FF index comes formally as:

$$FF_k^p = \frac{\sum_j (X_{j,k}^p + M_{j,k}^p)}{\sum_j (X_{j,k} + M_{j,k})} \quad (6)$$

After calculating the FF index, trade flows can be classified as follows: horizontal two-way trade, vertical two-way trade and one-way trade. The FF index tendentiously provides higher values compared to GL-type indices (like the GHM index) as equation 5 refers to total trade, treated before as two-way trade (Fontagné and Freudenberg, 1997). The authors suggest that FF index complements rather than substitutes GL-type indices as they have measured the relative weight of different trade types in total trade. In conclusion, they found that the value of GHM index is usually between the GL and FF index.

All the indices shown above measure the share of IIT instead of its level which is a much better index. According to Nilsson (1997), IIT should be divided by the number of product groups in total trade, resulting in an average IIT by product group. The Nilsson index is formally expressed as follows (Nilsson, 1997):

$$N_k^p = \frac{\sum_j \left[(X_{j,k}^p + M_{j,k}^p) - \left| X_{j,k}^p - M_{j,k}^p \right| \right]}{n^p} \quad (7)$$

where the numerator equals that of the GHM index, while *n* refers to the number of product groups in total trade. Nilsson (1997) argues that his measure provides a better indication of the extent and volume of IIT than GL-type indices and is more appropriate in cross-country IIT analyses.

In order to calculate IIT indices, the article uses raw data from the Eurostat international trade database using the HS6 system (six digit breakdown). Agri-food trade is defined as trade in product groups HS 1-24, resulting in 1229 products. The article works with trade data for the period 1999-2013 due to data availability. In this context, the EU is defined as the Member States of the EU-28.

The nature of intra-industry trade in the Visegrad countries

Using the methods outlined above, indices of HIIT and VIIT for agri-food products between the Visegrad countries and the EU were calculated for the period 1999-2013. Agri-food IIT is mainly vertical in nature, according to all indices, suggesting the exchange of products of different quality (Table 1). However, low values for total IIT (the sum of vertical and horizontal IIT) suggest that IIT prevails in the agri-food trade of these countries with the EU in the analysed period. These findings are consistent with the results of previous research (Fertő, 2005; Jámbor, 2014) and with earlier studies indicating that proportion of the IIT was higher for food products involving a greater degree of processing (McCorriston and Sheldon, 1991; Qasmi and Fausti, 2001).

HIIT and VIIT in agri-food products shows a significant increase after the 2004 EU enlargement (Figure 1). The GHM and FF indices generally increased for horizontal and vertical IIT by four times from 2003 to 2013, while N indices increased by 11-18 times in the same period. In all cases, vertical IIT increased less than horizontal IIT.

Using the idea of Blanes and Martín (2000), VIIT was separated into vertically high and low categories, suggesting different qualities of trade. Low vertical IIT predominates in total vertical IIT in the majority of the cases, indicating low quality export products to EU-28 markets (Table 2). Hungary had the highest share (45 per cent) of low vertical IIT in total IIT in 1999-2013, while Poland had the lowest (38 per cent). Similar results can be obtained if this pattern is analysed in time (data not shown). The overall picture is quite unfavourable as the trade of low quality products is

Table 1: Horizontal and vertical intra-industry trade in agri-food products between the Visegrad countries and EU Member States in the period 1999-2013.

Country	Horizontal			Vertical		
	GHM	FF	N (EUR)	GHM	FF	N (EUR)
Czech Republic	0.03	0.05	15,189	0.09	0.14	32,098
Hungary	0.02	0.04	7,266	0.09	0.14	27,002
Poland	0.02	0.04	22,063	0.07	0.11	53,621
Slovak Republic	0.01	0.02	6,455	0.05	0.08	20,811

GHM: Greenaway-Hine-Milner method; FF: Fontagné-Freudenberg method; N: Nilsson method
Source: own calculations based on Eurostat data

Table 2: Horizontal and vertical intra-industry trade in agri-food products between the Visegrad countries and EU Member States by country in the period 1999-2013 (per cent of total, based on the GHM method).

