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Foreword

It has been suggested[1] that, since the 1970s, agricultural economics has primarily focused on seven broad topics: technical change and the returns to human capital investments; environmental and resource issues; trade and economic development; agricultural risk and uncertainty; price determination and income stabilisation; market structure and the organisation of agricultural businesses; and consumption and food supply chains. The eight papers in this issue address many of these aspects of agricultural economics.

The first two papers deal with the topic of insurance risks in agriculture. Using a financial methodology and data from Ukraine and the United States, Tarasov shows that high interest rates may create certain conditions under which some alternatives to insurance become more appealing, thereby decreasing a financial incentive to insure. He concludes that it would require considerable government subsidies, in addition to informational support, to facilitate the development of agricultural insurance markets in emerging economies.

Kemény *et al.* assessed the territorial differentiation of damage to agricultural crops in Hungary caused by drought, heavy rain and spring frost. They found that there are extremely high differences in the probabilities of damage in different LAU1 micro-regions. Therefore the design of agricultural insurance products should be based on different absolute deductibles and different insurance premiums for micro-regions. In the long term only a *bonus-malus* system developed for individual agricultural producers can mitigate different risks.

In practice, many farm households in the European Union (EU) do not depend solely on farming for their income. The study of Polish farms of 2 to 8 ESU by Augustyńska-Grzymek *et al.* showed that the income of farms with off-farm activities was 2.2 times higher as compared to the holdings generating income only from agricultural activity. The low availability of non-agricultural jobs to persons residing in rural areas acts as one of the major barriers to rural development and agricultural modernisation.

Török and Jámbor analysed the effects of EU enlargement on the competitiveness of fruit spirits in six Central and Eastern European countries by using the theory of revealed comparative advantages. Their results indicate that these countries are losing their market positions in their traditional fruit spirit sector in the EU-15 beverages market in spite of the fact that the majority of these products have a geographical indication. By contrast, Italian grappa is shown to be competitive in terms of both price and quality.

Continuing on the theme of agricultural markets, but at a much more theoretical level, Abunyuwah demonstrates the conceptual limits of current empirical market integration time series models by using specifically generated data sets. The nature of the true underlying data generation process, resulting from inter-market rent dynamics, may not follow the threshold effects as the model assumes. Additional non-linear attributes and dynamics can lead to different results and conclusions if they are not taken into account.

Environmental and resource issues are the theme of the paper by Takács-György *et al.* They calculate that the savings in pesticide use across the EU-27 following the adoption of precision plant protection can be 30,000 tonnes per annum. The authors also show that in Hungary the rates of uptake of the different elements of precision crop production vary, and that larger farms are more likely to adopt the technology. This environmentally friendly farming practice can enhance the future 'green' component of Pillar 1 of the Common Agricultural Policy.

On the topic of consumption patterns, Grzelak and Maciejczak found that students from the United States and Poland, countries with different levels of organic market development, have different perceptions of organic products. Where there is a higher level of development (such as in the United States), consumers already have a basic knowledge about the products, such as origin or organic label, and are more focused on their qualities, such as taste or variety. The opposite applies in Poland.

Finally, regarding trade and economic development, Jablanović proposes a theoretical framework of how externalities can influence long-run agricultural monopolistic competitor equilibrium. This is done by constructing a relatively simple chaotic long-run monopolistic competitor's agricultural output growth model that is capable of generating stable equilibria, cycles or chaos.

This issue of *Studies in Agricultural Economics* brings together the results of researchers from Hungary and four other European countries. I trust that their findings will prove to be of use to you in your own work.

Andrew Fieldsend
Budapest, January 2013

[1] C. Ford Runge (2006): Agricultural economics: A brief intellectual history. Working Paper WP06-1. St. Paul MN: University of Minnesota.

Arthur TARASOV*

Impact of interest rates on the decision to insure in agricultural production

This paper seeks to define the relationship between interest rates and decisions to insure among agricultural producers using the financial methodology. The choices are ultimately reduced to two options: to insure or to limit and absorb risk. Each choice produces a complex cash flow that is compared to the alternative and discounted by several factors. The difference between the options produces a quantitative measure of the financial incentive to insure. Some discounting factors of the cash flows follow the key interest rate to an extent for the latter to influence the decision to insure along with demand for insurance. The proposed method is tested on data from the emerging economy of Ukraine and the United States for the period 2002-2011. All participants of agricultural insurance markets can use the proposed methods to maximise efficiency. The research shows that *ceteris paribus* agricultural insurance requires bigger government subsidies to be viable under higher interest rates. Further empirical research is suggested.

Keywords: risk management, agricultural insurance, interest rates, demand for insurance

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Introduction

A strong effect of interest rates on insurance markets is acknowledged by many economists. There is no consensus on the nature of the relationship between interest rates and the insurance industry performance. Equity, underwriting profitability and supply of insurance all appear to be affected by interest rates. Although interest rate changes are systematic and affect the entire insurance sector across all lines simultaneously, empirical results differ, as well as theoretical explanations for such results.

Haley (1993) shows a negative relationship between interest rates and underwriting margins for stock property-liability insurers across an extended period. Grace and Hotchkiss (1995) find a positive relationship between a combined ratio and interest rates, hence a negative relationship between underwriting profits and interest rates. Other research shows mixed results regarding the relationship between the insurer's profits and interest rates (Leng and Meier, 2002; Park and Choi, 2011). Mixed results are mostly explained by the fact that both assets and liabilities of insurers are sensitive to interest rates (Doherty and Garven, 1995). Therefore, the relationship of equity and profits with interest rates is determined by the balance between durations of assets and liabilities. The problem is further complicated by the influence of capacity constraints, caused by exogenous factors, such as business cycles or systemic shocks to the insurance industry.

Interest rates affect assets through the insurer's investment portfolio. Low interest rates tend to decrease the supply of premiums owing to the fact that portfolios of most property and casualty insurers consist largely of various government, municipal and high-grade corporate bonds according to NAIC (2011), which intrinsically are highly correlated with the key interest rate (Merton, 1973). In fact, researchers that investigate the interest rate impact on the insurance industry often refer to bond yields as interest rates. Decline in the investment portfolio yield of insurance companies forces them to raise premiums in order to cover expenses. Owing to the elasticity of supply for insurance (Gron, 1994), the amount of insurance policies sold eventually decreases as well.

Insurer's liabilities are also subject to duration if the firm is leveraged. Higher rates, for example, increase the cost of capital and reduce net income. Although in most cases duration of assets exceeds duration of liabilities (Doherty and Garven, 1995), therefore there is weakness in such explanation for the negative relationship between interest rates and insurers' financial results.

Alternatively, there is another explanation from a perspective of financial theory for the negative impact of high interest rates on insurers' profitability: the capital asset pricing model (CAPM), modified for the insurance industry (Fairley, 1979; Hill, 1979). Haley (1993), Doherty and Garven (1995), and Leng and Meier (2002) use CAPM along with other similar insurance pricing models to justify the negative relationship between interest rates and the performance of the insurance industry. An interest rate in a form of a risk free rate is used to discount earnings and obtain an internal rate of return. The rise of interest rates reduces the internal rate of return; however, it has no effect on accounting profit figures, which are used for empirical testing. There is also no evident connection between a quantity of premiums supplied and interest rates that can be explained by CAPM and the other insurance pricing models.

All of the above-mentioned literature studies the impact of interest rates on the supply-side, represented by insurers, while there is a gap in the demand-side research. Aside from the financial sector, production risks in most industries are not directly affected by interest rates. However, high interest rates may create certain conditions, under which some alternatives to insurance become more appealing, thereby decreasing a financial incentive to insure. It may provide another theoretical explanation of the negative relationship between interest rates and insurance industry performance based on the impact of interest rates on the demand-side of the insurance market. This hypothesis is thoroughly discussed in this paper with a focus on the case of agricultural producers.

Methodology

In order to provide sufficient in-depth analysis of the problem, observations, data samples and the conceptual framework are narrowed down to the specifics of the agricultural sector. The initial hypothesis is that at some point interest rates should be high enough for an agricultural producer to be able to limit some of the risk by refraining from usual production activities without bearing significant opportunity costs. To the author's knowledge, much of the research about interest rate impacts on insurance markets ever since Cummins and Outreville (1987) has been done mostly in highly developed countries, possibly because of the availability of information. However, most of the developed countries historically had relatively low interest rates for the past 25 years. All of the research has been carried out in a relatively lower margin of the interest rate fluctuations in comparison to global interest rates. In order to observe possible negative influence of high interest rates on decisions to insure, it is proposed to take a look at agricultural insurance markets in developing economies.

There are several emerging economies, also large agricultural producers, with constantly high interest rates, which have problematic agricultural insurance markets. The initial observation is made in Ukraine, one of the world's top producers of sunflower seeds and barley. Despite government attempts to facilitate agricultural insurance market development, it is poor and inefficient mostly due to low demand for insurance. Meanwhile, the key interest rate in Ukraine averages 9 per cent for the past ten years. Further observations show that Brazil, currently with a key interest rate of 9.75 per cent (as of March 2012[1]), is known to struggle with the implementation of insurance in its massive agricultural sector. Most farmers choose not to purchase insurance and, as observed by Tueller *et al.* (2009), bear substantial losses owing to such choice, while government support appears futile. Another notable example is Argentina, where supply of insurance is abundant with 26 companies providing cheap hail insurance for nearly half of the cereals and oilseeds produced, and yet only 5 per cent is covered by a multiple peril crop insurance (Miguez, 2010). Implementation of non-hail insurance products is still problematic in the country. Hail insurance is naturally viable with very low premium rates as it avoids two of the major drawbacks of agricultural insurance: asymmetry of information and systematic losses (Hertzler, 2005). Unfortunately, hail insurance only covers a small part of the production risks that farmers face. There are numerous factors that put pressure on demand for agricultural insurance in developing economies, making it difficult to isolate the interest rate factor. Among the most important of these factors in Ukraine, for instance, are lacking statistical data and an inefficient law system that makes it difficult to settle any possible disputes between the insurer and the insured. The influence of these and other issues on the demand for insurance is hard to quantify or control for. While all of the factors are interconnected and undoubtedly considered in the decision making process, the quantitative measure of the interest rate factor can be independently determined under the assumption that the farmer is risk neutral and rational.

[1] Central Bank of Brazil SELIC interest rates: http://www.bcb.gov.br/?INTEREST.

To adequately compare conditions under which insurers operate, we can look at a simple demand function for insurance (*ID(p,q)*), proposed by Weiss (2007):

$$ID(p,q) = f(\mu_\Lambda(\iota), E, S, \sigma^2_\Lambda, \sigma_{\Lambda\varepsilon}, O) \tag{1}$$

where p is price, q is quantity, μ_Λ is the average of expected losses, ι is expected inflation, E is equity, S is assets, σ^2_Λ is the variance of expected losses, $\sigma_{\Lambda\varepsilon}$ is the covariance between expected losses (Λ) and expected income (ε), and O is business opportunities (general growth of the economy). Notable variables are inflation and business opportunities. However, both are proportional to demand and are high in emerging economies by definition. That is, emerging economies expand at a faster pace and provide opportunities for business growth, and inflation accompanies rapid growth. Therefore, there may be something missing, and to logically come up with a missing variable it is worth taking a closer look at the overall process of managing production risk in agriculture, specifically at alternatives to insurance.

Production risk in agriculture is mainly caused by weather patterns, which are unpredictable and stochastic in nature. Owing to the natural lag between the allocation of capital and the time of harvest, weather conditions are impossible to predict with certainty. Unlike price risk, which can be minimised by hedging, production risk (beyond horizontal diversification) can only be insured against, pooled, or limited to the point where it can be absorbed by a farm. Risk pooling is not suitable for all farm businesses, as it requires a certain degree of cooperation based on trust and ethics among members. Risk pooling is obviously a preferred method, since it does not have any associated costs except loss costs, and it is fair to assume that, if it is among options, farm businesses already use it. Farmers that do not pool risks have two options: to purchase an insurance policy and eliminate some or all of the risk, or limit the risk by diversification (other than horizontal) and absorb it. 'Wright and Hewitt (1994) suggest that the perceived demand for agricultural insurance may be overstated, because farmers can use diversification and savings to cushion the impact of production shortfalls on consumption' (Mahul and Stutley, 2010, p.23).

A common opinion is that a decision to insure is mostly determined by an individual preference towards risk (Hojjati and Bockstael, 1988; Coble *et al.*, 1996; Guiso and Jappelli, 1998). This may be relevant for some small family farms to a certain extent, but risk aversion is hardly a determinant in decisions to insure by medium to large agribusinesses and corporate entities, as noted by Mayers and Smith (1982). Von Neumann and Morgenstern (1944) originally stated that it is pointless to measure risk preference for entities that operate in terms of costs and profits. Therefore the following research is set in a framework of financially motivated decisions that are defined by the rules of financial theory.

Definition of choices

There are many choices that agricultural producers face when it comes to insurance. Hojjati and Bockstael (1988) show that a farmer can choose between insurance plans as well as crops to plant, which crop to insure, and to what extent, thereby facing a countless variety of choices. Selecting an appropriate insurance plan by itself is a complicated process that makes choice analysis quite difficult (Ginder *et al.*, 2009). Crop rotation and other technical factors further sophisticate decision making. Clearly, on a macroeconomic level, given territorial differences, the approach that would consider even simplified versions of all important choices is hard to apply. In this paper choices are limited to two ultimate options: to insure or not to insure. It implies that when an agricultural producer considers insurance, it is the optimal insurance solution that is available along with an optimal production portfolio. In this way the theory has few constraints and can be applied to any area and any country.

Let the decision to insure be choice *A*, and the decision to limit and absorb risk be choice *B*. Choice *A* leads to cash flows C_{An}, where *n* is a number of a cash flow. A net future value of cash flows ΣC_{An} is C_A. Choice *B* leads to cash flows C_{Bn} with the net future value C_B. If an agricultural producer has no personal risk preference or is risk-neutral, then the decision to insure (*A*) is determined by equation (2):

$$A\begin{cases} = 1\ if\ C_A \geq C_B \\ = 0\ if\ C_A < C_B \end{cases} \quad (2)$$

Let us closer examine cash flows from choice *A*:

$$C_A = -\pi + \varphi$$

$$\varphi = l \times x \quad (3)$$

where π is the future value of the insurance premium and φ is an indemnity payment *(l)* multiplied by its probability to occur *(x)*, assuming, for simplicity's sake, that 100% of the loss from a risk event is indemnified.

