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## Contents



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# Foreword

Agricultural market developments are at the heart of policy debates, particularly since the onset of increasing food prices and short-term fluctuations of commodity prices. Since agricultural commodity prices peaked in 2007-2008, price volatility has continued to occur and 2011-12 saw comparably high levels of prices. These price increases and price volatility have contributed to insecurity in national and international markets. As the European Union (EU) is the biggest trader in agricultural products globally, both in terms of exports and imports, EU agriculture is clearly interrelated through trade with agriculture in the rest of the world, and influenced by global developments.

However, with the series of enlargements to the EU that have occurred over the years, especially with the accession from 2004 onwards of the post-socialist Member States, intra-EU trade also has an important place on the policy agenda. The EU represents a large, organised but highly competitive market and newly-accessing countries that had suffered from years of under-investment in their agricultural sectors have had to cope not just with competition within the EU but also in their domestic markets.

Beside commodity trade, markets for higher value-added agricultural and food products are developing, both in the EU and elsewhere, as actors in the agri-food value chain seek to enhance their profitability. Examples include organic production and products sold through short supply chains. Furthermore, more attention is being paid to quality attributes such as traceability.

The above topics provide the context for this thematic issue of *Studies in Agricultural Economics*.

Djokoto examines the variations in mean technical efficiency (MTE) estimates in organic agriculture by reviewing 42 studies constituting 109 observations published in the period 2002-2014. His results demonstrate wide fluctuations in MTE with a gentle declining trend, suggesting that there is a need to re-invigorate efforts to increase productivity of organic inputs. More responsive breeding stock and planting materials, alongside more diverse fertilising materials and crop production products are needed.

The first of two papers about Russia is authored by Belyaeva and Hockmann. It examines the grain production potential of 61 regions using a modified approach to stochastic frontier analysis that covers not only production technologies but also region-specific conditions. The authors present evidence that climate in combination with the levels of human and institutional development and infrastructure have a significant effect on the production structure of the region.

Using the historically large agrarian region of Voronezh *Oblast* as an example, Kharin investigates vertical price transmission along the whole milk supply chain for the period 2002-2014, taking into account seasonality. He demonstrates that price changes are not transmitted efficiently: a change in retail price has a significant effect on the farm gate price, but not vice versa. This shows that Russian retailers have more market power than farmers.

The next two papers deal with the topic of intra-industry trade (IIT) in agri-food products in the EU. The pattern and drivers of horizontal IIT and relative factor endowments between 1999 and 2010 are analysed by Fertő. He concludes that the standard IIT theory finds some support in the data when the sum of capital-labour ratios instead of relative country-size variables is controlled in the estimating equations.

Jámbor analyses country- and industry-specific determinants of horizontal and vertical IIT in the four Visegrad countries (Czech Republic, Hungary, Poland and Slovak Republic). Factor endowments and distance are mainly negatively related to IIT, while product differentiation is not found 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.

Information asymmetry, bounded rationality and behavioural uncertainty have given rise to incomplete contracts, especially in the agricultural sectors of most developing economies. The moderating effect of traceability is therefore proposed by Kang'ethe W. Gachukia to reduce these uncertainties and is as such a form of assurance to promote both a holistic approach in compliance with standards and a seamless mechanism for product and process integration.

Finally, Szabó and Juhász conducted a consumer and producer survey of direct and short supply chain markets in Hungary. Vendors are found to overestimate their service level above that of the customers' experiences which means that they do not have an accurate understanding of their customers' requirements. There is also a big deficiency between the services expected by customers and those experienced at markets.

The dynamic development of agricultural markets makes this a subject that always merits new research. Hence, I hope that this special issue of *Studies in Agricultural Economics* represents a useful contribution to our pool of knowledge.

**Andrew Fieldsend**
Budapest, July 2015

**Justice G. DJOKOTO***

# Technical efficiency of organic agriculture: a quantitative review

This article examines the variations in mean technical efficiency estimates in organic agriculture and the factors that explain the observed variations. A three-stage process was employed in data collection. Firstly, journals on organic agriculture and related disciplines were identified and searched. Secondly, several publishers' websites and databases, namely Cambridge Journals, Elsevier, Emerald, Oxford University Press, Sage, Taylor and Francis, and Wiley, among others, were covered. Databases included AgEcon Search, CAB Abstracts, DOAJ, EBSCOhost, Google Scholar and ScienceDirect. Thirdly, the reference lists of studies found in the first and second stages were searched to identify additional literature. In all, 42 studies constituting 109 observations published in the period 2002-2014 were found. Unlike existing literature on technical efficiency quantitative reviews in agriculture, this article employs a battery of tests to select the appropriate solution for multiple observations from the same primary study, as well as the appropriate functional form for the selected fractional regression model. The mean technical efficiency of organic agriculture for the period of study and the effects of other study characteristics are thoroughly discussed.

**Keywords:** fractional regression, meta-regression, organic agriculture, quantitative review, technical efficiency

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## Introduction

Organic agriculture (OA) seeks to combine tradition, innovation and science to benefit the environment and promote fair relationships and a good quality of life for all involved. This production system is intended to sustain the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions rather than the use of chemical inputs that can have adverse effects (IFOAM, 2015).

Ramesh *et al.* (2005) noted that the benefits of OA to the developed nations include environmental protection, biodiversity enhancement, reduced energy use and $CO_2$ emissions. These have been enhanced by providing aid payments to organic farmers and premiums for organic products. For developing countries which are largely exporters of organic products, the benefits of OA lie in sustainable resource use, increased crop yields without over-reliance on costly external inputs, and environment and biodiversity protection. For these countries in particular, depletion and degradation of land and water resources pose serious challenges to the production of sufficient food and other agricultural products to sustain livelihoods and meet the needs of urban populations. Studies that focus on OA are therefore relevant because agriculture has a substantial impact on natural resources that must be better managed to supply sustainable ecosystem services, particularly in the light of climate change (Lakner *et al.*, 2012).

Although OA is a common practice in many areas of the developing world, certification of OA is relatively recent (Bouagnimbeck, 2013; Paull, 2013a, b). Certified OA is underpinned by the principles of health, ecology, fairness and care (IFOAM, no date). Certification bodies evaluate operations according to different organic standards and can be formally recognised by more than one authoritative body. The label of a given certification body, therefore, informs the consumer of the type of recognition granted to the certification body. There are other categories of standards such as international voluntary standards, national mandatory standards and local voluntary standards (FAO, 2015).

Organics certification generally predates the 1972 founding of IFOAM, the International Foundation for Organic Agriculture (Paull, 2010). In Australia, for example, there has been active and structured advocacy of OA since 1944 but organics certification only started in 1987 (Paull, 2008; 2013a). Certification is based on a pledge by certified farmers (operators) to comply with standards which are produced and enforced by both private institutions and governments and which originate mostly in developed countries (Latruffe and Nauges, 2014). The UK Soil Association has its own standards although Council Regulation 2092/91 of the European Union (EU) is in force in the EU. Countries such as Australia, Canada, Japan and the USA have their national standards (Mayen *et al*. 2009). Given the many standards, there are certainly some differences; nevertheless, these standards recognise the organic principles. For the purpose of this study, organic practices are recognised so long as they are certified by a national or international organic certifying body.

The OA applicant usually completes a questionnaire at the start of the certification process. Where the land has been cultivated, applicants are granted in-conversion status. When this period (usually between two and five years, depending on the crop or livestock) elapses, full organic status may be granted. After the first inspection, there is an annual inspection to ensure compliance. Farmers are expected to ensure that farm facilities and production methods conform to the standards, and maintain extensive records detailing the farm history and current set-up. Keeping written day-to-day farming and marketing records covering all activities (which must be available for inspection at any time) forms an integral part of OA. A written annual production plan would usually be submitted.

The difference between the observed output and what is attainable is technical efficiency (TE) (Farrell, 1957). TE and productivity of agriculture are fundamental for food security and poverty reduction (POST, 2006). The increase in TE provides an opportunity for farmers to increase output using the same level of resources (Beltrán-Esteve and Reig-Martínez, 2014). This has led to a plethora of studies in agricultural efficiency. Studies focusing on conventional agriculture (CA) have demonstrated variations in mean technical effi-

ciency (MTE) (the sample's average) over time (Thiam *et al.,* 2001; Bravo-Ureta *et al.,* 2007; Ogundari and Brummer, 2011; Ogundari, 2014). Additionally, study attributes such as methodology, product and location have explained the observed differences. Therefore, some questions come to the fore in respect of OA. Firstly, how has MTE in OA varied over time? Secondly, what factors explain the variations in reported MTE in OA? Thirdly, do these factors influence MTE of OA similarly as CA?

Since a single study will not resolve a major issue in science, meta-analysis provides an effective alternative for assessing the generalisability of research in science (Hunter and Schmidt, 1990). Thiam *et al.* (2001), Bravo-Ureta *et al*. (2007), Moreira Lopez and Bravo-Ureta (2009), Ogundari and Brümmer (2011), Iliyasu *et al*. (2014) and Ogundari (2014) conducted meta-regression on TE in agriculture which focused on CA. However, this article assesses the variations in reported MTE in OA. It also investigates the roles of other factors in explaining the variations in reported MTE and identifies the similarities and differences in the effect of these factors on MTE of OA.

Only Ogundari (2014) used a fractional regression model (FRM) and selected the logit functional form without any statistical test as Papke and Wooldrige (1996) did. In this article, batteries of tests were employed to select the appropriate functional form for the selected FRM. The contribution of multiple observations from the same primary study to the metadata set in meta-regression is a common occurrence with its associated biases to the metadata set. Ogundari (2014) used sample weighted regression (WR) *a priori*. In this article, a solution was chosen based upon a set of statistical tests such as the goodness-of-functional form tests (Ramalho *et al*., 2010; 2011).

# Methodology

## Meta-analysis

Pooling together these studies for further investigation constitutes meta-analysis. Quantitative review allows researchers to combine results of several homogenous studies into a unified analysis that provides an overall estimate of interest for further discussion (Sterne, 2009). A general model for carrying out meta-analysis is to relate a key (dependent) variable to some characteristics that are believed to explain that variable (Alston *et al*., 2000). With reference to the present study, MTE from the primary study is considered as the dependent variable, while study attributes; methodological characteristics, product and regional groups, and publishing outlet and quality are taken as explanatory variables. In accomplishing TE meta-analysis, various MTEs are extracted from the studies reviewed. The corresponding study characteristics are identified and the resulting metadata set is fitted to a model. Multiple observations on MTE reported in a study constitute observations; otherwise, each primary study constitutes one observation.

## Data

To gather data, firstly, journals on organic and related disciplines were identified and searched. Secondly, various publishers' websites and databases, namely Cambridge Journals, Elsevier, Emerald, Oxford University Press, Sage, Taylor and Francis, and Wiley, among others, were covered. Databases included AgEcon Search, CAB Abstracts, DOAJ, EBSCOhost, Google Scholar and ScienceDirect. Thirdly, the reference list of studies found in the first and second stages was searched to identify additional literature. In all, 42 studies constituting 109 observations covering the period 2002-2014 were found (Table 1).

**Table 1:** Literature from which metadata were extracted.

| Author(s) and year | MTE | Product | Year | Country |
|---|---|---|---|---|
| Alkahtani and Elhendy (2012) | 0.650 | Date palm | 2010 | SAU |
| Alkahtani and Elhendy (2012) | 0.470 | Date palm | 2010 | SAU |
| Arandia and Aldanondo-Ochoa (2008) | 0.140 | Vineyard | 2001 | ESP |
| Arandia and Aldanondo-Ochoa (2008) | 0.138 | Vineyard | 2001 | ESP |
| Arandia and Aldanondo-Ochoa (2008) | 0.140 | Vineyard | 2001 | ESP |
| Arandia and Aldanondo-Ochoa (2008) | 0.136 | Vineyard | 2001 | ESP |
| Artukoglu *et al.* (2010) | 0.677 | Olive | 2008 | TUR |
| Artukoglu *et al.* (2010) | 0.748 | Olive | 2008 | TUR |
| Bayramoglu and Gundogmus (2008) | 0.852 | Raisin | 2004 | TUR |
| Beltrán-Esteve and Reig-Martínez (2014) | 0.656 | Citrus | 2009 | ESP |
| Beltrán-Esteve and Reig-Martínez (2014) | 0.607 | Citrus | 2009 | ESP |
| Breustedt *et al.* (2009) | 0.965 | Dairy | 2005 | GER |
| Breustedt *et al.* (2009) | 0.833 | Dairy | 2005 | GER |
| Charyulu and Biswas (2010) | 0.737 | Multiple crops | 2010 | IND |
| Charyulu and Biswas (2010) | 0.667 | Multiple crops | 2010 | IND |
| Chen *et al.* (2012) | 0.982 | Rice | 2006 | CHN |
| Chen *et al.* (2012) | 0.999 | Rice | 2006 | CHN |
| Chen *et al.* (2012) | 0.892 | Rice | 2006 | CHN |
| Chen *et al.* (2012) | 0.983 | Rice | 2006 | CHN |
| Cisilino and Madau (2007) | 0.422 | Crops and livestock | 2003 | ITA |
| Cisilino and Madau (2007) | 0.543 | Crops and livestock | 2003 | ITA |
| Elhendy and Alkahtani (2013) | 0.135 | Date palm | 2010 | SAU |
| Elhendy and Alkahtani (2013) | 0.543 | Date palm | 2010 | SAU |
| González (2011) | 0.327 | Crops and livestock | 2005 | NIC |
| González (2011) | 0.433 | Crops and livestock | 2005 | NIC |
| Guesmi *et al.* (2012) | 0.796 | Grapes | 2008 | ESP |
| Guesmi *et al.* (2014) | 0.975 | Cereals and horticulture | 2010 | EGY |
| Jayasinghe and Toyoda (2004) | 0.450 | Tea | 2002 | LKA |
| Karagiannias *et al.* (2006) | 0.809 | Dairy | 2002 | AUT |
| Karagiannias *et al.* (2012) | 0.783 | Dairy | 1997 | AUT |
| Karagiannias *et al.* (2012) | 0.808 | Dairy | 1998 | AUT |
| Karagiannias *et al.* (2012) | 0.788 | Dairy | 1999 | AUT |
| Karagiannias *et al.* (2012) | 0.794 | Dairy | 2000 | AUT |

| Author(s) and year | MTE | Product | Year | Country |
|---|---|---|---|---|
| Karagiannias *et al.* (2012) | 0.770 | Dairy | 2001 | AUT |
| Karagiannias *et al.* (2012) | 0.756 | Dairy | 2002 | AUT |
| Kramol *et al.* (2015) | 0.416 | Vegetables | 2008 | THA |
| Kramol *et al.* (2015) | 0.220 | Vegetables | 2008 | THA |
| Kumbhakar *et al.* (2009) | 0.796 | Dairy | 1998 | FIN |
| Kumbhakar *et al.* (2009) | 0.798 | Dairy | 1998 | FIN |
| Kumbhakar *et al.* (2009) | 0.759 | Dairy | 1998 | FIN |
| Lakner (2009) | 0.640 | Dairy | 2005 | GER |
| Lakner *et al.* (2012) | 0.740 | Grass | 2005 | GER |
| Lakner *et al.* (2014) | 0.825 | Crops and livestock | 2006 | CHE |
| Lakner *et al.* (2014) | 0.772 | Crops and livestock | 2006 | AUT |
| Lakner *et al.* (2014) | 0.847 | Crops and livestock | 2006 | GER |
| Lakner *et al.* (2014) | 0.579 | Crops and livestock | 2006 | CHE |
| Lakner *et al.* (2014) | 0.532 | Crops and livestock | 2006 | AUT |
| Lakner *et al.* (2014) | 0.564 | Crops and livestock | 2006 | GER |
| Larsen and Foster (2005) | 0.440 | Multiple crops | 2002 | SWE |
| Latruffe and Nauges (2014) | 0.850 | Cereals and oil seeds | 2006 | FRA |
| Latruffe and Nauges (2014) | 0.790 | Other field crops | 2006 | FRA |
| Latruffe and Nauges (2014) | 0.800 | Fruits and vegetables | 2006 | FRA |
| Latruffe and Nauges (2014) | 0.850 | Horticulture | 2006 | FRA |
| Latruffe and Nauges (2014) | 0.720 | Wine with origin | 2006 | FRA |
| Latruffe and Nauges (2014) | 0.630 | Fruits and vegetables | 2006 | FRA |
| Latruffe and Nauges (2014) | 0.750 | Permanent crops | 2006 | FRA |
| Latruffe and Nauges (2014) | 0.900 | Multiple crops | 2006 | FRA |
| Lohr and Park (2006) | 0.713 | Multiple crops | 1997 | USA |
| Lohr and Park (2006) | 0.722 | Multiple crops | 1997 | USA |
| Lohr and Park (2006) | 0.789 | Multiple crops | 1997 | USA |
| Lohr and Park (2006) | 0.847 | Multiple crops | 1997 | USA |
| Lohr and Park (2006) | 0.660 | Multiple crops | 1997 | USA |
| Lohr and Park (2007) | 0.787 | Multiple crops | 1997 | USA |
| Lohr and Park (2007) | 0.856 | Multiple crops | 1997 | USA |
| Lohr and Park (2007) | 0.805 | Multiple crops | 1997 | USA |
| Lohr and Park (2007) | 0.812 | Multiple crops | 1997 | USA |
| Lohr and Park (2007) | 0.801 | Multiple crops | 1997 | USA |
| Lohr and Park (2007) | 0.764 | Multiple crops | 1997 | USA |
| Lohr and Park (2010) | 0.581 | Multiple crops | 1997 | USA |
| Lohr and Park (2010) | 0.588 | Multiple crops | 1997 | USA |
| Lohr and Park (2010) | 0.592 | Multiple crops | 1997 | USA |
| Lohr and Park (2010) | 0.560 | Multiple crops | 1997 | USA |
| Madau (2007) | 0.831 | Multiple crops | 2002 | ITA |
| Mayen *et al.* (2010) | 0.817 | Dairy | 2005 | USA |
| Mayen *et al.* (2010) | 0.770 | Dairy | 2005 | USA |
| Nastis *et al.* (2012) | 0.420 | Alfalfa | 2008 | GRC |
| Nastis *et al.* (2012) | 0.540 | Alfalfa | 2008 | GRC |
| Onumah *et al.* (2013) | 0.800 | Cocoa | 2011 | GHA |
| Onumah *et al.* (2013) | 0.590 | Cocoa | 2011 | GHA |
| Oude Lansink *et al.* (2002) | 0.910 | Multiple crops | 1997 | FIN |
| Oude Lansink *et al.* (2002) | 0.860 | Multiple crops | 1997 | FIN |
| Oude Lansink *et al.* (2002) | 0.880 | Livestock | 1997 | FIN |
| Oude Lansink *et al.* (2002) | 0.930 | Livestock | 1997 | FIN |
| Park and Lohr (2010) | 0.716 | Multiple crops | 2008 | USA |
| Park and Lohr (2010) | 0.727 | Multiple crops | 2008 | USA |
| Park and Lohr (2010) | 0.725 | Multiple crops | 2008 | USA |
| Park and Lohr (2010) | 0.735 | Multiple crops | 2008 | USA |
| Pechrová and Vlašicová (2013) | 0.790 | Cereals and oil seeds | 2008 | CZE |
| Poudel *et al.* (2011) | 0.890 | Coffee | 2010 | NPL |
| Serra and Goodwin (2009) | 0.940 | Cereals and oil seeds | 2002 | ESP |
| Sipiläinen *et al.* (2008) | 0.658 | Multiple crops | 1996 | FIN |
| Sipiläinen *et al.* (2008) | 0.664 | Multiple crops | 1997 | FIN |
| Sipiläinen *et al.* (2008) | 0.697 | Multiple crops | 1998 | FIN |
| Sipiläinen *et al.* (2008) | 0.598 | Multiple crops | 1994 | FIN |
| Sipiläinen *et al.* (2008) | 0.646 | Multiple crops | 1999 | FIN |
| Sipiläinen *et al.* (2008) | 0.651 | Multiple crops | 2000 | FIN |
| Sipiläinen *et al.* (2008) | 0.690 | Multiple crops | 2001 | FIN |
| Sipiläinen *et al.* (2008) | 0.631 | Multiple crops | 2002 | FIN |
| Sipiläinen *et al.* (2008) | 0.654 | Multiple crops | 1995 | FIN |
| Songsrirote and Singhapreecha (2007) | 0.866 | Multiple crops | 2006 | THA |
| Tiedemann and Latacz-Lohmann (2013) | 0.928 | Multiple crops | 2007 | GER |
| Toro-Mujica *et al.* (2011) | 0.660 | Sheep | 2008 | ESP |
| Tzouvelekas *et al.* (2001a) | 0.716 | Olive | 1996 | GRC |
| Tzouvelekas *et al.* (2001b) | 0.691 | Olive | 1996 | GRC |
| Tzouvelekas *et al.* (2002a) | 0.683 | Olive | 1996 | GRC |
| Tzouvelekas *et al.* (2002a) | 0.746 | Cotton | 1996 | GRC |
| Tzouvelekas *et al.* (2002a) | 0.760 | Raisin | 1996 | GRC |
| Tzouvelekas *et al.* (2002a) | 0.680 | Grapes | 1996 | GRC |
| Tzouvelekas *et al.* (2002b) | 0.845 | Wheat | 1999 | GRC |

## Model

Consider

$$y=f(x) \quad (1)$$

where $y$ is MTE and $x$ is vector of covariates;

*ORGONLY, ORGMEAT, DATAYEAR, DATASIZE, SFA, DEA, CS, CD, TL, TERMS, CRS, VRS, CAOS, OFC, FAV, NEH, PC, MC, DAIRY, LIVESTOCK, NAMERICA, CAMERICA, ASIA, EUROPEM, SCAND, JOURNAL, IF*

Models for TE meta-analysis have quite a number of dummy variables constituting the total number of variables: Thiam *et al*. (2001), 10 out of 13; Bravo-Ureta *et al*. (2007), 12 out of 13; Ogundari and Brummer (2011), 10 out of 14; Ogundari (2014), 14 out of 17. These references are evidence of the importance of dummy variables in TE meta-analysis models. Dummy variables are useful in capturing factors that determine the study-to-study variation in the MTE (Nelson and Kennedy, 2009). Therefore, the multiplicity of dummy variables in the TE meta-analysis model specified above and described below is relevant. Fears of not obtaining robust estimates may be attenuated by the battery of tests employed in the model selection to be described shortly. The statistical insignificance of dummies may have research and policy implications. Thus, the high number of predictors, 27, used in the estimation model is important and represents one of the highest in agricultural TE meta-analysis.

The output-oriented MTE which is the dependent variable is defined as the simple average of the computed technical efficiencies of primary studies. *ORGONLY* represents studies that considered only organic data as opposed those that used organic and conventional sub-samples. *ORGONLY* took 1 and 0 otherwise. The coefficient of this variable may

be positive or negative. *ORGMETA* represents studies that used metafrontier production function. *ORGMETA* is 1 and 0 otherwise. Since metafrontiers are farther from the group or primary frontier, the coefficient of *ORGMETA* is hypothesised to be negatively signed.

Year of data (*DATAYEAR*) refers to the year in which the data were collected in the case of cross-sectional data. For panel and time series data, the terminal year was used to represent year of data. However, where the MTE reported pertains to a specific year, that was taken as the *DATAYEAR*. It is anticipated that with time technology will improve, therefore the coefficient of *DATAYEAR* should be positively signed. *DATASIZE* is the number of observations in the primary study. Increased sample size generally produces more efficient estimates. This efficient estimate may not necessarily be high or low. Thus, the sign of the coefficient for *DATASIZE* may be positive or negative. *SFA* represents stochastic frontier estimation: *SFA* = 1 and 0 otherwise (*DEA*, distance functions). DEA stands for the non-parametric approach Data Envelopment Analysis. This dummy takes the value 1 for DEA and 0 otherwise (SFA and distance functions). Owing to the nature of the error term, the coefficient of the variable SFA should be positively signed. Data type (CS) represents cross-sectional data. *CS* = 1 and 0 otherwise (panel data). Moreira Lopez and Bravo-Ureta (2009) and Ogundari (2014) reported conflicting results on the sign of the coefficient of this variable. Thus, the sign of the coefficient may be negative or positive.

Functional forms employed in the estimations of TE in the primary study were observed to be Cobb-Douglas (CD), translog (TL) and non-functional forms. *CD* = 1 and 0 otherwise (translog; *TL* and non-functional forms). Also, *TL* = 1 and 0 otherwise (non-functional forms and *CD*). Bravo-Ureta *et al*. (2007) and Moreira Lopez and Bravo-Ureta (2009) have shown that MTE computed from *CD* functions are higher than those from *TL*. Thus the coefficient of *CD* is hypothesised to be positive. The number of explanatory variables in the TE estimation model of the primary study is *TERMS*. Since TE is estimated as part of the residual from production functions (not in the case of DEA), an increased number of *TERMS* should improve the fit of the model thereby reducing the residual. This would likely result in lower TE, hence MTE. Therefore, the coefficient of *TERMS* is hypothesised to be negative. Returns-to-scale may be constant (*CRS*) or variable (*VRS*): *CRS* = 1 for CRS, and 0 otherwise; *VRS* = 1 for VRS and 0 otherwise. The reference is studies that reported MTE of *CRS* and *VRS* plus distance functions or unspecified RTS. *CRS* and *VRS* were captured for only DEA, and hence the dummies are equal to 0 in the case of other methods to calculate efficiency. Nevertheless, how these variables are expected to influence *MTE* is unclear; thus, no *a priori* expectations have been formulated for them.

The studies found during the literature search contained several products and product groups. These have been classified into groups such as cereals, oil seeds and protein seeds *(CAOS)*; other field crops (*OFC*); fruits and vegetables (*FAV*); horticultural crops (*NEH*); permanent crops (*PC*); multiple crops (*MC*); dairy (*DAIRY*); livestock (non-dairy) (*LIVESTOCK*). One dummy for each of these products was specified. The reference category was mixed products (livestock and crops). Owing to the categorisations, the influence of these on *MTE* is unclear and therefore no *a priori* signs were formulated.

Studies included in the metadata covered diverse geographical areas. *NAMERICA* represented North America, *CAMERICA* represented Central America, *EUROPEM* represented mainland Europe and *SCAND* was used to capture Scandinavian countries. The control group was Africa. Owing to different geographical influences, the sign of the coefficients could not be stated *a priori.*

The method of dissemination of studies was considered. The dummy *JOURNALS* is set to 1 for academic journals, and 0 otherwise (conference papers, working papers among others). Finally, the quality of outlet, measured by the ISI impact factor (*IF*) was considered. The 2013 IF was used as proxy for journal quality. Where the dissemination outlet did not have an impact factor, that study was given *IF* of zero and those with impact factors had *IF* with a numerical index. Since journal quality relates more to the reliability of results than size of statistic, the sign of the coefficient *IF* may be positive or negative.