Country	Horizontal	Low vertical	High vertical
Czech Republic	23.5	42.2	34.3
Hungary	20.1	45.2	34.7
Poland	24.2	37.5	38.3
Slovak Republic	17.8	42.4	39.8

Source: own calculations based on Eurostat data

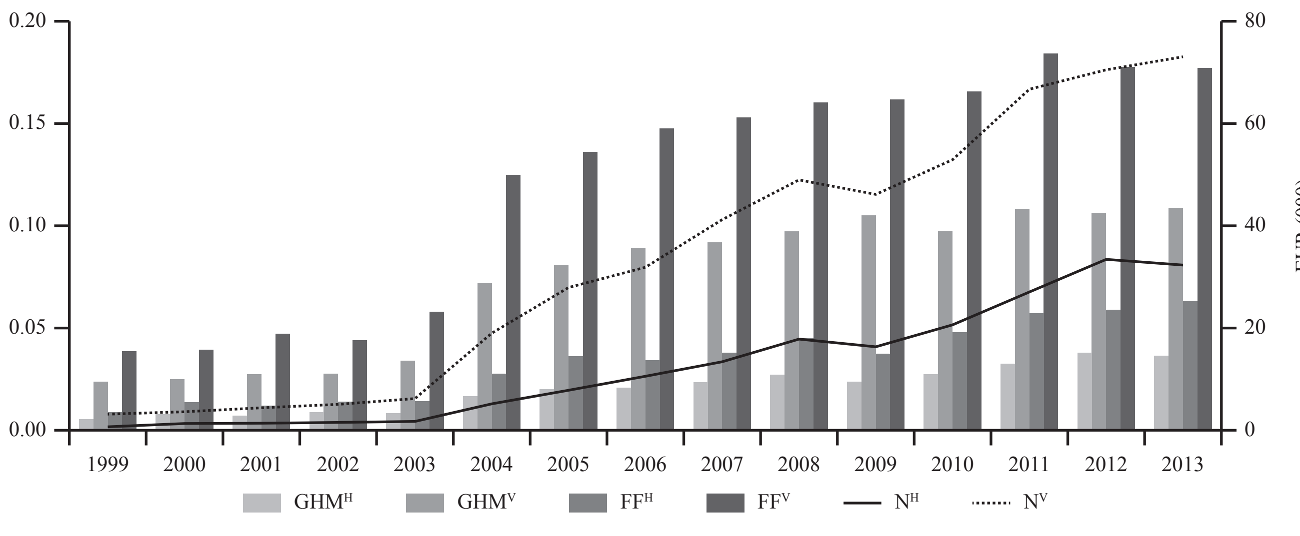

Figure 1: Horizontal and vertical intra-industry trade in agri-food products between the Visegrad countries and EU Member States over time in the period 1999-2013.
For abbreviations see Table 1. ^{H} = horizontal; ^{V} = vertical; N is measured on the right hand axis
Source: own calculations based on Eurostat data

usually associated with low prices and unit values, suggesting structural problems in agriculture (Ambroziak, 2012).

In short, IIT is mainly of a vertical nature in the agri-food trade of the Visegrad countries, suggesting the exchange of products of different quality. The share of IIT has increased significantly since the 2004 EU enlargement, though these countries are mainly exporting low quality agri-food products to EU-28 markets. However, it seems that the majority of agri-food trade has still remained one-way (or inter-industry) in nature, suggesting complementarity rather than competition in production (Fertő, 2007).

Hypotheses and econometric specifications

Based on the theoretical and empirical research to date, the following five hypotheses are tested in the article. Of these, the first two are related to country-specific, and the last three to industry-specific determinants of HIIT and VIIT.