The premium for a property and casualty insurance generally consists of loss expenses (L_e), profit of the insurer (R_I), and administrative and operating expenses (O_e). Also return on the insurer's investment portfolio in currency form (I_I) and government subsidies (*G*) are subtracted from the premium, because they are positive cash flows from a point of view of an insured. The future value of cash flows from choice *A* with a disaggregate premium looks as follows:

$$C_A = -L_e - R_I + I_I - O_e + G + \varphi \quad (4)$$

It is easy to approximate the amount of the insurer's profit in a premium using equation (5). The ratio of equity (or surplus) (*TE*) to premiums (*TP*) can be calculated from data available in financial statements of the insurer along with the insurer's return on equity (*RoIE*):

$$R_I = P \times \frac{TE}{TP} \times RoIE \quad (5)$$

where *P* is the amount of insurance premium, *TE* is the insurer's total equity, *TP* is the total amount of premiums, which the insurer collects in a year, *RoIE* is a rate of return on the insurer's equity. Note that all returns on equity in this research are calculated using current local currency units; therefore, there is no need for inflation adjustments.

$$I_I = P \times r_i \quad (6)$$

where r_i is a rate of return on the insurer's investment portfolio.

Equation (4) represents the future value of cash flows of choice *A* with two variables discounted by two different factors. It is important to discount cash flows separately, because one of the discounting factors has an evident high correlation with interest rates, while the other does not. The importance of this correlation will be demonstrated later on. Both discounted variables (equations 5 and 6) are approximated for simplification. Return on the insurer's investment portfolio and profit per a specific amount of premium can only be determined by the insurer using detailed information that is usually not disclosed in accounting statements. Discounting factors throughout this paper are assumed to be in a form that incorporates all of the time specifications and the frequency of compounding for simplicity's sake. For instance, r_i and other discounting factors in this paper can be calculated using a nominal interest rate (*z*) and a number of compounding periods (*t*) as follows:

$$r_i = (1 + z)^t - 1$$

For more complicated cases of discounting refer to Jorion (2009).

The alternative to insurance is the second choice *B*: not to insure or to limit and absorb risk. Whenever any production is intentionally limited, a certain amount of capital is turned into cash or financial assets and acts as a reserve (*R*) or is used to reduce debt. In agricultural production any type of a liquid asset can act as a reserve with a purpose of self-insurance (Binswanger and Rosenzweig, 1986), yet cash and short-term financial assets are clearly preferred in a majority of scenarios and are analysed in this research. Although we do not have comprehensive information on savings rates among agricultural producers in developing countries, there are supporting data that farmers in developed countries rely on savings to smoothen financial consequences of the yield variability. A study of farmers in the Australian Mallee indicates that almost all farmers build reserves or reduce debt in good years in an effort to reduce the magnitude and impact of income variability (Wright and Hewitt, 1994). At the same time as the reserve is formed, opportunity costs (C_o) occur owing to reduced operating income. If a farm chooses to limit and absorb risk, financial consequences of such decision are demonstrated by the following formula:

$$C_B = -C_o + Y_R - \gamma \quad (7)$$

where C_o is the opportunity cost, Y_R is the yield of the reserved capital, and γ represents additional losses, caused by a sharp decline in revenue owing to a risk event.

The opportunity (C_o) cost can be defined as a product of a rate of return on the farm's equity (*RoFE*) and the amount of the reserved capital (*R*):

$$C_o = RoFE \times R \quad (8)$$

The yield of the reserved capital (Y_R) is represented as a product of a rate of return on the reserved capital (y_r) and the size of the reserve (*R*):

$$Y_R = y_r \times R \tag{9}$$

Note that the loss from a risk event itself is not included as a negative cash flow for choice *B*, simply because it does not exist in such form for a farm that is profitable in the long term. Such a variable would be a part of an average income from agricultural production, hence it is superfluous.

Intuition behind γ is a sum of negative financial consequences which an agricultural producer faces by experiencing a large loss at once, rather than it being averaged across an extended period:

$$\gamma = f(\sigma, R, \omega, L_F, L_O) \tag{10}$$

where σ is a quantitative measure of production and/or price risk, ω is a level of diversification, L_F is a measure of financial leverage, L_O is a measure of operating leverage. σ is not necessarily volatility, it can be a more comprehensive measure of risk (e.g. probability distribution function, value-at-risk).

In other words, γ is a residual between all losses that a risk event causes and the expected loss over time, which can be described as φ (equation 3). Thereby, when a farm experiences a risk event with a loss (l), it also suffers additional to φ losses, determined by γ. The primary reason behind insurance is to eliminate γ by swapping l for φ for a price of π.

Equation (7) is set up in a way for the following to be true:

$$Y_R \propto C_o \propto R$$

$$R = -b \times \gamma + a \tag{11}$$

where b represents the relationship between R and γ as well as Y_R and γ, and a is a level of R, at which γ is deemed insignificant. The linear inverse relationship here suggests that for the value of the function γ to decrease, more cash must be reserved by limiting production. More opportunity costs (C_o) will occur and the yield on the reserved capital will increase (Y_R). The opposite should also be true. If a farm does not use any debt, has few fixed costs, and the revenue cash flows are highly diversified, then γ should be insignificant. The reserved capital (R) directly reduces γ and also produces a diversified cash flow (Y_R) with no correlation to income from agricultural production.

If a farm business is leveraged, choice *B* becomes even more appealing with higher interest rates (lending rates in this case). Instead of reserving capital, a farm uses cash to pay out debt and limits production in exactly the same way (equation 7). Decline in the cost of debt in currency form (C_D) replaces increment in the yield on the reserved capital (Y_R). For instance, consider $L_F = \frac{D}{E}$, where D is debt, E is equity, and $E \neq 0$. If $L_F > 0$, then $C_B = -C_o - C_D - \gamma$, where $C_D = -D \times r_D$. The cost of debt (r_D) should always be greater than the rate of return on the reserved capital (y_r) for the same time setting: $r_D > y_r$. This is simply because capital, lent to any farm business, holds more risk than a nearly risk-free financial asset (e.g. a deposit certificate) and therefore requires an additional risk premium. The case of a leveraged farm business is described in detail in Appendix A.

Comparing the choices

The choice to insure (*A*) and the choice not to insure or to limit and absorb risk (*B*), as mentioned earlier, are determined by equation (2). It can also be written alternatively as a function ΔC to allow continuity:

$$\Delta C = C_A - C_B \tag{12}$$

Positive values of ΔC indicate that insurance is financially viable, while negative ΔC shows the opposite. ΔC can be viewed as a quantitative measure of the *financial incentive to insure*. If we substitute formulas for C_A and C_B from equations (4, 5, 6, 7, 8, and 9) into equation (12), the result will be as follows:

$$\Delta C = -L_e + P \times \left(r_i - \frac{TE}{TP} \times RoIE\right) - O_e + G + \varphi + R(RoFE - y_r) + \gamma \tag{13}$$

For further analysis it is necessary to eliminate similar variables by several assumptions and isolate interest rate correlated variables. Once interest rate related factors are defined, the assumptions can be then relaxed if needed. It can be set that the loss expenses (L_e) are equal to the indemnity φ (equation 3). If $L_e = \varphi$, then:

$$\Delta C = P \times \left(r_i - \frac{TE}{TP} \times RoIE\right) - O_e + G + R(RoFE - y_r) + \gamma$$

Consider a scenario, where an agricultural producer chooses to limit agricultural production and instead store freed up capital in nearly riskless financial assets to achieve a level of income diversification, at which γ becomes insignificant and equals to zero. This is ultimately choice *B*, which opposes insurance. It is an equivalent of a combination of what was originally defined as a self-protection and self-insurance by Ehrlich and Becker (1972). If $R = \frac{\varphi}{x} = l$, then $\gamma = 0$; if $\gamma = 0$, then:

$$C_B = -C_o + Y_R$$

$$\Delta C = P \times \left(r_i - \frac{TE}{TP} \times RoIE\right) - O_e + G + R(RoFE - y_r) \tag{14}$$

Interest rate sensitivity

Equation (14) consists of four terms, two of which can be highly correlated with the key interest rate, and the other two have no clear correlation. The return on the insurer's equity (equation 5) and the farm's opportunity costs (C_o) or the return on the farm's equity are determined by market conditions that incorporate multiple factors and have no evident consistent connection to interest rates[2]. The return on the insurer's investment portfolio, which is roughly estimated by equation (6), and the yield of the reserved capital (Y_R) are basically determined by interest rates.

It is appropriate to use a specific interest rate if the correlation with the key interest rate is too low to achieve a

[2] Return on the insurer's equity cannot be adequately represented in any correlation with interest rates, although logically some positive correlation may exist. Venezian (2002) states that in order to relate insurer's returns to interest rates a complex model must be built that is beyond verification owing to the amount of data needed.

desired level of accuracy. Otherwise the key interest rate can be used to calculate r_i and y_r with an adjustment for their historical ratio as follows:

$$r_i = r \times \mu\left(\frac{r_{in}}{r_n}\right)$$

$$y_r = r \times \mu\left(\frac{y_{rn}}{r_n}\right)$$

where r is the key interest rate set by the central bank of a country, μ is the average value represented by the arithmetic mean, r_{in} is the rate of return on the insurer's investment portfolio or the bond yield in this particular case at time n, r_n is the key interest rate at time n, and y_{rn} is the rate of return on the reserved capital or the yield of deposit certificates at time n.

The financial incentive to insure can be written as a function of the key interest rate r:

$$\Delta C = f(r) = P \times \left[r \times \mu\left(\frac{r_{in}}{r_n}\right) - \frac{TE}{TP} \times RoIE \right] - O_e + G + R \times \left[RoFE - r \times \mu\left(\frac{y_{rn}}{r_n}\right) \right] \quad (15)$$

If ΔC is calculated for a particular crop and a risk event with a known size of casualty and the probability to occur, then the financial incentive to insure can be computed with equation (15). A graph of the function *f(r)* on Figure 1 demonstrates the linear relationship between interest rate changes and the financial incentive to insure (ΔC).

The slope of *f(r)*, however, also depends on the values of the premium (P) and the reserved capital (R), which can change across different crops and levels of risk. The slope of *f(r)* may change at a rate that is determined by a ratio of yields that the insurer and the farm business get on their capital (P and R respectively) to the key interest rate (see Appendix B for a mathematical explanation). The change of the financial incentive to insure (ΔC) caused by varying P depends on $\mu\left(\frac{r_{in}}{r_n}\right)$, and the change owing to varying R is determined by $\mu\left(\frac{y_{rn}}{r_n}\right)$. An important implication of this is that a moderate increase in R tends to amplify either a positive or a negative value of ΔC without changing its sign. A large increase in R, as in presence of catastrophic risk, may, however, shift ΔC into a positive value (owing to the relationship in equation 11) and favour the decision to insure. The main purpose of this research, however, is to establish the impact of the key interest rate on decisions to insure using the financial incentive to insure (ΔC or *f(r)*).

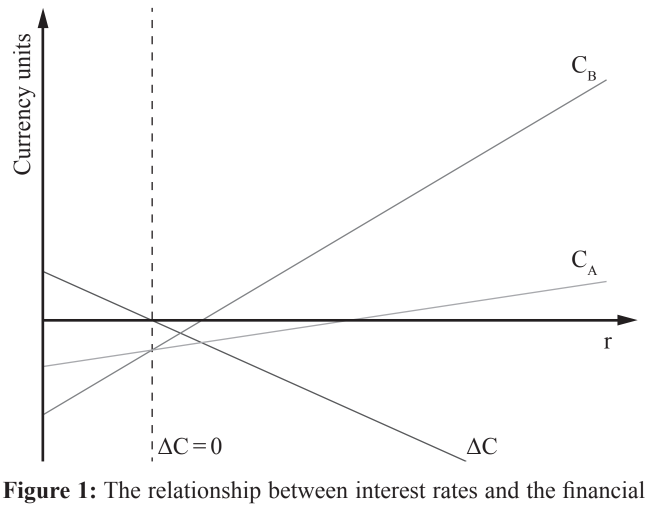

Figure 1: The relationship between interest rates and the financial incentive to insure.

Results

We apply the proposed technique to agricultural insurance markets of Ukraine and the United States. Input parameters and the financial incentive to insure, shown in Table 1, demonstrate differences between agricultural insurance markets of the developing and developed economies.

Logically, insurance should not be viable if ΔC is significantly negative in a medium to long term, unless there are factors, aside from ΔC components, that outweigh the negative impact. Empirical study shows that in the developing economy of Ukraine the financial incentive to insure is at the average of -0.18 per 1 LCU of producer premium, while in the United States it is at USD 1.15 per USD 1 of premium (Table 1). The measure is so high in the United States mainly owing to abundant government subsidies and low interest rates. Notably, the returns on insurers' equity among seven insurance companies that share 91 per cent of the agricultural insurance market in Ukraine is below the rate of inflation, key interest rate, and lower than the rate of return of the United States insurance companies for the years 2002-2011. Insurance companies in Ukraine also take more risk by lowering the *TE/TP* ratio. This demonstrates possible relationships between ΔC components and demand for insurance, which can be useful to insurers seeking to implement new products in emerging economies with high interest rates.

Table 1: Input parameters and the financial incentive to insure for agricultural producers of Ukraine and Kansas farms of the United States, 2002-2011.

Parameter	Ukraine	Kansas state of the United States
Interest rates (%)*		
Average	14.4	2.1
Standard deviation	3.2	1.7
Return on farmers' equity (%)		
Average	13.0	1.1
Standard deviation	7.0	1.6
Return on insurers' equity (%)		
Average	5.8	7.1
Standard deviation	5.0	4.1
Ratio of total equity to total premiums of insurers		
Average	0.63	1.09
Standard deviation	0.26	0.30
ΔC (LCU)**		
Average	-0.18	1.15
Standard deviation	0.43	0.34

* Yields on three month deposit certificates for Ukraine and one year treasuries for the United States.
** The financial incentive to insure in local currency units (LCU) per one LCU of premium paid by the farmer.
Source: Author's calculations based on the USDA RMA data, the Federal Reserve data, Insurance Services Office data, and financial statements of insurers. The raw data are available from the author upon request.

Discussion

This research provides a method for evaluating agricultural insurance decisions from a financial perspective. The choice to insure opposes the choice to limit and absorb risk, and each choice has financial consequences for a farm business, represented in a form of cash flows. The sensitivity of some of the cash flows to interest rates is significant enough to influence the decision to insure on a microeconomic level and demand for insurance on a macroeconomic level. The *financial incentive to insure* quantitatively measures a gain or a loss from the choice to insure in the context of the financial outcome of the choice not to insure in currency form per a specific amount of premium. The use of such a method has a variety of implications for agricultural producers, insurers and government support for insurance. Agricultural producers benefit greatly from quantifying information about risk and risk minimisation techniques. It allows large producers to seamlessly integrate risk management into an enterprise financial management system and decrease risk management costs. Small farms can rely less on intuition and more on objective data and avoid costly mistakes. The financial incentive to insure (ΔC) is a useful criterion for such decision making. Owing to the quantitative nature of the measure, it can be used with other factors that may influence the decision to insure, including risk preference, tax policy etc. The empirical research shows that it would require considerable government subsidies, in addition to informational support, to facilitate the development of agricultural insurance markets in emerging economies. Demand for agricultural insurance in emerging economies, in particular those of Eastern Europe, should be negatively affected by the financial incentive to insure owing to higher interest rates.