## Estimation procedure

Ordinary least squares (OLS) and Tobit procedures are commonly used in TE meta-regression. With OLS, many predicted values would fall outside the unit interval. Although the Tobit procedure ensures that the predicted values lie within the unit interval, a censored data generation process (DGP) is assumed contrary to the fractional DGP for technical efficiency. Appropriately, fractional regression model (FRM) is employed in this article and specified as:

$$E(y \mid x) = G(x\theta) \tag{2}$$

where $y$ is the dependent variable (MTE) and $x$ are variables of the nature descried above. The conditional expected mean of $y$ given $x$ is $E(y \mid x)$. $G(\cdot)$ is some nonlinear function satisfying $0 \leq G(\cdot) \leq 1$ and $\theta$ is a vector of parameters to be estimated.

Papke and Wooldridge (1996) proposed logit and probit, respectively specified as:

logit:

$$G(x\theta) = \frac{e^{x\theta}}{1 + e^{x\theta}} \tag{3.1}$$

with partial effect;

$$\frac{\partial E(y \mid x)}{\partial x_i} = \theta_i \phi(x\theta)[1 - G(x\theta)] \tag{3.2}$$

and probit:

$$G(x\theta) = \Phi(x\theta) \tag{4.1}$$

with partial effect;

$$\frac{\partial E(y \mid x)}{\partial x_i} = \theta_i \phi(x\theta) \tag{4.2}$$

However, Ramalho *et al*. (2010, 2011) noted that, the logit and probit are most sensitive to covariates when the

mean of TEs (of DEA in particular) are around 0.5. What if that was not the case? They then showed that the other two models behaved differently:
loglog:

$$G(x\theta) = e^{-e^{-x\theta}} \tag{5.1}$$

with partial effect:

$$\frac{\partial E(y \mid x)}{\partial x_i} = \theta_j g(x\theta)\alpha G(x\theta)^{\alpha - i} \tag{5.2}$$

and cloglog:

$$G(x\theta) = 1 - e^{e^{x\theta}} \tag{6.1}$$

with partial effect:

$$\frac{\partial E(y \mid x)}{\partial x_i} = \theta_j g(x\theta)\alpha[1 - G(x\theta)^{\alpha - i}] \tag{6.2}$$

Indeed, failure to test the latter two could result in mis-specification. Following from these, all four functional forms were estimated.

### Tests and model selection

In the absence of *a priori* theoretical formulation of the appropriate functional form for the FRM, statistical methods of selection offer a viable alternative. Also, the second objective of meta-analysis is to identify the determinants of variability in MTE and this study seeks to achieve this. Furthermore, Papke and Wooldridge (1996) and Ogundari (2014) used logit functional form without justification *save* that this is commonly used. Since MTE meta-regression models could well follow functional forms other than logit, selection from a number of model specifications is an appropriate econometric exercise.

This selection was accomplished by three tests: Ramsey RESET test, goodness-of-functional form tests (GOFF-1 and GOFF-2) and non-nested *P* test (Davidson and MacKinnon, 1981). The RESET test examines the presence of mis-specification in the model. Unlike the usual hypothesis test, the RESET, GOFF1 and GOFF2 tests note that the model is free of mis-specification if the null hypothesis cannot be rejected. The goodness-of-functional form tests, test for how well the data fit the functional form specified[1]. It is possible that more than one model would be selected by the RESET and goodness-of-functional form tests. Therefore, the *P* test provides an opportunity for one-on-one tests using the selected models from the first two stages as alternative hypotheses.

Some studies contributed more than one observation to the metadata set. Espey *et al*. (1997) noted this could bias standard errors and hence invalidate hypothesis tests. Their solution to the problem requires limiting multiple observations from the same study to five. Stanley (2008) proposed averaging these multiple observations to one. These recommendations would further limit the organic TE metadata set. An approach that keeps all multiple observations from a study in the metadata set is weighted regression (WR). Ogundari (2014) weighted the MTE by the sample size of the primary study. Perhaps a better weighting approach is to weight the MTE by the number of observations contributed by each primary study to the metadata. Jarrell and Stanley (1990) employed dummy variables to control for the number of data points contributed by primary studies to the metadata. This and the WR approaches were implemented to address the bias identified by Espey *et al*. (1997). The models from these two approaches were subjected to the tests described above. Further, robust standard errors were computed. Despite the barrage of estimations and tests, these were necessary to arrive at a reliable model to be discussed.

[1] See Ramalho *et al*. (2010) for details on type 1 and type 2 GOFF tests; formulation, testing and distributional assumptions.

## Results and discussion

### Summary statistics

The studies composing the metadata are almost equally split between *SFA* models on one the hand and *DEA* and distance function models on the other hand (Table 2). The metadata are composed of 74 MTEs obtained from organic-only studies, five of which were computed with respect to a metafrontier. The use of cross-sectional data (CS) was popular among researchers of OA technical efficiency. This may have arisen from the ease and lower cost of collection, unlike

**Table 2:** Summary statistics of dummy measured variables.

| | | Number | Percentage |
|---|---|---|---|
| Nature of study | *ORGONLY* | 35 | 32.1 |
| | Comparative | 74 | 67.9 |
| Method of comparison | *ORGMETA* | 5 | 4.6 |
| | Non-frontier approach | 104 | 95.4 |
| Model | *SFA* | 59 | 54.1 |
| | *DEA* | 40 | 36.7 |
| | *DF* | 10 | 9.2 |
| Data structure | *CS* | 79 | 72.5 |
| | *PL* | 30 | 27.5 |
| Functional form | *CD* | 23 | 21.1 |
| | *TL* | 45 | 41.3 |
| | Non-functional | 41 | 37.6 |
| Returns-to-scale | *CRS* | 10 | 9.2 |
| | *VRS* | 19 | 17.4 |
| | SFA and DDF, unspecified | 80 | 73.4 |
| Products | *CAOS* | 11 | 10.1 |
| | *OFC* | 3 | 2.8 |
| | *FAV* | 13 | 11.9 |
| | *NEH* | 3 | 2.8 |
| | *PC* | 11 | 10.1 |
| | *MC* | 37 | 33.9 |
| | *DAIRY* | 15 | 13.8 |
| | *LIVESTOCK* | 3 | 2.6 |
| | *CROPS* and *LIVESTOCK* | 13 | 11.9 |
| Country | *NAMERICA* | 21 | 19.3 |
| | *CAMERICA* | 2 | 1.8 |
| | *ASIA* | 18 | 16.5 |
| | *EUROPEM* | 48 | 44.0 |
| | *SCAND* | 17 | 15.6 |
| | AFRICA | 3 | 2.8 |
| Publication outlet | *JOURNAL* | 68 | 62.4 |
| | Others | 41 | 37.6 |

Source: own composition

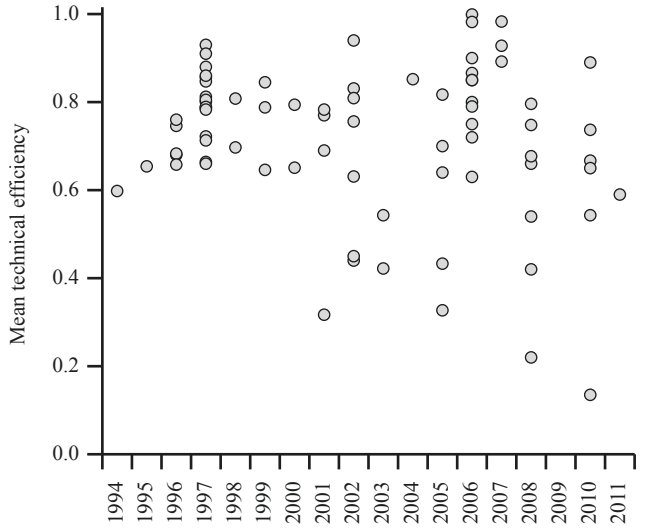


**Figure 1:** Global organic mean technical efficiency time path (1994-2011).
Source: metadata

panel data. The largest share of observations corresponded to MC farming type. About 60 per cent of the metadata was contributed from studies in Europe (EUROPEM and SCAND).

The time path of the MTE shows that MTE rose from 1994 (0.598) to 1997 (0.859) (Figure 1). MTE witnessed wide fluctuations with a gentle declining trend.

The average MTE (AMTE) of 0.696 (Table 3) implies organic producers could on average increase output by about 30 per cent without any increase in input use. Both the simple AMTE and the weighted AMTE (0.685) are within the range of 0.680 and 0.784 found for previous studies. The earliest data employed in the studies were collected in 1994, close to the latest data year of 1997 for Thiam *et al*. (2001). This is a reflection of the relatively recent nature of certified OA (Paull, 2008, 2013). For the 34 observations extracted from journals with an ISI 2013 impact factor, the lowest impact factor was 0.33 with a peak of 3.19 (Table 3). It must be noted however that the impact factors are related to different disciplines and not all studies had an ISI impact factor.

## Choice of multiple observation amelioration approach

The RESET test was statistically significant for all functional forms for the sample size-weighted and multiple observation controlled models, implying mis-specification and therefore unsuitable for further use in this article (data not shown). At least one functional form could not be rejected by the RESET test (Table 4). Thus, the number of observations-weighted approach is preferred to the other two.

## Model selection

From Table 4, all functional forms are mis-specified except the logit functional form. Similarly, at least one of the GOFF tests, GOFF2 showed that the logit functional form is well fitted to the data. Since only the logit passes both RESET and GOFF2 tests, there is no need for comparison with any other functional form.

**Table 3:** Summary statistics of scale measured variables.

| | MTE | *DATASIZE* | *TERMS* | *DATAYEAR* | *IF* |
|---|---|---|---|---|---|
| N | 109 | 109 | 109 | 109 | 109 |
| Minimum | 0.135 | 18 | 2 | 1994 | 0.33 |
| Maximum | 0.999 | 1717 | 40 | 2011 | 3.19 |
| Simple mean | 0.696 | 176 | 10 | 2003 | 1.60 |
| Weighted mean | 0.685 | - | - | - | - |
| Standard deviation | 0.190 | 227 | 9.00 | 4.90 | 0.90 |

Source: own composition

**Table 4:** Specification tests of number of observations-weighted regression estimation.

| | Logit | Probit | Loglog | Cloglog |
|---|---|---|---|---|
| RESET† | 2.579 | 3.458* | 6.510** | 4.164** |
| GOFF1† | 3.212* | 3.263* | - | 4.401** |
| GOFF2 | 2.558 | 3.651* | 6.919*** | - |
| P-test | | | | |
| $H_{1Logit}$ | - | 4.041** | 10.479*** | 0.399 |
| $H_{1Probit}$ | 3.166* | - | 9.314*** | 0.508 |
| $H_{1Loglog}$ | 0.012 | 2.078 | - | 0.045 |
| $H_{1Cloglog}$ | 5.340** | 6.662*** | 13.564*** | - |

***,**,* represent levels of significance of 1%, 5% and 10% respectively;
† $H_1$: model is mis-specified
Source: own composition

## Discussion of selected estimated model

The selected logit model produced an $R^2$ type measure of 0.670 implying the explanatory variables accounted for about 67 per cent of the variability in the MTE (Table 5). The residual degree of freedom of 82 arose from the 27 explanatory variables. In the literature, Ogundari (2014) employed the highest number of explanatory variables in TE meta-regression in agriculture, 17. The 27 explanatory variables therefore constitute a departure from previous studies. The statistical insignificance of the constant term may have arisen from the high number of explanatory variables employed, suggesting the adequacy of the explanatory variables employed in the model. The explanatory variables can be categorised into four groups: methodological, products, region and dissemination. Except the dissemination, at least two coefficients and marginal effects are statistically significant. Despite the numerous variables, no correlation coefficient above 0.6 was found.

Despite the declining trend of MTE over time (Figure 1), the parameters of *DATAYEAR* are positive and statistically insignificant. The recognition of other factors that influence MTE may have caused a change of sign from a negative to positive. The statistically insignificant parameters imply MTE for OA have not increased significantly over the period. The finding of a non-increasing MTE over time for organic agriculture is not different from the earlier conclusions of Thiam *et al*. (2001) and Iliyasu *et al*. (2014) for CA. Indeed, in the literature, multi-country meta-analysis of TE has shown either stagnation or decline in MTE over time. Since an individual country study (Ogundari and Brummer, 2011) has shown a positive change in MTE over time, the effect of good performers in TE may have been masked by those of poor performers.

While studies using organic data only constituted 32 per cent of the metadata set, the positive and statistically signifi-

**Table 5:** Selected logit estimation results.

| | Coeffi-cients | Robust SE | Marginal effects | |
|---|---|---|---|---|
| | | | dy/dx | Delta method SE |
| DATAYEAR | 0.096 | 0.075 | 0.016 | 0.012 |
| ORGONLY | 0.997*** | 0.438 | 0.163*** | 0.069 |
| ORGMETA | -0.286 | 0.334 | -0.047 | 0.055 |
| DATASIZE | 0.001 | 0.001 | 0.000 | 0.000 |
| SFA | 1.908*** | 0.693 | 0.312*** | 0.114 |
| DEA | -2.814** | 1.122 | -0.460** | 0.181 |
| CS | 1.263*** | 0.462 | 0.207*** | 0.072 |
| CD | -3.577*** | 0.542 | -0.585*** | 0.088 |
| TL | -4.059*** | 0.871 | -0.663*** | 0.138 |
| TERMS | -0.006 | 0.018 | -0.001 | 0.003 |
| CRS | -0.848*** | 0.283 | -0.139*** | 0.046 |
| VRS | -1.033** | 0.411 | -0.169** | 0.068 |
| CAOS | -0.578 | 0.526 | -0.094 | 0.086 |
| OFC | -0.244 | 0.739 | -0.040 | 0.121 |
| FAV | 1.507*** | -0.535 | -0.246*** | 0.087 |
| NEH | 1.840** | -0.709 | 0.301** | -0.114 |
| PC | -1.079** | 0.505 | -0.176** | 0.081 |
| MC | -0.567* | 0.324 | -0.093* | 0.053 |
| DAIRY | -0.085 | 0.494 | -0.014 | 0.081 |
| LIVESTOCK | -0.394 | 0.787 | -0.064 | 0.128 |
| NAMERICA | -1.435* | 0.850 | -0.235* | 0.139 |
| CAMERICA | -3.085*** | 0.696 | -0.504*** | 0.108 |
| ASIA | 0.568 | 0.484 | 0.093 | 0.079 |
| EUROPEM | 0.119 | 0.692 | 0.019 | 0.113 |
| SCAND | 0.250 | 1.135 | 0.041 | 0.185 |
| JOURNAL | 0.569 | 0.375 | 0.093 | 0.061 |
| IF | -0.006 | 0.107 | -0.001 | 0.018 |
| CONSTANT | -190.9 | 150.7 | - | - |
| Model properties | | | | |
| R2-type measure | 0.669 | | | |
| No. of observations | 109 | | | |
| Residual d.f. | 82 | | | |
| Deviance | 12.1 | | | |

***,**,* represent levels of significance of 1%, 5% and 10% respectively
Source: own composition

cant coefficient and marginal effect show that these studies produced higher MTE than those that used both organic and conventional data (Tables 2 and 5). It must be noted that the latter contains MTEs that are measured with respect to the meta-frontier, which is farther from the group frontier thus, producing lower values of MTE. Although the magnitude of the coefficient and marginal effect of *ORGMETA* are not statistically different from zero, the negative sign of the parameter confirms this explanation. The statistical insignificance also implies that differences between the two sets of MTEs are statistically immaterial.

The infinitesimal value of the parameters of *DATASIZE* suggests little influence of this variable on MTE. Moreover, the parameters are statistically insignificant. Thus, controlling for the other 26 explanatory variables, the observed differences in size of study sample did not influence MTE. Since certified OA is recent and the certification process constitutes a barrier that prevents farmers from signing-on, fewer farmers participate, unlike conventional production. Therefore smaller numbers of farmers and consequently small samples for studies would result. The resulting sample sizes, although seemingly adequate, did not influence the size of the MTE. For conventional studies, the conclusions of Thiam *et al*. (2001) and Bravo-Ureta *et al*. (2007) are consistent with the finding of this study while those of Moreira Lopez and Bravo-Ueta (2009) and Ogundari and Brummer (2011) are not.

The estimated parameters of *SFA* imply MTE estimated from stochastic frontier models are higher than those estimated from DEA and distance functions. Also, for *DEA*, MTE estimated from *DEA* are lower than those from distance functions. The result found for DEA vs. SFA is intuitive. Theoretically, the error term in *SFA* is composed such that not all the error in the *SFA* model is attributable to TE, and hence TE calculated with SFA does not capture noise and thus is always higher than TE calculated with DEA. Iliyasu *et al*. (2014), however, found a negative sign for the *SFA* variable while Thiam *et al*. (2001) showed a statistically insignificant parameter. Following from the results of the *SFA* and *DEA*, MTEs from distance functions are higher than those of *DEA* but lower than those of *SFA*. This result is enlightening as none of the previous studies considered distance functions as variables except Ogundari (2014), who combined distance functions and non-functional forms with translog and Cobb-Douglas functions but found no statistical difference between these.

The statistically significant parameters of *CS* imply that MTE estimated from cross-sectional data are higher than those estimated from panel data. Cross-sectional data captures TE at a point in time. On the other hand, panel data represent both point-in-time and point-over-time situations. Thus, at points in time, TEs estimated may be increasing. However, other factors in the model and related to panel data studies may have created a negative pressure over time within the panel environment thereby resulting in a lower MTE for panel data MTEs. While this finding is consistent with the theoretical assertion of Greene (1993), Thiam *et al*. (2001), Bravo-Ureta *et al*. (2007) and Moreira Lopez and Bravo-Ureta (2009) found the opposite. No reasons were however assigned for the departure from the theoretical position. Ogundari (2014), however, reported a parameter statistically not different from zero. The multi-dimensional representation of panel data requires disentangling the effect of the two dimensions in arriving at appropriate conclusions. Also, the cost of gathering this is higher than for cross-sectional data. These points notwithstanding, the choice of data structure should be informed by the objectives of the study.

The negatively signed coefficients of *CD* and *TL* imply that the reference, *DEA* and distance functions produce higher MTEs. It must be recalled that together *DEA* and distance functions constitute the reference category. Since *DEA* MTEs were earlier found to be lower than SFA, the MTEs of distance functions certainly have overshadowed the effect of MTEs from *DEA* to produce this finding. While previous studies showed MTE from translog are higher than those from Cobb-Douglas functions (Bravo-Ureta, 2007; Moreira Lopez and Bravo-Ureta, 2009), recent studies provide contrary evidence, that is, translog functional forms generate lower MTEs than MTEs estimated from Cobb-Douglas functions (Iliyasu *et al*., 2014; Ogundari, 2014). Since Ogundari (2014) used a logit fractional regression model, his conclusions corroborate that of this study. This shows another similarity in the results from conventional and organic data estimations.

By construction, the *TL* has more than twice the number of terms of *CD*. Thus, the negative sign of *TERMS* is consistent with the negative sign of *TL*. Therefore, for organic studies there is a tendency for estimation models with a high number of terms to yield lower estimates of TE. Researchers should therefore be mindful of decisions on inclusion of explanatory variables in the production function. This finding for OA differs from those of CA.

The coefficients of *CRS* and *VRS* are negative and statistically significant. These results are expected as the sign of *DEA* was earlier found to be negative. In line with the explanation for *DEA*, MTE estimated with both reported *CRS* and *VRS* are lower than those of unreported *CRS*, *VRS*, *SFA* and distance functions. Since the reference group includes *DEA* MTEs for which the returns-to-scale have not been reported, the concordance of the signs of *DEA* and *VRS* cum *CRS* parameters implies that the MTEs from unreported returns-to-scale similarly follow the behaviour of *DEA* MTEs with reported returns-to-scale. Since the sizes of the marginal effects are similar, it is most likely that their effects via magnitudes will be similar. Thus, for the organic metadata used in this study, in as much as the choice of returns-to-scale in estimating technical efficiency in *DEA* environment influences MTE, these effects of *CRS* and *VRS* on MTE are similar. These results bring up some important points. Firstly, to a limited extent, the behaviour of *VRS* and *CRS DEA* towards MTE may be generalised even if returns-to-scale is unknown. Secondly, there is no apparent difference in the effect of *CRS* and *VRS* on MTE. These results on returns-to-scale are rare since none of the previous studies reported the effect of returns-to-scale on MTE. Although the results follow the direction of *DEA*, it provides empirical evidence, at least for this organic metadata, that *CRS* and *VRS* models influence MTE in a similar fashion.

The coefficients of all product groups are negatively signed implying that, generally, there is the tendency that MTE of these organic product groups are lower than those of the reference group, crops and livestock. The statistical significance of *MC*, although weak, shows the general high risk associated with crop farming. The statistical significance of the parameters of these variables suggests the relatively risky nature of these products.

The parameters of *DAIRY* and *LIVESTOCK* are statistically insignificant from zero, signifying statistical parity in the MTEs of these product groups with those of the control. Since some of the crop products groups have statistically significant negative parameters, there is a tacit pointer to the seemingly strong positive influence of livestock and related products on MTE. The greater MTE of crops and livestock combination is particularly instructive. The finding of Ponisio *et al*. (2015) that agricultural diversification within the organic system significantly reduced yield gaps between organic and conventional production suggests that organic producers should consider agricultural diversification. These findings are inconsistent with some previous studies on conventional agriculture. However, Bravo-Ureta *et al.* (2007) showed that for both developed and developing countries, animal production enterprises posted higher MTE, while Thiam *et al.* (2001) found a neutral effect of products on MTE.

The results for *CAMERICA* and *NAMERICA* imply MTE of organic production in these regions are lower than those in Africa. Thus differences in climatic conditions may explain the differences in MTE. However, production practices for specific products captured for countries (regions) in the metadata may be important. Certified organic production is certainly more developed in the US than in Africa. However, as noted by Paull (2008; 2013a, b), uncertified organic production predates recent certifications. In Ghana for example, many cocoa farmers have relied on no-chemical production for so long and are essentially *de facto* organic producers (Afari-Sefa *et al*., 2010). Thus, application of certified organic practices should not be that difficult to implement. The literature on CA has shown that largely Africa has produced lower MTEs compared to other regions, especially North America and Europe.

The statistical insignificance of the parameters of *JOURNAL* implies indifference between MTEs from studies published in journals and those in sources other than journals. These points to statistical parity in estimated MTE of organic agricultural operations. The finding of this study is however inconsistent with that of Ogundari (2014) who showed that studies published as journal articles showed higher MTE than those presented in working papers, conference proceedings and theses. Organic agriculture MTEs are indistinguishable based on the quality of journals in which it is published. Unlike publishing outlet, the findings of organic agriculture are consistent with those of conventional agriculture (Ogundari, 2014).

## Conclusions

The study examined the variations in MTE estimates in organic agriculture and the factors that explain the observed variations using fractional regression modelling. The metadata consisting of 42 studies and 109 observations revealed TE, on average, which did not increase over time. The non-increasing MTE over time implies efforts to develop OA have not reflected positively on global MTE on average. Generally, there is a need to re-invigorate efforts to increase productivity of organic inputs. Specifically, further improvements in more responsive breeding stock and planting materials, increased availability and use of more diverse fertilising materials and crop protection products would be needed. While stakeholders' support is important in this direction for crops in particular, special attention should be given to fruits and vegetables, other horticultural crops and permanent crops.

The numbers of factors that account for variability in the MTEs vary for OA compared to CA while in some cases they influence MTEs in similar fashion. To further elucidate the findings of this article, more individual country TE meta-analyses in agriculture and specifically for OA and those that assess the role of distance functions and returns-to-scale on MTE would be useful. While policy makers may discriminate between journal and other sources on the one hand and between 'quality' journals and 'non-quality' journals on the other, the results for technical efficiency are unlikely to be different since MTEs from studies published in journals and those in sources other than journals do not differ statistically.

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**Maria BELYAEVA* and Heinrich HOCKMANN***

# Impact of regional diversity on production potential: an example of Russia

Russia is often considered the most prominent country to become a leader on the world grain market. However, several issues slow down Russia's agricultural progress, for example: a lack of infrastructure and investments, unequal regional development and inefficient use of production technologies. This study therefore examines the grain production potential of Russian regions by employing a modified approach to stochastic frontier analysis that allows us to include not only production technologies, but also indicators of the country's heterogeneity and diversity among regions. The results obtained indicate that climate conditions in combination with the level of human and institutional development, and infrastructure have significant effects on the production structure of regions and therefore should not be neglected while assessing regional policies and production potential.

**Keywords:** technical efficiency, stochastic frontier analysis, heterogeneity, production potential

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## Introduction

For many years the question of the development of Russian agriculture has been a matter of great concern for economists and politicians. Underdeveloped and old infrastructure, combined with large unoccupied territories, always prevented successful performance of agricultural markets in Russia and slowed down not only growth rates of agricultural product exports, but also the transition of the country towards a more developed economy. We therefore aim to estimate the performance of Russia, as one of the most controversial examples of a transition economy, on the world agricultural market. One of the approaches of evaluating the performance of the country on the global market is to measure the country's production potential. Therefore, the objective of this research is to estimate the agricultural production potential of Russia on the regional level, taking into account that all regions are heterogeneous in their development, determined by availability of infrastructure, development of institutions and climate conditions.

The analysis of the efficiency of agricultural production in transition economies has been a popular research topic in the last twenty years, especially focusing on Russia because of its production potential and vast resources. Previous research primarily concentrated on the measurement of farm-level efficiency (e.g. Bokusheva and Hockmann, 2006; Osborne and Trueblood, 2006). However, given the size of the country, as well as the disparity of the country's development together with climate zones and soil quality, it becomes more reasonable to conduct the analysis on the regional level, thus estimating the production potential of the whole country rather than of each separate region.

In fact, there are several studies that focus on estimating the efficiency of production at a regional level (Arnade and Gopinath, 2000; Sedik *et al*., 1999; Sotnikov, 1998). These studies pay attention to changes in technical efficiency of Russian agricultural production during the years of transition. For instance, Sotnikov (1998) reported an increase in technical efficiency in the early 1990s, followed by a decline in efficiency scores in the period 1993-95. The author concluded that an increase in technical efficiency took place primarily due to the efficient use of inputs, together with significant technical changes, while a following decrease in efficiency resulted from state price controls and government subsidies. These results are in line with the findings of Sedik *et al*. (1999), who, in addition, explained the decreasing technical efficiency scores in the period 1993-95 by price changes for agricultural inputs as well as by subsidising the most inefficient farms. Furthermore, from their findings, the authors concluded the more specialised a region is in a particular crop, the more efficient is the production in this region, i.e. that specialisation leads to efficiency.

Arnade and Gopinath (2000) estimated production functions by measuring financial efficiency in addition to technical efficiency. They indicated that only six out of 73 examined Russian regions have achieved technical efficiency, while 19 regions were experiencing financial efficiency in the period 1994-95. Potential reasons for such inefficiency scores could be inefficient terms of trade, as concluded in previous studies, as well as unstable weather conditions, unsuitable for agricultural production. Arnade and Trueblood (2002) confirmed the common finding that the efficiency of farms tends to be responsive to input prices, and find a prevalence of technical and allocative efficiencies in Russian agricultural production.