H1. The difference in factor endowments between trading partners increases (decreases) the share of vertical (horizontal) IIT in total trade. The difference in factor endowments is usually measured by inequality in per capita GDP, in line with the model developed by Falvey and Kierzkowski (1987). Linder (1961) considers that countries with similar demands have similar products; consequently vertical-type trade increases with differences in relative factor endowments. Factor endowments are proxied by several variables. Firstly, the logarithm of absolute value of the difference in per capita GDP is used among each and every EU Member State (lnDGDPC), which is expected to be positively (negatively) related to the share of vertical (horizontal) IIT. Per capita GDP is measured in PPP in current international dollars and data come from the World Bank World Development Indicators database (hereafter 'WDI').

Secondly, however, the use of per capita GDP as a proxy for relative factor endowments is problematic. Linder (1961) already noted that inequality in per capita income may serve as a proxy for differences in preferences as suggested. In addition, Hummels and Levinsohn (1995) argued that this proxy is appropriate only when the number of factors is limited to two and all goods are traded, thus they proposed income per worker as a measure of differences in factor composition and also using actual factor data on capital-labour and land-labour ratios. Interestingly, despite these limitations in the use of GDP per capita, it has become a popular and dominating proxy for factor endowments in empirical literature. However, the nature of factor endowments may also play an important role in specialisation in quality ranges. Thus, it is necessary to use more variables to consider various aspects of factor endowments including physical, technological and human capital. The standard solution is to employ investment in physical capital, R&D expenditure and education expenditure (e.g. Milgram-Baleix and Moro-Egido, 2010).

As the article analyses agri-food trade patterns, agricultural-related relative factor endowment variables are used as proxies for factor endowments. More specifically, three traditional agricultural factors (land, labour and capital) are measured by the logarithm of absolute value of the difference in agricultural land, labour and machinery per capita (lnDLAND, lnDLAB, lnDMACH) among EU trading partners, which are expected to be positively (negatively) related to the share of vertical (horizontal) IIT. Agricultural land per capita is measured in hectares/person (data source: FAO), agricultural labour is measured in annual working units/person (data sources: Eurostat and FAO), while agricultural machinery is measured in EUR/person (data sources: FADN and FAO).

H2. IIT will be greater the closer the countries are geographically. The distance between countries well reflects transport costs. The closer the countries are, the cheaper trade is. Variable lnDIST indicates the geographic distance between the reporting country and each of its trading partners by calculating the logarithm of the distance between the capital cities of trading partners in kilometres. The source of data is the CEPII database. LnDIST is expected to be negatively related to HIIT and VIIT.

H3: Vertical product differentiation (VPD) encourages (discourages) VIIT (HIIT). It seems quite evident that high-quality products foster quality-based trade. Although previous studies (Greenaway *et al*. 1995; Crespo and Fontoura 2004; Ekanayake and Veeramacheneni 2009) show that a positive relationship exists between VIIT and VPD, Sun and Koo (2002) did not find any significant relationship for agri-food products. This hypothesis was constructed based on the theoretical models of Falvey and Kierzkowski (1987) and Shaked and Sutton (1987). VPD allows evaluating the remuneration to factors of production (K, L) as well as consumer preferences. The model of Falvey and Kierzkowski (1987) demonstrates that it is possible to use the assumptions of comparative advantage (HO theorem) to explain VIIT. Shaked and Sutton (1987) make reference to the different type of utility, that is, factors that explain why the choice of consumers for a given product in another function. The authors demonstrate that the permanence of companies in the market depends on consumer choice. VPD is measured by the percentage of employment in the agri-food industry. Data come from WDI. According to empirical studies (Crespo and Fontoura, 2004; Ekanayake and Veeramacheneni, 2009), a positive sign is expected for VIIT, and a negative for HIIT.

H4: Foreign direct investment has adverse effects on IIT. Multinational companies play an important role in IIT through their FDI activities. Investing in production facilities abroad encourages the exchange of different quality products, thereby contributing to IIT. However, the literature does not always support this argument. On the one hand, Yoshida (2009) analysed VIIT and FDI between Japan and the EU and found a positive relationship, but Török and Jámbor (2013) found a negative impact of FDI on VIIT. These data also come from WDI.