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Appendix A

The case of a leveraged enterprise

A leveraged agricultural producer has an option to reduce risk by lowering or eliminating financial leverage. If available, this option is preferred over reserving funds because it is cheaper by definition, as the cost of debt incorporates the risk premium: $r_D = r_f + r_p$ (Brigham and Ehrhardt, 2011), while $y_r \approx r_f$, where r_f is a risk free rate and r_p is a risk premium. In this case:

$$C_B = -C_o - C_D - \gamma \tag{A.1}$$

$$C_D = -D \times r_D \tag{A.2}$$

where C_D is the cost of debt in currency form, and D is the amount of debt that is liquidated in order to reduce risk. The direct relationship $|C_D| \propto C_o$ in equation (A.1) remains accurate and determines the amount of D. Note that in function γ (equation 10) decline in D reduces L_F, while in the case of an unleveraged farm business rising R reduces the impact of income variability and Y_R increases ω. In both cases γ is reduced. When $\gamma = 0$,

$$C_B = r_D \times D - RoFE \times D \tag{A.3}$$

Return on equity should be similar to return on debt according to Modigliani and Miller (1958). Return on equity in equation (A.3) can be replaced with return on debt for a higher precision if enough information is available for its calculation. The financial incentive to insure for a leveraged farm is calculated as follows:

$$\Delta C = P \times \left[r \times \mu\left(\frac{r_{in}}{r_n}\right) - \frac{TE}{TP} \times RoIE \right] - O_e + G + D \times \left[RoFE - r \times \mu\left(\frac{r_{Dn}}{r_n}\right) \right] \tag{A.4}$$

If a tax shield is applicable, then

$$C_B = r_D \times D \times (1 - \tau) - RoFE \times D \tag{A.5}$$

where τ is the tax rate.

If debt is fully eliminated ($L_F = 0$ in equation 10), yet γ (equation 10) is not decreased to an acceptable level, then R needs to increase to reduce γ further:

$$C_B = -C_o - C_D + Y_R - \gamma \tag{A.6}$$

$$\Delta C = P \times \left[r \times \mu\left(\frac{r_{in}}{r_n}\right) - \frac{TE}{TP} \times RoIE \right] - O_e + G + RoFE \times (D + R) - r_D \times D - y_r \times R \tag{A.7}$$

The cost of debt (r_D) that is closely correlated to the key interest rate r can be alternatively calculated as $r_D = r \times \mu\left(\frac{r_{Dn}}{r_n}\right)$.

Appendix B

If the amount of premium (P) and the reserved capital (R) vary along with interest rates, the financial incentive to insure is:

$$f(r,R,P) = P \times \left[r \times \mu\left(\frac{r_{in}}{r_n}\right) - \frac{TE}{TP} \times RoIE \right] - O_e + G + R \times \left[RoFE - r \times \mu\left(\frac{y_{rn}}{r_n}\right) \right]$$

where TE, TP, $RoIE$, $RoFE$, O_e, *and* G are held constant.

$$f_r = P \times \mu\left(\frac{r_{in}}{r_n}\right) - R \times \mu\left(\frac{y_{rn}}{r_n}\right)$$

$$f_R = RoFE - r \times \mu\left(\frac{y_{rn}}{r_n}\right)$$

$$f_P = r \times \mu\left(\frac{r_{in}}{r_n}\right) - RoIE \times \frac{TE}{TP}$$

$$f_{rR} = -\mu\left(\frac{y_{rn}}{r_n}\right)$$

$$f_{Rr} = -\mu\left(\frac{y_{rn}}{r_n}\right)$$

$$f_{Pr} = \mu\left(\frac{r_{in}}{r_n}\right)$$

Therefore the rate of change of the financial incentive to insure ultimately depends on yields, at which both the insurer and the farm business are able to store their financial assets.

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The effects of weather risks on micro-regional agricultural insurance premiums in Hungary

This paper examines the effects of territorial differentiation of damage to wheat, maize, barley, sunflower and rapeseed production caused by drought and heavy rain. Our study evaluated the differences between LAU1 micro-regions in Hungary in the effects of the weather on agricultural production and found that there are extremely high differences in the probabilities of damage occurring. Therefore the design of agricultural insurance products should be based on different absolute deductibles and different insurance premiums for micro-regions. Furthermore, we found that within a micro-region individual producers face a very high diversity of risks which implies that in the long term only a *bonus-malus* system developed for individual agricultural producers can mitigate different risks, and that this can be the basis of a well performing risk management system that is suitable for a wide risk community.

Keywords: weather risks, micro-regions, insurance premiums, crop yields

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Introduction

The role of insurance in management of risk in agricultural production has long been the centre of attention for researchers and policy makers. Agricultural insurance products were first offered by private companies approximately two hundred years ago, initially in Europe and then in the United States (Smith and Glauber, 2012), and these followed different development paths during the progress of the two agricultural insurance markets (Székely and Pálinkás, 2009). The development of these markets has required an increasing role of government due to the persistence of moral hazard, adverse selection and systemic risks problems in agricultural production. Today, almost 90 per cent of the global agricultural premium of about USD 20 billion is collected in high-income countries where agricultural insurance products are heavily subsidised by governments (Mahul and Stutley, 2010).

The Hungarian agricultural insurance market has experienced major changes during the last decade (Kemény *et al.*, 2012a). A new agricultural insurance system based on two pillars started to operate from 2012. The first pillar is the continuation of the National Disaster Fund but with two important changes: the participation of farmers is compulsory above a certain farm size and there is a stricter control of the damage compensation. The second pillar focuses on the expansion of the agricultural insurance market by introducing insurance fee support for farmers who contract insurance policies for hail, fire, storm and winter frost damage as well as for drought, heavy rain and spring frost, which previously were not insurable risks. The insurance premiums are calculated for actual insurance products based on country level variables, except for hail risk where different variations of the (LAU1) micro-regional insurance premium calculation procedure are applied. The outcome of these country level insurance premiums for different weather risks is the formation of very heterogeneous risks communities, and this does not permit the sustainable operation of an agricultural insurance system.

Many studies in the Hungarian agricultural economics literature (e.g. Csete, 2004; Pesti *et al*., 2004) emphasise the importance of exploring the effects of micro-regional weather impacts on variations in the yield of agricultural crops but do so without having conducted any empirical investigations since the political and economic changes of 1989. Empirical observations suggest that the main weather risk factors vary widely among macro-regions as well as among micro-regions, implying the need for a more detailed examination of the effects of the weather on crop yields. Therefore the objective of this study is to estimate the optimal insurance premiums for the stakeholders of the Hungarian agricultural insurance market, based on micro-regional weather conditions. These should take into account the willingness to pay of farmers, the financial capacities of insurance companies and the governmental budget resources.

The structure of the article is as follows. The next section presents the theoretical and empirical background of the paper, and this is followed by a description of the methodology and data used to achieve the research objectives. The penultimate section contains the results of our calculations and the final section concludes with six policy implications.

Theoretical background

The estimation of insurance premiums is based on two primary principles of risk management. On the one hand, an equitable insurance system is characterised in the long term by the parity of the total insurance premium and the expected value of the damage incurred. On the other, farmers' decisions are characterised by a risk aversion attitude in the long term, implying that they are disposed to pay higher insurance premiums than the compensation value of their crop damage for assuring incomes from their farm operations. If these conditions are valid the insurance premium covers the compensation for damage incurred while the extra charge attributable to the risk aversion attitude of farmers covers the earnings and costs of insurance companies (Zweifel and Eisen, 2012).

However these principles do not always apply in the short term. Before introducing a comprehensive insurance product covering drought, heavy rain and spring frost risks the insurance premium system should take into account the following essential conditions: (i) the insurance premium should be set at an acceptable level for producers; (ii) the damage compensation should not overload insurance companies even in years with high rates of damage; (iii) the insurance premium for every crop should cover the costs of insurance at least at national level even if this objective cannot be achieved for every micro-region; (iv) the insurance premium system should not be too complex and there must not be exaggerated differences between producers' insurance premiums (Kemény *et al.*, 2012b).

The *acceptable level of insurance premiums for farmers* (i) is considered to be 2-3 per cent of the output. Even considering the maximum of allowed governmental support of insurance premiums (65 per cent) in the European Union, the total insurance premium paid by farmers complemented by the governmental insurance premium support cannot exceed 5 per cent of the farm output of insured product due to the low willingness to pay of farmers for insurance (Kemény *et al.*, 2010).

That *damage compensation should not overload insurance companies* even in years with high rates of damage (ii) is a fundamental condition for insurance companies providing risk management products for Hungarian agriculture as they have suffered losses in five of the last six years. This makes it even harder to solve the optimisation problem of calculating acceptable insurance premiums for farmers and insurance companies while taking into account the low willingness to pay of farmers for agricultural insurance and the fact that agricultural insurance companies exhausted their reserves in previous years, which prevents them from accepting further losses in their agricultural insurance operations. An acceptable solution for both farmers and agricultural insurance companies can be achieved only with governmental support for agricultural insurance premiums.

The condition *the insurance premium for every crop should cover the costs of insurance* (iii) states that there are not preferred crops where the total insurance premium collected from farmers complemented by governmental support is lower than the damage compensation paid by insurance companies. This implies the differentiation of insurance premiums for different crops.

The condition *the insurance premium system in a micro-region should cover the damage compensation, not be too complex and there must not be exaggerated differences between producers' insurance premiums* (iv) defines the need for a transparent and clear agricultural risk management insurance system. Such a system would have less than ten insurance premium categories and in a micro-region all crops would fall into the same category. Moreover in every micro-region the collected insurance premiums should cover the damage compensation, which implies that the farmers are using crop rotation in the case of insurable crops. To overcome inverse selection in the risk community in a micro-region it is imperative to not have exaggerated differences between producers' insurance premium rates.

Methodology

We applied the linear programming method to solve the multi-conditional optimisation problem when calculating micro regional level insurance premiums. The model is formulated according to the description of Bakos (2000). Matrix (1) represents a set of scenarios $V = \{V_1, V_2, \ldots, V_m\}$ and a set of attributes $C = \{C_1, C_2, \ldots, C_n\}$, where c_{ij} is the value of future *i* of scenario *j*.

$$\begin{array}{cccccc} & V_1 & V_2 & \ldots & V_n \\ C_1 & c_{11} & c_{12} & \ldots & c_{1n} \\ C_2 & c_{21} & c_{22} & \ldots & c_{2n} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ C_m & c_{m1} & c_{m2} & \ldots & c_{mn} \end{array} \tag{1}$$

The c_{ij} values of the matrix are normalised; every row is transformed to values between zero and one. The rows of the transformed matrix contain a set of usable parameters $U = \{U_1, U_2, \ldots, U_n\}$ making possible the comparability of the variables (2).

$$\begin{array}{cccccc} & V_1 & V_2 & \ldots & V_n \\ U_1 & u_{11} & u_{12} & \ldots & u_{1n} \\ U_2 & u_{21} & u_{22} & \ldots & u_{2n} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ U_m & u_{m1} & u_{m2} & \ldots & u_{mn} \end{array} \tag{2}$$

Depending on which values of attributes are preferred, lower (3) or higher (4) values of u_{ij} are calculated with the formula:

$$u_{ij} = \frac{c_{ij} - c_{i\min}}{c_{i\max} - c_{i\min}} \quad \text{(lower is preferred)} \tag{3}$$

or

$$u_{ij} = \frac{c_{i\max} - c_{ij}}{c_{i\max} - c_{i\min}} \quad \text{(higher is preferred)} \tag{4}$$

The *p* vector contains the values of weighting parameters defined by decision maker and the sum of these values is one (5).

$$\sum_{i=1}^{m} p_i = 1 \tag{5}$$

The weighting parameters are values between zero and one, which are used to express the importance of usable parameters for selecting the most favourable solution (6).

$$z = Opt_{j=1}^{n} \sum_{i=1}^{m} p_i u_{ij} \tag{6}$$

Owing to the gradual introduction of the limiting conditions described in the previous section, in our case the insurance premium optimisation matrixes have the following forms:

$$\begin{array}{cccccc} & V_1 & V_2 & \ldots & V_n \\ C_1 & c_{11} & c_{12} & \ldots & c_{1n} \\ C_2 & 0 & c_{22} & \ldots & c_{2n} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ C_m & 0 & 0 & \ldots & c_{mn} \end{array} \qquad \begin{array}{cccccc} & V_1 & V_2 & \ldots & V_n \\ U_1 & u_{11} & u_{12} & \ldots & u_{1n} \\ U_2 & 0 & u_{22} & \ldots & u_{2n} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ U_m & 0 & 0 & \ldots & u_{mn} \end{array} \tag{7}$$

The four conditions presented above were introduced gradually according to their importance, obtaining the minimum values of insurance premium sums in the *C* triangle matrix and the elements of the transformed *U* matrix (7).

These matrixes are multiplied by the *p* column vector, which contains the weighting factors attributed by decision maker, thus providing different scenarios, among these Z which represents the optimal scenario.

Micro-regional yield loss values were calculated from Hungarian Statistical Office data for the period 2003-2009 collected from about 7,000 farms operating as companies. The yield loss is estimated in each of 173 LAU1 micro-regions in Hungary (i.e. all micro-regions except Budapest) as a difference from the weighted average of the micro-regional crop yield in the analysed period. The weights (*p* vector) are the utilised agricultural area of farms in the sample from a micro-region. When the yield loss for a crop (wheat, maize, barley, sunflower, rapeseed, grape and apple) exceeds a certain threshold in a micro-region, the farmers in that micro-region are entitled to compensation. We evaluated the compensation value in every micro-region as a product of yield loss of a certain crop and its average producer price.

Micro-regional meteorological data were interpolated from over 100 automatic weather station records provided by the Hungarian Meteorological Service for the same period (2003-2009). Applying conditions of meteorological variation to define yield loss made it possible to identify all-risk yield losses caused by weather risks. Those yield losses that satisfy certain meteorological conditions are considered to be damage eligible for compensation. *Drought* is considered for wheat, winter barley, maize, sunflower and rapeseed production when there is a lower yield than the defined threshold and the total rainfall is less than 10 mm in at least one month between March and September. *Heavy rain* risk is considered for wheat, winter barley, maize, sunflower and rapeseed production when the yield is lower than the defined threshold and in at least one month between March and September the average rainfall is higher than 80 mm.