Based on regional level data, Osborne and Trueblood (2006) noted a decreasing pattern of technical and allocative efficiency scores in the period 1993-98. Voigt and Hockmann (2008) observed a considerable decrease in the original possibilities of production in this period, and indicated a positive development and restructuring of the sector only starting from 2003. In addition, the authors found evidence of different technologies of production across regions due to diversity of regional development. Bokusheva *et al*. (2011) found a decreasing trend in regional efficiency until 2000, followed by steady improvement afterwards. Based on calculations of total factor productivity, the authors found heterogeneity of the economic and institutional environment across the country. This is the crucial finding that has been outlined in almost all studies mentioned above: production in Russia is being influenced by other factors rather than by efficient (or inefficient) use of production inputs. Therefore, the current study aims to measure the production potential of

 

Russian agriculture and identify factors that determine the heterogeneity of the country and, thus, influence the productivity of the agricultural sector. We distinguish three indicators that could serve as proxies for factors that determine heterogeneous development of the country, namely: level of human development, level of infrastructural development, and climate and soil conditions.

This study is organised as follows. The next section describes the theoretical approach used in the research and gives a/the methodological concept of the model. Then we describe the data used and provide the empirical model. The results obtained are then presented, together with discussion and proofs regarding the validity of the model. The final section concludes the paper by presenting a brief review of the methodology and results obtained.

## Theoretical approach and methodology

Conventional stochastic frontier theory implies that farms (or regions) are inefficient rather than influenced by institutional, economic and climatic factors. Therefore, inefficiency scores are estimated assuming that all producers have access to homogeneous technology. However, this assumption cannot be the case while estimating production potential on the regional level (especially on the regional level of Russia, where the size of the country simply cannot allow for this kind of assumption). Therefore, choosing an incorrect model will most probably result in overestimated efficiency scores, while factors that influence potentially the most will be left without attention. Moreover, with appearance of more advanced technologies and more experienced workers, production is more likely to be efficient and therefore the heterogeneity of regions becomes the factor that could have a negative impact on the production of the country.

The current study assumes that production is defined by particular characteristics of regions. These characteristics indicate the level of regional development and influence the implementation of production technologies. Among such characteristics we can include the level of economic and social development; system of transport and infrastructure; and climate and soil conditions and their suitability for agricultural production.

We develop the theoretical model based on the stochastic frontier for panel data framework, following the approach proposed by Álvarez *et al*. (2003) and further developed by Álvarez *et al*. (2004). We assume that the production function can take the form of the output distance function, and apply the homogeneity property to transform the function in order to estimate multiple outputs.

The homogeneity property of the output distance function (Kumbhakar and Knox Lovell, 2003) states that:

$$D^o(x,\lambda y) = \lambda D^o(x,y) \quad f\ or\ \lambda > 0 \tag{1}$$

In the multiple output framework distance function is described as $D^o(x, y_1, y_2, \ldots, y_N)$. Assuming that $1/y_1 = \lambda$ we can apply homogeneity property (1) to the distance function to get:

$$D^o\left(x, \frac{y_1}{y_1}, \frac{y_2}{y_1}, \ldots, \frac{y_N}{y_1}\right) = 1/y_1 D^o(x, y_1, y_2, \ldots, y_N) \tag{2}$$

Transforming equation (2) in the logarithmic form leads to:

$$\ln D^o\left(x, \frac{y_1}{y_1}, \frac{y_2}{y_1}, \ldots, \frac{y_N}{y_1}\right) = \ln\left(\frac{1}{y_1} D^o(x, y_1, y_2, \ldots, y_N)\right) = -\ln y_1 + \ln D^o(x,y) \tag{3}$$

Following the specification above, we can describe the production as follows:

$$1/y_{it}^{act} = f(x,y,\beta)h(z,x) \tag{4}$$

where $y$ is the vector of agricultural outputs, $x$ is the vector of production inputs, $z$ is the vector of heterogeneity indicators. Function $h(\cdot)$ captures the effect of specific time invariant conditions and production technologies on production possibilities through the turn of the marginal product curves and the shift of the production frontier. We expect that the production function is monotonically increasing in the heterogeneity effect, assuming that a higher value of the heterogeneity indicator increases production possibilities.

The stochastic production frontier in the translog form can be therefore expressed as:

$$\begin{aligned} &\ln f(x, y_{it}^{opt}) = \beta_0 + \beta_t t + \beta_y \ln y_{it} + \beta_{yt} t \ln y_{it} + \beta_x \ln x_{it} + \\ &\beta_{xt} t \ln x_{it} + \tfrac{1}{2}\beta_{yy} \ln y_{it} \ln y_{it} + \tfrac{1}{2}\beta_{xx} \ln x_{it} \ln x_{it} + \\ &\beta_{yx} \ln y_{it} \ln x_{it} + (\alpha_0 + \alpha_t t + \alpha_x \ln x_{it})(y_0^{opt} + y_z^{opt} z) \\ &\forall i = 1,2,\ldots,N;\ t = 1,\ldots,T \end{aligned} \tag{5}$$

where superscript *opt* denotes values of the parameters at the frontier, i.e. optimal production and conditions for production.

However, regions usually are not capable of exploring their production possibilities at full capacity. Therefore, we assume that only $y_{it}^{act} (y_{it}^{act} \leq y_{it}^{opt})$ is being produced with the technology described by the following production function:

$$\begin{aligned} &-\ln y_{it}^{act} = \beta_0 + \beta_t t + \beta_y \ln y_{it} + \beta_{yt} t \ln y_{it} + \beta_x \ln x_{it} + \\ &\beta_{xt} t \ln x_{it} + \tfrac{1}{2}\beta_{yy} \ln y_{it} \ln y_{it} + \tfrac{1}{2}\beta_{xx} \ln x_{it} \ln x_{it} + \\ &\beta_{yx} \ln y_{it} \ln x_{it} + (\alpha_0 + \alpha_t t + \alpha_x \ln x_{it})(y_0^{opt} + y_z^{opt} z) \\ &\forall i = 1,2,\ldots,N;\ t = 1,\ldots,T \end{aligned} \tag{6}$$

Applying the same technique to the multiple output production function we can calculate technical efficiency as:

$$\begin{aligned} &\ln TE_{it} = -\ln y_{it}^{act} - \ln f(x, y_{it}^{opt}) = \\ &(\alpha_0 + \alpha_t t + \alpha_x \ln x_{it})(y_0^{*} + y_z^{*} z) \end{aligned} \tag{7}$$

where $y_0^* = y_0^{opt} - y_0^{act}$ and $y_z^* = y_z^{opt} - y_z^{act}$.

Because technical inefficiency is equal to the negative of technical efficiency we can get the following production function, expressed by the technical inefficiency term:

$$-\ln y_{it}^{act} = \ln f(x, y_{it}^{opt}) - \ln TE = \ln f(x, y_{it}^{opt}) + u \tag{8}$$

**Table 1:** Main characteristics of Russian regional production: agricultural inputs and outputs, 1995-2011.

| Variable | Notation | Unit | Mean | SD | Min | Max | Growth rate, 1995-2011 (%) | Average annual growth rate (%) |
|---|---|---|---|---|---|---|---|---|
| Gross harvest of grain | $y_1$ | 1000 tonnes | 11,649 | 16,247 | 57 | 116,344 | 50.9 | 2.45 |
| Gross animal production | $y_2$ | RUR million | 5,738 | 4,531 | 158 | 29,389 | 1.1 | 0.06 |
| Gross crop production (excluding grain) | $y_3$ | RUR million | 3,023 | 2,711 | 76 | 19,220 | -22.8 | -1.51 |
| Labour | $x_1$ | 1000 workers | 106 | 85 | 4 | 485 | -20.4 | -1.33 |
| Land | $x_2$ | 1000 hectares | 1,258 | 1,265 | 20 | 5,833 | -24.3 | -1.62 |
| Capital | $x_3$ | RUR billion | 14,610 | 20,918 | 66 | 180,623 | -68.3 | -6.53 |
| Variable inputs | $x_4$ | RUR million | 4,800 | 4,422 | 19 | 25,599 | -41.9 | -3.15 |

Source: Rosstat, own calculations

**Table 2:** Average indices by federal district of the determinants of heterogeneity in Russia.

| Federal district | Climate index | Human development index | Transport and infrastructure index |
|---|---|---|---|
| Central | 0.572 | 0.353 | 0.465 |
| North-West | 0.623 | 0.295 | 0.494 |
| South | 0.663 | 0.351 | 0.238 |
| Volga | 0.482 | 0.386 | 0.283 |
| Ural | 0.391 | 0.436 | 0.217 |
| Siberia | 0.335 | 0.341 | 0.102 |
| Far East | 0.356 | 0.262 | 0.113 |

Source: authors' calculations

Therefore, the final specification of the production function with heterogeneity effect can be written as:

$$\begin{aligned} -\ln y_{it}^{act} = {} & \beta_0 + \beta_t t + \beta_y \ln y_{it} + \beta_{yt} t \ln y_{it} + \beta_x \ln x_{it} + \\ & \beta_{xt} t \ln x_{it} + \tfrac{1}{2}\beta_{yy} \ln y_{it} \ln y_{it} + \tfrac{1}{2}\beta_{xx} \ln x_{it} \ln x_{it} + \\ & (\alpha_0 + \alpha_t t + \alpha_x \ln x_{it})(y_0^{opt} + y_z^{opt} z) - \\ & (\alpha_0 + \alpha_t t + \alpha_x \ln x_{it})(y_0^{*} + y_z^{*} z) \end{aligned} \quad (9)$$

In order to obtain unbiased estimators of the model above we impose a set of restrictions, designed to guarantee standard properties of the production function, i.e. convexity in outputs and quasi-convexity in inputs (Coelli *et al*., 1998).

## Data and empirical model

The data used in the empirical analysis consist of a balanced panel of 61 Russian regions which were involved in grain production. The study had intentionally to exclude several regions whose data caused validity concerns and therefore could have significantly distorted the estimation results. The data come from statistical publications of the Russian Federation Federal State Statistics Service (Rosstat) and cover the period 1995-2011. Summary statistics of the main production characteristics of the country are presented in Table 1. In general, there is no clear specialisation of regions according to the type of agricultural production. Since in the majority of regions the dominant type of farm is the large cooperative (or agroholding), production tends to be combined in order for a farm to maintain self-sufficiency.

The group of variables used in the analysis consists of output and input vectors. The output vector is defined by gross harvest of grain as the dependent variable and by gross animal production and production of other crops as the independent variable. The vector of inputs consists of the amount of land used in crop production, the number of workers involved in agricultural production, and the amounts of capital and variable inputs used in agriculture. Capital is defined as the net value of agricultural capital, and variable input costs are measured as the difference between gross agricultural production and gross regional agricultural product.

Our study focuses on identifying sources and measuring the country's heterogeneity determinants. Thus, we firstly define factors that could determine the degree of a region's development, its social and economic environment, and its climate. For this purpose we used three indices:

- Climate index ($z_1$) is set to identify the level of climate and soil conditions. It is calculated as a cumulative mean of average temperature and precipitation in each region.
- Stable economic and social development is presented by the index of human development ($z_2$), defined following the methodology introduced by UNDP (UNDP, 1990) and further developed by Klugman *et al*. (2011). It is calculated as a geometric mean of three normalised indicators of achievements of populations: life expectancy at birth, gross regional income per person and number of children enrolled in school each year[1].
- As a proxy for transport system we used a normalised index of the density of railways in each region ($z_3$). This is not a perfect indicator of transport development since there exist several regions with no railway connection at all, but unavailability of data prevents us from using a more precise indicator.

These indices combined serve as an aid in determining the level of differences across regions within Russia. Table 2 shows the distribution of average indices' values across federal districts[2] and Figure 1 illustrates the share of agricultural

[1] Lately, it has been recommended to use expected years of schooling as a more precise measure of education dimension, but lack of data limits the possibility to calculate desired indicators.

[2] Federal districts in Russia present groups of federal subjects (*oblasts*, republics, *krais*, cities of federal importance, autonomous *oblasts* and autonomous *okrugs*). Hereinafter for the sake of simplicity we refer to federal subjects of Russia as regions.


**Figure 1:** Agricultural production in Russia, share of agricultural production in gross regional product, 2011.
Source: Rosstat, authors' interpretation

production in gross regional product of federal districts. The climate index shows that districts located in the European part of the country (Central, North-West and South federal districts) on average tend to have better conditions for agriculture than those located beyond the Ural Mountains. Moreover, federal districts with high density of railways are those located in the European part of the country, where the density of the population is high as well. The highest level of human development occurs in regions located in the Ural federal district that connects the Asian and European parts of Russia and is considered to be the main mining district in the country.

Following the available data and the model specification, we can present the equation to be estimated as follows:

$$\begin{aligned} -\ln y_{1it}^{act} &= \beta_0 + \beta_t t + \beta_y \ln y_{it} + \beta_{yt} t \ln y_{it} + \beta_x \ln x_{it} + \\ &\beta_{xt} t \ln x_{it} + \tfrac{1}{2}\beta_{yy} \ln y_{it} \ln y_{it} + \tfrac{1}{2}\beta_{xx} \ln x_{it} \ln x_{it} + \\ &(\alpha_0 + \alpha_t t + \alpha_x \ln x)(y_0^{opt} + y_z^{opt} z) - u_{it} + v_{it} \end{aligned} \quad (10)$$

where $y_{1it}^{act}$ is the actual gross production of grain, $y_{it} = (y_{2it}, y_{3it})$, with $y_{2it}$ being the gross animal production and $y_{3it}$ the gross production of other crops. We define the vector of inputs as $x_{it} = (x_{1it}, x_{2it}, x_{3it}, x_{4it})$, where $x_{1it}$ is the labour input, $x_{2it}$ is the land input, and $x_{3it}$ and $x_{4it}$ are the capital and material inputs respectively. The time trend variable $t$ permits neutral technical change at a constant rate, allowing the shift of the frontier. Potential sources of heterogeneity are defined as $z = (z_1, z_2, z_3)$, with $z_1$ denoting the climate index, $z_2$ the index of human development, and $z_3$ the index of infrastructure and transport. The usual two-sided error term is denoted as $v_{it}$, while $u_{it}$ is defined as the negative of $\ln TE_{it}$ (see equation 7). We employ constrained maximum likelihood techniques to obtain consistent estimates of $\beta$, $\alpha$ and $\gamma$, and impose convexity restrictions for outputs and quasi-convexity for inputs, following Morey (1986).

## Results

The results of the estimation of the stochastic cost frontier by constrained maximum likelihood are presented in Table 3. All the explanatory variables were normalised by their geometric mean, thus allowing us to interpret their first order coefficients as cost elasticities. Therefore, the function is increasing in output and is decreasing in input levels. In addition, owing to the functional form and normalisation, parameters of output variables indicate the share of each type of output in agricultural output. Our results suggest that agricultural output in the country consists 50 per cent of animal output, 22 per cent of production of other crops and 28 per cent of grain production. According to the official statistical data, on average, animal production accounts for 51 per cent of total agricultural production, with grain production contributing 28 per cent and production of other crops 21 per cent, therefore making the results of our estimation valid.

The estimates of the production function indicate the importance of production factors for agricultural production, specifically for grain production. Inputs elasticities sum up to 90 per cent, suggesting the existence of increasing returns to scale. The highest elasticity is observed for variable inputs (0.40). It indicates the close connection between materials and production without other factors that could potentially contribute to the production.

Therefore, reduction in the use of materials (fertilisers and other variable inputs) would considerably reduce gross production of agricultural goods. Moreover, land has an elasticity of 0.21, indicating that production is becoming more material-intensive rather than land-intensive. That is not surprising, taking into account a considerable decrease of land input during the observed period, which coincided with a significant increase in agricultural production. The estimated elasticities of labour and capital are slightly less intense but still statistically significant, with indicators of 0.16 and 0.13 respectively. The relatively low elasticity of labour with respect to materials and land indicate the decreasing importance of labour in agricultural production and its replacement with technological advancements. In fact, the coefficient of the correlation between technical change and labour is negative, suggesting the introduction of labour-saving technologies.

**Table 3:** Constrained maximum likelihood parameter estimates of the stochastic cost frontier.

| Parameter | Estimate | Standard error | t-ratio |
|---|---|---|---|
| $\beta_o$ | 0.026 | 0.010 | 2.680 |
| Technical change | | | |
| $\beta_t$ | -0.032 | 0.003 | -10.376 |
| $\beta_{tt}$ | 0.012 | 0.000 | 28.164 |
| Output effects | | | |
| $\beta_{y_2}$ | 0.500 | 0.016 | 30.401 |
| $\beta_{y_3}$ | 0.220 | 0.008 | 27.071 |
| $\beta_{y_2t}$ | -0.020 | 0.004 | -4.906 |
| $\beta_{y_3t}$ | 0.015 | 0.004 | 4.189 |
| $\beta_{y_2y_2}$ | 0.476 | 0.048 | 9.939 |
| $\beta_{y_3y_3}$ | 0.255 | 0.007 | 33.767 |
| $\beta_{y_2y_3}$ | -0.173 | 0.018 | -9.628 |
| Input effects | | | |
| $\beta_{x_1}$ | -0.164 | 0.015 | -10.893 |
| $\beta_{x_2}$ | -0.210 | 0.015 | -13.889 |
| $\beta_{x_3}$ | -0.129 | 0.018 | -7.349 |
| $\beta_{x_4}$ | -0.402 | 0.021 | -18.812 |
| $\beta_{x_1t}$ | -0.005 | 0.003 | -1.644 |
| $\beta_{x_2t}$ | 0.007 | 0.004 | 1.996 |
| $\beta_{x_3t}$ | 0.003 | 0.002 | 1.503 |
| $\beta_{x_4t}$ | -0.003 | 0.001 | -1.754 |
| $\beta_{x_1x_1}$ | -0.084 | 0.056 | -1.497 |
| $\beta_{x_2x_2}$ | 0.058 | 0.021 | 2.700 |
| $\beta_{x_3x_3}$ | 0.004 | 0.018 | 0.248 |
| $\beta_{x_4x_4}$ | -0.136 | 0.028 | -4.770 |
| $\beta_{x_1x_2}$ | 0.042 | 0.029 | 1.454 |
| $\beta_{x_1x_3}$ | -0.025 | 0.015 | -1.675 |
| $\beta_{x_1x_4}$ | 0.037 | 0.034 | 1.071 |
| $\beta_{x_2x_3}$ | -0.021 | 0.024 | -0.864 |
| $\beta_{x_2x_4}$ | -0.007 | 0.007 | -1.032 |
| $\beta_{x_3x_4}$ | 0.034 | 0.033 | 1.028 |
| Output-input effects | | | |
| $\beta_{y_2x_1}$ | -0.023 | 0.031 | -0.734 |
| $\beta_{y_2x_2}$ | 0.238 | 0.030 | 7.979 |
| $\beta_{y_2x_3}$ | -0.063 | 0.023 | -2.724 |
| $\beta_{y_2x_4}$ | -0.176 | 0.023 | -7.586 |
| $\beta_{y_3x_1}$ | -0.034 | 0.021 | -1.635 |
| $\beta_{y_3x_2}$ | 0.033 | 0.019 | 1.749 |
| $\beta_{y_3x_3}$ | -0.016 | 0.020 | -0.819 |
| $\beta_{y_3x_4}$ | 0.101 | 0.022 | 4.558 |

Source: authors' calculations

Our estimates indicate that returns to scale at the regional level are lower than one. Given the dominance of agroholdings and large farms in the Russian market this result is quite astonishing. Often it is argued that a Russian farm can benefit from its enormous size and realise its potential for cost reductions. However, the cost reduction does not result in extraordinary increase in production. In addition, the reduction in costs due to economies of scale and an increase in production is most likely to be compensated by additional transaction and transport expenses. Estimation results, presented in Table 3, support our view. Firstly, decreasing economies of scale are consistent with reductions in sown areas: according to Rosstat data, during the analysed period the planted area fell by 30 per cent on average. Taking into account the fact that the number of farms did not change significantly over the period 1995-2011, the average farm size has declined. This development was accompanied by intensive technical progress (3 per cent annually). At the same time, technical change was found to be capital-intensive, thus proving the initial assumption of decreasing use of labour and increasing importance of capital as the part of production technology. In principle, these changes in technologies cannot be separated and require a minimum farm size to operate profitably. This suggests that size itself does not necessarily result in positive economies of scale, but it might foster technical progress. Such a strategy is more efficient than concentrating on an increase of purely technical economies of scale. Similarly, technical change is land-intensive, proving the statement that production has increased due to increase in yields rather than increase in land farmed. Overall, the impact of technical change on agricultural production is increasing at a rate of 3.1 per cent annually with a decelerating rate of technology development.

The initial model assumption implies that production in the country is primarily determined by the specific characteristics of each particular region. We measure these characteristics by means of the three indices described in the data section. Estimation of technology and heterogeneity indicators (Table 4) suggests that there are two leading characteristics that shape the technology and determine the level of production, namely climate ($z_1$) and human development ($z_2$).

The effect of climate was expected to be high since Russia is the biggest country in the world with many climatic zones, and the influence of climate on agriculture is of great impor-

**Table 4:** Technology and heterogeneity parameter estimates.

| Parameter | Estimate | Standard error | t-ratio |
|---|---|---|---|
| Technology | | | |
| $\alpha_m$ | 0.225 | 0.018 | 12.661 |
| $\alpha_{mt}$ | 0.137 | 0.015 | 9.166 |
| $\alpha_{m1}$ | 0.053 | 0.040 | 1.333 |
| $\alpha_{m2}$ | -0.002 | 0.006 | -0.283 |
| $\alpha_{m3}$ | -0.034 | 0.033 | -1.022 |
| $\alpha_{m4}$ | -0.032 | 0.021 | -1.493 |
| Heterogeneity | | | |
| $\gamma_0$ | 0.013 | 0.024 | 0.545 |
| $\gamma_1$ | 0.284 | 0.061 | 4.685 |
| $\gamma_2$ | 0.298 | 0.049 | 6.105 |
| $\gamma_3$ | 0.196 | 0.043 | 4.543 |
| $\sigma_v$ | 0.217 | 0.004 | 53.088 |
| $\sigma_u$ | 0.102 | 0.152 | 0.670 |

Source: authors' calculations

tance, especially for grain production. The level of economic and social development, reflected by the human development index, is positive and statistically significant, with a value similar to that of climate. These results indicate that the higher is the level of region's development, the more investment is attracted to the region, and the better the skills workers and farm managers have, the higher will therefore be the level of production. The indicator of transport and infrastructure system ($z_3$) is significant in determining the level of heterogeneity of the country – it plays an important role in agriculture in general, occupying an important position in trade and in the distribution process. Estimation of technology (Table 4) indicates that regions with higher values of heterogeneity effect tend to have higher levels of technical change, suggesting a more advanced development of agriculture in those regions.

Heterogeneity effects play a notable part in determining the production potential: the higher is the value of heterogeneity indicator, the higher is the positive impact of heterogeneity indicators on technology implementation and production efficiency (Figure 2). The level of influence of the heterogeneity indicators on production decreased in the period 1995-2001. Such a decrease can be explained by an overall decrease of actual agricultural production, caused by economic instability and the transition to a market economy.

Figure 3 provides an overview of heterogeneity indicator values across Russia. We assume that characteristics of

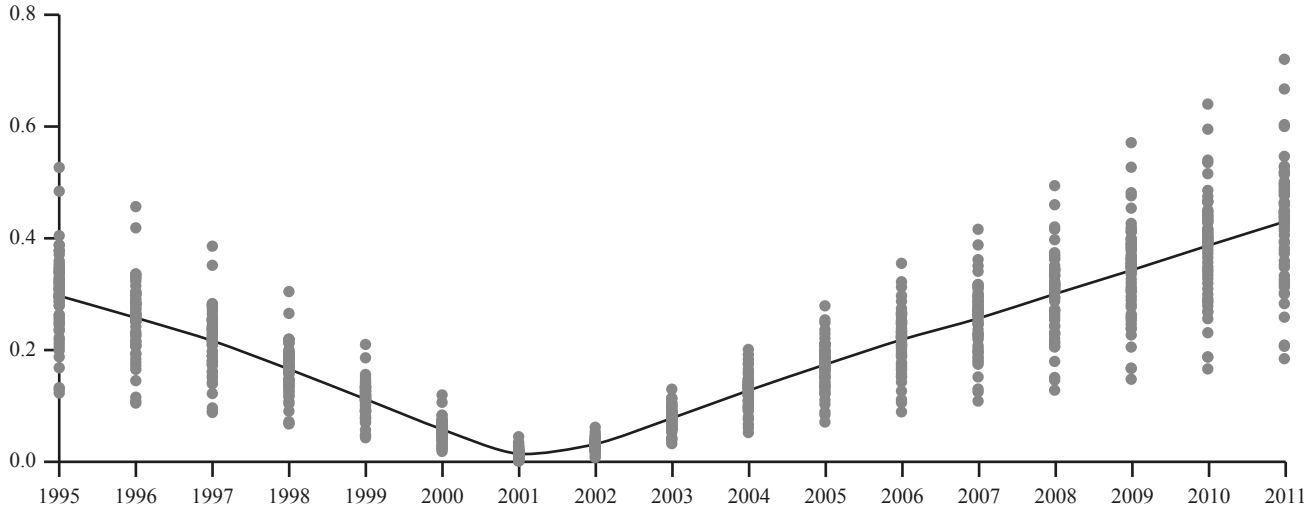


**Figure 2:** Estimated influence of heterogeneity effect on agricultural production levels (1995-2011).
Source: authors' calculations