H5: Productivity is negatively related to both sides of IIT. This hypothesis considers that the most productive sectors have higher levels of product differentiation. Previous studies (Faustino and Leitão, 2007) suggest positive signs for high-quality products and negative for low-quality ones. As the previous section suggests, low-quality agri-food trade prevails in trade among EU-28 Member States; therefore, a negative sign is expected here. The productivity vari-

Table 3: Description of independent variables and related hypotheses.

Variable	Variable description	Data source	Expected sign	
			HIIT	VIIT
ln DGDPC	The logarithm of per capita GDP absolute difference between trading partners measured in PPP in current international dollars	WDI	-	+
ln DLAND	The logarithm of agricultural area/capita absolute difference between trading partners measured in hectares/person	FAO	-	+
ln DLAB	The logarithm of per capita agricultural labour absolute difference between trading partners measured in annual working units/person	Eurostat, FAO	-	+
ln DMACH	The logarithm of per capita agricultural machinery absolute difference between trading partners measured in euro/person	FADN, FAO	-	+
ln DIST	The logarithm of absolute difference between trading partners capital city measured in kilometres	CEPII	-	-
ln VPD	Percentage of employment in the agri-food industry by trade partner	World Bank	-	+
ln FDI	Foreign direct investment, net inflows	World Bank	+;-	+;-
ln PROD	Value added by the employer	World Bank	-	-

Source: own composition

able is explained in terms of remuneration of the factors of production. Productivity (PROD) is the value-added by the employer and the data source is again WDI.

The paper applies the gravity equation approach to analyse the determinants of HIIT and VIIT in the agri-food trade of the Visegrad countries with the EU in 1999-2013. Because the dependent variables range between zero and one, the logit transformation is employed, consistent with recent studies (Turkcan and Ates, 2010; Leitão, 2012). The model by Flam and Helpman (1987) is tested with the following specification (see also Table 3):

$$\begin{aligned} \ln IIT_{ijt} &= \alpha_0 + \alpha_1 \ln DGDPC_{ijt} + \alpha_2 \ln DLAND_{ijt} \\ &+ \alpha_3 \ln DLAB_{ijt} + \alpha_4 \ln DMACH_{ijt} + \alpha_5 \ln DIST_{ijt} \\ &+ \alpha_6 \ln VPD_{ijt} + \alpha_7 \ln FDI_{ijt} + \alpha_8 \ln PROD_{ijt} \\ &+ v_{ij} + \varepsilon_{ij} \end{aligned} \tag{8}$$

In estimating the determinants of IIT, this study applies the generalised method of moments (GMM) panel model elaborated by Blundell and Bond (1998) and used in the recent literature (Leitão, 2012; Jámbor, 2014). Although many other static panel data techniques are available in the literature including pooled OLS, fixed effects (FE) and random effects (RE), feasible generalised least squares (FGLS) and the panel-corrected standard errors (PCSE) method, they are criticised for many reasons. Firstly, these models ignore unobserved cross-country heterogeneity (Turkcan and Ates, 2010). Secondly, static panel data models are unable to manage heteroscedasticity and autocorrelation (Beck and Katz, 1995). Thirdly, Baltagi (2008) has shown that when endogeneity among the right-hand-side regressors matters, the OLS and random effects estimators are substantially biased and both yield misleading inferences. The problems of serial correlation and endogeneity were solved by Arellano and Bover (1995) and Blundell and Bond (1998) by developing the GMM system estimator. Moreover, the GMM estimator is efficient for panels with short time series (t) and large sample sizes (n) such as ours (Baltagi 2008). This research uses Windmeijer (2005) criteria.

Table 4: Panel unit root test results for the model variables.