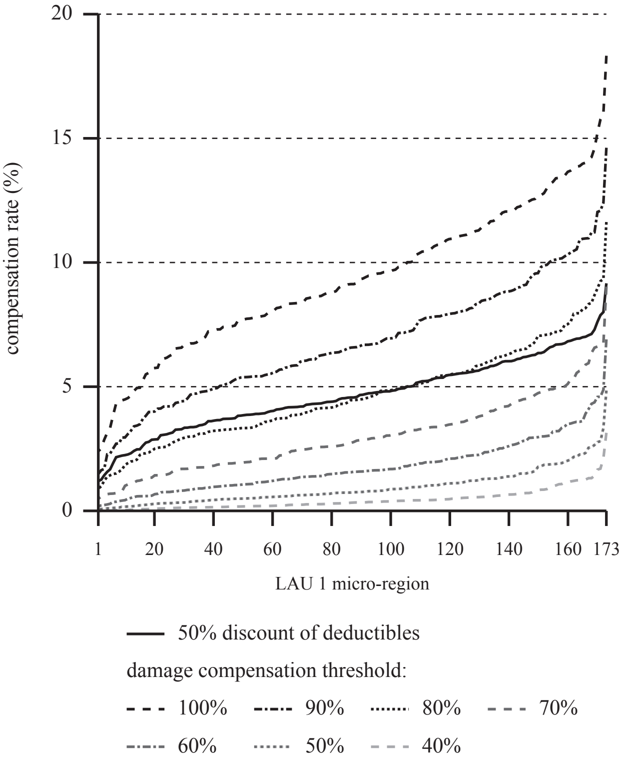
Results

When calculating optimised insurance premiums that take into account micro-regional differences we adhered to the two principles of risk management identified by Zweifel and Eisen (2012), described above. Since our intention was to reconcile conflicting conditions when calculating optimised insurance premiums, as a first step we present here the effects of each of our four conditions on the rate of damage compensation and then we gradually introduce these conditions for solving our linear programming problem. In the second stage, optimised insurance premium results are presented based on three scenarios according to different deductible rates.

The relationship between damage compensation rates and the defined conditions

Damage compensation rates for when condition (i) is considered are presented in Figure 1. The damage compensation rate is calculated as a share of damage value and insurance value in the 173 micro-regions based on yearly average output, when the deductible rate is gradually increased from 0 to 60 per cent (this means that the damage compensation threshold is decreased gradually by 10 per cent from 100 per cent to 40 per cent).

Figure 1: Crop damage compensation rates of Hungarian LAU1 micro-regions for different damage compensation thresholds or a 50% discount of deductibles as an average of the period 2003-2009.



Source: own composition

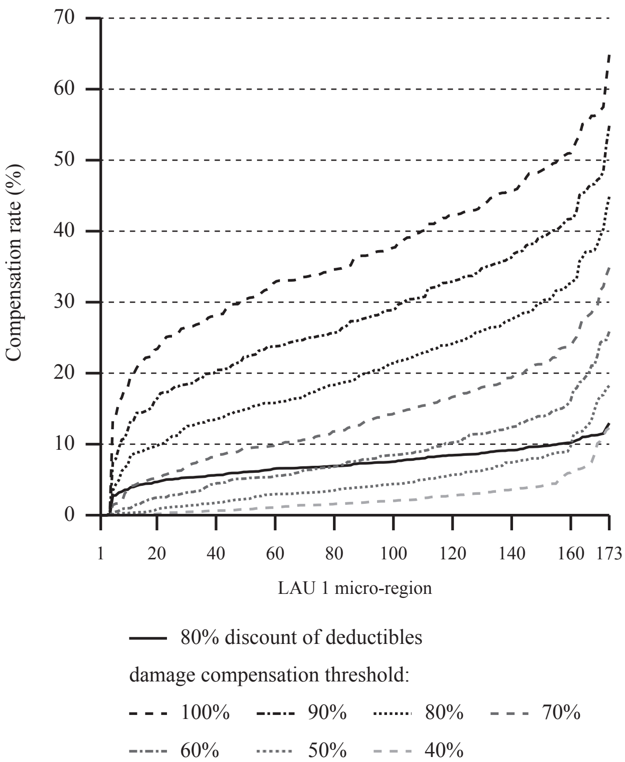
There are major differences among the damage compensation rates of micro-regions. In the best performing micro-region, in the case of a 100 per cent damage compensation threshold the justified insurance premium is 2.5 per cent of average output while in the worst performing micro-region it is 18 per cent. This figure shows that if we wish to have acceptable insurance premiums for all farmers it is necessary to reduce the discount or the absolute value of deductibles. We can have an acceptable insurance premium rate at 70 per cent damage compensation threshold, where in the worst performing micro-region the insurance premium rate is below 10 per cent. The same acceptable insurance premium rates can be attained at 60, 50 and 40 per cent of the deductible threshold.

If the insurance product fulfils condition (ii), i.e. that even in a year with heavy damage such as 2003 there are no losses in the insurance system of insured products, the results presented in Figure 2 are obtained.

In years with heavy damage almost 50 per cent of output is lost, which implies very high insurance premiums for 100 per cent compensation. In this case the insurance premiums should be set at around 40 per cent, which is unacceptable for farmers if we take into account their willingness to pay is around 5-6 per cent. This problem can be solved in two ways. One possibility is to reduce the damage compensation threshold to 50 or 40 per cent, which means that only those farmers whose output decrease was higher than 50 or 60 per cent receive any compensation. The other possibility is to increase the discount of deductibles to 80 per cent.

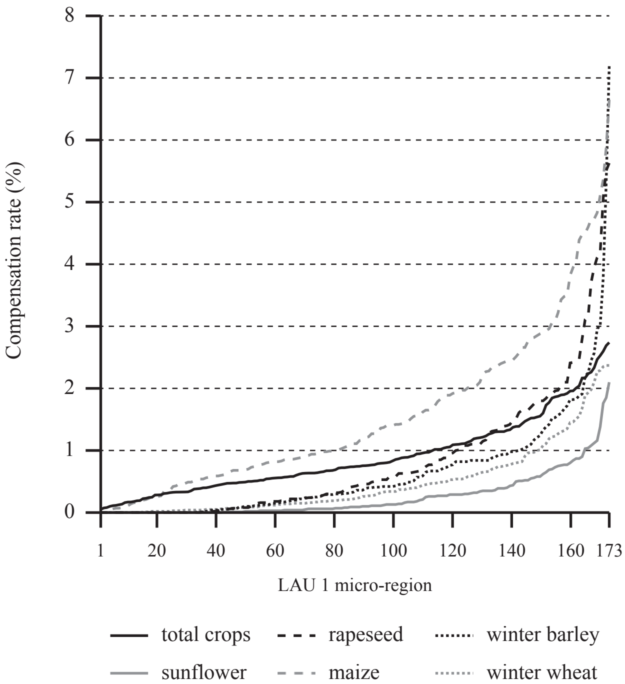
For a crop producer the option of a damage compensation threshold set at 50 per cent seems more plausible than the option of a discount of damage set at 80 per cent.

Figure 2: Crop damage compensation rates of Hungarian LAU1 micro-regions for different damage compensation thresholds or an 80% discount of deductibles in 2003.



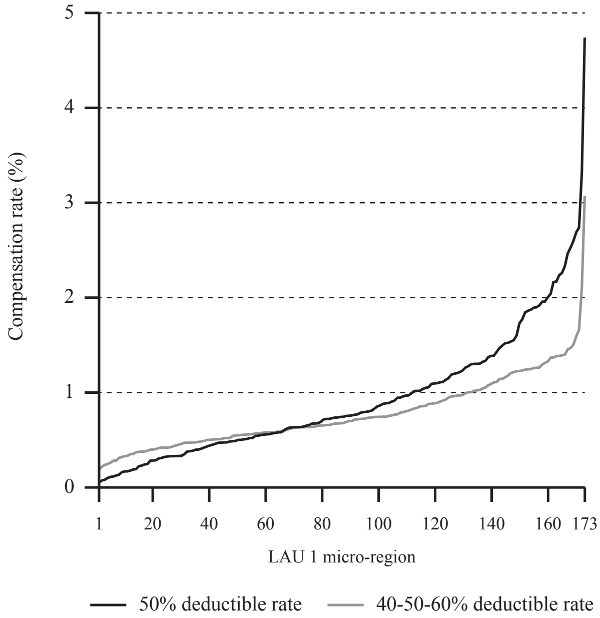
Source: own composition

Figure 3: Crop damage compensation rates of Hungarian LAU1 micro-regions for different crops as an average of the period 2003-2009, using a damage compensation threshold of 50 per cent rate of deductibles.



Source: own composition

Figure 4: Crop damage compensation rates of Hungarian LAU1 micro-regions as an average of the period 2003-2009, using 50 per cent and 40-50-60 per cent rates of absolute deductibles.



Source: own composition

Condition (iii) is to have, at least at national level, an insurance system where the insurance premiums cover all damage incurred. This can be attained by applying highly differentiated insurance premiums for different crops (Figure 3).

For sunflower, with the most favourable damage compensation rates, where in the micro-region with the highest damage of 50 per cent, the insurance premiums can be set around 1 per cent of the farms' sunflower output value. However for maize, with most unfavourable damage compensation rates, for 30 per cent of farmers the insurance premiums can be set at the 2 per cent level, while in the case of most farms exposed to weather risks the insurance premiums should be set at 7 per cent of the maize output value.

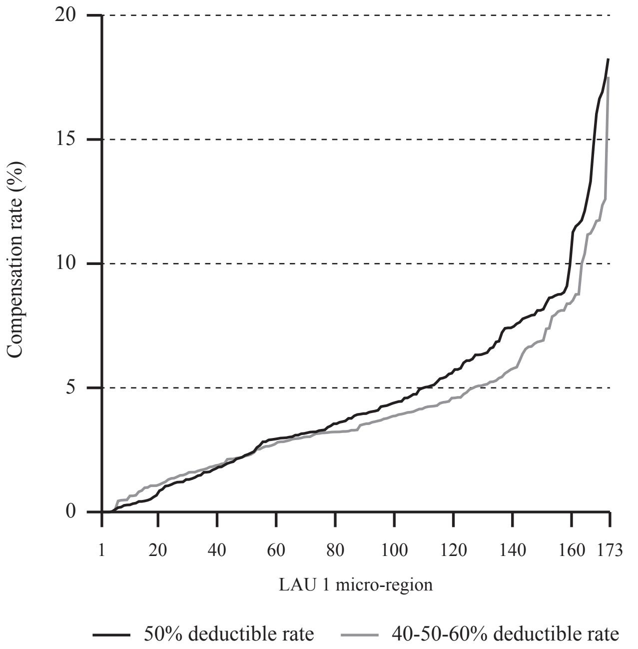
Condition (iv) contains the clauses of insurance premium calculation at micro-regional level: on the one hand the coverage of damage incurred by insurance premiums collected in the micro-region and on the other hand to not have exaggerated differences among insurance premiums paid by different farmers in the micro-region.

The micro-regions are classified according to their damage compensation threshold records averaged over seven years in three categories: the micro-regions characterised by the highest damage are connected to 40 per cent, the micro-regions with medium damage to 50 per cent and the micro-regions when the least damage are connected to a 60 per cent yield threshold.

By applying differentiated 40-50-60 per cent absolute deductible rates according to the risk exposure of a micro-region, more homogeneous insurance premium rates can be obtained compared to general valid average 50 per cent absolute deductible rate (Figure 4).

The same situation arises in the years with heavy damage, for example in 2003 the differentiation of micro-regions according to their risk exposure makes it possible to set lower insurance premiums for most of the farms (Figure 5).

Figure 5: Crop damage compensation rates of Hungarian LAU1 micro-regions in 2003, using 50 per cent and 40-50-60 per cent rates of absolute deductibles.



Source: own composition

Optimisation of insurance premiums by gradual introduction of conditions

Introducing gradually the four conditions presented in the previous section and referring to our principle that the insurance premiums should cover damage compensation we developed three scenarios.

In scenario A we consider conditions (i) and (ii), which imply that the damage threshold is set at 50 per cent, the discount of deductibles is 10 per cent, the same insurance premium rates are applied for all crops, the damage compensation rate is set at 75 per cent of the average values for 2003-2009, and even in the case of years with high levels of damage compensation this cannot exceed 110 per cent.

Insurance premium rates for drought and heavy rain should be set threefold higher (see Kemény *et al.*, 2012b) for all farmers, micro-regions and crops considering condition (ii) to avoid serious damage by insurance companies when extreme weather conditions cause a drastic fall of farm output (Table 1 column 2).

Applying a flat 3.6% insurance premium rate for compensating insurance companies because of years with extreme crop damage contributes to increasing their profits. This scenario can be applied only in the case of introducing a new insurance premium system followed by increasing the damage threshold or reducing the insurance premium rates. Scenario A does not satisfy our expectations as there are big differences in damage compensation rates among different field crops (Table 2) and there is a high redistribution of insurance premiums among different micro-regions (Figure 6).

In scenario B condition (iii), which does not allow cross financing of insurance premiums between different crops, is considered together with conditions (i) and (ii). In this scenario the conditions of scenario A are complemented with the condition that the same damage compensation rate is applied to every crop. The difference between sunflower, with the least damage, and maize, with the most damage, is fivefold and the insurance premium of maize remains at an acceptable level (Table 1 column 3).

Scenario B allows us to calculate acceptable insurance premiums which handle the situation of years with extreme

Table 1: Insurance premium rates for drought and heavy rain insurance for five crops, when cross financing of insurance premiums between different crops is allowed or not allowed.

Crop	Insurance premium rate (%)	
	Allowed	Not allowed
Rapeseed	3.6	3.2
Maize	3.6	5.6
Sunflower	3.6	1.1
Winter wheat	3.6	1.7
Winter barley	3.6	2.7

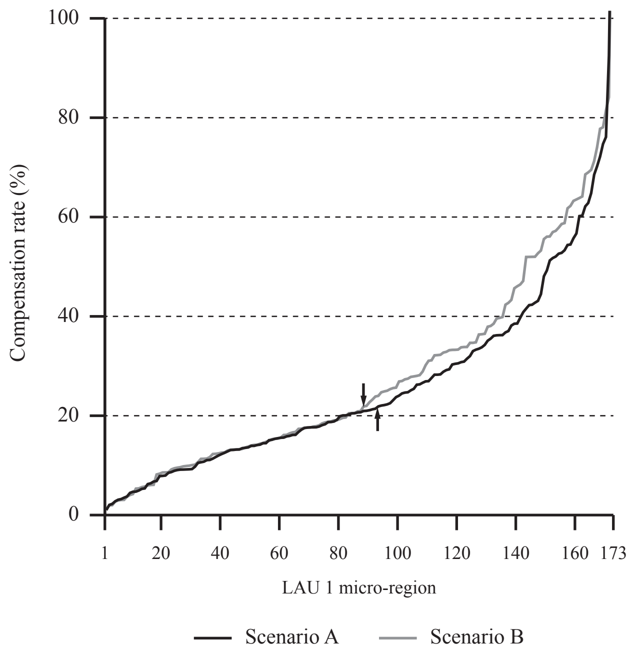
Source: own data

Table 2: Crop damage compensation rates (per cent) for drought and heavy rain insurance for five crops for the period 2003-2009 under scenario A.

	2003	2004	2005	2006	2007	2008	2009
Rapeseed	301.4	0.5	0.5	0.0	36.1	0.0	22.1
Maize	100.7	0.0	1.2	0.1	132.8	0.5	14.5
Sunflower	25.4	0.0	1.9	0.0	13.4	0.0	9.1
Winter wheat	63.8	0.0	0.3	0.0	9.9	0.0	4.7
Winter barley	109.5	0.0	5.2	0.0	25.1	0.0	14.6
Total damage compensation rate	110.0	0.1	1.1	0.1	61.6	0.2	10.7

Source: own data

Figure 6: Crop damage compensation rates of Hungarian LAU1 micro-regions for scenarios A, i.e. taking into account conditions (i) and (ii), B, i.e. taking into account also condition (iii).