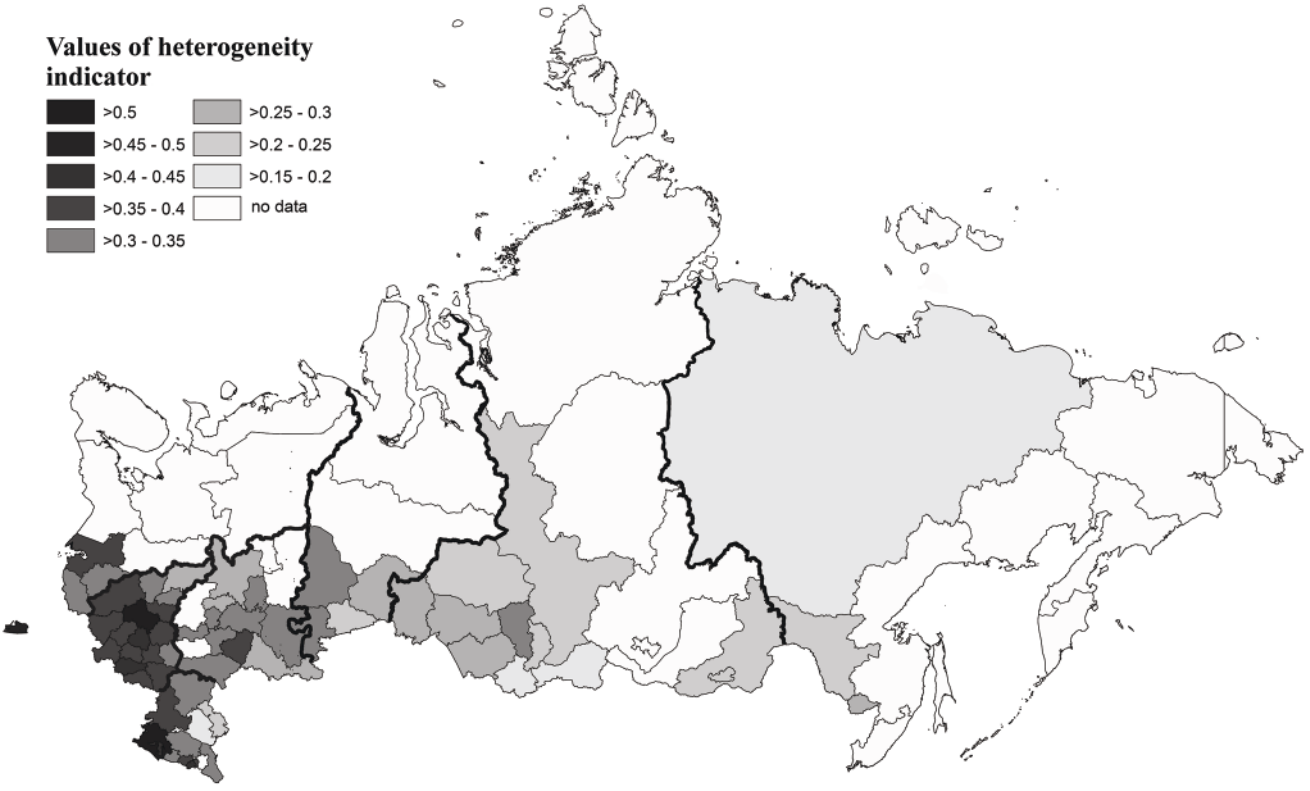


**Figure 3:** Values of heterogeneity indicators in Russian regions (average 1995-2011).
Source: authors' calculations

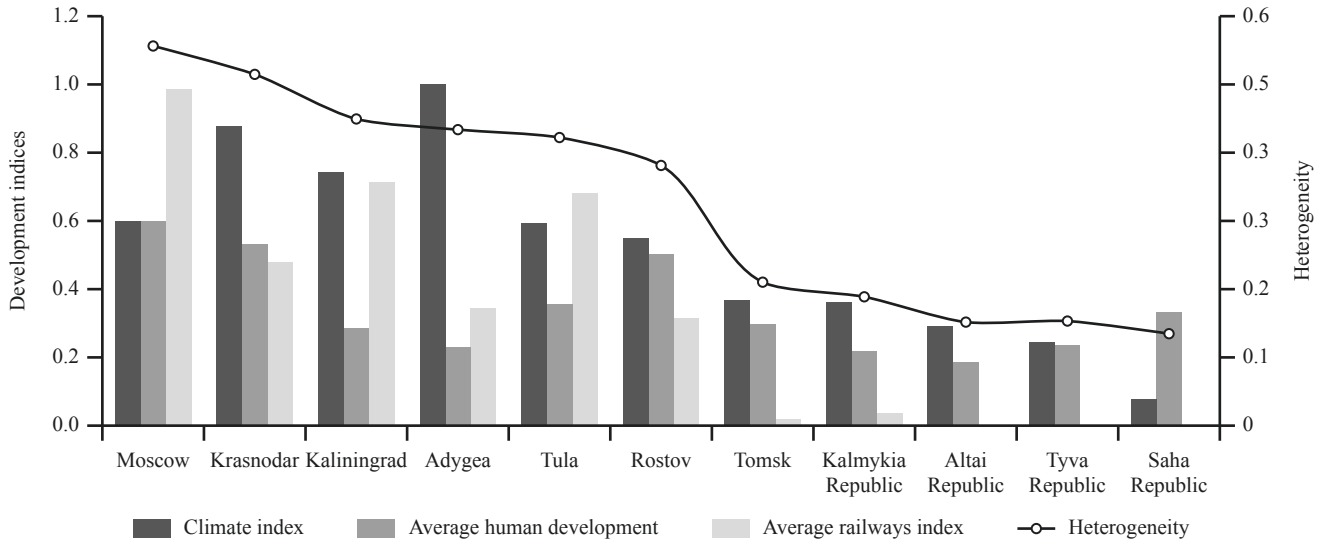


**Figure 4:** Comparison of heterogeneity levels in selected regions (average 1995-2011).
Source: authors' calculations

environment and social and infrastructural development did not change significantly over the observed period. Therefore, heterogeneity values can be interpreted as indicators of the diversity of each region, average for the observed period. Conditions for agricultural production are better in the western and south-western parts of the country, where climate allows for higher productivity, while higher development of regions implies better infrastructure and facilities for agricultural production and trade.

Figure 4 shows the heterogeneity indicator for selected regions (with favourable and unfavourable conditions for agricultural production). A high indicator of heterogeneity implies that conditions in a region are better suited for agricultural production than they are in regions with a low value of heterogeneity. At first glance, Moscow region is the one with the highest production possibilities among all regions. However, such a suggestion is ambiguous upon examination of the determinants of such a high indicator: the highest density of roads provides the most favourable conditions for transport and trade of grain, but relatively low climate index suggests that Moscow may not be the best suited for agricultural (especially crop) production. Krasnodar region, on the contrary, has favourable climate conditions, a higher than average value of human development index and well-developed infrastructure, which makes it the most attractive region in terms of agricultural, and in particular crop, production. In contrast to regions with high values heterogeneity indicators, regions with poor heterogeneity value (e.g. the Saha, Tyva, Altai and Kalmykia Republics, and Tomsk) suffer from a severe climate that does not allow successful crop production, as well as a low density of railways, indicating the underdevelopment of infrastructure across the region and, therefore, poor connections with other regions and trading centres.

## Conclusions

In this study, we extend the existing literature by evaluating the impact of regional diversity on agricultural production when farms in regions face different time-varying production technologies and time-invariant region-specific conditions. The consideration of heterogeneous regional impact essentially changes the traditional approach to stochastic frontier analysis, which implies that production is technically inefficient by default, and it is the technical inefficiency that does not allow farms to reach the frontier. Our paper, on the contrary, assumes that production is defined by specific characteristics of regions that indicate the level of regional development and influence the implementation of production technology. The applied approach provides a new insight into the analysis of agricultural production of the country, and allows for consistent estimation of production potential in general. Using regional level data for Russia, we test the hypothesis that grain production in the country has become efficient and entirely depends on production technology and regional conditions. We find evidence that climate in combination with the levels of human and institutional development and infrastructure has a significant effect on the production structure of the region and therefore should not be neglected while assessing regional policies and production potential. Moreover, exploitation of production possibilities potentially can have a positive impact on the transition process and lead to successful development of the region and its agriculture, thus helping regional development to become a self-enforcing process.

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**Sergei KHARIN***

# Vertical price transmission along the diary supply chain in Russia

Many studies have analysed vertical price transmission using time-series econometric methods but vertical price transmission in the milk market in Russia has not been investigated. This paper studies vertical price transmission along the whole milk supply chain in the Russian market using the autoregressive distributed lags model. Monthly farm-gate and retail prices in Voronezh *Oblast*, a historically large agrarian region located to the south of Moscow, covering the period from 2002 to 2014 were used in the analysis. When estimating the vertical price transmission in the dairy market, seasonality should be taken into account. Using a cointegration technique, no empirical evidence is found for cointegration between farm-gate and retail prices. There is unidirectional Granger causality from retail to farm prices and not vice versa. The results support the assumption that price changes are not transmitted efficiently from one level to another and support the view that Russian retailers have more market power than farmers.

**Keywords:** seasonality, market power, cointegration, autoregressive distributed lags model, dairy prices

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## Introduction

Price is the main tool with which different levels of the market are linked (Serra and Goodwin, 2002). Agricultural efficiency results to a large degree from the perfection of the price mechanism in the system of agents' relationships. Hence, rising food prices might provide an opportunity for agricultural development if price changes at one level (retail) were efficiently transmitted to another one (farm). However, in Russia, dairy producers express concerns about the fact that price changes are not efficiently transmitted from retailers to farmers. Price disparity has led to losses and underproduction in the rural economy. This state of play has caused redistribution of incomes from the agricultural sector to other sectors.

The phenomenon of price transmission has attracted the attention of scientists in various commodity markets. In recent years, studies have been carried out to examine price relationships between farm, wholesale and retail markets. The main focus of this research has been oriented to estimating the elasticities and speed with which shocks are transmitted between the different levels of the market chain.

Existing models that analyse vertical price transmission issues utilise several variations of a model originally introduced by Wolffram (1971) and later modified by Houck (1977). These models are based on the regression of differentiated price data and on lagged price differences where considerations can be made for the differential effects of positive and negative lagged differences. Goodwin and Holt (1999) used a vector error correction (VEC) model to evaluate monthly beef price relationships at the farm, wholesale and retail levels. They found evidence of statistically significant thresholds and asymmetries in price adjustments. Most of the literature on price transmission relies on cointegration techniques. Von Cramon-Taubadel (1998) was one of the first to incorporate the concept of cointegration into models of asymmetric price transmission. A comprehensive review of estimating and testing for asymmetric price transmission is provided in Meyer and von Cramon-Taubadel (2004).

As regards dairy products, the literature reports similar results regarding the existence of asymmetric price transmission. Serra and Goodwin (2003) identified asymmetric price relationships for sterilised milk in the Spanish dairy industry, while Lass (2005) found evidence of short-run price asymmetries in the retail milk price in the USA and observed that retail milk prices do not return to the same level following the equivalent price increases and decreases, causing an increase in the marketing margins. Stewart and Blayney (2011) have taken up the debate on asymmetric price transmission by using the threshold error correction model on milk and cheese. Bor *et al*. (2014) applied an asymmetric error correction model to monthly price data and their results suggest that there is a positive price asymmetry in the farm-retail price transmission in the Turkish milk market. Other researchers found similar asymmetries using different econometric methods: Acosta and Valdes (2013) for Panama, Falkowski (2010) in the Polish fluid milk sector and Holm *et al*. (2012) in the German milk market.

As noted above, many studies have analysed vertical price transmission using time-series econometric procedures. However, vertical price transmission in the milk market in Russia has not been investigated. In this research, vertical price transmission along the dairy supply chain in Russia (taking the case of Voronezh *Oblast* as a historically large agrarian region) is studied to gain an insight into the price interactions between the various levels of the farm-retail marketing chain.

Voronezh *Oblast* is located to the south of Moscow and has a population of approximately 2.5 million inhabitants, of whom one third live in rural areas. The Voronezh dairy sector is one of the most important, socially-significant industries. One of the major trends in the Voronezh milk market is the persistent increase in the number of dairy cattle from 2009. It is estimated that the number of milk cows in Voronezh *Oblast* rose by 3.8 per cent annually over the period 2009-2014. State support helps to maintain this trend. Within the framework of the national programme *Development of Agro-Industrial Complex*, the government subsidises and provides financial support for the renovation of existing farms and construction of new ones. Thanks to government support, investments in fresh milk production in Voronezh *Oblast* have increased significantly in recent years. Practically all the supply volume in the mar-

 

ket comes from domestic milk producers; imported milk accounts for less than 2 per cent of supply. Milk production has increased by 15 per cent over the last five years but the productivity has dropped by 3.2 per cent (own calculations based on data from the Federal State Statistics Service of Russia). Seasonality is an important factor in milk production: the summer production volume is 2-2.5 times higher than in the low season. Voronezh raw milk producers provide about 3 per cent of total production volume in Russia. The fluid milk production is mainly from three types of milk producers: agricultural establishments (56 per cent), household farms (40.5 per cent) and private farmers (3.5 per cent).

There are problems related to price transmission and distribution of value-added between farmers and traders in the functioning of the milk supply chain. According to the National Union of Milk Producers and the Institute for Agrarian Market Studies, the farmers' share in the retail price for milk is 30-34 per cent (the suggested optimum figure in terms of incurred costs is 50 per cent) and the traders' share is 22-30 per cent (optimum: 20 per cent).

Retail sales of milk products grow annually by at least 3-5 per cent. In 2013, retail sales of dairy products in Russia increased by almost 15 per cent, including whole milk the figure was about 30 per cent. The largest retailers in the Voronezh milk market are X5 Retail Group (Russia), Tander (Russia), O'Key Group (Russia), Lenta (Russia), Auchan Group (France) and Metro Group (Germany). They control a major part the of milk retail market. The rise in retail sales of milk products is a consequence of the increasing per capita consumption level. However, per capita milk consumption has not yet reached the levels in mature economies. Increasing demand for milk is partly provided by imports but in August 2014 Russian officials introduced sanctions on dairy products and banned imports from Australia, Canada, the European Union (EU) and the USA for one year. It is envisaged that undersupply will be compensated for with imports from Belarus, Turkey and Latin American countries.

## Methodology

Econometric time series and multiple regression methods were adopted for price transmission analysis. The influence of farm-gate (retail) price on retail (farm-gate) price was investigated using multiple linear regressions. The estimation of price transmission magnitude (elasticity) follows the algorithm outlined in Table 1. For a pair of prices (farm-gate and retail) for whole milk, the following steps were implemented to identify the appropriate econometric model. Depending on the price series properties, various econometric models were estimated.

Price time series are mostly non-stationary, generally leading to spurious regression. In the presence of non-stationary data, it is necessary to make them stationary by carrying out a transformation such as differencing (or detrending). Otherwise, the regression cannot be estimated correctly with ordinary least squares (OLS). Non-stationarity means presence of unit roots. In testing for the presence of unit roots, several methodological options are available. Widely used among them are the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979) and the Phillips-Perron (PP) test (Phillips and Perron, 1988).

As a standard procedure to test the non-stationarity of price series the ADF test uses following regression:

$$P_t = c + \beta t + \alpha P_{t-1} + \sum_{i=1}^{k} \psi_i \Delta P_{t-i} + \varepsilon_t \quad (1)$$

where $P_t$ - natural logarithm of the price, $c$ - intercept, $t$ - linear time trend.

The PP test builds on the ADF test. While the latter uses a parametric autoregression, a great advantage of the former is that it is non-parametric. The main disadvantage of the PP test is that it works well only with large samples. It also shares some of the disadvantages of ADF tests: sensitivity to structural breaks and poor power resulting from small samples.

In a modified version of the ADF test, known as the ADF-GLS test, the time series is transformed via a generalised least squares (GLS) regression before performing the test (Elliott *et al*., 1996). The ADF-GLS test is performed analogously but on GLS-detrended data. Elliott *et al*. (1996) and later studies have shown that this test has significantly greater power than the previous versions of the ADF test.

However, it is not possible to come to a reliable conclusion about price series integration order without taking into account the seasonality in the milk markets. The approach that helps to reveal seasonal unit roots was developed by Hylleberg *et al*. (1990). The HEGY test applies to quarterly data. The seasonal unit root test for monthly data was developed by Franses (1990).

The following equation is estimated for the seasonal unit roots in monthly data:

$$\begin{aligned}\Delta_{12} P_t = {} & \pi_1 P_{1,t-1} + \pi_2 P_{2,t-1} + \pi_3 P_{3,t-1} + \pi_4 P_{3,t-2} + \pi_5 P_{4,t-2} + \\ & \pi_6 P_{4,t-2} + \pi_7 P_{5,t-1} + \pi_8 P_{5,t-2} + \pi_9 P_{6,t-1} + \pi_{10} P_{6,t-2} + \\ & \pi_{11} P_{7,t-2} + \pi_{12} P_{7,t-2} + \sum \alpha_i \Delta_{12} P_{t-i} + \varepsilon_t\end{aligned} \quad (2)$$

where

**Table 1:** Algorithm for conducting the vertical price transmission analysis.

| Step | Test | Result | Action |
|---|---|---|---|
| 1 | *Stationarity* test of time series for unit root | Stationarity | Perform test for Granger causality and estimate vector autoregression (VAR) model with stationary data |
| | | Non-stationarity | Move to step 2 |
| 2 | *Cointegration* test | Exists | Estimate the Vector Error Correction (VEC) model and measure asymmetry |
| | | No | Perform test for Granger causality and estimate vector autoregression (VAR) model using logarithmic prices in first differences |

Source: own composition

$$
\begin{aligned}
P_{1,t} &= (1+L)(1+L^2)(1+L^4+L^8)P_t \\
P_{2,t} &= -(1-L)(1+L^2)(1+L^4+L^8)P_t \\
P_{3,t} &= -(1-L^2)(1+L^4+L^8)P_t \\
P_{4,t} &= -(1-L^4)(1-3^{1/2}L+L^2)(1+L^4+L^8)P_t \\
P_{5,t} &= -(1-L^4)(1+3^{1/2}L+L^2)(1+L^4+L^8)P_t \\
P_{6,t} &= -(1-L^4)(1-L^2+L^4)(1-L+L^2)P_t \\
P_{7,t} &= -(1-L^4)(1-L^2+L^4)(1+L+L^2)P_t \\
P_{8,t} &= (1-L^{12})P_t
\end{aligned} \tag{3}
$$

Where $L$ is the lag operator in the polynomial.

Deterministic components (such as constant, trend and seasonal dummy variables) can be added to equation (2). $F$ statistics is applied for seasonal complex roots and $t$ statistics are applied for other roots ($\pi_1$, $\pi_2$). If the null hypothesis ($\pi=0$) cannot be rejected, it indicates the presence of seasonal unit root. The critical values are given in Franses and Hobijn (1997).

Structural breaks are often present in time series. A preliminary visual assessment of the price series in Figure 1 supports the assumption that structural breaks might be present within the period 2007-2008. To prove this, a technique developed by Zivot and Andrews (1992) was used.

Given that some price series will be non-stationary, the conventional Granger-Engle approach (Engle and Granger, 1987) which included the static following regression estimated with OLS was applied to test for co-integration:

$$\tilde{P}_{1t} = \alpha + \beta\tilde{P}_{2t} + v_t \tag{4}$$

If $\tilde{P}_{1t}$ and $\tilde{P}_{2t}$ are $I(1)$ price series, then the residuals $v_t$ from the regression would be $I(0)$ if they are co-integrated. So, if the residuals are $I(1)$ we accept the null hypothesis of non-cointegration, otherwise, if the residuals are stationary, $I(0)$, we reject the null hypothesis and accept that $\tilde{P}_{1t}$ and $\tilde{P}_{2t}$ are co-integrated. However, the power of the Engle-Granger test is reduced if there is a structural break in the co-integrating relationship. To avoid this problem, Gregory and Hansen (1996) improved the Engle-Granger regression in order to take into account structural breaks in the intercept or in the intercept and trend.

After testing for co-integration, the Granger causality test (Granger, 1969) was applied to evaluate the possible direction of the price transmission. The starting point of the method is that $P_1$ variable Granger causes $P_2$ variable but $P_2$ does not Granger cause $P_1$.

$$P_{2t} = \sum_{i=1}^{n} \alpha_i P_{2t-i} + \sum_{j=1}^{q} \beta_j P_{1t-j} + \upsilon_t \tag{5}$$

where $\upsilon_t$ is the white noise, and $n$ and $q$ are the lag order of $P_2$ and $P_1$ variables respectively.

In this study, $P_2$ and $P_1$ are the retail and farm-gate prices, and $\alpha$ and $\beta$ are parameters. The Granger causality test requires that the variables are stationary. In order to take into account deterministic seasonality, eleven seasonal dummies are added in the estimated regressions. In order to determine the optimum lags in the models, the Akaike Information Criterion (AIC; Akaike, 1973) and the Schwarz-Bayesian Information Criterion (BIC; Schwarz, 1978) are used. Ng and Perron (2001) proposed modified versions of AIC (mAIC) and BIC (mBIC) as a model selection criterion which are based on quasi-likelihood function.

If the price series are co-integrated, a VEC model is estimated; otherwise a vector autoregression (VAR) model for farm-gate and retail prices is built in order to investigate price dynamic relationships. The general equation of the VEC model as follows:

$$\Delta P_{2t} = \alpha + \rho(\Delta P_{2t-1} - \beta\Delta P_{1t-1}) + \delta\Delta P_{1t-1} + \theta\Delta P_{2t-1} + \varepsilon_t \tag{6}$$

where $\Delta P_{2t}$ and $\Delta P_{1t}$ are changes in retail and farm-gate prices respectively; $\Delta P_{2t\text{-}1}$ and $\Delta P_{1t\text{-}1}$ are lagged changes in retail and farm-gate prices respectively; $\rho$ is an error correction term (speed of adjustment to long-run equilibrium); $\beta$ is the long-run elasticity of price transmission; $\delta$ is the short-run elasticity of price transmission between two prices, and $\varepsilon_t$ is the residual (white noise).

If the tests reveal non-cointegration, the VAR model can be specified and estimated. The VAR model includes two equations and can be written as follows:

$$P_{1t} = \alpha_0 + \alpha_1 P_{1t-1} + \ldots\ldots + \alpha_k P_{1t-k} + \gamma_1 P_{2t-1} + \ldots\ldots + \gamma_k P_{2t-k} + \varepsilon_t \tag{7}$$

$$P_{2t} = \beta_0 + \beta_1 P_{2t-1} + \ldots\ldots + \beta_k P_{2t-k} + c_1 P_{1t-1} + \ldots\ldots + c_k P_{1t-k} + \varepsilon_t \tag{8}$$

where $P_{1t}$ and $P_{2t}$ are farm-gate and retail prices, and $P_{1t\text{-}k}$ and $P_{2t\text{-}k}$ are lagged farm-gate and retail prices.

In the case of unidirectional Granger causality running from the farm-gate (retail) to the retail (farm-gate) price, the autoregressive distributed-lags model can be specified and the immediate and dynamic effects of one price on another estimated.

## Data and empirical results

The price transmission analysis at the farm-gate and retail levels in Voronezh *Oblast* was carried out using 153 monthly observations from January 2002 to September 2014. The observations relate to nominal prices for cow whole milk per litre. The source of the data is the Federal State Statistics Service of Russia. The logarithmic transformation of monthly prices measured in RUR per litre is used. This transformation allows the results to be interpreted in percentage change terms. Analyses between prices commonly use logarithms because, with trending data, the relative error declines through time (Banerjee *et al*., 1993). Moreover, from a statistical point of view, Hamilton (1994) pointed out that the logarithmic transformation mitigates fluctuations of individual series, increasing the likelihood of stationarity after first differencing. The chain from farmers to retailers in Russia is investigated (Figures 1 and 2).

Using the methodology described above, the analysis of price series was started with the unit root tests without structural breaks. In order to select the highest number of lags for the tests, the common rule for determining $P_{\max}$, suggested by Schwert (1989) was applied.

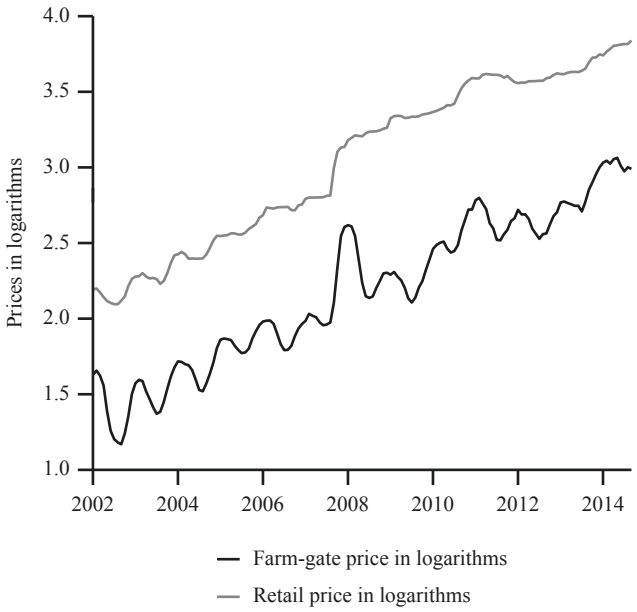


**Figure 1:** Price series for whole milk in logarithms in Voronezh *Oblast*, January 2002 - September 2014.

Source: own calculations based on Federal State Statistics Service of Russia data

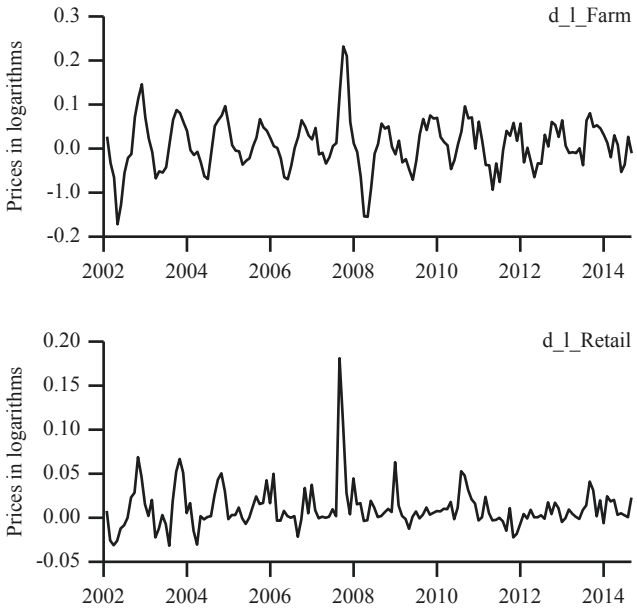


**Figure 2:** Price series for whole milk in logarithms (first differences), January 2002 - September 2014.

Source: own calculations based on Federal State Statistics Service of Russia data

Stationarity of the price series was checked with the conventional ADF test, ADF-GLS test, PP test, HEGY test and test with structural breaks. The number of optimal lags was determined using mBIC. The preliminary visual examination of the price series graphs provides the insight that the model for unit-root test should contain a constant and a time trend.

The null hypothesis of stationary price series in levels was rejected for all variables (Table 2). Tests based on first differences show that all the test statistics are significant at the 1 per cent level. Hence, it can be concluded that all price variables are integrated of the order one, $I(1)$. Each farm-gate and retail price series has one seasonal unit root, but not at the corresponding frequencies. So it can be concluded

**Table 2:** Unit root test results in levels and first differences.

| Price variable (log price) | Model | ADF-GLS test | | | |
|---|---|---|---|---|---|
| | | Lag | Levels | Lag | First difference |
| Farm-gate price | Trend and intercept | 6 | -1.772 | 1 | -6.036*** |
| | Intercept only | 7 | 0.980 | 1 | -5.920*** |
| Retail price | Trend and intercept | 1 | -2.341 | 1 | -6.871*** |
| | Intercept only | 1 | 1.660 | 1 | -6.879*** |

**/*** null hypothesis of non-stationarity rejected at 5% and 1% of significance;
The ADF, PP, HEGY and Gregory-Hansen test results are not presented but are available from the author upon request
Source: own calculations

**Table 3:** Cointegration test (Engle-Granger test).

| Price pair (in logarithms) | Test value | |
|---|---|---|
| | Intercept only | Trend and intercept |
| Whole milk (farm-retail) | -1.804<br>(0.628) | -2.140<br>(0.709) |

The values in parentheses indicate p-values
Source: own calculations

**Table 4:** Granger causality F-test.

| Null hypothesis | F-statistics, (p-value) | Conclusion |
|---|---|---|
| $\Delta\ln$*Farm_milk* does not cause $\Delta\ln$*Retail_milk* (lag 1) | 1.050 | Accept |
| $\Delta\ln$*Retail_milk* does not cause $\Delta\ln$*Farm_milk* (lag 1) | 18.491*** | Reject |

$\Delta\ln$*Farm_milk* is the farm log-price for whole milk (in first difference); $\Delta\ln$*Retail_milk* is the retail log-price for whole milk (in first difference);
***/** statistically significant at the 1% and 5% levels, respectively
Source: own calculations

that there is no seasonal cointegration between them and both series are $I(1)$. Structural breaks are insignificant and are therefore not taken into account. Hence, it can be stated that the price series are $I(1)$ and that the conventional test of Engle and Granger can be run.