Variable	Without time trend		With time trend	
	Adjusted *t* statistic	Probability	Adjusted *t* statistic	Probability
GHM^H	-15.1305	0.0000	-10.1100	0.0000
GHM^V	-6.0565	0.0000	-6.7999	0.0000
FF^H	-30.7285	0.0000	-25.4123	0.0000
FF^V	-6.5759	0.0000	-6.5155	0.0000
N^H	-4.8184	0.0000	-4.2295	0.0000
N^V	-6.0129	0.0000	-6.5821	0.0000
ln DGDPC	-0.2194	0.4132	-4.5973	0.0000
ln DLAND	118.2510	1.0000	135.5230	1.0000
ln DLAB	-7.8753	0.0000	-3.7726	0.0001
ln DMACH	-0.1006	0.4600	26.7738	1.0000
ln VPD	32.7392	1.0000	35.1338	1.0000
ln FDI	-8.7274	0.0000	-8.4576	0.0000
ln PROD	16.5270	1.0000	56.0169	1.0000

For abbreviations see Tables 1 and 3
Source: own calculations based on the method of Levin *et al*. (2002).

Results and discussion

Before estimating the panel regression models, the model variables are pre-tested for unit root tests. None of the IIT variables have unit roots, that is, are stationary with individual effects and individual specifications (Table 4).

By applying the GMM panel model to the sample, it is apparent that determinants of HIIT and VIIT differ as expected. In general, it is also observable that the three indices produce quite similar results (Table 5). As another general observation, lagged variables are positive and significant in all but one case, similarly to Faustino and Leitão (2007) and Leitão (2011), indicating that past performance plays an important role in present indices.

As to the country-specific determinants of IIT, the GMM model shows that lnDLAND and lnDIST are negatively related to both sides of IIT, while lnDMACH and labour are positively related. This suggests that the smaller the difference in agricultural land between the trading partners and the closer the countries are, the higher the possibility that IIT appears. However, it seems strange that countries closer to each other in terms of agricultural labour and capital allocation have a higher IIT index. It also seems evident from the results that GDP/capita differences well explain agri-food IIT patterns, just as expected. The results seem to be highly significant for the vast majority of the cases. The models present consistent estimates, with no serial correlation (AB1, AB2 statistics). The specification Sargan test shows that

Table 5: Determinants of intra-industry trade in the EU-28 agri-food sector.

Variable	Horizontal			Vertical		
	GHM	FF	N	GHM	FF	N
L1.IIT	0.1454***	-0.0032	0.1740***	0.2723***	0.2951***	0.2425***
ln DGDPC	0.0006***	-0.0008	0.0823***	-0.0025***	0.0002	-0.0472***
ln DLAND	-0.0014***	-0.0037***	-0.0584***	-0.0022***	-0.0054***	-0.0505***
ln DLAB	0.0056***	0.0046***	0.2139***	0.0096***	0.0200***	-0.1186***
ln DMACH	0.0010***	0.0020***	0.1063***	0.0032***	0.0059***	0.0884***
ln DIST	-0.0459***	-0.1319***	-0.9238***	-0.0424***	-0.0525***	-1.3483***
ln VPD	-0.0023***	-0.0036***	-0.5891***	-0.0107***	-0.0097***	-0.5259***
ln FDI	-0.0004***	-0.0005***	-0.1146***	-0.0017***	-0.0011***	-0.1304***
ln PROD	-0.0006***	-0.0004**	-0.0105***	-0.0010***	-0.0021***	-0.0721***
Constant	0.3081***	0.9388***	0.1118***	0.3348***	0.3720***	0.1807***
Observations	1568	1568	1568	1568	1568	1568
AB1 (p-value)	0.0003	0.0216	0.0000	0.0015	0.0000	0.0002
AB2 (p-value)	0.8472	0.7357	0.8815	0.1310	0.1786	0.7959
Sargan test (p-value)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

***/**/* statistically significant at the 1%, 5% and 10% levels respectively
For abbreviations see Tables 1 and 3
Source: own calculations based on Eurostat data

there are no problems with the validity of instruments used. The GMM system estimator is consistent if there is no second-order serial correlation in the residuals (AB2 statistics). The dynamic panel data are valid.