Values for micro-region 173 are 132% (scenario A) and 129% (scenario B)
Parity with the average damage compensation rate is indicated thus: upward arrow: scenario A; downward arrow: scenario B
Source: own composition

damage. The insurance premiums are financing the damage compensation in the case of different crops (Table 3), thus the first three conditions are held, but the problem of redistribution of insurance premiums among micro-regions remain unsolved (Figure 6). Furthermore in half of the micro-regions the insurance premiums are higher than in scenario A.

Table 3: Crop damage compensation rates (per cent) for drought and heavy rain insurance for five crops for the period 2003-2009 under scenario B.

	2003	2004	2005	2006	2007	2008	2009
Rapeseed	334.1	0.5	0.5	0.0	36.3	0.0	22.1
Maize	63.8	0.0	0.6	0.2	75.7	0.3	8.4
Sunflower	83.4	0.0	5.5	0.0	39.6	0.0	27.0
Winter wheat	133.0	0.0	0.6	0.0	18.7	0.0	8.7
Winter barley	146.3	0.0	6.3	0.0	30.1	0.0	17.6
Total damage compensation rate	110.0	0.1	1.1	0.1	61.6	0.2	10.7

Source: own data

We managed without any difficulties the inclusion of the first three conditions in our linear programming model. But solving the problem of redistribution of insurance premiums among micro-regions (condition iv) cannot be performed in the same way as we have 173 micro-regions, five crops and ten insurance premium rate categories, which results in an over-identification model. Consequently we grouped the micro-regions into six categories according to their exposure to risk (Table 4): in the first two categories, which are the least exposed to risk, the farmers are compensated when their output decreases below 60 per cent of the average output in the micro-region. In the third and fourth categories, namely those with medium exposure to risk, farmers are compensated after their output decreases by 50 per cent, while in the last two categories of micro-regions, where the exposure to risk is the highest, farmers are compensated when their output falls below 40 per cent of the average output of the micro-region.

In scenario C there are six categories of micro-regions with three output thresholds. The risk exposure of the six categories of micro-regions is increasing from the first to the sixth category. The insurance premium rates vary among categories of micro-regions and crop products (Table 4), and consequently the insurance premium rate is lower and the output threshold is higher in micro-regions and crop products with lower exposure to risk.

The inclusion of micro-regions in different categories according to their exposure to risk and the differentiation of insurance premium rates within the category of micro-regions led to improved results: in years with heavy crop damage excessive compensation is avoided, the redistribution of insurance premium is reduced to an acceptable level and the problem of redistribution of insurance premiums between micro-regions are considered (Table 5).

Table 4: Output threshold levels and crop insurance premium rates for drought and heavy rain insurance in six micro-region categories.

	1	2	3	4	5	6
Output thresholds	60%	60%	50%	50%	40%	40%
Rapeseed	2.0	4.0	3.0	3.5	3.5	3.5
Maize	4.0	6.0	4.0	4.5	4.5	6.0
Sunflower	0.8	2.0	0.8	1.0	1.0	1.0
Winter wheat	1.0	1.5	0.8	1.5	1.5	1.5
Winter barley	2.5	2.5	2.5	2.5	2.5	2.5

Source: own data

Table 5: Crop damage compensation rates for drought and heavy rain insurance for five crops in six micro-region categories as an average of the period 2003-2009 under scenario C.

	1	2	3	4	5	6	Average
Rapeseed	14.0	19.0	21.3	20.2	19.9	20.5	19.6
Maize	23.1	31.7	20.2	26.3	20.6	34.5	25.5
Sunflower	15.5	14.3	14.9	20.6	16.1	19.3	17.5
Winter wheat	20.7	21.5	22.3	23.1	12.8	24.6	20.9
Winter barley	21.6	25.0	16.4	12.8	16.4	23.0	21.0
Total damage compensation rate				23.8			

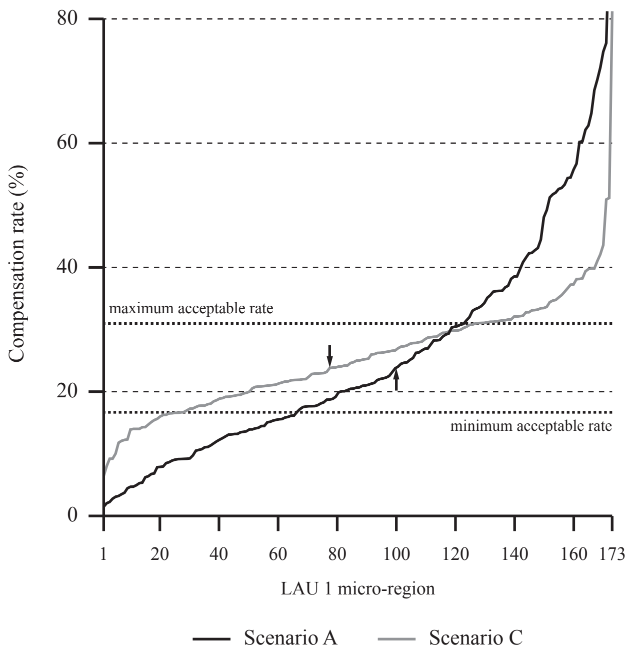
Source: own data

The insurance premiums optimised in scenario C are lower than in scenario A (Figure 7), namely in the majority of micro-regions the insurance premiums remain in an acceptable zone. Furthermore in this last scenario the redistribution of insurance premiums among micro-regions is solved in an acceptable manner (see Kemény *et al.*, 2012b).

Discussion

This study investigates the spatial distribution of natural risks and their effects on the yield variations in Hungarian crop production. The conflicting conditions presented cannot be entirely taken into consideration at the same time when insurance premiums are calculated. There are only solutions

Figure 7: Crop damage compensation rates of Hungarian LAU1 micro-regions for scenarios A, i.e. taking into account conditions (i) and (ii), and C, i.e. taking into account all four conditions.



Parity with the average damage compensation rate is indicated thus: upward arrow: scenario A; downward arrow: scenario C
Source: own composition

which are approaching the perfect insurance premium system. In addition to an insurance premium system optimised to the interests of stakeholders 'strategies to enhance knowledge and trust are needed to ensure that farm managers are able to utilize insurance products for readjusting their production decisions and improving their performance' (Spörri *et al.*, 2012, p.12).

The calculation of the insurance premiums is based on all-risk yield loss and consequently the calculation of premiums according to every type of risk is very difficult due to methodological problems. Therefore the settlement of insurance premiums should be carried out with extreme caution taking into account the actuarially fair insurance premium rate, the willingness to pay for insurance of farmers (Chambers, 2007) and the opinions of experts.

Our theoretical expectation was that the size of the multi-risk insurance system payments required to cover the costs and the profits of insurance companies would not have a considerable influence on the output and income levels of crop producing farms at the macro level. However the performance of the multi-risk insurance system is beyond question because the macro-level income of producers suffering damage is increased. According to our model estimations, during the years with heavy adverse weather conditions 24-35 per cent of farmers can suffer crop damage and their income can increase due to contracting multi-risk insurance by 26 per cent in the case of operational profit and 36 per cent in the case of profit before tax.

The micro-level performance of the multi-risk insurance system is not clear. The damage caused by the insurable risks (drought, heavy rain) reduces the income per production value by 15 per cent in the case of 30 per cent of farmers suffering damage, while the compensation for damage is higher than 8 per cent only in the case of 10 per cent of farmers with damage due to the high absolute value of deductibles.

The policy implications of these findings, which in the long term will allow an enlargement of the risk community and the reduction of exposure to risks, as well as a reduction in government expenditure and a certain level of profitability of insurance companies, are the following:

1. The introduction of the agricultural insurance scheme presented here, in addition to the interests of agricultural producers and insurance companies, is also in the government interest because setting up this insurance structure allows agricultural producers to cut their financial losses, which in turn reduces the pressures on producers and at the same time on the state damage mitigating fund.
2. Successful operation of this agricultural insurance scheme can be achieved only if the risk community grows to a suitable size. Therefore government support is needed for a rapid expansion of the risk community to this size. This can be achieved by means of an insurance premium subsidy, other allowances granted for farmers with insurance contracts, or even administrative regulations that specify a certain level of insurance engagement.
3. Enhanced risk coverage offers the possibility of better protection against risks for every financing organisation. Thus banks financing agricultural crop production and integrators can reduce credit rescheduling and the risks of non-payment caused by adverse weather conditions if they oblige agricultural producers to take out the all-risks crop insurance that is available on the market.
4. Government monitoring of agricultural insurance companies and market processes is required to prevent the increase of insurance premiums above the market equilibrium premium level due to government stimulation of the spreading of agricultural insurance. Nevertheless the likelihood of charging extra insurance premiums because of the insurance fee subsidy is very low based on the experience of the last ten years which is characterised by a very low insurance damage rate.
5. The introduction of the insurance scheme presented in this study can be performed only with high insurance premiums and a high value of deductibles which would be expected to yield lower loss ratios for insurance companies, but after the spreading of this insurance scheme among farmers the loss ratio should gradually decline to 75 per cent. This should be achieved by decreasing the absolute value of deductibles instead of reducing the insurance premiums. In this way an increased level of protection of farmers can be achieved by agricultural insurance, which reduces the risk of a drastic decrease in farmers' profit before tax caused by adverse weather conditions
6. The high range of yields in micro-regions indicates large differences in crop output in Hungarian agriculture within the same micro-region. Since the technological losses cannot be perfectly separated from losses caused by adverse weather conditions it is not sufficient to classify micro-regions according their risk characteristics except in the short term, i.e. the year of introducing the insurance scheme. In the long term insurance premiums should be based on the individual records of loss ratios in the case of every crop producer, developing a *bonus-malus* insurance premium system. This insurance scheme can adequately handle the extent of the differences in country-wide and micro-regional level risks due to the differences in natural endowments and the production skills of farmers. In this case, in a micro-region with a high loss ratio a farmer producing in favourable microclimatic conditions and/or with excellent production skills can obtain an insurance contract for her/his crop production at a lower insurance premium, while in a micro-region with a low loss ratio a poorly performing farmer should accept higher insurance premiums according to her/his higher loss ratio compared to the average micro-regional loss ratio.

In conclusion, insurance in agriculture is becoming an essential risk management tool for farmers to handle unexpected effects of different shocks. The introduction in Hungary of multi-risk yield insurance based on macro-regional and micro-regional differentiated damage thresholds, as well as on macro-regional and micro-regional differentiated insurance premiums, will help to preserve the standard of living of those who depend on farming, strengthen the viability of farm businesses, and provide an environment which supports investment in the farming sector. The introduction of micro-regional optimised insurance premiums will lead to wider risk communities in agricultural production and a sustainable agricultural insurance system.

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The pluriactive development of agricultural holdings in Poland with regard to the living standards of their users

This paper illustrates the regional diversity in terms of the agricultural income of economically weak farms in Poland (i.e. from 2 to 8 ESU). The results, expressed as average values for 2005-2009, indicate that farms are finding themselves in a very difficult situation. Furthermore, the assessment included farms that gained their income not only through agricultural activity, but also through doing non-agricultural work. The diversification of income sources created the opportunity to sustain less profitable agricultural production while providing a higher standard of living for farmers and their families. Such factors as the intensity of production, and the productiveness of current expenditures and fixed capital, as well as the financial position of the farms and the level of their debt, have been analysed. An important aim of the study was to identify the influence of the Common Agricultural Policy on the performance of farms.

Keywords: farm income, off-farm income, diversification of income, economically weak farms

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Introduction

Publically available statistical data indicate that in 2002 and 2010 there were 2.2 and 1.9 million agricultural farms operating in Poland respectively, with more than 99 per cent of them being private farms (CSO, 2011a). In terms of economic size, farms with up to 2 ESU (European Size Unit) accounted for 70 per cent, farms of 2-8 ESU for approximately 20 per cent and those of 8 ESU and more accounted for around 10 per cent (CSO, 2008). Agricultural holdings with up to 2 ESU are usually subsistence farms that do not market their produce. However, they are home to 3.7 million people, accounting for approximately 10 per cent of the total population (Zegar, 2009a), and provide employment for 915,000 people expressed in AWU i.e. Annual Work Units (CSO, 2008). Although the farms are of little economic relevance, they are very important from the social perspective.

Economists are normally more interested in farms larger than 2 ESU – these are commercial farms in Poland that are included in the Farm Accountancy Data Network (FADN). In the FADN's field of observation, farms with 2-8 ESU, described as economically weak, account for 70 per cent (Goraj *et al*., 2008). These farms utilise 4.4 million hectares of agricultural land, which accounts for approximately one third of the agricultural land owned by private farms, and provide employment for 803,000 people expressed in AWU (CSO, 2008).

The majority of farms of 2-8 ESU do not have the capacity to develop, and therefore there is no certainty as to their chances of sustaining their operation in the long term (Józwiak, 2009). The income of these farms is often too low to provide their users with a satisfactory standard of living (Zegar, 2009a). In order to enhance the living standards of the farmers' families, as well as to improve the financial situation of the farms, such as through the supply of funds for investments (Hertz, 2009), the owners are often forced to seek off-farm income. Usually, they do so by undertaking other off-farm activity, understood as employment outside the farm with other entities in the form of labour for which salary is received, obtaining social benefits and carrying out non-agricultural activity.

Based on data provided by the Central Statistical Office, Zegar (2009a) concluded that 87 per cent of the families of individual farmers made their living from at least two income sources in 2007, with 52 per cent of the families gaining off-farm income. According to the results of the FADN study and the surveys of the farmers' families carried out by the Institute of Agricultural and Food Economics – National Research Institute (IAFE-NRI), the highest share of non-agricultural income in the total income of farmers' families could be observed among farms of 2-4 ESU (62 per cent), followed by farms of 4-8 ESU (45 per cent), with the smallest share being identified in farms of 100 ESU and more (7 per cent) (Goraj *et al.*, 2010). The share of this income in the overall income of farmers' families tended to decrease as the economic size of the farms increased.

Supporting farmers' families' income through non-agricultural income is a common practice not only in Europe, but also in North America, Latin America, Africa and Asia. According to many studies, off-farm income accounted for approximately 40 per cent of the household income in the first years of the 21st century (e.g. Zhang, 2003; Ellis and Allison, 2004; Pfeiffer *et al*., 2009). In Poland, a considerable number of farmers' families gain part of their income from activities unrelated to the farm. However, the availability of work constitutes a barrier. Despite the fact that rural areas account for 93 per cent of the total area of Poland, with 39 per cent of the population being resident in these areas, the professionally-active inhabitants of rural regions account only for 19 per cent of the professionally-active Polish citizens (CSO, 2011b). Such a small percentage hampers the multifunctional development of rural areas, including the development of agricultural farms.