Within this test for co-integration the static equation (4) is first estimated with OLS and then the stationarity of the residuals of the relationship (between farm and retail prices for whole milk) is tested with the ADF test using the critical values proposed by MacKinnon (1991). ADF test statistics for the Engle-Granger test are shown in Table 3.

The null hypothesis of non-cointegration in the whole milk farm-retail chain cannot be rejected. Hence, it was found that both price pairs are not co-integrated. The VAR model can be specified and estimated in first differences. But, firstly, Granger causality F-tests of zero restrictions within the framework of VAR should be implemented. In order to estimate the possible direction of price transmission, a causality test was carried out. The appropriate lag length was selected in accordance with BIC. Seasonal dummies were added in the model. In order to avoid autocorrelation problem, heteroskedasticity and autocorrelation-consistent (HAC) standard errors within the model were computed. The direction of price transmission goes from retailers to farmers and not vice versa (Table 4).

From the findings, the ARDL (autoregressive distributed-lags) model can be specified, and immediate and dynamic effects (elasticity) of retail price on farm price for whole milk estimated (Table 5). Since the constant and time trend are statistically insignificant and also have no significant effect on the whole regression model, these variables were eliminated from the model.

**Table 5:** Estimation results for whole milk farm-retail chain, dependent variable ln$Farm_milk_t$.

| Variables | Coefficient | Standard error | t-statistic | Significance (p-value) |
|---|---|---|---|---|
| $\Delta\ln Farm\_milk_{t-1}$ | 0.41*** | 0.076 | 5.395 | 2.93e-07 |
| $\Delta\ln Retail\_milk_t$ | 0.312** | 0.124 | 2.514 | 0.013 |
| $\Delta\ln Retail\_milk_{t-1}$ | 0.483*** | 0.126 | 3.822 | 0.000 |
| S1 | 0.007 | 0.011 | 0.702 | 0.484 |
| S2 | -0.017*** | 0.005 | -3.214 | 0.002 |
| S3 | -0.028*** | 0.006 | -4.528 | 1.28e-05 |
| S4 | -0.025** | 0.010 | -2.510 | 0.013 |
| S5 | -0.047*** | 0.009 | -5.353 | 3.55e-07 |
| S6 | -0.025*** | 0.007 | -3.424 | 0.001 |
| S7 | -0.014* | 0.008 | -1.753 | 0.082 |
| S8 | 0.027*** | 0.006 | 4.495 | 1.47e-05 |
| S9 | 0.031*** | 0.009 | 3.466 | 0.001 |
| S10 | 0.029*** | 0.007 | 3.901 | 0.000 |
| S11 | 0.027*** | 0.006 | 4.296 | 3.27e-05 |
| $R^2$ | 0.799 | | | |
| Adjusted $R^2$ | 0.780 | | | |
| S.E. of regression | 0.028 | | | |
| Residual sum of squares | 0.107 | | | |
| Mean dependent | 0.009 | | | |
| S.D. dependent | 0.059 | | | |
| F-statistic | 38.818 | | | 1.07e-40 |

Estimates are given, taking into account HAC standard errors
$\Delta\ln Farm\_milk$ is the farm log-price for whole milk (in first difference); $\Delta\ln Retail\_milk$ is the retail log-price for whole milk (in first difference)
***/**/* statistically significant at the 1% 5% and 10% levels, respectively
Lag order has been selected in accordance with information criteria (BIC)

The results of the ARDL model indicate that there is a positive and significant relationship between the farm-gate and retail prices. According to the calculated price transmission elasticity, there is evidence of immediate effect that a 1 per cent increase in retail prices results in a 0.31 per cent increase in farm-gate prices. Also the dynamic long-run effect of a 1 per cent increase in retail price leads to a 1.35 per cent increase in farm-gate price.

## Conclusions

This study has investigated the relationship between the farm-gate and retail prices for whole milk in the Voronezh *Oblast* of Russia. Monthly farm-gate and retail prices during the period from January 2002 to September 2014 were used in the analysis. Prices were expressed in natural logarithms to calculate percentage change. The data are integrated of order one.

Structural break tests revealed breaks but they were not significant and have not been taken into account. Vertical price transmission was evaluated in the cointegration framework, using the classical Engle-Granger approach. Visual inspection showing that price series incorporate seasonal patterns has been proved using the HEGY test. According to the findings of the research, both price series have seasonal unit roots at non-corresponding frequencies. The inclusion of seasonal dummies to reflect seasonality of price fluctuations improved the fit of the model and almost all seasonal dummies are significant. The results show that a long-run cointegration relationship does not exist between farm and retail prices, that is, they do not move together. There is evidence that change in retail price has a significant effect on farm-gate price; that is, the Granger test established unidirectional causality from retail to farm prices and not the opposite. The results on calculated price transmission elasticity revealed a short-run effect that a 1 per cent increase in retail prices leads to a 0.31 per cent increase in farm-gate prices. In addition, the dynamic long-run effect of an increase in retail price by 1 per cent causes a 1.35 per cent increase in farm-gate price. Hence, the results of this paper support the view that retailers have significant market power as highlighted by unidirectional price responses in the Russian milk market.

These findings are important for Russian policymakers in the context of the import substitution of the dairy products from the EU, USA and other countries. The results may be helpful for new policy making and support for Russian farmers. Within the framework of the new agricultural development paradigm, it is recommend to improve farmers' distribution infrastructure in order to eliminate the monopolistic power of retailers.

Further research on the topic could include the wholesale stage in the analysis to better understand price links along the dairy supply chain. Follow-up research is also needed to investigate price transmission using a wider range of advanced unit root and cointegration tests under the multiple breaks and seasonal pattern.

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**FERTŐ Imre***

# Horizontal intra-industry trade in agri-food products in the enlarged European Union

International trade theory suggests that advanced trade integration may lead to higher levels of intra-industry trade (IIT). The enlargement of the European Union (EU) during last decade is as a good example for which to analyse the IIT in agri-food products. The aim of the paper is to analyse the pattern and drivers of horizontal IIT within the EU between 1999 and 2010. Previous empirical studies fail to provide an exact link between the theory and the data. Thus, a new empirical strategy developed to test the predictions of Helpman and Krugman (1985) model is employed. At the country level, Belgium, France, Netherlands and Germany report the highest levels of IIT within the EU. The calculations mainly support Cieslik's (2005) proposal to find the missing link between empirics and theory of IIT. In addition, the results are robust to alternative subsamples.

**Keywords:** intra-industry trade, agri-food products, EU enlargement, relative factor endowments

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## Introduction

In recent decades intra-industry trade (IIT) has become a widespread phenomenon with its growing role in international trade, providing strong incentives for theoretical and empirical research. New trade theory offers several models to explain IIT based on different assumptions on product differentiation. In the case of horizontal product differentiation the usual conclusions are about the role of factor endowments and scale economies that stem from the framework of monopolistic competition. This framework, summarised in Helpman and Krugman (1985), and often referred to as the Chamberlin-Heckscher-Ohlin (C-H-O) model, allows for inter-industry specialisation in homogeneous goods and IIT in horizontally differentiated goods. This model suggests a negative relationship between differences in relative factor endowment, proxied usually by GDP per capita and the share of IIT. The available empirical evidence provides rather puzzling evidence on the impact of relative factor endowments on IIT. One of the possible explanations of the diverging results is that the majority of empirical studies fail to provide any exact link between theory and data. Empirical studies on IIT usually employ a rather eclectic approach using simply the most common explanatory variables to test hypotheses based on different theoretical frameworks.

The formation of stronger economic ties between European countries due to the creation and expansion of the European Union (EU) has contributed to an increase in IIT among EU Member States. There is a wealth of literature on the IIT between a particular EU Member State and its partner (see for recent examples Jensen and Lüthje, 2009; Milgram-Baleix and Moro-Egido, 2010). However, a significant proportion of the studies still focus on industrial products. Although the importance of IIT has already been well documented in agri-food sectors since the late 1990s (Fertő, 2005, 2007), in the last decade research on the determinants of agri-food IIT has remained limited. The main reason is probably that agricultural markets are still usually assumed to have perfect competition. But, 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. Leitão and Faustino, 2008; Wang, 2009; Leitão, 2011; Rasekhi and Shojaee, 2012; Varma, 2012). In addition, recent studies (e.g. Jámbor, 2014a, b; Fertő and Jámbor, 2015) suggest that the role of IIT has been increasing in agricultural trade between EU Member States.

The aim of the paper is to analyse the pattern and drivers of horizontal IIT within the EU in the period 1999-2010. This paper is the first attempt to analyse agri-food trade within the EU including all bilateral agri-food trade relationships. Such an approach aims to contribute to the literature of the field in five ways. Firstly, specific theoretical models are tested instead of the usual eclectic approach. More specifically, following Helpman (1987) and Hummels and Levinsohn (1995) the focus is on the theoretical relationships between factor proportions and horizontal IIT within the original Helpman-Krugman (1985) model. Moreover, the impact of the sums of capital-labour rations is controlled as proposed by Cieslik (2005). Secondly, a multilateral dataset is employed instead of the bilateral framework still predominating recent empirical research. Thirdly, this approach raises an additional issue, namely the accuracy of trade data. In the bilateral approach, studies use data only from the exporter point of view. However it is well known, although less investigated, that trade data are very rarely symmetric. Thus, special attention is paid here to analysing the possible bias due to the asymmetric nature of trade data. Fourthly, research using panel data in the empirical IIT literature should face some additional issues coming from recent developments of panel data econometrics which are not always tackled carefully. Consequently, this analysis moves beyond simple pooled OLS and standard static panel models. Finally, although the Helpman-Krugman model is based on horizontal product differentiation, empirical tests of their model usually neglect the distinction between horizontal and vertical IIT when they measure the IIT. Thus this paper concentrates only on horizontal IIT indices.

The next section presents the theoretical foundation of the empirical model, and this is followed by a brief outline of the standard measurement of IIT. These approaches are then applied to the data set used in this research. The theoretical basis for investigation of the country-specific determinants

 

of IIT is outlined next, and the results of the regression analysis are then presented, followed by a summary and some conclusions.

## Theoretical framework

The traditional IIT model, often referred to as the Chamberlin-Heckscher-Ohlin (C-H-O) model, assumes that goods are horizontally differentiated. In these models (Krugman, 1979; Lancaster 1980; Helpman 1981), IIT opens up in monopolistically competitive markets, with increasing returns to scale on the supply side and diverse consumer preferences on the demand side. Helpman and Krugman (1985) add factor endowment differences to a model that explains the co-existence of intra- and inter-industry trade. Consider two countries (A and B), two factors (labour and capital) and two goods: a homogeneous commodity which is relatively labour intensive and a differentiated product which is relatively capital intensive. If country A is relatively labour-abundant and country B is relatively capital abundant, Helpman and Krugman (1985) show how country A tends to export homogeneous product and both countries import the differentiated good. This model predicts that IIT will decrease as countries' factor endowments diverge. Moreover, Bergstrand (1990) expanded earlier theoretical works by proposing a new framework, using a gravity-like equation that explains the relationship between the share of IIT in total trade and factor endowments as well as income. Important determinants of the share of IIT in total bilateral trade in the Bergstrand model are: differences in income, average income and average capital-labour ratios as well as differences therein.

However Cieslik (2005) points out that previous empirical studies fail to provide an exact link between the theory and the data. He shows that the Helpman-Krugman (1985) model does not predict any unique theoretical relationship between IIT and relative country size if we keep differences in capital to labour ratios unchanged. Thus Cieslik (2005) developed a formal model to eliminate this shortcoming, providing two complementary propositions. Firstly, the share of IIT between two countries is larger than the sum of their capital-labour ratios, given the fixed difference in their capital-labour proportions. Secondly, the share of IIT between two countries is larger the smaller the difference in their capital-labour ratios given the constant sum of their capital-labour ratios. His results imply that the theory finds support in the data when we control for the sum of capital-labour ratios in the estimating equations instead of relative country-size variables.

## Measuring intra-industry trade

The basis for the various measures of IIT used in the present study is the Grubel-Lloyd (GL) index (Grubel and Lloyd, 1975), which is expressed formally as follows:

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

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 the level of countries and industries as follows:

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

where $w_i$ denotes the share of industry $i$ in total trade.

The literature suggests several options to disentangle horizontal and vertical IIT. Greenaway *et al.* (1995) developed the following approach: 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, and otherwise they define vertically differentiated products. Formally, this is expressed for bilateral trade of horizontally differentiated products as follows:

$$1 - \alpha \leq \frac{UV_i^X}{UV_i^M} \leq 1 + \alpha \tag{3}$$

where $UV$ means unit values, $X$ and $M$ means exports and imports for goods $i$ and $\alpha = 0.15$. The choice of a 15 per cent range is rather arbitrarily, thus already Greenaway *et al*. (1994) proposed that the spread should be widened to 25 per cent. Interestingly, the papers that check the possible impact of various thresholds on results confirm that results coming from the selection of the 15 per cent range do not change significantly when the spread is widened to 25 per cent (Jensen and Lüthje, 2009). Based on the logic above, the GHM index comes formally as follows:

$$GHM_k^p = \frac{\sum_j \left| (X_{j,k}^p + M_{j,k}^p) - \left| X_{j,k}^p - M_{j,k}^p \right| \right|}{\sum_j (X_{j,k} + M_{j,k})} \tag{4}$$

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

Trade data from the Eurostat COMEXT database using the HS6 system (six digit level) are employed. Agri-food trade is defined as trade in product groups HS 1-24, resulting in 964 products using the six digit breakdown. The analysis focuses on the period 1999-2010. In this context, the EU is defined as the Member States of the EU-27.

## Econometric specifications

Three different specifications are used to test the theoretical propositions of Helpman-Krugman (1985) model and modified versions developed by Cieslik (2005). Early tests of Helpman-Krugman were based on the following specifications introduced by Helpman (1987):

$$\begin{aligned} \ln IIT_{ijt} = {} & \alpha_0 + \alpha_1 \ln DGDPC_{ijt} + \\ & \alpha_2 \min(\ln GDP_{it}, \ln GDP_{jt}) + \\ & \alpha_3 \max(\ln GDP_{it}, \ln GDP_{jt}) + v_{ij} + \varepsilon_{ijt} \end{aligned} \tag{5}$$

where *IIT* is the bilateral GL index.

To separate the effect of absolute country size from the impact of relative country size, Helpman (1987) suggests the following modification of equation (5):

$$\ln IIT_{ijt} = \alpha_0 + \alpha_1 \ln DGDPC_{ijt} + \alpha_2 \text{sum}(\ln GDP_{it}, \ln GDP_{jt}) + \alpha_3 \ln dispersion_{ijt} + v_{ij} + \varepsilon_{ijt} \quad (6)$$

where dispersion is expressed by the following:

$$dispersion = \ln\left[1 - \left(\frac{GDP_i}{GDP_i + GDP_j}\right)^2 - \left(\frac{GDP_j}{GDP_i + GDP_j}\right)^2\right] \quad (7)$$

To test two propositions by Cieslik (2005) the following model was estimated:

$$\ln IIT_{ijt} = \alpha_0 + \alpha_1 \ln DCAPLAB_{ijt} + \alpha_2 \ln \text{sum}CAPLAB_{ijt} + v_{ij} + \varepsilon_{ijt} \quad (8)$$

From capital-labour ratios the physical capital was estimated by the perpetual inventory method. The variables and related hypotheses are summarised in Table 1.

## The nature of intra-industry trade

One well-known problem in any research in empirical trade analysis including IIT is that of the accuracy of the data used. Most researchers study IIT bilaterally, that is one country's trade with several others, using the data of the former one. Mostly it is a member of the OECD, with a good reputation for reporting accuracy. Consequently an index measuring IIT between two countries should remain invariant if it is calculated from trade data reported by a certain country or by data reported from its trade partner due to the symmetry of the formulae. This is so obvious that articles often do not even mention the issue. However, investigation of multilateral trade between different combinations of OECD and non-OECD countries reveals serious inconsistency in the accuracy of trade data (Fertő and Soós, 2009). Jensen and Lüthje (2009) provide some evidence that data accuracy is less severe for the trade within Europe. To see whether this is the case, correlations between horizontal intra-industry trade (HIIT) indices based on trade data reported by a country and data reported by its partner countries are presented in Figure 1.

**Table 1:** Description of independent variables.

| Variable | Variable description | Data source | Sign |
|---|---|---|---|
| ln *DGDPC* | The logarithm of per capita gross domestic product (GDP) absolute difference between trading partners measured in PPP in current international USD | WDI | - |
| ln *GDP*min | The logarithm of minimum GDP measured in PPP in current international USD | WDI | + |
| ln *GDP*max | The logarithm of maximum GDP measured in PPP in current international USD | WDI | - |
| ln *GDP*sum | The logarithm of average GDP absolute difference between trading partners measured in PPP in current international USD | WDI | + |
| ln *dispersion* | The logarithm of absolute difference between trading partners capital city measured in kilometres | WDI | + |
| ln *DCAPLAB* | The logarithm of absolute difference of capital labour ratios between trading partners | Penn, WDI | - |
| ln sum*CAPLAB* | The logarithm of sum of capital labour ratios between trading partners | Penn, WDI | + |
| ln *DIST* | The logarithm of absolute difference between trading partners capital city measured in kilometres | CEPII | - |

WDI: World Bank World Development Indicators database; Penn: Penn World Table 7.0; CEPII: Centre d'Études Prospectives et d'Informations Internationales.
Source: own composition

The first striking finding is that correlation indices range significantly across countries from 0.05 to 0.95. Secondly, a higher level of economic development does not necessary imply higher accuracy of trade data, see for example Luxembourg and the UK. In short, in line with Fertő and Soós (2009), this preliminary analysis cast some doubt on trade data accuracy.

The level of HIIT is rather low in agri-food trade in the EU (Figure 2). However, one may observe considerable differences between countries. Germany Belgium, France and Netherlands, Austria and Denmark record the highest HIIT indices.

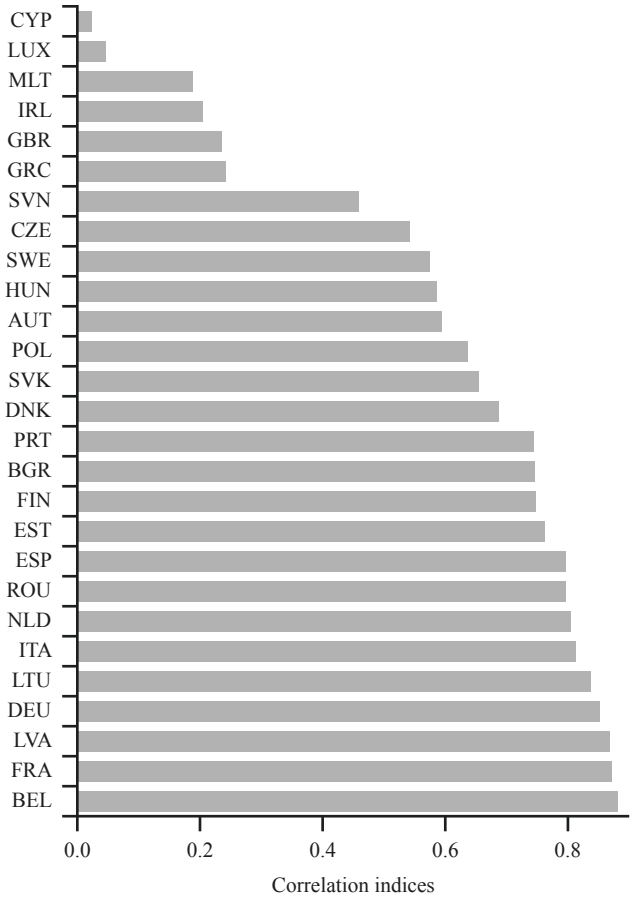


**Figure 1:** Correlations of horizontal intra-industry trade indices based on trade data reported by a country and data reported by its partner countries.

Source: own calculations based on the Eurostat database

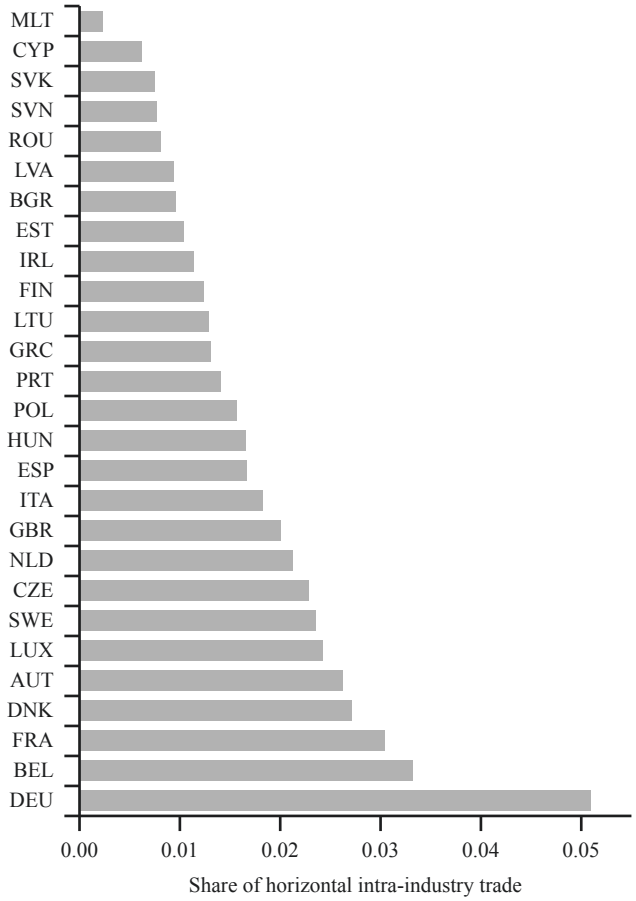


**Figure 2:** Agri-food horizontal intra-industry trade in the EU-27 by Member State.

Source: own calculations based on the Eurostat database

## Regression results

Before estimating the panel regression models, the main model variables are pre-tested for unit root tests. A number of panel unit root tests are available. Considering the well-known low power properties of unit root tests, in this paper a battery of unit root tests are employed: the Levin *et al*. (2002) method (common unit root process), the Im *et al*. (2003) method (assuming individual unit root processes), ADF-Fisher Chi square and PP-Fisher Chi square, with different deterministic specifications (with constant, and with constant and trend). Mixed results were obtained (Table 2). The most important model variables such as the IIT and HIIT do not have unit roots, i.e. are stationary, with individual effects and individual trend specifications. GDP-related variables such as ln *GDPC*, ln *GDP*min and ln *GDP*max are more ambiguous in terms of unit root in a panel context. Five of the nine panel unit root tests reject the panel unit root null hypothesis for ln *GDPC*, while five of the nine panel unit root tests support the existence of panel unit root for ln *GDP*-min and ln *GDP*max. We may conclude we do not have definite conclusions for rejecting/accepting the panel unit root. Capital-labour ratios variables show a clearer picture; the majority of tests reject the existence of panel unit root.

To ensure that both variables are stationary $I(0)$ and not integrated of a higher order, unit root tests are applied on first differences of all variables. All tests reject the unit root null hypothesis for the first differences (data not shown). It can be concluded that the panel is likely stationary.

Several estimation techniques are applied to equations (5, 6 and 8) in order to ensure the robustness of the results. Preliminary Hausman tests favour the use of fixed effect panel models for the majority of the models. However, there are some additional issues that have to be addressed when estimating such panel models. Firstly, heteroscedasticity may occur because trade between two smaller countries or between a smaller and larger country is probably more volatile than trade between two larger countries. The panel dataset is also subject to the existence of autocorrelation. Contemporaneous correlation across panels may occur because exporting to one country can take place as an alternative to exporting to another country. Similarly, adjacent exporter(s)'/importer(s)' time-specific shocks result in larger correlated error terms of their trade with their partners. Preliminary analysis (likelihood ratio tests, Wooldridge test for autocorrelations (Wooldridge, 2002) and Pesaran tests (Pesaran, 2004)) confirms the presence of heteroscedasticity, autocorrelation and cross-sectional dependence. Because the period of analysis used here is shorter than the cross sectional unit, to deal with issues of contemporaneous correlation the panel corrected standard error model (PCSE) is applied which controls for heteroscedasticity and the AR(1) type of autocorrelation and contemporaneous correlation across panels (Beck and Katz, 1995, 1996).

To check the robustness of the results to possible bias due to trade data inaccuracy, three different models are estimated for each case using total-, reporter- and partner-based samples.

**Table 2:** The results of four different panel unit root tests of the main panel regression model variables (p values).

| | **Intra-industry trade** | **Horizontal Intra-industry trade** | **ln *DGDPC*** | **ln *GDP*min** | **ln *GDP*max** | **ln *DCAPLAB*** | **ln sum*CAPLAB*** |
|---|---|---|---|---|---|---|---|
| *With constant:* | | | | | | | |
| Levin, Lin & Chu t* | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Im, Pesaran and Shin W-stat | 0.000 | 0.000 | 0.214 | 0.991 | 1.000 | 0.000 | 0.000 |
| ADF-Fisher Chi-square | 0.000 | 0.000 | 0.007 | 1.000 | 1.000 | 0.000 | 0.000 |
| PP-Fisher Chi-square | 0.000 | 0.000 | 0.000 | 1.000 | 1.000 | 0.1538 | 1.000 |
| *With constant and trend:* | | | | | | | |
| Levin, Lin & Chu t* | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Im, Pesaran and Shin W-stat | 0.000 | 0.000 | 0.621 | 0.000 | 0.000 | 0.000 | 0.000 |
| ADF-Fisher Chi-square | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| PP-Fisher Chi-square | 0.000 | 0.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

See Table 1 for descriptions of the variables

Source: own estimations

## Baseline models

Table 3 shows the results on the benchmark Helpman model (equation 5). Estimations highlight that relative factor endowments proxied by difference in per capita GDP do not have a significant impact on horizontal IIT for all specifications except the partner HIIT model. Country size effects are strongly significant, however ln*GDP*max variables has unexpected signs. In general, results are fairly robust to different and subsamples.

In the next step, the alternative specification of the benchmark model is considered to separate the effect of absolute country size from impact of relative country size (Table 4).

The results are rather mixed. Similarly to previous model, difference in per capita GDP does not influence significantly the HIIT except for the last specification. However, the estimations support a positive effect of relative and absolute country size. Again, the estimations are robust to various subsamples.