As to the industry-specific determinants, all variables analysed were found to be highly significantly and negatively related to both sides of IIT, which is somehow different than initially expected. Note again that the signs are similar for both sides. These results suggest that the product differentiation, interestingly, does not foster two-way trade of quality-differentiated goods. As to productivity, all model runs show a negative relationship with both sides of IIT, implying that low-quality product exports dominate EU-28 agri-food trade (see also Table 2). Furthermore, FDI was also found to have a negative relationship with IIT, suggesting that foreign capital does not foster IIT.

Our findings are similar to the majority of the literature (Fertő, 2005; Turkcan and Ates, 2010; Jámbor, 2014) who found a negative relationship between vertical IIT and GDP per capita differences. Similarly to studies on manufacturing sectors, the results do not support comparative advantage explanation of vertical IIT (Milgram-Baleix and Moro-Egido, 2010). Contrary to Fertő (2005) and Rasekhi and Shojaee (2012), agriculture-related variables are negative for most specifications. However, the results are similar to previous studies (e.g. Blanes and Martin, 2000; Jensen and Lüthje, 2009) showing that differences in land have a rather negative impact on vertical IIT. Moreover, proximity to markets still remains as one of the most important explanations for IIT specialisation (McCorriston and Sheldon, 1991). As to the results on industry-specific determinants, the negative sign on VPD is contrary to the majority of the empirical literature (Greenaway *et al*., 1995; Crespo and Fontoura, 2004; Ekanayake and Veeramachenenim, 2009), while the findings on productivity and FDI are more or less in line with the majority of the literature (Török and Jámbor, 2013; Fertő, 2015).

The first hypothesis of the article is rejected as GDP/capita and agriculture-related factor endowments are negatively related not only to HIIT, but also to VIIT in some cases, contrary to initial expectations. This suggests that similar factor endowments can lead to the trade of both homogenous and quality-differentiated agri-food products. Distance variables have expected signs and are significant in the majority of the cases, supporting hypothesis 2 and the classic gravity model stating that geographical proximity fosters agri-food trade. As to industry-specific determinants, hypothesis 3 is rejected on the basis that vertical production differentiation was found to be negatively related to both sides of IIT, while hypothesis 4 also does not hold as FDI was definitely found to have negative impacts on IIT. However, hypothesis 5 cannot be rejected as productivity was found to have a negative relationship with IIT.

Summary and conclusions

Country- and industry-specific determinants of HIIT and VIIT in agri-food products among the EU-28 in 1999-2013 were analysed and a number of conclusions were drawn. Firstly, that agri-food IIT is mainly of a vertical nature in the Visegrad countries, suggesting the exchange of products of different quality. The share of IIT has been increasing significantly since the 2004 EU enlargement, though the majority of these countries are exporting low quality agri-food products to the common market. However, it seems that the majority of agri-food trade of the Visegrad countries remains one-way (or inter-industry) in nature, suggesting complementarity rather than competition in production.

Secondly, by applying different specifications of panel data models, it was shown that factor endowments are mainly negatively related to both sides of IIT, suggesting that similar factor endowments can lead to trade of homogenous as well as quality-differentiated agri-food produce. Thirdly, the results show that distance and IIT are negatively related as is the common case in the classic gravity model, indicating that geographical proximity fosters agri-food trade (including HIIT and VIIT). Fourthly, product differentiation was found not to foster two-way trade of quality-differentiated goods. Fifthly, all model runs show a negative relationship between productivity and IIT, implying that low quality/value-added product exports dominate EU-28 agri-food trade. Finally, FDI was also found to have a negative relationship with IIT, suggesting that foreign capital does not foster IIT. Future research might generalise these results by extending the size of the sample in terms of involving more countries, more variables or different time horizons.

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