The aim of the study was to show the diversity in the income situation of the economically vulnerable farms (with 2-8 ESU) located in four agricultural regions of Poland. The only income for those farms was from agricultural activity. The economic situation of farmers' families gaining their income (apart from agricultural activities) from non-agricultural activities was analysed separately. Therefore, an attempt was made to indicate a way out of impasse (i.e. the difficult economic situation) of small farms (economically and territorially), taking into account the production, economic and social functions of these holdings. Also the role of the Common Agricultural Policy (CAP) in reaching this goal was considered.

Methodology

The study was based on two data sources, with the data from agricultural farms from the FADN system being the main source. The second source was a voluntary survey of the non-agricultural income of farmers' families (carried out on the same farms as those included in the FADN accountancy) by IAFE-NRI. Monthly data are collected on income from four sources: from employment, pensions, allowances and compensation for social security and donations, net of income tax advances, and the system also collects annual data on income after tax from non-agricultural registered activities.

Two farm samples were selected. Both included private farms sized 2-8 ESU that did FADN accountancy continuously in 2005-2009 (balanced panel data) and that were located across the entire area of Poland. The differentiating characteristic for the selection of the samples was the source of income: income from farm only for the first sample of households and additional off-farm income for the second sample.

The first sample included 527 farms owned by farmers who gained their income based exclusively from their agricultural activity. To present the regional diversity of the results, the sample farms were grouped according to their regional (i.e. FADN regions[1]) locations.

The second sample, selected independently from the first, comprised 188 farms owned by families which, apart from their farm income, gained off-farm income (group A), and were therefore undergoing pluriactive development. In order to examine whether pluriactive development facilitates economic performance and provides a higher living standard for farmers' families, a comparative sample was selected for the farms from this sample. The comparative sample also comprised 188 farms (group B), that were selected from the first study sample (527 households). Households from group B were homogenous with the group A farms in terms of their economic size and agricultural type. The farms were selected in pairs based on the rule of statistical twins. For each group A farm its group B counterpart would be selected to be as similar as possible in terms of average economic size specified for 2005-2009, with its agricultural type established, due to its changeability over the years, for the last year of the study. This selection method made it possible to reduce the influence of economic size and agricultural size on the performance of farms included in the comparative sample (group B), and consequently to present the diversity in results for both groups according to the different causal factors.

Income from the family farm was the factor adopted as a basic measure for evaluating the effects of running an agricultural activity, while output value and costs incurred were also shown. The following ratios which relate to productivity of chosen resources and other fields of the farms' activity were used in the study:

$$\text{The productivity of current expenditures}\,[\%] = \frac{\text{the total production value}}{\text{current assets}} \times 100 \quad (1)$$

$$\text{The productivity of fixed capital expenditures}\,[\text{ratio}] = \frac{\text{the total production value}}{\text{depreciation}} \quad (2)$$

$$\text{The total productivity of assets}\,[\%] = \frac{\text{the total production value}}{\text{total assets}} \times 100 \quad (3)$$

$$\text{Fixed assets to current assets}\,[\text{ratio}] = \frac{\text{fixed assets}}{\text{current assets}} \quad (4)$$

$$\text{The fixed assets renewal rate}\,[\%] = \frac{\text{net investments}}{\text{fixed assets}} \times 100 \quad (5)$$

$$\text{The farms debt rate}\,[\%] = \frac{\text{total liabilities}}{\text{total assets}} \times 100 \quad (6)$$

$$\text{The debt structure ratio}\,[\%] = \frac{\text{long-term liabilities}}{\text{total liabilities}} \times 100 \quad (7)$$

The analysis of resource productiveness is a management tool for evaluating the performance of farms and comparing them with others, particularly those selected according to the same criterion (Kosieradzka, 2004; Lis *et al.*, 1999; Nowak, 2008). The fixed assets to current assets ratio indicates the degree to which the farm goods are immobilised. The higher the ratio, the longer the immobilisation period. This means that farms are less able to restructure and adapt to market changes (Nowak, 2008).

The fixed assets renewal rate indicates the degree to which assets are renewed. If the value of this ratio ranges from -1.0 to 1.0 per cent, then farms represent simple asset renewal, while values exceeding 1.0 per cent represent extended renewal, and those below -1.0 indicate restricted renewal (Józwiak, 2003). In the case of simple renewal only part of the fixed assets used during the production cycle is renewed, meaning that gross investments cover only depreciation. With extended renewal, investments not only cover depreciation but also increase fixed asset resources. In turn, restricted renewal means that the fixed assets used in the course of production are not fully renewed.

The debt level of farms is indicative of the financial risk related to production activity. The higher the value of the ratio, the bigger the financial risk. For private farms the ratio should not exceed 50 per cent (Goraj and Kulawik, 1995). In turn, the debt structure ratio reflects the financial stability of agricultural farms. The higher the ratio, the more financially stable the farm (Nowak, 2008).

The intensity of agricultural production was also analysed. This factor is considered to be a universal indicator of progress. Over the years, the approach to selecting optimum parameters for evaluating intensity has changed (Manteuffel, 1984; Hernández-Rivera and Mann, 2008). As plant production predominated in the tested farms, for the study, production intensity was measured based on farm input expressed as the level of direct costs (per hectare of agricultural land) and the selected components thereof, i.e. the cost of seeds, fertilisers and plant protection products.

The degree to which farms depend on subsidies on current operations was also evaluated. Furthermore, the paper pro-

[1] Pomorze i Mazury [PL_A], Wielkopolska i Śląsk [PL_B], Mazowsze i Podlasie [PL_C], Małopolska i Pogórze [PL_D].

Table 1: Selected information on 527 private farms sized 2-8 ESU grouped according to their regional location in Poland. Average figures for 2005-2009.

Parameter		Agricultural regions in Poland			
		Pomorze i Mazury [PL_A]	Wielkopolska i Śląsk [PL_B]	Mazowsze i Podlasie [PL_C]	Małopolska i Pogórze [PL_D]
Number of farms surveyed		65	97	245	120
Economic size of farms	[ESU]	5.5	5.1	5.4	4.8
Area of agricultural land (AL)	[ha]	16.8	11.0	11.9	8.8
Total labour input per 100 ha of agricultural land	[AWU]	10.0	13.0	14.3	19.1
Share of farm managers with agricultural education	[%]	41.5	59.1	41.6	40.5
of which: with academic education		1.5	7.2	1.6	2.8
Wheat yield	[dt/ha]	50.8	47.8	42.9	37.5
Maize grain yield	[dt/ha]	-	85.6	44.5	63.9
Structure of total production value	[%]	100	100	100	100
of which: crop production		44.9	63.5	68.0	41.1
animal production		55.1	36.5	32.0	58.9

[-] – in the surveyed households in region of Pomorze and Mazury there was no cultivation of maize for grain.
Source: Own calculations based on unpublished FADN data.

vides data on total employee labour input (Annual Work Unit – AWU) as well as on own labour input (Family Work Unit – FWU) and the labour intensity of production.

Results

Regional diversity in performance of farms of 2-8 ESU

The spatial diversity in natural, economic and social conditions influences the scale, intensity and line of production. This creates regional diversity in agricultural areas which, to some extent, also results from different past experiences. The 527 farms whose income source was agricultural activity were evaluated in order to identify how these factors influence regional diversity in performance. The economic strength of the farms was regionally equal, with values of around 5 ESU (Table 1). By contrast, there were differences in the area of agricultural land and the labour intensity of production, up to twofold in the extreme values of the two variables (the PL_A and PL_D region).

Around 50 per cent of farm managers were agriculturally educated, which is understood as having completed basic agricultural education, agricultural high school or agricultural university, (40.5-59.1 per cent), whereas the percentage of farmers with an academic education (understood as having at least a university degree in agriculture or equivalent) in agriculture tended to be low at 1.5-2.8 per cent, with the PL_B region being an exception at a several fold higher level, which nonetheless remained low at 7.2 per cent. Knowledge is a major factor in stimulating progress in all branches of the economy, including agriculture. Each day farmers must make decisions concerning the most complicated of work objects that living organisms (plants, animals) are. In that respect, the situation in the farms surveyed was unfavourable.

There were regional differences in the structure of production value of farms. In two regions: PL_B and PL_C the focus was on crop production, with its share in total production value at 63.5 and 68.0 per cent respectively, whereas the PL_A and PL_D regions were involved mainly in livestock production, with shares in total production of 55.1 and 58.9 per cent respectively (Table 1). The situation had a direct impact on economic performance. Regions focussed on crop production generated lower production values and farm incomes. By contrast, the regions with predominantly livestock production performed better. However, particular attention should be paid to production values which derive from the volume of production and its prices. These farms also had higher incomes (Table 2).

Since 2004, farm income has been heavily augmented by CAP direct support and funding from European Union (EU) structural funds. The share of subsidies on current operations in farm income differed for the farms surveyed, ranging from 34.1 per cent for the PL_D region to 78.1 per cent for the PL_A region. The funding per farm increased with farm size. On average, the amount of subsidies received by the biggest farms, i.e. those with an average of 16.8 ha of agricultural land (in the PL_A region), exceeded the funding received by farms with the smallest area, i.e. 8.8 ha (in the PL_D region), by more than twofold.

As opposed to the income of a farm, the income (average in 2005-2009) per full-time employed member of the family (FWU) was more equal, with its ratio to average net remuneration in the national economy (PLN 21,796 (i.e. EUR 5,602) per AWU) being at similar level (51.4-61.2 per cent) for all regions. The data indicate that, despite receiving subsidies, the farms surveyed did not provide their users with an income comparable to off-farm income.

Another factor indicative of the unfavourable situation of the farms surveyed is the percentage of farms with a negative income, which ranged from 6.7 to 12.5 per cent. The farms were generally reluctant to take loans, thereby stifling their development potential. The share of indebted holdings ranged from 27.8 to 44.1 per cent.

Two universal indicators were used to evaluate the intensity of farming for the surveyed farms: land efficiency (production value per hectare of agricultural land) and labour efficiency (production value per AWU). The results (Table 2) suggest that the ratio of labour efficiency to land efficiency was regionally less diversified. Labour efficiency ranged

Table 2: The economic performance of 527 private farms sized 2-8 ESU grouped according to their regional location in Poland. Average figures for 2005-2009.

Parameter		Agricultural regions in Poland							
		Pomorze i Mazury [PL_A]		Wielkopolska i Śląsk [PL_B]		Mazowsze i Podlasie [PL_C]		Małopolska i Pogórze [PL_D]	
		PLN	EUR	PLN	EUR	PLN	EUR	PLN	EUR
Total production value	[farm]	66,983	17,286	50,389	12,968	48,339	12,477	64,186	16,489
Total costs	[farm]	60,422	15,584	42,227	10,857	38,830	9,997	49,553	12,724
The income of a farm	[farm]	20,085	5,173	15,167	3,907	18,022	4,672	21,346	5,495
	[FWU]	12,632	3,267	11,667	3,001	11,194	2,909	13,341	3,427
Share of subsidies on current operations in the income of a farm	[%]	78.1		55.4		55.9		34.1	
Subsidies on current operations	[farm]	15,678	4,023	8,400	2,153	10,071	2,591	7,271	1,873
Ratio of income per 1 FWU to net salary in the national economy	[%]	58.0		53.5		51.4		61.2	
Share of farms with a negative income of a farm	[%]	6.7		12.0		7.2		12.5	
Share of indebted holdings	[%]	44.1		40.2		38.4		27.8	
Land efficiency	[ha AL]	3,989	1,027	4,598	1,183	4,076	1,053	7,261	1,864
Labour efficiency	[AWU]	40,110	10,317	35,485	9,132	28,435	7,357	37,982	9,746

Source: Own calculations based on unpublished FADN data.

from PLN 28,435 to PLN 40,110 (from EUR 7,357 to EUR 10,317) per AWU, whereas land efficiency ranged from PLN 3,989 to PLN 7,261 (from EUR 1,027 to EUR 1,864) per hectare of agricultural land. This means that there are significant differences in the level of agriculture in the respective regions. However, they can also be used as an advantage to facilitate the development of a production profile that is optimum for the country.

Comparison of holdings with income from agricultural activity only to those with additional off-farm income

A family holding and pluriactivity are the two characteristics which determine the role and character of agricultural holdings. The latter, which may take various forms, is becoming a leading strategy for rural families in Poland, including especially those that run agricultural holdings with low economic strength (up to 8 ESU). Pluriactivity covers the combination of agricultural and off-farm activities, performed by farmers or their family members. Our analysis covered 188 holdings with an economic size of 2-8 ESU which continually generated off-farm income in the years 2005-2009 to supplement their income from agriculture (group A). The comparative sample was made of 188 families for whom agricultural activity was the only source of income (group B).

The holdings had predominantly poor quality soils, whose value in use amounted to 0.87 and 0.85 points respectively (Table 3). The labour intensity in production was higher in group B holdings (by 7.1 per cent). Farmers generating agricultural income only were estimated to be more involved in agricultural activity: group A farmers tended to limit their labour input in order to earn a salary from outside their holding. Crop production was predominant within the structure of the production value, its share amounting to 61.8 per cent in group A and 65.0 per cent in group B. This difference is mainly due to the fact that in households with wage labour grain occupied 63.2 per cent of agricultural land, which generates relatively low production value because of unfavourable prices. In family households living only from agriculture,

Table 3: Selected information on two sets of farms in Poland sized 2-8 ESU: A: farms run by families earning income from both agricultural work and off-farm income; B: farms run by families earning income from agricultural work only. Average figures for 2005-2009.

Parameter		Farms group	
		[A]	[B]
Number of farms surveyed		188	188
Economic size of farms	[ESU]	4.6	4.9
Area of agricultural land (AL)	[ha]	10.5	11.4
Share of rented agricultural land	[%]	20.5	17.7
Quality classification of agricultural land	[points]	0.87	0.85
Total labour input per holding	[AWU]	1.40	1.62
of which: own labour input	[FWU]	1.35	1.54
Total labour input per 100 ha of agricultural land	[AWU]	13.3	14.2
Average age of holding manager	[years]	44	45
Share of farm managers with agricultural education	[%]	46.3	45.0
of which: with academic education		11.7	2.7
Share of holdings with a declared farmer's successor*	[%]	36,0	47.2
Wheat yield	[dt/ha]	40.7	45.0
Maize grain yield	[dt/ha]	73.6	74.2
Structure of total production value	[%]	100	100
of which: crop production		61.8	65.0
animal production		36.8	31.1

* Concerns the holdings the managers of which are aged 50 years or more.
Source: Own calculations based on unpublished FADN data and on questionnaires regarding income generated outside agricultural holdings by farmers' families.

this share was just 54.8 per cent. The crop production profile was adopted despite poor quality soils, probably from the desire to simplify the holding organisation and to restrict the labour demand. Animal production involves a higher labour input and requires from farmers their full availability.

The share of managers with a higher agricultural education in group A holdings is higher by nine percentage points than in group B (Table 3). It seems that the function of group A holdings was slightly different, i.e. they were not subordinated to household-specific interests and objectives. They served as the place of residence and food production but the principal source of income of household members was work outside the holding. Holding managers, owing to their higher education, were better predisposed to undertake suitable work, and more jobs were available to them. A different function of group A holdings is also reflected in the share of holdings with a declared farmer's successor, which was 11.2 percentage points lower than in group B.