**Table 3:** The impact on horizontal IIT of relative factor endowments proxied by difference in per capita GDP using total-, reporter- and partner-based samples according to the benchmark Helpman model 1.

| | Total | Reporter | Partner |
|---|---|---|---|
| ln*DGDPC* | 0.0004 | -0.0001 | 0.0010** |
| ln*GDP*min | 0.0082*** | 0.0085*** | 0.0078*** |
| ln*GDP*max | 0.0015*** | 0.0007* | 0.0023*** |
| constant | -0.2193*** | -0.2073*** | -0.2326*** |
| N | 7722 | 3861 | 3861 |
| $R^2$ | 0.0471 | 0.0473 | 0.0474 |

N: number of observations. ***/**/*: statistically significant, respectively at the 1%, 5%, and 10% levels
Source: own estimations

**Table 4:** The impact on horizontal IIT of relative factor endowments proxied by difference in per capita GDP using total-, reporter- and partner-based samples according to the benchmark Helpman model 2.

| | Total | Reporter | Partner |
|---|---|---|---|
| ln*DGDPC* | 0.0004 | -0.0001 | 0.0010** |
| ln*GDP*min | 0.0048*** | 0.0046*** | 0.0051*** |
| ln*dispersion* | 0.0277*** | 0.0316*** | 0.0234** |
| constant | -0.2334*** | -0.2233*** | -0.2443*** |
| N | 7722 | 3861 | 3861 |
| $R^2$ | 0.0466 | 0.0466 | 0.0473 |

N: number of observations. ***/**/*: statistically significant, respectively at the 1%, 5%, and 10% levels
Source: own estimations

## New evidence

It is well known that 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 of the use of the GDP per capita, it has become a popular and dominating proxy for factor endowments in the empirical literature.

In the first step, the results focusing on the relationships between the IIT and differences in capital-labour ratios, with control for the variation in the sum of capital-labour proportions predicted by Cieslik (2005), are presented. The estimated coefficients are highly significant and consistent with the theoretical predictions (Table 5), irrespective to alternative subsamples. The absolute value of differences in capital-labour ratios negatively, while the sum of these ratios positively, influences the IIT.

**Table 5:** The impact on horizontal IIT of relative factor endowments proxied by capital to labour ratios using total, reporter- and partner-based samples according to the Cieslik model.

| | Total | Reporter | Partner |
|---|---|---|---|
| ln*DCAPLAB* | -0.0052*** | -0.0054*** | -0.0049*** |
| lnsum*CAPLAB* | 0.0125*** | 0.0123*** | 0.0128*** |
| constant | -0.1810*** | -0.1676*** | -0.1942*** |
| N | 7722 | 3861 | 3861 |
| $R^2$ | 0.0300 | 0.0282 | 0.0325 |

N: number of observations. ***/**/*: statistically significant, respectively at the 1%, 5%, and 10% levels
Source: Own estimations

## Sensitivity analysis

To check the robustness of the results, several alternative specifications including common control variables offered by the empirical literature are performed. Bergstrand (1990) suggests distinguishing the demand and supply side to explain the IIT. He argues that since the inequality in per capita incomes between countries seems to influence the share of IIT via two channels, both of them should be taken into account in econometric analysis. Cieslik (2005) proposes two different tests for Bergstrand's considerations. In the first step, the logs of the absolute value of the difference in GDP per capita and the logs of the sum of GDP per capita of trading partners are added, to control for divergence in tastes and the average level of development. Estimation shows that the capital-labour variables are significant and in line with theoretical expectations (Table 6). Both GDP per capita variables significantly influence the HIIT for all specifications.

Alternatively, the previous model is extended with absolute and relative country size variables. These results are more ambiguous (Table 7). The coefficients of difference in capital-labour ratios significantly and negatively influence the HIIT, confirming theoretical predictions. However, the sum of capital-labour ratios has become insignificant. The estimations of country size variables support *a priori*

**Table 6:** Sensitivity analysis of Cieslik model 1.

| | Total | Reporter | Partner |
|---|---|---|---|
| ln*DCAPLAB* | -0.0044*** | -0.0046*** | -0.0041*** |
| lnsum*CAPLAB* | 0.0097*** | 0.0096*** | 0.0098*** |
| ln*DGDPC* | -0.0081*** | -0.0083*** | -0.0079*** |
| ln*GDPC*sum | 0.0060*** | 0.0056*** | 0.0064*** |
| constant | -0.1660*** | -0.1478*** | -0.1839*** |
| N | 7722 | 3861 | 3861 |
| $R^2$ | 0.0739 | 0.0715 | 0.0772 |

N: number of observations. ***/**/*: statistically significant, respectively at the 1%, 5%, and 10% levels
Source: own estimations

expectations. The per capita GDP variables also have strong impacts on the HIIT.

Finally, the role of distance in explanation of the IIT is investigated. Bergstrand (1990) provided a formal justification for the relationship between HIIT and transport costs. These results support the traditional concerns, namely that distance is significantly and negatively related to the HIIT in all specifications (Table 8). At the same time, the estimates of the coefficients on differences and sums of capital-labour ratios have the predicted signs and remain statistically significant at the 1 per cent level.

**Table 7:** Sensitivity analysis of Cieslik model 2.

| | Total | Reporter | Partner |
|---|---|---|---|
| ln*DCAPLAB* | -0.0021** | -0.0020** | -0.0022** |
| ln sum*CAPLAB* | 0.0026 | 0.0020 | 0.0031 |
| ln *GDP*sum | 0.0034*** | 0.0035*** | 0.0032*** |
| ln*dispersion* | 0.0086 | 0.0117* | 0.0054 |
| ln*DGDPC* | -0.0074*** | -0.0075*** | -0.0073*** |
| ln *GDPC*sum | 0.0042*** | 0.0037** | 0.0047*** |
| constant | -0.1824*** | -0.1671*** | -0.1975*** |
| N | 7722 | 3861 | 3861 |
| $R^2$ | 0.0784 | -0.0020** | 0.0802 |

N: number of observations. ***/**/*: statistically significant, respectively at the 1%, 5%, and 10% levels
Source: own estimations

**Table 8:** Sensitivity analysis of Cieslik model 3.

| | Total | Reporter | Partner |
|---|---|---|---|
| ln*DCAPLAB* | -0.0046*** | -0.0049*** | -0.0044*** |
| ln sum*CAPLAB* | 0.0116*** | 0.0113*** | 0.0119*** |
| ln*Dist* | -0.0000*** | -0.0000*** | -0.0000*** |
| constant | -0.1533*** | -0.1387*** | -0.1677*** |
| N | 7722 | 3861 | 3861 |
| $R^2$ | 0.0563 | 0.0561 | 0.0571 |

N: number of observations. ***/**/*: statistically significant, respectively at the 1%, 5%, and 10% levels
Source: own estimations

## Summary and conclusions

The aim of the paper is to analyse the pattern and driving forces of the HIIT and relative factor endowments using the integrated Helpman and Krugman (1985) model. This framework predicts a negative relationship between differences in capital-labour ratios and the HIIT. However, there exists rather puzzled evidence to support this theory. Previous empirical studies have failed to provide an exact link between the theory and the data. Thus, an empirical strategy developed by Cieslik (2005) is employed to test the predictions of the Helpman and Krugman (1985) model.

The results show a low level of HIIT for agri-food products within the enlarged EU during the analysed period. At the country level, Belgium, France, Netherlands and Germany report the highest levels of IIT within the EU.

The empirical evidence suggests that the standard IIT theory finds some support in the data when the sum of capital-labour ratios instead of relative country-size variables is controlled in the estimating equations. In other words, the theory can work if an appropriate framework for empirical analysis is employed.

The results have several implications for future empirical work. Instead of using the usual eclectic and/or *ad hoc* approach, the empirical research on IIT should be based on specific theoretical models. Similarly to the vertical IIT literature, empirical research based on the C-H-O model should distinguish the horizontal from the vertical IIT. The calculations in this paper confirm the findings of Fertő and Soós (2009) that data accuracy can be a serious issue in empirical IIT research, although the estimations are relatively robust to various subsamples. Thus, sensitivity analysis is important for checking the robustness of results. Finally, the empirical research should use the relevant and new developments in panel data econometrics.

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**JÁMBOR Attila***

# 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):

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

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:

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

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:

$$1 - \alpha \leq \frac{UV_i^X}{UV_i^M} \leq 1 + \alpha \tag{3}$$

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:

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

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 ($j, k = 1, \ldots n$).

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:

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

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:

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

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

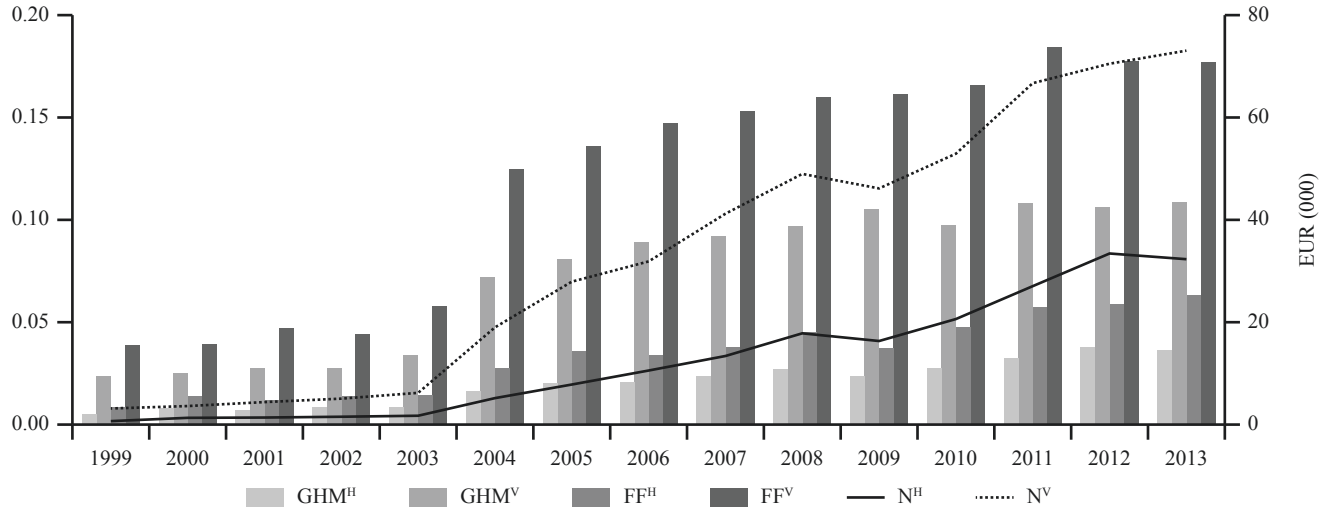


**Figure 1:** Horizontal and vertical intra-industry trade in agri-food products between the Visegrad countries and EU Member States over time in the period 1999-2013.

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):

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

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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**Martin Kang'ethe W. GACHUKIA***

# Moderating effect of traceability on value chain governance of credence goods: a perspective of the New Institutional Economics framework

This paper reviews the application of New Institutional Economics (NIE) theoretical assumptions and the way they relate to value chain governance and are moderated by traceability and information technology. Through literature review, NIE assumptions are examined by comparing how they are partially mitigated by traceability. The effect of these mitigations is realised in the readjustment of value chain governance typologies to suit lean and more competitive and visible value chains. The findings are based on the fact that information asymmetry, bounded rationality and behavioural uncertainty have given rise to incomplete contracts, especially in the agri-food sectors of most developing economies. Supply chain actors in this sector have the constant burden of assurance in ascertaining that credence goods remain authentically safe. The moderating effect of traceability is therefore proposed to reduce these uncertainties and is as such a form of assurance to promote both a holistic approach in compliance with standards and a seamless mechanism for product and process integration. However, this moderating effect, despite being novel in the value chain governance discourse, needs to be empirically ascertained. The novelty of this paper is based on the agricultural development agenda of developing economies in the light of the discourse on market-oriented reforms, following multilateral trade liberalisation and especially structural adjustment programmes in developing countries. The consequent increase in world market integration has led to the promotion of value chain strategies and reconsideration of how food is governed in these markets.

**Keywords:** agri-food chain, transaction costs, information asymmetry, bounded rationality, behavioural uncertainty

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## Introduction

Changes in agri-food markets have significantly affected the typology of agri-food value chains. (Jaffee 2003; Henson and Reardon; 2005; Swinnen; 2014). Consolidation of the power of retailers or end-use markets, and globalisation of supply chains have occurred in the last two decades (Lee *et al*., 2012). Other major drivers and contributors to these changes include increasing competition from global market participants, and economies of size and scope in production and distribution. These changes have introduced different forms of vertical integration and alliances, which are now increasingly dominating the agri-food value chain as opposed to the traditional (spot) agricultural markets (Kherallah and Kirsten, 2002).

In addition to reorganisation of supply chains, changes in the determination of food product safety have been extended to subtle characteristics that were initially classified as known prior to purchase (search goods), or after purchase (experience goods) and those that are currently discerned with difficulty after consumption (credence goods) (Martino and Perugini, 2006). A credence good is a complex, new product with quality and/or safety aspects that cannot be known to consumers through sensory inspection or observations in consumption. The quality and safety characteristics that constitute credence attributes include (a) food safety; (b) healthier, more nutritional foods (low fat, low salt etc.); (c) authenticity; (d) production process that promotes a safe environment and sustainable agriculture; and (e) 'fair trade' attributes (e.g. working conditions) (Reardon *et al*., 1999).

In meeting these demands, there has been a rise in third party certification bodies and a transition in governance typologies from traditional agricultural (spot) markets to relational, hierarchical and vertically-integrated governance structures. The extent of these changes have been described by Busch (2011) as a 'cacophony of governance'. Buhr (2003) suggests there is ambiguity about the impact of information technology and information systems on organisation structure. Although it has been suggested that the greater use of networks would eventually lead to market-like relationships among firms, Buhr (2003) concluded that the more the use of inter-organisational networks, the more hierarchical would be the trading relationships.

This paper contends that traceability and traceability systems as information management tools play a moderating role in agri-food value chain governance as backed by the theoretical underpinning of New Institutional Economics (NIE) theories of Transaction Cost Economics (TCE), Principal Agency Theory (PAT), Property Rights Theory (PRT), Network Theory (NT) and Resource Based View (RBV). NIE principles bridge the gap between market uncertainties and market assurances by determining the nature of transactions through the institutions of contracts, property rights, conventions and authority. Contracts respond to market conditions, either assisted by prevailing institutions where these are supportive by giving assurance, or hindered where they are incomplete, hence creating uncertainty (Hubbard, 1997; Kherallah and Kirsten, 2002).

This paper is structured as follows. Firstly, the theoretical background is clarified. Secondly, the relaxed NIE assumptions of imperfect information, existence of transaction costs and bounded rationality are related to the literature on value chain governance structures. Thirdly, traceability is proposed as a moderator in mitigating the NIE assumptions in the context of the nature of contracts and the consequent adjustment of agri-food value chain governance structures, while promoting competitive advantage of the supply chain actors.

## Theoretical background

NIE recognises the cost of transacting as determined by institutions and institutional arrangement to be key to economic performance (Kherallah and Kirsten, 2002). These institutions are the institutions of contracts, property rights, conventions and authority (Hubbard, 1997). The rise of NIE was affirmed by the acknowledgement of the role of institutions and relaxes the assumptions of neo-classical economics of perfect information, zero transaction costs and full rationality. To NIE, these assumptions are moderated as imperfect information, existence of transaction costs and bounded rationality. Some of the theories discussed under the NIE include transaction cost economics (TCE), property rights theory (PRT), principal agency theory (PAT), network theory (NT) and resource-based view (RBV).

The choice of these theories under the NIE framework and specific to this research relates to the considerations that, firstly, the theories from previous research have gained prominence in the supply chain management (SCM) discourse. Defee *et al*. (2010) audited various theories applied in logistics and SCM research and found that SCM research "is at the intersection of multiple disciplines including strategic management, purchasing, manufacturing, marketing, retail and logistics" (p.405). Secondly, this choice is related to the conclusions of Halldorsson *et al*. (2007) that the first three theories answer the question of how to structure a supply chain when viewed as a collaboration between institutions and the latter two ascribe what is needed to manage a particular internal structure of an organisation. TCE, PRT and PAT are typically used to identify the best organisational structure within institutions (Coase, 1937; Williamson, 1985, 1999; Eisenhardt, 1989). NT and RBV view the use of resources by institutions as dynamic ways of promoting inter-organisational relationships that are unique and competitive. Thirdly, to a large extent, SCM research is derived from these disciplines' theoretical paradigms. Specifically, the five theories can be clustered as competitive (RBV), microeconomic (TCE, PAT and PRT) and systems (NT), which form 52.8 per cent of the theories analysed. TCE and RBV formed the largest number of theoretical incidences, of 10.4 and 8.6 per cent, respectively (Defee *et al*., 2010). Fourthly, these theories inform this research on how to structure a supply chain by ascribing what is required in each structure. Fifthly, these five theories are based on the larger NIE framework that seeks to overcome the limitations of Neo-Classical Economics and Old Institutional Economics frameworks. Finally, the TCE theory, PAT and PRT elaborate on particular characteristics of information asymmetry, uncertainty and opportunism as related to traceability, and asset specificity is related to NT and RBV theory under governance relations.

### Transaction cost economics

NIE posits that institutions are transaction cost minimising arrangements. The main focus of TCE is the definition of the main structures and coordination of transactions through markets or hierarchies. Transaction costs are thus conceived as the costs of carrying out any exchange, whether between firms in a market place or by transfer of resources between stages in vertically-integrated firms. Hobbs (1996) separates transaction costs into three components: *information costs* that are related to information about products, prices, inputs and buyers and sellers; *negotiation costs* that arise from the physical act of the transaction especially in writing of contracts, and *monitoring costs* that emanate after an exchange has been negotiated.

TCE relates to two main assumptions, human behaviour and environmental characteristics. The assumption about human behaviour further relates to opportunism and bounded rationality. Opportunism as defined by Williamson (1979) as 'self-interest seeking with guile' recognises that businesses and individuals sometimes seek to exploit situation(s) to suit their own advantage. In as much as opportunism may not be prevalent, the theory however recognises it as often present in some instances. TCE also views humans as bounded rational individuals who, although they may always intend to make rational decisions, have physically limited capacity to evaluate accurately all possible decisions and alternatives. Bounded rationality recognises this human limitation in the face of complex situations and future uncertain events (Selten, 1990). On the other hand, the assumption about environmental characteristics further elaborates asset specificity, uncertainty and frequency of transactions. Asset specificity was defined by Williamson (1985) as 'a durable investment undertaken in support of particular transactions'. It ensures that resources in a given transaction relationship are not transferable to other activities (Greenberg *et al*., 2008). Williamson (1989) elaborates six asset-specific types related to site specificity, physical asset specificity, human asset specificity, dedicated assets, brand name capital and temporal specificity.

The uncertainty characteristic contrasts with the perfect information assumption of the neo-classical economists. Information about the past, present and the future state is not perfectly known for various reasons; in such a state it would be difficult to determine *ex-ante* opportunistic behaviour as well as confirm *ex-post* bounded rationality. It would be prudent to consider these aspects in the light of contract formulation for the unanticipated changes in circumstances surrounding a transaction (Ji *et al*., 2012). Owing to uncertainty, the formulation of contracts *ex-ante* and the ability to verify compliance *ex-post* have largely led to emergence of incomplete contracts. The frequency of transaction assumption implies that if transactions are infrequent, then the cost of alternative governance structures may not be justified. Therefore, the volume, number and/or time spread in transactions are important considerations even with the previous assumptions. If they are infrequent, alternative governance structures may not be necessary.

### Principal agency theory

Eisenhardt's (1989) review of PAT was concerned in answering, firstly, the agency problem which aims at establishing the goals of the principal to the agent and the verification of what the agency is doing, and secondly, the problem of risk sharing, especially when the principal and the agent have different attitudes towards risk. The focus of this theory is thus

to determine the most efficient contract governing a given principal-agent relationship while focussing on the assumptions of the NIE framework. In the light of the principal not knowing the outcome of the agent's behaviour, the agency problem presents itself in view of the agent behaving inappropriately, either by the misgivings of moral hazard or adverse selection. The solution to moral hazards and adverse selection in the context of simple contract is based on investment in information systems that would reveal the agent's behaviour to the principal or by the formulation of outcome-type contracts. However, a trade-off in cost occurs to the principal in the form of the cost of measuring behaviour and the cost of measuring outcomes and transferring the risk to the agent.

## Property rights theory

PRT focuses on improvement in social welfare by elaborating on the rights to use, to own income from, and to transfer or exchange assets and resources (Coase, 1960). Property rights discourse highlights diverse views, especially in so far as claims to portions of rights are concerned. In view of this, the concerned parties are said to lay claim to portions of rights in what Alchian and Demsetz (1973) refer to as 'bundles of property rights'. PRT therefore complements an organisational economics approach that informs analysis of both institutions and governance within interrelated disciplines such as strategic management and economics.

The tenets of PRT stem from the argument of incomplete contracts as an improvement to PAT theory. NIE posits that contracts are consequentially incomplete in view of imperfect information, bounded rationality and the transaction costs involved in negotiating and monitoring of the contract, i.e. the *ex-ante* and *ex-post* costs respectively. Hart and Moore (1999) define incomplete contracts as 'contracts that either party would wish to add contingent clauses, but are prevented from doing so by the fact that the state of nature cannot be verified (or because states are too expensive to describe *ex-ante*)'. As a result, PAT is mediated by PRT with the introduction of common asset ownership either through joint ventures or alliances. Kim and Mahoney (2005) affirmed that "the modern property rights theory complements extant agency theory and transaction costs theory by introducing ownership concepts in an incomplete contract setting and emphasising relation-specific assets (both physical and human asset specificity)" (Kim and Mahoney, 2005, p.227).

Some aspects of ownership in an incomplete contract are arrived at due to the limitation of measuring costs, specifically *ex-post* monitoring costs. Many quality attributes are characterised as credence attributes by buyers in the absence of monitoring information asymmetry arising from experience; this asymmetry increases transaction costs for downstream food firms and requires confirmation after experience (Martino and Perugini, 2006). Barzel (1982) elaborated this emergent issue with the view that "measurement is by the seller, whether in advance or at the time of exchange. Quite often, however, measurement is automatic, or its cost is greatly reduced as the commodity is used. Therefore, substantial savings will result if measuring is left to the buyer to be performed at the time of consumption" (p.32).

This arrangement of vesting to the consumer the responsibility for certainty measurement is made tenable by the arrangements espoused in product guarantees, warranties, share contracts, brand names and labels. Measurement of value by the consumer minimises the *ex-ante,* opportunism and uncertainty costs.

## Resource based view theory

Madhok (2002) posed the questions that are most often raised by entrepreneurs and business partners alike. These include: (a) why is an activity organised within firms and not purchased from the market; and (b) why is an activity organised within a particular firm and not another? RBV theory strives to answer these questions and others. To some, the firm has been viewed from the cost aspect such as in the TCE theory; yet to others, the view of the firm has been related to incentives and safeguards which has yielded theories related to PAT and PRT. The resurgence of interest in the firm has been reviewed from the role of the firm's resources as the foundations of the firm's strategy. RBV theory is hinged upon the foci of the resources and capabilities of the firm (Skjoett-Larsen, 1999). Asher *et al.* (2005) make the link between PRT and RBV theory by affirming that firms have continually placed emphasis on their resources such as intellectual property rights and knowledge-based resources and capabilities.

Grant's (1991) framework through which the RBV approach to strategy analysis is applied entails identification, classification and appraisal of the potential of the competitive advantages of the firm's resources and capabilities, selection of a strategy which best optimises these to external opportunities and, finally, identification of resource gaps that need to be filled. While resources are appraised as factors available or owned by firms for the purpose of achieving a desired end, capabilities are viewed as abilities of the said resources to perform certain tasks. Resources and capabilities in the RBV theory result in competitive advantage that is boosted by their characteristics that are value-adding, rare, costly to imitate and with limited transferability (Zajac and Olsen, 1993; Skjoett-Larsen, 1999). These are referred to as the strategic resources or the core competencies of a firm. Non-transferability of resources can be occasioned by geographical immobility, imperfect information, firm-specific resources and immobility of capabilities (Grant, 1991). The ultimate aim of these resources and capabilities is to promote competitive advantage as the degree to which a firm reduces its costs, exploits opportunities and neutralises threats (Newbert, 2008).

## Network theory

Individual firms depend on resources controlled by other firms. Jraisat (2011) noted that network relationships create information sharing by enabling buyers and sellers to have access to resources and knowledge beyond their abilities through long-term relationships. NT includes three interrelated components: activities, actions and resources. Actors are defined by the resources they control and the incentives they perform; the relationships between a firm in a network arrangement generates two separate types of interactions, namely exchange processes and adaptation processes (Skjo-

ett-Larsen, 1999). While the former includes exchange of information, goods and services, and social processes, the latter includes mutual modifications of products, administrative systems and production processes in order to achieve a more efficient exploitation of resources (Skjoett-Larsen, 1999).

Adaptation processes help to strengthen the bonds between partners; they also signal mutual relationships that can be improved to increase stability. NT therefore affirms the definition of SCM as the integration of key processes from the final customer to the original suppliers that provide products, services and information that adds value for customers and other stakeholders (Rogers *et al*., 2002).

## Nature of contract in agri-food supply chains

From the NIE literature the need for contracts is to reduce uncertainties while promoting assurance (Hubbard, 1997). Part of the challenge in all contracts is uncertainties in relation to incomplete contracts. Cannon *et al*. (2000) argue that when a transaction involves relationship-specific adaptations and are (a) subject to dynamic forces and future contingencies that cannot be foreseen or (b) involve ambiguous circumstances where tasks are ill-defined and prone to exploitation, the difficulty of writing, monitoring and enforcing contracts is increased and their overall governance effectiveness weakened. This happens to be the case in most agricultural contracts in the wake of globalisation. In this case, efforts to govern geographically-dispersed relationships on the basis of detailed and formal contracts – without the benefit of some additional clauses – are not likely to enhance performance.

The nature of contract is construed to be related to aspects of rights and obligations of the contracting parties. Following from human limitation in unforeseen events, information is said to be limited or skewed. Despite this limitation, parties continue to contract to safeguard their interests as related to ownership rights. Ownership rights, interpreted in the economic sense as property, offer an effective mechanism for providing economic agents with appropriate incentives to create, maintain and improve assets (Chaddad and Cook, 2004; Chaddad and Iliopoulos, 2013). For these authors, ownership rights relate to two distinct concepts: residual returns (or claims) and residual rights of control. "Residual rights of control are defined as the rights to make any decision regarding the use of an asset that is not explicitly attenuated by law or assigned to other parties by contract" (Chaddad and Cook, 2004, p.349). While residual claims are understood as "the rights to the net income generated by the firm, i.e. the amount left over after all promised payments to fixed claim holders (e.g. employees and debtors)" (Chaddad and Cook, 2004, p.349). Residual rights of control emerge from the impossibility of crafting, implementing and enforcing complete contracts. Because all contracts are unavoidably incomplete, it is the residual right of control over an asset that defines who is the owner of an asset (Grossman and Hart, 1986).