Income from agricultural holdings and total income of farmers' families

The total production values, the total costs, and the total income of the farmers' families of holdings in groups A and B differed significantly ($p \leq 0.05$, Table 4). The income from agricultural in holdings for group A was lower, although the support obtained through subsidies on current operations was higher: 74.4 per cent, compared with 60.0 per cent for group B. Subsidy payments per hectare of agricultural land were also much higher, by 15.7 per cent. This may imply that the holdings with non-agricultural income were more active in gaining financial support available from various EU programmes, thereby searching for more efficient ways to improve their economic standing. But for such support, the income from agricultural production would only account for 25 per cent of the income that was actually generated by group A farmers, and for 40 per cent of that earned in group B.

The farm income of group B holdings was more favourable, and the production efficiency was higher, although this difference was just 2.8 per cent. Overall efficiency was measured by the unit cost of the production value. Agricultural production in both groups of holdings was commodity-oriented, and the share of the value of sold production accounted for around 75 per cent of the total production value. The financial means generated were most likely retained by holdings, allowing them to finance the purchase of current assets, and to carry out minor repairs and refurbishments.

The income of a farm per family work unit (FWU) shows the potential amount of remuneration available to farmers and their family members. In this respect, the situation of farmers in both groups of holdings was similar, with their income reaching a comparable level. The income was around 47 per cent of the average net wage and salary in the national economy. This means that the analysed holdings failed to satisfy the conditions of parity holdings, i.e. they did not provide their users with income comparable to that generated by persons employed in non-agricultural sectors (when converted per FWU). This is likely to have stemmed from an inadequate production scale and poor information on optimal production technologies, as well as from insufficient managerial skills and marketing knowledge. Józwiak and Kagan (2008) showed that an income from own work that is similar to parity pay may only be generated in holdings run by natural persons with a size of 8-16 ESU.

The off-farm income of group A holdings was 57% higher than the income earned from agricultural holdings. In effect, the total income of farmers' families in group A holdings was 2.2 times higher than that of families generating income from agricultural activity only (i.e. group B). Given the much more favourable standing of group A farmers' families, it can be assumed that the resources generated from off-farm activity were, at least to some extent, used to finance the agricultural holding. This is reflected by the share of holdings with negative income, being by 1.6 percentage points lower, and by a slightly lower percentage of indebted holdings (Table 4).

Table 4: The income of families in Poland earning income from A: both agricultural work and off-farm income; B: agricultural work only. Average figures for 2005-2009.

Parameter		Farms group				A/B
		[A]		[B]		
		PLN	EUR	PLN	EUR	%
Total production value	[farm]	38,273	9,866	48,522	12,502	78.9
Share of the value of sold production in total production value	[%]	73.0		74.2		98.4
Total costs	[farm]	32,882	8,460	40,525	10,427	81.1
The income of a farm	[farm]	13,883	3,591	16,084	4,154	86.3
	[FWU]	10,304	2,666	10,405	2,688	99.0
Share of subsidies on current operations in the income of a farm	[%]	74.4		60.0		124.0
Subsidies on current operations	[1 ha AL]	981	251	848	217	115.7
Relationship between income per 1 FWU to net salary in the national economy	[%]	47.3		47.7		99.0
Share of farm with a negative income of a farm	[%]	9.6		11.2		85.7
Share of indebted holdings	[%]	36.9		37.1		99.5
Off-farm income	[farm]	21,819	5,611	-	-	-
Total income of farmer's family	[farm]	35,703	9,202	16,084	4,154	222.0

-: calculations were not applicable.
Source: Own calculations based on unpublished FADN data.

Table 5: Production intensity in Poland in A: farms run by families earning income from both agricultural work and off-farm income; B: farms run by families earning income from agricultural work only. Average figures for 2005-2009.

Parameter		Farms group				A/B
		[A]		[B]		
		PLN	EUR	PLN	EUR	%
Total production value	[ha AL]	3,635	937	4,264	1,098	85.2
Direct costs	[ha AL]	1,397	359	1,501	385	93.1
Costs of sowing materials, fertilisers and plant protection products	[ha AL]	520	133	595	153	87.4
The income of a farm	[ha AL]	1,318	342	1,413	365	93.3
Labour efficiency	[AWU]	27,338	7,065	29,952	7,724	91.3

Source: Own calculations based on unpublished FADN data.

Production intensity

The holdings exhibit certain cause-and-effect relationships between production intensity and its economic outcomes (Table 5). Direct costs per hectare of agricultural land, used as the measure of production intensity, were higher in the holdings run by families whose income only came from agricultural activity (group B). Their average level in 2005-2009 reached PLN 1,501 (EUR 385), exceeding by 7.4 per cent the costs incurred by group A. A parallel trend involves the three components of direct costs, i.e. sowing materials, fertilisers and plant protection products, which in group B holdings were 14.4 per cent higher compared to group A. Based on these comparisons, it can be inferred that higher production intensity entails higher effectiveness of land use and better production outcomes. As a result, the profitability of land (the income of a farm per hectare of agricultural land) in group B holdings, as compared to group A, was 7.2 per cent higher, and so was labour efficiency, by 9.5 per cent. Higher labour efficiency, i.e. greater utilisation of the production resources, is considered to be one of the principal factors behind the competitive power of agricultural holdings. Low labour efficiency constitutes a barrier to more intensive development. Both production intensity and labour efficiency in the group A holdings were lower, which also triggered weaker production results and economic outcomes.

Analysing the input-side cost of fertilisers and plant protection products, it is estimated that their negative environmental impact was lower in group A holdings. A simple measure was provided by the total cost of fertilisers and plant protection products per the income of a farm unit, and the difference in favour of group A reached 5.5 per cent. In the production process, the level of expenditure on production means is a significant element, as it is mostly farmer-dependent. The consequences of the decisions made are apparent in the relationship between agricultural activity and natural environment.

The productivity of current expenditure and fixed capital, and the use of holding assets

Intensity translates itself into productivity, i.e. the amount of production in relation to expenditure. This indicator reflects both the technical and economic aspects of economic activity (Coelli *et al*., 2005). The productivity analysis of current expenditure (current assets) shows the impact of the expenditure management model on the resultant products. As in the case of production intensity, the results indicate the superiority of group B holdings. The average productivity of current expenditure in group B in the surveyed years was 12.4 percentage points higher than in group A holdings (Table 6).

Table 6: Selected indicators describing the production and economic standing in Poland of A: farms run by families earning income from both agricultural work and off-farm income; B: farms run by families earning income from agricultural work only. Average figures for 2005-2009.

Parameter		Farms group		A/B
		[A]	[B]	%
Productivity of current assets	[%]	128.5	140.9	91.2
Productivity of fixed assets	[ratio]	4.7	4.5	104.5
Total productivity of current and fixed assets	[%]	18.1	20.0	90.7
Share of fixed assets in total assets	[%]	85.7	85.6	100.1

Source: Own calculations based on unpublished FADN data.

The productivity of fixed capital expenditure (fixed assets) was expressed as the production value per 1 PLN depreciation of the fixed assets involved. This type of productivity reflects the intensity of using fixed assets in the production process, i.e. fixed assets activity. The results show that the productivity of fixed capital expenditures in both holding groups was at a comparably low level. This can be partly explained through the analysis of the assets structure in the surveyed holdings, which indicates a dominating share of fixed assets in both holding groups (85.7 and 85.6 per cent). A considerable share of fixed assets in total assets was hardly conductive to high effectiveness of capital use, and it made the reproduction of assets rather difficult.

The effectiveness of assets use is illustrated in more detail in Table 7. In general, the surveyed holdings were characterised by a limited predisposition towards restructuring and adjusting to market transitions, as shown by the central immobilisation index, exceeding 1.0. In average terms, the central immobilisation index in the surveyed period amounted to 6.0 in both groups of holdings. Farmers probably had insufficient financial resources to modernise and upgrade their holdings. They also made a minor use of loans, with the share of indebted holdings amounting to around 37 per cent. The structure of liabilities was dominated by long-term loans (which constituted around 70 per cent), generally allocated to investments.

The debt ratio in both types of holdings was similar, in group A amounting to 3.7 per cent and in group B to 4.0 per cent. Nevertheless, group A holdings indicated higher reproduction of fixed assets, at the rate of -1.4 per cent, as compared to -3.0 per cent in group B. The limited reproduction of fixed assets, as indicated by the data, means that the rate of reproduction was insufficient, and fixed assets were subject to depreciation. It is projected that the future of most such holdings, operating as self-sufficient and self-financed production entities, is very uncertain.

Table 7: Selected indicators describing the financial risk and predisposition towards restructuring in Poland in A: farms run by families earning income from both agricultural work and off-farm income; B: farms run by families earning income from agricultural work only. Average figures for 2005-2009.

Parameter		Farms group		A/B
		[A]	[B]	%
Fixed assets to current assets	[ratio]	6.0	6.0	100.0
Rate of reproduction of fixed assets	[%]	-1.4	-3.0	47.0
Share of indebted holdings	[%]	36.9	37.1	99.5
Debt ratio of holdings	[%]	3.7	4.0	92.9
Debt structure ratio	[%]	66.9	70.8	94.4

Source: Own calculations based on unpublished FADN data.

Discussion

The use of land for agricultural production forms the intrinsic quality of rural areas. In Poland, agricultural land constitutes over 50 per cent of the total area of the country. However, the fragmentation of agricultural holdings is a factor that at least partly restricts their use. This phenomenon is especially strong in the southern regions of Poland. The economic results achieved by the holdings are characterised by regional diversity, arising from the diversified concentration of production intensity, which stems from historical processes, as well as from dissimilar natural conditions. In certain regions, the scattered holding structure leads to the marginalisation of agriculture, or even to the disappearance of agricultural activity, which may result in a considerable landscape downgrading.

The average income situation in 2005-2009 of the surveyed holdings was very unfavourable, despite substantial support through EU subsidies, the share of which in holding income ranged from 34.1 to 78.1 per cent, depending on the region. Nonetheless, the income of agricultural holders was not comparable with the income earned by persons employed in non-agricultural sectors, amounting to as little as 51.4-61.2 per cent of the latter. The results of Augustyńska-Grzymek and Skarżyńska (2011) also show that farms of 2-8 ESU find themselves in a difficult situation and that their long-term viability is uncertain. Some might survive if they adopt a more professional management approach. It is necessary for farmers to improve their agricultural qualifications and become more active in gaining external financial support, including loans, as well as considering starting non-agricultural farm activity or seeking external sources of income. From the economic point of view, land concentration in family farming is necessary to (a) increase labour productivity, (b) make efficient use of technology, in view of the problem of overinvestment in small holdings, (c) relieve the pressure to reduce unit costs, which is of major importance to economic competitiveness, and (d) create grounds for increasing the income of the agricultural population (Zegar, 2009b).

In Poland, income from work outside agriculture is the prevailing source of income in rural households, followed by social transfers, retirement pay and pensions, whereas income from agricultural activity constitutes the third major source (Grosse and Hardt, 2010). The growth in the employment of rural residents outside their own holding, which has been noted in Poland in recent years, is connected with growing entrepreneurship and the investment attractiveness of rural areas. These lead to a decreased share of agricultural income, combined with an increased share of off-farm income, in the overall income generated by rural residents. Research conducted in Norway also indicates that the financial situation small family farms is generally better when family members are also employed outside the farm. The greater involvement in off-farm work resulted in a reduction of economic effects of farms (Lien *et al.*, 2010).

The concept of multifunctional agriculture indicates that it is possible for farms to combine the function of agricultural production (in compliance with the environmental and landscape preservation requirements) with additional activities oriented towards diversifying the business. Despite being small in terms of area and having a low industrial capacity, farms with 2-8 ESU have a considerable capacity to produce traditional local food or niche products (e.g. rarely produced goods). The challenge for these farms is to adapt their production profile to their production and environmental capacity.

While insufficient income from agricultural production fosters the undertaking of non-agricultural investments, farmers are more inclined to opt for multi-occupation or diversification of their activity. Holdings in the EU countries, which are small in terms of land (up to 5 ha) and economy (up to 8 ESU), usually base their additional income on the work performed outside their own holding. This concerns more than one third of agricultural holders in the EU-27. In turn, the diversification of agricultural holding activity is generally more popular with larger holdings (over 50 ha). In 2007, along with agricultural production, more than 1,361,000 holdings in the EU-27 conducted non-agricultural activity. This accounts for around 10 per cent of all holdings (EC, 2008; Krakowiak-Bal, 2010).

In Poland, off-farm activity has been the prevailing source of income of rural households in recent years. Our survey showed that the income of farmers' families was 2.2 times higher as compared to the holdings generating income only from agricultural activity. The availability of work outside the agricultural holding is, nevertheless, determined by some factors that can cause difficulties in finding a suitable job, and that may deepen intra-regional development differences. These include, among other things, the communication barriers and the low level of transport infrastructure in rural areas, the demand for work in the rural population and the supply, i.e. adjusting the qualifications of rural residents who look for a job, to the nature of the demand for work. Nonetheless, the availability of non-agricultural jobs to persons residing in rural areas acts as one of the major barriers to rural development and agricultural modernisation.

However, there are efforts being made to improve the living conditions of the Polish countryside, especially towards the development of entrepreneurship and creating non-agricultural jobs. Examples include activities under the Rural Development Programme 2007-2013 (RDP), i.e. *Diversification into non-agricultural activities* and *Establishment and development of micro enterprises*. Agency for Restructuring and Modernisation of Agriculture data show that by the end of 2011 under both of these activities, the payments amounted to PLN 1.1 billion (ARMA, 2012a). Moreover, in the second action (*Establishment and development of micro enterprises*) to the end of 2011, work in small firms found 12.5 thousand people and 15 thousand applications from entrepreneurs awaited examination (Farmer – portal nowoczesnego rolnika, 2012). An example of successful use of funds under this activity is creation new jobs in the company MEGA MOLD Sp. z o.o. in Jesionka village near Rzeszów (Bobrowska, 2011), as well as the newly-opened clinic for horses EQUUS-VET in Śrem, near Poznań, and in the modernised confectionery Supreme PPH in Brąszewice in Łódź voivodeship (ARMA, 2012b).

Actions towards improving the economic situation of small farms are also shown in the European Commission proposals for the CAP after 2013. Efforts to improve the distribution of the Single Farm Payment between farms with very different area of agricultural land (capping) and to simplify the support system for small individual farms can be assessed positively. This means that participants will have to meet less stringent requirements for the cross compliance and will be exempt from the requirements of 'greening'. Another benefit of introducing the small farms scheme will be lower transaction costs, the amount of which is often close to the payments for these households. Therefore, the concept of the differentiated treatment of small farms should be interesting. The obligation to use 7 per cent of agricultural land for ecological purposes (such as fallow land) may be unfavourable from the point of view of small farms, as may be the required maintenance of permanent pasture by each household (even not maintaining livestock) that does not join the small farms scheme. That will create many but mostly small ecological areas, which do not improve the relationship between agriculture and the environment. Also perceived negatively is the inability to return to the small farms scheme in case of an earlier withdrawal (EC, 2011; MARD, 2012a; MARD, 2012b).