## Propositions to the moderating effect of traceability on NIE assumptions

There is a lack of common understanding of the term 'traceability' (Ringsberg and Jönson, 2010). However, van Dorp's (2002) discussion of the concepts of 'track' and 'trace' have been adopted as the main roots for the development of the traceability concept. These provide for product tracking and forward and backward traceability. Kelepouris *et al*. (2007) clarified the concept of product traceability depending on the direction in which information is recalled in the chain. Backward tracking relates to finding the origin and characteristics of a product from one or several criteria, while forward traceability is the ability at every point of the supply chain to find the locality of product(s) from one or several given criteria. The definition by the European Union of traceability as "the ability to trace and follow a food, feed, food-producing, animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution" (EC, 2002) is adopted in this research.

The moderating role of traceability is adopted in this research to mitigate partly the NIE assumptions of information asymmetry and behavioural uncertainty while promoting some level of assurance related to Barzel's (1982) product right guarantee. This gives the first proposition that:

> **P1***: The moderating effect of traceability may determine the nature of food governance relationships along the food supply chain by replacing loose contractual relationships with formal and short-period contracts with a high information base.*

Associated with the reduced asymmetric information, delayed rights/guarantees and transactions costs, supply chain management efficiency is improved, while an indirect effect resulting in change in governance structures is here proposed. The basis of this view is the property right division theory of Barzel (1982) which supports the idea that, by delayed right or through provisions of guarantees and warranties offered to the downstream actors and consumers, costs related to human opportunism, monitoring and compliance, and behavioural uncertainty would be minimised to a large extent. Consequently, the second proposition is:

> **P2***: Implementation of traceability systems provides delayed rights through an* ex-post *punishment mechanism that binds the producer in the food supply chain to be charged in the likelihood of failure to comply with safety and standards.*

Prior to implementing traceability systems, transactions between a given contracting company as the principal and contracted agents, say in an agricultural setting, were completed when agents delivered the products to the contracting company. The ownership of all dimensions of the products were transferred from the contracted agents to the company. When quality and safety issues arise, the contracting company would suffer liabilities due to the opportunistic behaviour

and bounded rationality of the unscrupulous agents. The contracting company would eventually lose its reputation, suffer claims of tort liability and added costs from the losses accrued due to product recall. On implementing traceability system(s), such a simplistic principal agency transaction would be regarded as incomplete since the agent who supplies the products as per the contractual agreement still keeps ownership of one dimension tagged to food safety guarantee despite it having transferred the ownership of the other dimensions of the products to the contracting company. It is by selling the product to consumers, especially of credence good(s), that food safety and quality attributes are confirmed upon consumption. It is therefore after this *ex-post* exchange (consumption) that a transaction is considered complete and hence the delayed right of ownership on the part of the agent persists until this confirmation that was first given as a guarantee is assured as promised. Through traceability systems, the *ex-post* information revealing mechanism of the product trace leads to either punishment by product recalls due to non-compliance or reward by increased customer confidence and trust. Traceability systems would thus mitigate for *ex-ante* opportunism, bounded rationality and *ex-post* information asymmetry, and also discourage moral hazards such as misuse of chemicals.

Without traceability systems, transaction costs in defining property rights of 'all bundles of rights' in food safety attributes would be high and incomplete since not all rights are clearly defined *ex-ante* as witnessed in credence goods. In order to control the opportunistic behaviour while facilitating value chain coordination, there is a need for formal and informal governing instruments. Traceability systems are thus proposed to act both as a formal legitimate rule – the procedure of enforcement that follows a certain normative requirement and fulfils a criterion of integration (Mueller *et al*., 2009) – while complementing the informal rules or voluntary standards.

Asymmetric distribution of information has been attributed as the essence of many problematic aspects of food supply. All standards, either public or private, related to food safety and quality have a critical information element. Carlton and Perloff (1989) cite the following reasons for information asymmetry, namely: (a) information varies in its reliability, hence not all information can be processed as accurate, some may be deemed to be inaccurate; (b) information may well be withheld and hence the search and collection of information may be costly; (c) owing to human limitation, a consumer can only retain limited amounts of information; due to bounded rationality, information is processed subjectively by different actors; and (d) owing to limitation in knowledge on the subject matter, processing information on all products correctly is limited due to lack of expert knowledge.

In the light of these limitations, two means of remedying information asymmetry have been appraised positively, especially in agricultural commodities, namely the use of quality labels and traceability. Raynaud *et al*. (2002) argued in favour of quality labels by asserting that consumers may not know automatically the quality of the products or the accuracy of the information supplied to them. Informed experts or agents would signal to the consumer on the quality of the products and hence reduce the cost of the ultimate consumer's search and measurement costs.

On the other hand, Hobbs (2004) proposed the use of traceability systems to mitigate information asymmetry depending on the desired result of traceability implementation. Firstly, reactive traceability systems enable *ex-post* cost reduction after a problem has arisen. This is enabled through a trace-back of food to the source of contamination in what Coff *et al*. (2008) describe as the effect of traceability to origin or attribution and quality assurance. Secondly, Hobbs posits that the adoption of traceability systems is promoted by threats of legal action against firms producing unsafe food and the resulting damages that may result from a lack of demonstrable products or process trace or tracking. Resende-Filho (2007) and Resende-Filho and Buhr (2008) highlight two directions that traceability as a liability function has taken. They state that information asymmetry on food safety and quality has developed due to adverse selection or withholding of information and problems related to opportunistic behaviour. As a result, a common point in promotion of signalling (Martino and Perugini, 2006) and use of traceability systems has been embraced with the aim of protecting institutions' reputation and also as an incentive mechanism to enhance compliance among the agri-food value chain actors. The ability to trace products allows liability for food safety systems to be easily established along the supply chain while reducing the monitoring and enforcement costs for consumers and downstream food distributors and exporters (Hobbs, 2004). This proposition has been empirically established by Altal (2012) with the finding that consumers' perceived risk was mitigated by traceability, although at a price.

Accordingly, between quality labels and traceability, the latter solution seems to out-weigh the former in terms of the challenges of limiting information. Sodano and Verneau (2009) envisioned three kinds of firms that would exploit the maximum benefit of traceability systems: (a) firms such as the retailers of private quality labels and supermarkets will invest fewer resources against tort liability since the cost burden will be to the suppliers; (b) firms which already produce information could save on resources as they cover themselves against opportunistic behaviour in the presence of asymmetric information; and (c) traceability systems can give assurance to the third-party providers and hence reduce their costs through the certificate of origination (Jahn *et al*., 2005). Traceability therefore mitigates brand proliferation and price discrimination.

## Supply chain integration and value chain governance management

Supply Chain Integration (SCI) is considered as the degree to which a focal/lead firm collaborates strategically with its supply chain partners and collaboratively manages intra- and inter-organisation processes (Flynn *et al*., 2010; Maleki and Cruz-machado, 2013). The eventual goal of SCI is to achieve effective and efficient flows of products and services, information, money and decisions, to provide maximum value to the final customer.

Frohlich and Westbrook (2001) state that SCI through forward integration promotes the flow of materials and ser-

vices while backward integration promotes sharing of information from customers back to the suppliers. SCI indicators can include internal integration and external integration (Maleki and Cruz-machado, 2013), and product integration and process integration (Huo *et al*., 2014), while some scholars have within external integration alluded to both supplier and customer integration (Nogueira Tomas *et al*., 2014). The focus in this paper on supply chain integration from the perspective of internal integration, including both product and process integration (Helmi *et al*., 2013), supplier integration and customer integration (Boon-itt and Wong, 2011), gives a third proposition that:

**P3***: Adoption of traceability as an information management tool can promote supply chain integration of suppliers, products, processes and customers.*

Supply chain integration is required internally within and across functions and externally across suppliers and customers (Boon-itt and Wong, 2011) in order to achieve optimal results in traceability application. Internal integration is characterised by full systems visibility across functions such as procurement, production, logistics, marketing, sales and distribution; this forms the key driver for competitive advantage in supply chain management (Van Hoek and Mitchell, 2006). The goal of internal integration is to develop a process-oriented focus while concentrating on coordination across functional areas (Richey *et al*., 2010). Supplier integration promotes effective alignment, information sharing and participation in the interactions between firms and their suppliers requires cooperation, coordination and collaboration (Moharana *et al*., 2012). By including joint efforts in product development, problem solving and technology exchange, among others. On the demand side of a supply chain, customer integration is achieved through the understanding of product, culture, market and organisation in such a way that the chain members respond rapidly to the customer's needs and requirements. Both supplier and customer integration focus on coordination and collaboration efforts that occur among supply chain members.

While SCI promotes performance, it also redefines governance values in the way organisations interact and relate. Governance change is related to changing the organisations' ways of doing things by way of inclusive communication, strong working relationships, joint accountability and senior management involvement. These facilitate internal integration, interdependency, common goals and objectives, communication and information sharing as some of the factors considered to be key to the effective governance of firm relationships with others through external integration (Richey *et al*., 2010). Ultimately, SCI aims at promoting interdependency, structures or formative relationships which are communicated through exchange of information, collaborative alignment, profitability and competitive advantage (Engelseth, 2009). In spite of the benefits achieved through SCI, discussion of value chain governance must continue. For instance, Denolf *et al*. (2015) report that information sharing cannot be explained solely by governance structures; information systems as information tools can affect the nature of governance structures.

The emergent new approaches to supply chain value management are largely based on allocation of resources to core competencies and an increasing trend towards outsourcing and sub-contracting of non-core functions. This has resulted in a general loss of control over the stages of the production and distribution processes, especially to geographically dispersed regions. Vurro *et al*. (2009) broadened the concept of value chain governance from inter-firm relationships to global fora due to the coincidence of falling regulatory barriers to international trade, advances in communication technologies and declining transportation costs. This approach also led to the review of Coase's discourse on a firm's operations and governance as based on TCE.

Gereffi (1994, 2001) highlights the typologies of buyer-driven versus producer-driven forms of governance. Producer-driven commodity chains are found in capital-intensive sections that require a huge capital outlay; while buyer-driven governance relates to retailers or markets providing the leading role in managing the supply chains. The role of the lead firm is considered a key factor in coordination of activities, goods/services and information along the supply chain (Ponte and Gibbon, 2005; Gibbon *et al*., 2008).

Gereffi *et al*. (2005) reported that, owing to the wide range of inter-firms governance types in the global industries there is the recognition of the complexity of inter-firms relationships in the global economy. To them, "the key insight is that coordination and control of global scale production systems, despite their complexity, can be achieved without direct ownership" (p.81). The view of governance as coordination emphasises global value chains compared to the view of governance as a driver that is based on the understanding of global commodity chains. This nuance points to the value dimension of the coordination.

Gereffi *et al.* (2005) added three distinct types of *modular*, *relational* and *captive* governance forms to Williamson's categories of *markets* and *hierarchies*. This typology is based on three determinants (a) the complexity of information and knowledge transfer; (b) codification of information and knowledge transmitted to actors in a transaction; and (c) the capabilities of actual and potential suppliers in relation to the requirements of the transactions (Gereffi *et al*., 2005; Gibbon *et al*., 2008) (Table 1).

Global food supply chain systems seem to combine all the four aforementioned characteristics of governance. Martino and Perugini (2006) contextualise the need for a proper governance of food supply chains in relation to factors related to food quality and safety. To them, the subject of food safety

**Table 1:** key determinants of global value chain governance.

| Governance type | Complexity of transaction | Ability to codify transactions | Capability in the supply-base | Degree of explicit coordination and power asymmetry |
|---|---|---|---|---|
| Market | Low | High | High | Low |
| Modular | High | High | High | ↕ |
| Relational | High | Low | High | |
| Captive | High | High | Low | |
| Hierarchy | High | Low | Low | High |

Source: Gereffi *et al.* (2005)

is situated in relation to the provisions of TCE theory and its relevance to food safety, quality, information asymmetry, uncertainty, opportunism and governance structures. They characterised food safety as products with a typical asymmetric information pattern regarding the upstream and downstream supply chain actors, where poor quality is punished by the market while lack of safety may involve legal sanctions. The main motivation for quality assurance strategies is to create quality differentiation, increase consumers' trust and reduce exposure to risk of food safety incidents and subsequent liability cases (Hatanaka *et al*., 2005).

However, these alternative strategies come at an added cost that is normally passed on to the consumer. Despite the additional cost for quality, the underlying character of quality assurance is the aim of giving information on conformance; from this reality, one draws the inferences that (a) information issues have an impact on product and process quality in the agri-food chain; (b) greater information shortages are correlated to stronger integration of supply chain members; and (c) enhanced traceability reduces information costs for consumers arising from quality verification. As such, the key determinants of complexity of transaction, ability to codify transactions and capability of the supply base as affected by traceability may be viewed to be high and hence work towards modular type of governance with a low degree of explicit coordination and power asymmetry.

## Discussion

The New Institutional Framework offers a platform for broadening the agricultural development agenda related to the moderating role of traceability and the eventual value chain governance structures adjustments in agri-food chains. The supply chain as a key operational objective of traceability is related to provision of critical information regarding quality and safety of food, origin and quality assurance, control and governance. The moderating effect of traceability in the entire supply governance structure is proposed, albeit theoretically, to further the discourse that (a) agri-food value chain governance has changed from loose contractual relationships that previously relied largely on trust and were governed by spot markets to implementation of formal short-period contracts largely relying on high information base and lean processes; (b) traceability systems act both as a formal legitimate rule while complementing the informal rules in the food supply chain governance through the promotion of delayed rights, especially for credence goods; (c) adoption of traceability systems gives assurance to third party certification agencies about the certification of origin of traced products and hence reduces the costs and duplicity; and (d) adoption of traceability as an information management tool may promote supply chain integration of suppliers, products, processes and customers.

In terms of policy development, the NIE approach is to understand the need of institutions through which knowledge is discovered and employed to facilitate the coordination of economic activity. The costs of these institutional arrangements, together with the technology employed, determine the total costs of production and transaction and so help to determine competitiveness. Where information and knowledge acquisition can be made easily accessible, transaction costs are lowered and competition increased, ultimately supporting the demands of both the developing economies and developed economies in their financial needs and quality and safe products respectively.

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**SZABÓ Dorottya* and JUHÁSZ Anikó***

# Consumers' and producers' perceptions of markets: service levels of the most important short food supply chains in Hungary

In recent years, there has been a rapid growth in new type, direct and short supply chains (SSC) Hungary, and the markets have proved to be globalisation-resilient, keeping their market share from sales of fast-moving consumer goods. We conducted a consumer and producer survey to identify the most important expectations and experiences about markets in Hungary. We applied a service quality model (SERVQUAL) to measure the consumers' and producers' opinions and satisfaction of Hungarian markets. A warning result of our study is that vendors estimate their level of service above that of the consumers' experiences which means that, in spite of the direct communication, they do not have an accurate understanding of their customers' requirements. Our surveys also showed that there is a substantial deficiency between the services expected and experienced at markets in all dimensions (environment, service, convenience and produce) that influence the choice of retail channel. The most important dimension proved to be produce quality which should thus remain in the focus of market developments. In recent years, new trends in urban local food movements have started to emerge in Hungary which could not be detected at the time of our survey (2012). Thus we intend to extend our survey in the future to see whether these new local-alternative food movements have formed a new consumer segment for farmers' markets in Hungary, and in what way should the market vendors modify their services to be able to ride this new trend.

**Keywords:** short supply chain, farmers' markets, service quality

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## Introduction

In recent years, there has been a rapid growth in new type, direct and short supply chains (SSC) in Hungary (Benedek *et al*., 2014; Csíkné Mácsai, 2014; Györe, 2014; Kujáni, 2014). These forms of sale have been defined as part of the 'new rural development paradigm' (Marsden *et al*., 2000; van der Ploeg *et al*., 2000; Renting *et al*., 2003; Nemes, 2005). At the centre of this new approach to rural development lies the support of sustainable production and marketing as a way to comply with the growing interest of consumers in sustainability (Alkon, 2008; Seyfang, 2008). Benedek and Balázs (2014) concluded that SSCs "seem to offer a way to increase social cohesion, to generate consumer demand for healthy food as well as to halt the depopulation of rural areas" (p.22).

Policymakers have also recognised SSC and the growing local food movement as a useful rural development tool. In the 2007-2013 European Union (EU) programming period the Rural Development measures, especially Leader Local Action Groups, could provide help to local producers and villages to start or improve SSC operations. National funding was also available in Hungary to build or develop farmers' markets for products coming from special rural areas dominated by isolated farmsteads. The current EU Common Agricultural Policy (2014-2020) provides an even more focused possibility for Member States to support SSC development. According to article 2m of EC (2013), "short supply chain means a supply chain involving a limited number of economic operators, committed to co-operation, local economic development, and close geographical and social relations between producers, processors and consumers". Hungary is one of the few Member States to have taken up the option of including a SSC thematic sub-programme in its Rural Development Programme for 2014-2020.

The number and use of both traditional (e.g. markets) and modern (e.g. community supported agriculture) forms of SSCs has started to grow rapidly in Hungary in the last few years (Dezsény, 2013). This local food renaissance was driven by both consumer and producer demand and was strengthened by regulatory and support mechanisms. On the other hand the sustainability (all aspects, but especially the economic and social dimensions) of these initiatives was not fully taken into consideration. Although the literature draws attention to the importance of realistic planning and decision making (Marsden *et al*. 2000; Renting *et al*., 2003; Brown and Miller, 2008; Stephenson *et al*. 2008; Juhász and Szabó, 2014), the monitoring and evaluation methods and procedures of SSC sustainability are neither standardised nor routinely used in Hungary.

The purpose of our research was to draw a clearer picture of the economic and social sustainability of markets in Hungary, and was stimulated both by the increasing national and EU policy actions and by the growing number of markets. Earlier research done by our team and other Hungarian researchers (e.g. Benedek *et al*., 2014; Kujáni, 2014) concluded that SSC needs further but coordinated modernisation and knowledge sharing, especially in management, logistics and consumer loyalty. Our results also provide the opportunity for comparison with the findings of the small number of similar consumer satisfaction surveys conducted in other European countries (Lülfs-Baden *et al*., 2008; Rosa, 2010 and Cassia *et al*., 2012), namely that:

- Farmer-to-consumer direct marketing is a discrete business segment with its own factors of success. Consumers generally expected to find better food quality and lower prices. Quality, freshness and courtesy were the mostly appreciated attributes of this shopping experience, while criticisms were addressed to difficulties in parking and payment facilities;
- The farmers' markets are not standardised but stamped with the owner's personality;
- Store atmosphere as well as individual service must

reflect the farmer's unique approach. The store manager should create a special atmosphere that offers a positive alternative to the often cold, sterile design of modern supermarkets;
- The shoppers' satisfaction was not only influenced by tangible aspects, such as the product quality and the comparative price convenience, but that satisfaction is also influenced by the complementary impact of intangible factors.

In this article we address the following questions with the purpose to support decision making in SSC development: who are the customers of Hungarian markets and how many clear segments can be identified; are the consumers satisfied with the markets or could their loyalty be increased; how well do the producers know their customers' needs; do the consumers and producers confirm the shift of importance to social and environmental sustainability as the driving force behind the growing popularity of Hungarian markets or do other expectations and experiences lie behind their rapid growth.

Based on the above-mentioned results, our research hypotheses were as follows: (a) the economic reasons for farmers selling at markets are much stronger than the social and moral ones; (b) the farmers selling at markets are still not using fully the marketing opportunities of direct contact with consumers; (c) the buying decisions of consumers are most strongly influenced by the product characteristics; (d) the consumers of our survey will form distinct clusters and although there will be definite 'market enthusiast' and 'opposition' groups, most respondents will be in between, providing useful impetus for development plans.

# Methodology

## Sampling methods

Surveys to measure producers' and consumers' perceptions about markets in Hungary were carried out in 2012.

The opinions of consumers were measured with the help of a non-probability selection method, the unrestricted self-selected on-line surveys (Couper, 2011). We also provided a paper version of the questionnaire to reduce the bias of the sample inherent to this selection method. The validity concept of our selection was based on the demographic characteristics of consumers frequently shopping at markets (Henneberry and Agustini, 2004; McGarry Wolf *et al*., 2005; Varner and Otto, 2008), which are quite similar to that of Hungarian Internet users (NRC Piackutató, 2011): educated, above-average status, higher income, urban population. We received 1029 questionnaires (78 on paper and 951 on-line), of which 851 were validly completed. Residents of Budapest and neighbouring Pest county, the higher educated, women and the 30-59 age group were strongly represented in the sample, meaning that the demographics of the respondents were similar to those of the Hungarian market shoppers.

In the producer survey we gathered answers from farmers that use direct sales channels (as well), especially markets. Again, both on-line and paper questionnaires were used. For the on-line survey, we used the list-based probability sampling method (Couper, 2011) which meant that we used a representative producer database for the on-line survey and markets for the paper questionnaire. We sent out more than 500 questionnaires and collected 202 validly-completed forms from farmers. Our sample was biased, but towards the direct marketing channels; thus our results are relevant to this topic.

## Analysis methods and tools

The SPSS software package was used to perform cross tabulation, factor, cluster and variance analysis. To enhance our results we conducted several data transformations (with Recode, Count and Compute methods). The significance tests and the measured relationships between variables should be treated with caution as our samples are not fully representative.

We used the SERVQUAL (SERviceQUALity) model suggested by several authors (e.g. Parasuraman *et al.*, 1988; Lülfs-Baden *et al*., 2008) as a tool to draw a comprehensive picture of the customer perception of farmer's direct sales service quality. The starting point of the SERVQUAL model is the assumption that the expectations of consumers about the given service and the perceived characteristics of the service are different. Using the original method, five areas were examined using 22 statements: material environment, reliability, customer-orientedness, warranty/trust and empathy. Rosa (2010) adjusted the categories to a study of Italian farmers' shops, retaining four of them and somewhat modifying the statements: quality of relationships, quality of conditions, quality of services and quality of produce. As most of the statements describing producer stores could be matched to the factors of our own study relating to shopping and markets, we combined them with ideas from other farmers' markets consumer surveys questionnaires and a focus group discussion. In addition to the analysis of expectations and experience, we also examined which parameters could be used to describe our group of respondents on the basis of their evaluation (using a five-point Likert scale (1 = not true at all, 5 = completely true)) of the criteria relating to the markets they visited.

The accuracy of the SERVQUAL model was somewhat influenced by the fact that in our questionnaire the factors affecting the selection of the location of shopping, i.e. the expectations, did not always correspond to the statements evaluating the markets, i.e. the experience. In both cases, it was possible to establish five dimensions, taking Rosa's study as a basis, but only four of them could be matched according to our focus group discussion. These were as follows: (a) environment (high-standard, clean environment, suitable lavatories and the experience and atmosphere of shopping); (b) services (eating facilities, possibility of pre-ordering, programmes, website and bank card payment facilities); (c) convenience (parking, opening hours, range of goods and easy accessibility); and (d) produce (quality, origin and freshness). These modified dimensions then were fit to test the hypothesis of our research.

# Results

## Assessment of markets from the producers' perspective

In the study of the assessment of markets by producers, farmers were firstly asked why they had chosen (also) to sell their produce on a market. The results show that the surveyed producers began selling on the market mostly in order to increase their income and profit and to reduce their defencelessness against merchants (Table 1). Selling on the market allows producers to obtain a higher income than they would in a longer supply chain. More lenient food safety requirements and taking advantage of subsidies motivated respondents the least in choosing this form of sale.

The surveyed producers evaluated the market as well as other vendors selling on the market and their produce. In connection with the market, respondents considered the opening hours of the markets the most satisfactory (Table 2). In addition, participants also found easy accessibility, good public safety and the possibility of shopping in a family-friendly atmosphere. Programmes and shopping carts and baskets scored the lowest as factors that were missing the most often from markets.

**Table 2:** Producers' ratings for the question "What is appropriate for the market?"

| Factor | Mean | Standard deviation |
|---|---|---|
| Opening hours are convenient | 4.4 | 0.88 |
| Clean toilets are in the market or nearby | 4.3 | 0.89 |
| Easy access | 4.1 | 1.08 |
| Public safety is good | 4.1 | 1.16 |
| Easy to shop with children | 4.0 | 1.00 |
| Experience and mood for shopping is pleasant | 4.0 | 1.04 |
| Availability of parking for the market hall | 3.9 | 1.35 |
| Dealing with complaints is provided | 3.8 | 1.12 |
| Layout and cleanliness of the market is good | 3.8 | 1.26 |
| Meals are available | 3.7 | 1.47 |
| The market place is covered | 3.5 | 1.60 |
| The market has its own website | 2.9 | 1.93 |
| Programmes are organised in the market | 2.7 | 1.66 |
| Availability of shopping baskets/trolleys | 2.0 | 1.71 |

Scores: 5 = completely true for the market, the vendors and their produce; 1 = not true at all
Source: own data

**Table 1:** Producers' ratings of the factors influencing market sales.

| Factor | Mean | Standard deviation |
|---|---|---|
| Increasing income | 4.3 | 0.97 |
| Increasing profit | 4.0 | 1.23 |
| Reducing vulnerability to merchants | 4.0 | 1.49 |
| Concrete consumers' need | 3.9 | 1.35 |
| Need for direct connections with consumers | 3.8 | 1.47 |
| Sale of unique quality products | 3.8 | 1.54 |
| Exclusion from other sales channels | 3.4 | 1.44 |
| Small quantity of products ready for sale | 2.9 | 1.35 |
| Capacity use | 2.8 | 1.67 |
| Idealism | 2.6 | 1.59 |
| Less strict requirements for food safety | 1.9 | 1.20 |
| Use of financial support | 1.7 | 1.20 |

Scores: 5 = very important; 1 = not important at all
Source: own data

**Table 3:** Producers' ratings for the question "Is this true about the vendors or their products?" (N=27).

| Factor | Mean | Standard deviation |
|---|---|---|
| Tastes and appearance of the products are suitable | 4.4 | 0.58 |
| Availability of Hungarian products | 4.3 | 0.84 |
| Price/value ratios are appropriate (affordable) | 4.0 | 0.96 |
| Vendors/producers provide information about their products | 3.9 | 1.07 |
| Vendors weigh and calculate correctly | 3.9 | 0.97 |
| Wide range of products; everything is available in the same place | 3.9 | 0.86 |
| Food safety of products is appropriate | 3.9 | 0.99 |
| Local products are available | 3.8 | 1.02 |
| The origins of the products are sound | 3.8 | 1.23 |
| Tasting is possible | 3.7 | 1.17 |
| Organic products are available | 3.3 | 1.49 |
| Payment is possible with credit card | 1.5 | 0.92 |

Scores: 5 = very true; 1 = not true at all
Source: own data

Respondents considered it most often true about vendors and the produce on the market that, on the whole, the produce on their markets had satisfactory flavour and appearance (Table 3). This was followed by the supply of Hungarian produce[1] and the reliable origin of the produce. The supply of bio-products and bank card payment facilities were placed at the end as factors that were missing the most often from the services provided by vendors.

According to 69 per cent of respondents, the number and quality of services provided to producers by markets were only in part proportional to the level of the rent. They did not consider the layout of markets completely satisfactory either, and in the opinion of most of them, rivalry between the vendors also harmed the image of the market. At the same time, the majority considered the manager of the market to be rather cooperative.

On the whole, producers were less satisfied with factors on the markets that were independent of them, but directly affected their work, than with components relating to the service to consumers, be it either their own sales activity and produce or the conditions or services provided by the market.

Producers could mark factors that should be improved in their own sales activity and in respect of other vendors on the market. They most often marked their own website (37 per cent), followed by the widening of the range of goods (30 per cent) as factors to be improved. In connection with the conditions of the market, most would like to see improved parking facilities (26 per cent). In connection with other vendors and produce on the market, they would mainly increase the number of bioproducts (26 per cent) and the reliability of the origin of the produce (18 per cent). The fewest of them would change the price and quality of produce, and the range of goods (7 per cent for each factor).

[1] In the questionnaire, respondents were not asked to interpret the given terms, thus there may be differences in the interpretation of terms, such as 'local' or 'Hungarian', referring to origin of produce, but in our opinion, these do not affect the results significantly, because no explanatory model was built on the responses.

## Assessment of markets from the consumers' point of view

In our study of the assessment of markets by consumers, we were interested in the type of factors that influence consumers in deciding on a certain form of food procurement. For this, a combination of variables was devised, which summarised statements about the produce, vendors and the environment of shops and other considerations, for example convenience.

The surveyed consumers set requirements primarily for the produce: the freshness, reliable origin and appropriate price of the produce and a wide range of goods are the most important considerations for selecting the location of the purchase (Table 4). The services provided by the shop type were at the end of the list, i.e. respondents considered it less important that the shops have their own website or that they can order the food to be purchased in advance. On average, the provision of eating facilities received the lowest score among the statements.

After this, regular market customers who completed the questionnaire were asked to evaluate the conditions and accessibility of the markets they visited, the produce sold on the market and the vendors. On average, respondents were satisfied mainly with the accessibility of the markets, and then by the products on offer (Table 5). Participants gave the conditions of the markets and the vendors very similar average scores. The overall score for the markets of 3.3 does not indicate general satisfaction of them among consumers.

Consumers tend to be satisfied only with the responsibilities of vendors on the market taken in the narrow sense; other services that may be provided by them (such as the possibility of tasting, and other information about the produce) are not generally available. A breakdown of the subject areas is as follows: Respondents considered the accessibility of markets the most satisfactory out of the factors listed and, in their opinion, vendors were usually accessible on the markets. They believed it to be true that the produce of the vendors had not been imported, and were also satisfied with the quality of the produce. It was not characteristic of the markets visited by the participants that they would organise programmes for their customers. They usually did not have their own websites, and only a few large market halls tried to assist shopping by providing shopping baskets and carts. Respondents did not find organic products on the markets to be characteristic, and at the majority of vendors it was not possible to pay with bank cards.

**Table 4:** Consumers' ratings of factors influencing the choice of the shopping venue.

| Factor | Mean | Standard deviation |
|---|---|---|
| Fresh products | 4.7 | 0.63 |
| The quality of products is right | 4.5 | 0.73 |
| The origins of the products are sound | 4.4 | 0.90 |
| Product prices are affordable | 4.3 | 0.81 |
| Wide range of products, everything is available | 4.1 | 0.99 |
| Clean and organised environment | 4.1 | 0.85 |
| The market is close to your home/workplace | 3.8 | 1.10 |
| Payment is possible with credit card | 3.8 | 1.39 |
| Discount products are available | 3.5 | 1.14 |
| Parking places are in easy reach | 3.5 | 1.41 |
| Experience and environment of shopping are pleasant | 3.2 | 1.20 |
| Vendors/producers provide information about their products | 3.1 | 1.27 |
| Clean toilets are in the market or nearby | 3.0 | 1.35 |
| Possibility of purchasing own-brand products | 2.4 | 1.23 |
| Shop has its own website | 1.9 | 1.08 |
| Pre-ordering is possible | 1.6 | 0.87 |
| Meals are available | 1.4 | 0.80 |

Scores: 5 = very important; 1 = not important at all
Source: own data

**Table 5:** Consumers' ratings of the factors related to market services, market availability, the vendors at the market and the products on offer.

| Factor | Mean | Standard deviation |
|---|---|---|
| ***Market services*** | | |
| The market is clean and well organised | 3.7 | 1.03 |
| There is a dining place available | 3.7 | 1.28 |
| Good public safety | 3.7 | 0.97 |
| The market is covered | 3.6 | 1.42 |
| The experience and ambiance of shopping are appealing | 3.4 | 1.11 |
| It is easy to shop with children | 3.0 | 1.21 |
| Complaint handling is solved | 2.8 | 1.34 |
| There is a clean toilet at or near the market | 2.7 | 1.38 |
| There are programmes at the markets | 1.7 | 1.07 |
| The market has a webpage | 1.6 | 1.18 |
| Shopping carts are provided | 1.2 | 0.69 |
| Average of the category | 2.8 | 1.15 |
| ***Market availability*** | | |
| It is easy to reach (with car and public transport) | 4.2 | 1.04 |
| The opening hours are convenient | 4.0 | 1.09 |
| There is a car parking facility at the market | 3.5 | 1.25 |
| Average of the category | 3.9 | 1.13 |
| ***Vendors at the market*** | | |
| They are usually available at the market | 4.1 | 0.81 |
| They are ready to answer the customer's questions | 3.8 | 0.97 |
| They are weighing and calculating accurately | 3.6 | 0.90 |
| There are tasting opportunities | 2.9 | 1.16 |
| The vendors always give a receipt | 2.7 | 1.18 |
| The vendors provide information about the products | 2.5 | 1.25 |
| Bank cards are accepted | 1.3 | 0.64 |
| Average of the category | 3.0 | 0.99 |
| ***Products on offer*** | | |
| Hungarian products are available | 4.1 | 0.80 |
| The products are fresh and tasty | 4.0 | 0.74 |
| The food safety (hygiene) of the products is appropriate | 3.7 | 0.83 |
| Local products are available | 3.6 | 1.02 |
| The prices of the products are appropriate | 3.6 | 0.87 |
| The assortment is wide, one-stop shopping is possible | 3.6 | 1.01 |
| Organic products are available | 3.0 | 1.16 |
| Average of the category | 3.7 | 0.92 |

Scores: 5 = completely true for the market, the vendors and their produce; 1 = not true at all
Source: own data

**Table 6:** Demographic characteristics of consumer clusters created according to their attitude towards markets and the average ratings of their market evaluations.

| Demographic characteristic | Clusters | | | | | Mean |
|---|---|---|---|---|---|---|
| | Anti-market | Distancing | Experience seekers | Produce focused | Market lovers | |
| Number (persons) | 6 | 45 | 50 | 48 | 11 | |
| Share of total sample (%) | 3.8 | 28.1 | 31.3 | 30.0 | 6.9 | |
| Females (%) | 66.7 | 73.3 | 46.9 | 66.0 | 63.6 | 63.3 |
| Average age (years) | 50.3 | 37.8 | 43.6 | 43.3 | 43.4 | 43.7 |
| Married/in relationship (%) | 100.0 | 64.4 | 73.5 | 74.5 | 81.8 | 78.8 |
| Economic status (factor score average) | -1.12 | -0.06 | 0.01 | -0.23 | -0.08 | -0.30 |
| Economically active (%) | 50.0 | 84.1 | 79.6 | 60.0 | 72.7 | 69.3 |
| Graduates (%) | 33.3 | 73.3 | 75.5 | 74.5 | 90.9 | 69.5 |
| Residents of Budapest (%) | 16.7 | 24.4 | 33.3 | 19.1 | 45.5 | 27.8 |
| Residents of urban areas (%) | 50.0 | 62.2 | 52.1 | 53.2 | 27.3 | 49.0 |

For descriptions of the clusters see text
Source: own data

## Clusters of consumers according to their attitude towards markets

Only the respondents who gave valid answers to all 28 questions about the subject were included in the cluster analysis prepared on the basis of the evaluation of markets. Consequently, groups were identified on the basis of only 18.8 per cent of the research participants (160 respondents). Despite the low response rate, using k-means clustering, five well-defined groups can be distinguished among the participants (Table 6).

Although only six respondents comprised the first cluster ('anti-market consumers'), they represented such a markedly negative position in the assessment of markets that their scores cannot be ignored. The demographic characteristics of the different groups were compared using primarily ratios, thus the results had to be interpreted in the light of the small number of sample units. On average, anti-market consumers were the oldest among the five groups, and all were married or lived with a partner. Their economic status was the lowest and, in addition, the proportion of economically-inactive respondents was the highest, and the proportion of those with a high educational level and living in Budapest was the lowest among them. They rated four out of the five dimensions of the market with the lowest scores and, in general, they graded this shopping option at only 1.9 on a scale from 1 to 5.

The second cluster is the group of 'consumers distancing themselves from the market', which included 28.1 per cent of the respondents. Out of the five groups, the proportion of females is the highest among them and, in addition, this cluster is the youngest with an average age of 37.8 years. The members of the group were mostly economically active urban residents, with the highest proportion of single individuals compared to the other groups. Their economic status is the second highest, although the average value of the main component representing economic status was negative[2]. Similarly to the anti-market consumers, 'consumers distancing themselves from the market' had a negative assessment of the market in terms of every dimension, but to a lesser extent. In general, they rated this shopping option at 2.6. Within that, they were the least satisfied with the dimension of services; this is the only area that they gave a score even lower than the previous group. Out of the five dimensions, they were mostly satisfied with produce-related factors and convenience considerations, but the corresponding averages are not higher than 3.3. The assessment of the environment and vendors on the markets does not even reach a medium value. Therefore, all in all, despite their assessment of the markets similar to the first group, they represented a cluster with completely different characteristics.

The third cluster, described as 'experience seekers' is the largest: 31.3 per cent of the respondents belonged to this cluster. This is the only group where males are in the majority. In addition, they had the highest economic status among the five groups. Collectively, this group gave the markets an above-medium score (3.2). They rated positively primarily the dimension of convenience, and were also more satisfied with the environment of the markets than the first two groups. Although the rating of the services provided by the markets is below 2, this dimension still received the second-highest rating on average from the members of the third cluster.

The fourth cluster is that of 'produce-focused consumers' (30 per cent of the participants). In terms of demographics, it deviated from the overall average of the groups only in the low proportion of those living in Budapest. For them, satisfaction with the quality of the produce clearly represents the main attraction of shopping on a market; they gave the highest rating among all groups to the dimension of produce. In addition, they also evaluated convenience considerations positively as opposed to services, which this group was the least satisfied with. In general, they rated this shopping option at 3.4.

The fifth cluster is the 11-member group of 'market lovers'. They constituted a group of respondents who typically live in Budapest, hold a university degree, are married or live with a partner, are economically active and have formed a highly positive opinion about the market factors in all dimensions. Within that, convenience considerations received the highest average value, but this group was far the most satisfied also with the dimension of the environment. The lowest rating was given to the dimension of services, but the aver-

[2] Overall, the 160 participants answering the combination of variables had a lower than average economic status anyway, with a value of -0.295.

age value of 3.3 still highly exceeds the rating given by the other clusters. They were the only group who collectively rated the markets with a score above 4.

## Results of the SERVQUAL model: differences between consumer expectations and experiences

According to our results, in selecting the location of their shopping, the consumers participating in the study had higher expectations of the shop type concerned according to all four dimensions (environment, service, convenience and produce) than those they usually experienced when visiting markets (Table 7).

The combined average of the scores of the expected factors from 1 to 5 is 0.26 higher than the score given to markets. The produce on the markets met the expectations of the respondents the least; the difference between the scores of the expected and the experienced factors was the highest in this case (0.5). Convenience considerations were the closest to the expectations of consumers; the average of the expected factors was only 0.11 higher than the factors experienced. Notwithstanding the fact that the difference between the expected and the experienced factors was not significant (although in the absence of the representativeness of the study, the result of significance analysis has no methodological importance), the results are in no way negligible from the point of view of the operation of markets.

The expectations about shopping of anti-market consumers and consumers distancing themselves from the market were the farthest from their experience of markets; the difference between the values was nearly 1. Experience seekers and produce-focused consumers were less unsatisfied; with similar values, the rating of their experience fell short of the expected value by about 0.3. However, the opinion of market lovers about markets greatly exceeded their expectations; on average, they rated markets with scores 0.7 higher than the expected figures (Table 8).

Of the components determining the conditions of the market, the highest percentage of respondents marked the provision of appropriate lavatories available on the market or in its vicinity (24 per cent). About one-fifth of respondents were not satisfied with the layout and cleanliness of the market, and 14 per cent of respondents did not consider the facilities available to consumers with small children satisfactory either. The lowest number of respondents (6 per cent) marked the provision of eating facilities. The most often marked factor concerning the accessibility of markets was the improvement and expansion of parking facilities (25 per cent), as markets usually were built in the settlement centres and before widespread motorisation. It was followed by the provision of appropriate opening hours, which 16 per cent of the respondents would have changed, but 12 per cent of them would also have improved the accessibility of markets.

In connection with the produce sold on the market, most consumers urged the introduction or expansion of the range of organic products, but there also seemed to be demand for expanding the range of local produce. In this area, too, the last place was taken by the factor which consumers are generally satisfied with, i.e. the quality of produce offered on the market. Bank card payment facilities were not frequently available on markets. The surveyed consumers missed mostly this alternative from the services provided by vendors; in addition, the fulfilment of the obligation to issue invoices and reliable weighing and counting were also at the top of the list. The fewest responders would change the market presence of vendors, which otherwise they rated to be the most satisfactory.

**Table 7:** The aggregated result of SERVQUAL model (N = 160).

| Dimension | Expected | Experienced | Difference |
|---|---|---|---|
| | Averages of rankings | | (experienced – expected) |
| Environment | 3.4 | 3.2 | -0.26 |
| Service | 2.1 | 1.9 | -0.17 |
| Convenience | 3.6 | 3.4 | -0.17 |
| Produce | 4.2 | 3.5 | -0.75 |
| Aggregated sample | 3.3 | 3.0 | -0.34 |

Scores: 5 = absolutely true; 1 = not true at all
Source: own data

**Table 8:** The SERVQUAL model results according to the consumers cluster relying on their attitude towards markets.

| Clusters | Expected | Experienced | Difference |
|---|---|---|---|
| | Average of ratings | | (experienced – expected) |
| Anti-market | 2.7 | 1.9 | -0.87 |
| Distancing | 3.5 | 2.6 | -0.98 |
| Experience seekers | 3.5 | 3.2 | -0.27 |
| Produce-focused | 3.6 | 3.3 | -0.31 |
| Market lovers | 3.3 | 4.1 | 0.73 |
| Aggregated sample | 3.3 | 3.0 | -0.34 |

Scores: 5 = absolutely true; 1 = not true at all
Source: own calculations

It was also possible for respondents to propose other services not included in the above list, to which 113 entries were received. Respondents most often (18 per cent) raised the possibility of tasting products provided in various forms, and, within that, a form of catering where food made with ingredients available on the market can be purchased and consumed. In addition, there is a demand for product brochures and instructions for use. Respondents would be willing to become more familiar with producers, even within the framework of programmes organised for this purpose.

The second most frequent subject was finding a solution to parking issues, including appropriate bicycle parking. Seven respondents separately mentioned here the need to use shopping carts and three mentioned bank card payment facilities. The need to have catalogues about the vendors on the market, a clear separation of merchants and producers on the market, the possibility of using control scales, the redemption of meal vouchers, more favourable opening hours and the installation of seating were sometimes also mentioned.

Proposals were also received for establishing services independent of markets, but available in their immediate vicinity. Such services are, for example, ATMs, a shoemaker, a dry cleaner's, a post office and a shop where products missing from the market can be purchased. We also received a few comments drawing attention to the fact that markets are only a location for shopping, and that therefore it is not necessary to provide any other service.

# Discussion

## Comparison of assessment by consumers and producers

Shopping on the markets was primarily based on trust towards producers/vendors and their produce. The existence of trust is the most important attraction of this sales channel. At the same time, its absence is the most important factor restraining purchasing power.

According to our results, in general, producers assessed the market to be more satisfactory than consumers. It can be inferred from this that vendors on the market overrated their own situation and, despite a direct relationship, they did not rate the consumers' needs completely realistically. This may be dangerous for the future of market sales and draws attention to the need for training and consultancy in practical marketing issues.

According to consumer and producer experiences examined in the light of consumer expectations, the expectations about markets could be included in four different groups:

- 'Decisive and to be improved': This group included the considerations that consumers felt to be the most important but the rating of the experience of both consumers and producers about the markets remained below the desired value. It included produce characteristics primarily: tastefulness, freshness, food safety, appropriate price and product range. The requirement of a clean environment with a good layout also belonged to this group;
- 'Important and missing': Only a single factor, namely bank card payment facilities, was included in this group, for which there would be a much higher demand on markets than their current availability;
- 'Overrated but satisfactory': This group included convenience factors that reached or surpassed consumers' needs according to both producers and consumers;
- 'Overrated but less important': This covered, firstly, the group of factors that were the least important for consumers, which included considerations other than the methods of production and possibilities of use of producers' produce, i.e. the provision of information to customers, appropriate lavatories and the existence of the market's own website. Secondly, producers gave much higher scores to these considerations than consumers.

These results provide important warning signals and a few ready-to-use management ideas for the markets if they want to capitalise on the current urban local food trend and consolidate their position in the otherwise fiercely competitive Hungarian retail market. Markets are ideal places to satisfy the urban local food movements but they need to be more honest with themselves as our SERVQUAL model results quite clearly show an over-estimation: every category is over-rated by the vendors compared to the consumers and the consumers also report negative experience in every category. It would be important for market managers to bear in mind that the core feature of the markets is the quality of products (freshness, price, origin etc.) which should be enhanced and guaranteed. All the other services which are also important (availability, conditions, programmes) can only be built on the trusted quality of products.

## Comparison with international research results

Rosa's (2010) research results in Italy – with farmers' shops – on the segmentation of consumers according to their attitude toward SSCs are in line with our own findings, although there are some different characteristics which can be ascribed to the substantial differences in the economic and social situations of the two countries. There are also other differences, for example our segmentation is less detailed as we could only identify five clusters compared to the eight distinctive segments arising from the Italian research. On the positive side this could indicate more easily created and executed traditional marketing activities in Hungary, but on the negative side it could also implicate less precise targeting with modern marketing tools. The most important similarity is that Rosa (2010) also found quality and freshness – both produce related – to be the most important success factors of farmers' direct sales. The core importance of produce quality may seem to be an obvious statement but from our experience of farmers' market development programmes in Hungary we can say that it is not. Thus, the future subsidy programmes affecting SSC (the SSC thematic sub-programme and Leader measures in the Hungarian Rural Development Plan) should continue to be focused on it.

On the other hand, research conducted about consumer satisfaction by Cassia *et al*. (2012) in Italy – on farmers' markets – and Lülfs-Baden *et al*. (2008) – on farmers' shops – conclude that most important expectations are intangible and connected to customer service and the locality as such. These results also reflect economic and social differences between the countries as the surveys showed the importance of being 'alternative' compared to 'mainstream' consumers, a factor that was much less reflected in our results. Still it provides an important insight into the expectations of the urban (upper) middle class local-alternative food movement which was so small in Hungary at the time of our survey (2012) that we could not capture it with our results. However, it is clearly an upcoming trend that will motivate us to extend our survey in the future. The work of Lülfs-Baden *et al*. (2008), Rosa (2010) and Cassia *et al*. (2012) give us a valuable insight into what are the most important development factors if the Hungarian markets want to ride and keep the loyalty of urban locavores. The urban local food movement may well be too small today to maintain the Hungarian markets but it could help where markets are already located at tourist attractions such as for example near Lake Balaton or at the city centre 'ruin pubs' of Budapest.

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# Extended summary

**KESZTHELYI Szilárd and MOLNÁR András**

# Results of Hungarian FADN Farms 2013

The Hungarian Farm Accountancy Data Network (FADN) consists of 1,593 individual and 385 corporate sample farms. These farms are representative (in terms of farm type, economic size and legal form) of close to 110 thousand commercial Hungarian agricultural producers that utilise nearly 95 per cent of the total agricultural area and produce 93 per cent of the total Standard Output in Hungary. The Research Institute of Agricultural Economics (AKI) is responsible for the collection of micro-economic data on the costs and incomes of these. The results are published annually by AKI and may be downloaded in Hungarian or English from the AKI website (www.aki.gov.hu) or requested in printed form from aki@aki.gov.hu.

The publication begins with a short introduction about the general context and its purpose, definitions of the economic terms and indicators used, and a description of the method of deriving the balance sheet and income. The profitability and the change in assets in the agricultural sector as a whole are then described, the factors influencing the income situation of individual and corporate farms are separately highlighted, the effect of subsidies on profitability is discussed, and a comparison is made of the results of individual and corporate farms. Following this the development of land prices and rental fees across the different FADN regions of Hungary are reviewed, and a narrow international comparison limited only to financial indicators is made. Attention is then paid to the application of environmental indicators in the FADN context, and the publication concludes with a short overview on the small farms below the sampling threshold level. The book is supplemented by a comprehensive set of tables that introduce aggregated FADN farm data broken down by legal form, region, type of farming and economic size.

The main findings are as follows. The profitability of agriculture changed only marginally in 2013 compared to the previous year. Profit before taxes of individual farms declined by 1 per cent and that of corporate farms by 16 per cent. As in 2012 the net value added continued to stagnate. Significant income disparities were recorded across the different types of farming in regard to EUR thousand Standard Output per net value added. The highest (49 per cent) increase was achieved by vine growers while the fruit sector, field vegetables and indoor vegetable also witnessed strong (over 30 per cent) growth. The profitability of arable crop production suffered a 23 per cent decrease, while poultry, dairy and mixed farms as well as cattle and sheep rearing saw 14-16 per cent declines. The fall was even stronger in pig farming which recorded a 50 per cent drop in profitability compared to 2012.

The income per hectare of field crops fell by 3 per cent as the yield gains only partially offset the price drop in the sector. The gross output decreased by 2 per cent as the decline in income was moderately compensated by the increase in direct payments (+11 per cent). In contrast, farming costs rose by 4 per cent. In the dairy sector the output per livestock unit increased by 5 per cent, mostly due to the increasing milk prices. However, the dairy farms reported a 3 per cent loss in terms of net value added as the result of an 8 per cent growth in farming costs. Pig farming as well as cattle and sheep rearing made similar progress as the increases in their farming costs were stronger than in the their output values. Conversely, the poultry producers recorded a decline also in the output value, however the unit cost registered the lowest – 1 per cent – growth in the sector.

Investments per hectare (regarding all farms) amounted to HUF 96.8 thousand while the amount of subsidies attached to investments stood at HUF 7 thousand per hectare. The value of investments grew by 26 per cent and the amount of investment subsidies by 44 per cent in comparison to the previous year. The rise is clearly related to the increased investments in machinery and the uncompleted investments (23 and 28 per cent respectively). The net investment value also showed a significant increase (HUF 27 thousand per hectare), which means that technological development continued. The highest investment intensity was recorded for indoor vegetables, field vegetables, pig farming, cattle and sheep rearing as well as arable crop production. The growth in investments was boosted not only by development subsidies but also by the *Fund for Growth* plan of the Hungarian Central Bank.

The considerable expansion in investments greatly affected the financing structure of the farms and a long term trend came to a halt. Long-term loans expanded by 26 per cent, including the investment and development credits that made favourable progress after rising by 54 per cent (HUF 28.4 thousand per hectare). The expansion in development loans did not undermine the financial conditions of the farms as the result of the declining interest rates. The paid interest dropped by 22 per cent.

The increase in land prices continued in 2013. The price of arable land increased by 7.7 per cent – well above the inflation rate – to HUF 622.2 thousand per hectare. Consequently, the land rental fees also grew, by 4.2 per cent.

This was the second year that farms below the economic threshold were also selected for the purpose of rural development issues. Despite the fact that these households are producing a certain share of their own foodstuffs, a sizeable amount of their incomes are spent on food. The average share spent on food is 30 per cent but, because of the specific nature of the produced foodstuffs, in the case of mixed farms this share is higher (37 per cent).

# Abstracts of AKI publications

The results of AKI's research work are presented in detail in a series of Hungarian language publications. English language abstracts are reproduced below. The publications may be downloaded from the AKI website (www.aki.gov.hu) or requested in printed form from aki@aki.gov.hu.

**BIRÓ Szabolcs and RÁCZ Katalin (eds)**

## Agricultural and rural development cooperation in Hungary

Agroeconomic Book, published 2015, http://dx.doi.org/10.7896/ak.1501

The publication explores the situation, role, economic performance and development opportunities of cooperation in agriculture and rural development in Hungary. In a market economy, cooperation skills are among the most important tools of competitiveness of economic actors. Regarding cooperation trends in Hungary, similarly to the international situation, signs of concentration, accompanied by an integration of the product line, can be detected. According to the findings of this research, horizontal cooperation plays a significant role in stabilising supplier and marketing relations in reducing transaction costs, improving production levels and in disseminating new technologies. Its role in increasing farm revenues is only moderate. By contrast, cooperation leading to a higher level of vertical integration enables permanently favourable market positions and better results in economic performance to be achieved. Concerning social cooperation, which brings together rural actors, traditional forms are complemented by social networks, rural development clusters and platforms. A development path for agricultural cooperation might be for actors to make collective investments in order to increase the value-added and utilise economies of scale, and to organise themselves into alliances, associations and networks. Beyond the benefits originating from market concentration, these could stimulate the dissemination of expertise, improve the efficiency of advisory services, and increase innovation capacities. Regarding cooperation in rural development, there is a development potential in short supply chains organised into clusters and embedded into local economic development. The Hungarian Rural Development Programme 2014-2020 provides integrated tools for stimulating organisational investments.

**STUMMER Ildikó (ed.)**

## The market developments of the most important commodities in 2014

Agroeconomic Information, published 2015

This publication discusses the market developments of the most important commodities in 2014, mainly by presenting price trends. The material is based on the price information and data of the Market Price Information System of the Research Institute of Agricultural Economics and of various Hungarian and international sources. The producer price of milling wheat was almost unchanged in 2014 compared to 2013, while it dropped for feed wheat and feed maize by 4 and 13 per cent respectively. The producer price of sunflower seed was HUF 96 thousand/tonne in 2014, close to last year's level. On the contrary, the producer price of rapeseed fell by 9 per cent to HUF 102 thousand/tonne. As in previous years, in 2014 Hungarian pork prices followed the trends of prices in the European Union. The pig producer prices were 3.4 per cent lower than a year earlier. In Hungary the cattle producer prices decreased by 12 per cent in 2014. The producer prices of slaughter chickens increased by 6.3 per cent and those of light lambs increased by 4 per cent in 2014, while the raw milk price increased by 7 per cent compared to the previous year. The production of vegetables increased in 2014 compared to 2013, and the production of fruit increased because of the higher apple production. The processors' sale prices of wines without geographical indication and wines with protected geographical indication (PGI) decreased by 2 per cent in 2014 compared to the previous year.

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Submission of an article implies that the work described has not been published in English in any other peer-reviewed journal, is not under consideration for publication elsewhere, and that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out. The author will retain the copyright of the article but agrees to identify AKI as the original publisher. Papers will not normally exceed 6000 words including the reference list and figure and table captions. Authors intending to prepare a book review should first consult the Editor-in-Chief and such a review should not exceed 2000 words.

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