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Competitiveness and Geographical Indications: the case of fruit spirits in Central and Eastern European countries

In 2004 and 2007 twelve countries joined the European Union (EU), bringing about significant changes in the field of European agriculture. One of the major changes was the transformation of the agri-food trade of these countries. This paper analyses the effects of EU enlargement on the competitiveness of fruit spirits in six Central and Eastern European countries (CEECs), especially regarding geographical indications, by using the theory of revealed comparative advantages. Although the majority of the studied CEEC fruit spirits was both competitive and had a comparative advantage in the EU-15 beverages market in the period 2001-2011, during this time the competitiveness in terms of quality and price of fruit spirits in the region declined. The results indicate that these countries are losing their market positions in their traditional fruit spirit sector in the EU-15 beverages market in spite of the fact that the majority of these products have a geographical indication. These changes are in line with the overall trend of an increasing trade deficit in the overall beverages, spirits and vinegar market of the six CEECs with the EU-15 after 2003. By contrast, the well-known grappa of Italy is shown to be competitive in terms of both price and quality during this period. It is clear that such products with geographical indications can be competitive in European markets.

Keywords: competitiveness, geographical indications, fruit spirits, Central and Eastern Europe

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Introduction

In 2004 and 2007, twelve countries joined the European Union (EU), bringing about significant changes in the field of agriculture. One of the major changes was the transformation of their national agricultural trade (Gorton *et al*., 2006, Bojnec and Fertő, 2008a,b; Török and Jámbor, 2012). EU membership has made these countries part of a large market, thereby changing the competitiveness of their agricultural products, realised through agricultural trade. In such an enlarged, competitive environment, the role of high quality, region-specific products has measurably increased. These products, in many cases possessing Protected Designation of Origin (PDO) or Protected Geographical Indication (PGI) status, have special characteristics that European consumers appreciate.

PGI and PDO products currently play an important role in the EU's policy on agricultural product quality but, as very little analysis has been made of the competitiveness of products with geographical indication, the link between PGI/PDO products and their competitiveness remains unclear. Therefore, the aim of this paper is to assess whether products with geographical indications have any competitive and/or comparative advantage in European markets. To meet this aim, the paper analyses the competitiveness in EU-15 markets of traditional fruit spirits produced in six Central and Eastern European countries (CEECs). The longer established EU Member States have long traditions of producing highly matured spirits including such famous products as whisky, brandy and cognac, while CEECs have their own specialty – spirits distilled from fruits – and many of them have PGI status (Appendix 1).

Competitiveness of CEEC agriculture following EU enlargement

Many studies have looked at the competitiveness of agriculture in CEECs following EU enlargement. Gorton *et al*. (2006) analysed the international competitiveness of Hungarian agriculture by calculating domestic resource cost ratios and making estimations for 2007 and 2013. They projected that EU enlargement would have a negative impact on the international competitiveness of Hungarian agriculture by increasing land and labour prices. Similar estimations were conducted by Erjavec *et al*. (2006), who forecast that the newly accessed Member States would gain from higher prices and budgetary support, indicating real improvements in most agricultural sectors over recent production levels. Ivanova *et al*. (2007) analysed Bulgarian agriculture following EU accession using the AGMEMOD model and found that accession would have a very positive effect on the crop sector in Bulgaria, whereas the effect on the livestock sector would be the opposite.

The impacts of EU accession on agriculture in the New Member States were studied by Csáki and Jámbor (2010) who concluded that EU accession has had an overall positive effect, although Member States capitalised the opportunities provided by the enlarged market in different ways. Kiss (2011) added that competition in domestic markets in CEECs increased significantly, resulting in massive import penetration. Kiss (2007) analysed changes in the agri-food trade of Hungary since EU accession and concluded that national agri-food trade balance with the EU-27 decreased during that period. Rusali (2010) investigated post-EU accession trends in Romania's agri-food trade and showed that the low competitiveness of the processing sector was the main constraint in achieving higher revenue from exports.

Toming (2007) looked at the impact of EU accession on the export competitiveness of the Estonian food processing industry and showed that it has not yet been able to reap the benefits of the EU market. Bojnec and Fertő (2008a) analysed the agri-food trade competitiveness with the EU-15 of the newly accessed Member States and concluded that trade has increased as a result of EU enlargement, though there have been 'catching-up' difficulties for some Member States in terms of price and quality competition, more so in higher value-added, processed products. After studying price and quality competition in Hungarian–Slovenian bilateral agri-food trade, Bojnec and Fertő (2008b) confirmed that the separation of one-way non-price competition from price and quality competition in two-way trade (the latter of which means both exports and imports of a product group) is important to underline the reality of economics and trade in small countries. Bojnec and Fertő (2012) investigated the complementarities of trade advantage and trade competitiveness measures for the agro-food trade of five CEECs with the EU and confirmed that the revealed trade advantage is consistent with the one-way export and the successful price and quality competition categories in two-way trade.

Török and Jámbor (2012) also found that almost all newly accessed EU Member States experienced a decrease in their comparative advantage following accession. As for the stability of comparative advantage, their results suggest a weakening trend, underpinned by the convergence of the pattern of revealed comparative advantage. From analysing Hungarian agri-food trade after EU accession, Jámbor and Hubbard (2012) reached similar conclusions and added that EU accession has radically changed the survival time of agri-food trade, in that revealed comparative advantage is shown not to be persistent.

The economics of geographical indications

There has recently been an increasing amount of research on the economic impacts of geographical indications of wines and spirits. Malorgio *et al*. (2007) focused on the influence of the European wines with PDI status in the world market and showed that there is growing consumer attention and interest towards these products, although these wines are usually sold at a higher price. Research on the grappa industry in Trentino, Italy concluded that local producers considered geographical indication as one of the most important characteristics of the region (Trevisan, 2008). Trejo-Pech *et al*. (2010) examined the case of *mezcal*, a Mexican spirit distilled from agave, and suggested that the success of this ancient local product was due to its protected denomination awarded in 1995, according to which the producers could use the legal protection as a tool for product differentiation.

The analysis of the importance of non-alcoholic food and agricultural products also occupies a significant place in the literature. Teuber (2007) emphasised that geographical indications are useful tools for product differentiation and that therefore developing countries make attempts to secure such protection for their products. Belletti *et al*. (2007) pointed out that companies in Toscana, Italy use geographical indications for numerous reasons in order to succeed in world markets. They help to protect the products from cheaper imitations and the companies benefit from the the reputation of the region of origin. In Norway, Borch and Roaldsen (2007) found that the protection of the denomination of origin is a factor of competitiveness, especially for the high quality traditional food products in the premium sector.

Much of the literature underlines the fact that geographical indications are accompanied by higher perceived quality and therefore higher prices. Loureiro and McCluskey (2000) examined the case of Galician veal and stressed that geographical indication is a powerful marketing tool in combination with quality indicators. Based on the case of single-origin coffees, Teuber (2007) stated that coffees with geographical indication command a premium price because of the reputation of their high perceived quality. Monteiro and Lucas (2001) found that geographical indication protection is the most important attribute for consumers in the case of traditional Portuguese cheese; more important than price, quality certification label or ingredients. It is logical therefore to assume that products geographical indications are associated with higher perceived quality.

Concerning the effect of quality-based certifications (geographical indication, bio, GMO free etc.) on willingness to pay, two important factors should be underlined. On the one hand, the price premium of the certified products can be afforded only by the consumers of the developed countries (Henneberry, 2004); therefore at present this issue should be examined in European and North American markets. However, in some developing countries (primarily China), such products are experiencing an increasing demand because of their prestige and the fact that they are often a status symbol (Heslop and Papadopulos, 1993; Zhou and Hui, 2003). Moreover, there is a strong positive correlation between the demand for quality-certified products and the level of urbanisation. Bureau and Valceschini (2003) suggest that the bigger is the distance between the consumer and the producing area, the greater is the need of the product to be certified by quality.

The paper is structured as follows. The next part describes the methodology used for calculations, while the third part presents our results on the competitiveness of CEEC fruit spirits in EU-15 markets. The fourth part compares results with the performance of Italian grappa, while the last part concludes.

Methodology

The competitiveness of PGI/PDO products can be well investigated through their international trade performance, thus the analyses of revealed comparative advantages provides the basis for this research. The original index of revealed comparative advantage was first published by Balassa (1965) who defined the following:

$$B_{ij} = \left(\frac{X_{ij}}{X_{it}}\right) \Big/ \left(\frac{X_{nj}}{X_{nt}}\right) \qquad (1)$$

where X means export, i indicates a given country, j is for a given product, t stands for a group of products and n for a group of countries. If $B > 1$, a given country has a comparative advantage compared to focus countries or, in contrast, a revealed comparative disadvantage.

The Balassa-index is especially criticised because it is seen as neglecting the different effects of agricultural policies and asymmetric values. Vollrath (1991) suggested three different specifications of revealed comparative advantages in order to eliminate these problems: relative trade advantage index (RTA), logarithm of relative export advantage (lnRXA) and relative competitiveness (RC). Relative trade advantage index (RTA) takes both exports and imports into account and is the difference between relative export advantage index (RXA) and the relative import advantage index (RMA).

Expressed pro forma:

$$RTA_{ij} = RXA_{ij} - RMA_{ij} \quad (2)$$

where $RXA_{ij} = B_{ij}$ and $RMA_{ij} = (m_{ij}/m_{it})/(m_{nj}/m_{nt})$ (m means the import), that is,

$$RTA_{ij} = [(x_{ij}/x_{it})/(x_{nj}/x_{nt})] - [(m_{ij}/m_{it})/(m_{nj}/m_{nt})] \quad (3)$$

If $RTA > 0$, this reveals that a given country has a comparative advantage compared to focus countries or, in contrast, a revealed comparative disadvantage. Vollrath's second index is the logarithm of relative export advantages (ln*RXA*), while his third index is called revealed competitiveness (RC), which is the difference between the logarithm of relative export advantages and that of relative import advantages:

$$RC_{ij} = \ln RXA_{ij} - \ln RMA_{ij} \quad (4)$$

Positive ln*RXA* and *RC* indicate a competitive advantage, while negative values indicate competitive disadvantage.

The literature interlinks the model of revealed comparative advantages with new streams of trade theories. This approach stresses that price and quality competition in two-way trade is worth separating. To achieve this goal, the literature introduces a new concept: unit value difference (UVD), which is the difference between export and import unit values, defined as follows:

$$UV_{ij}^{x} = X_{ij}/Q_{ij}^{x} \text{ and } UV_{ij}^{m} = M_{ij}/Q_{ij}^{m} \text{ so } UVD_{ij}^{m} = UV_{ij}^{x}/UV_{ij}^{m} \quad (5)$$

where X stands for export, M indicates import, Q stand for quality, i means a given country and j is for a product. Equation (5) means that the difference of a product group's unit value (UVD) can be defined if import unit value (UV_{ij}^{m}) is deducted from export unit value (UV_{ij}^{x}); that is, export value achieved from a country's given product group (X_{ij}) is divided by export quantity (Q_{ij}^{x}), then divide import value (M_{ij}) by import quantity (Q_{ij}^{m}) and deduct the two values from each other. Trade balance (TB) can also be easily calculated from the formula above: ($TB_{ij} = X_{ij} - M_{ij}$), and is the difference between export and import values of a given product group running to/coming from the focus country.

By using the two new concepts (UVD and TB), the literature creates the following four categories in order to separate price-quality competition (GP-index on the basis of Gehlhar and Pick, 2002). These categories implicitly refer to two-way and not to one-way trade and are well able to separate the competitive positions of a country's product groups with regard to price and quality:

- Category A (successful price competition): $TB_{ij} > 0$ and $UVD_{ij} < 0$;
- Category B (unsuccessful price competition): $TB_{ij} < 0$ and $UVD_{ij} > 0$;
- Category C (successful quality competition): $TB_{ij} > 0$ and $UVD_{ij} > 0$;
- Category D (unsuccessful quality competition): $TB_{ij} < 0$ and $UVD_{ij} < 0$.

In order to calculate these various indices, we used the Eurostat trade database with eight digit breakdown (CN8), resulting in five products (indicated by 'j' in the equations above) for spirits distilled from fruits (Appendix 2). Data are then aggregated to two digit breakdown in order to identify the positions of fruit spirits in the *beverages, spirits and vinegar* sector (indicated by 't' in equations). We used trade data from 2001-2011, providing a clear basis for analysing the effects of EU accession. In this context, the EU is defined as the Member States of the EU-15. Owing to the lack of trade data in the spirit category for many newly accessed Member States, the results from six CEECs (Bulgaria, Czech Republic, Hungary, Poland, Romania, and Slovenia) are analysed.

Results

Trends in fruit spirits trade

Significant changes have occurred in the CEEC fruit spirits trade with the EU-15 following EU enlargement (Figure 1). Although some Member States (Bulgaria, Czech Republic and Romania) reached a positive trade balance in some years after 2003, fruit spirits imports exceeded exports in most cases, resulting in a trade deficit. The Czech Republic shows a mixed performance with large fluctuations between years. We may conclude that EU accession resulted in an increased trade deficit in fruit spirits in most CEECs.

These changes are in line with the overall trend of an increasing trade deficit in the beverages, spirits and vinegar market of the six CEECs with the EU-15 since 2003 (Figure 2). Prior to EU enlargement, Bulgaria, the Czech Republic and Hungary had in most years a trade surplus although all countries analysed experienced an increasing trade deficit over time. In most cases the deficit was the biggest in 2008

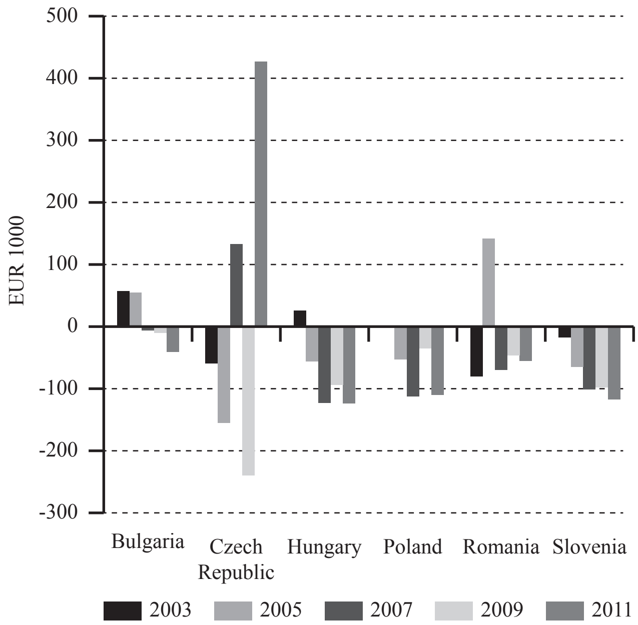

Figure 1: The trade balance in fruit spirits of six Central and Eastern European countries with the EU-15 in the period 2003-2011.

Source: authors' own calculations based on Eurostat data

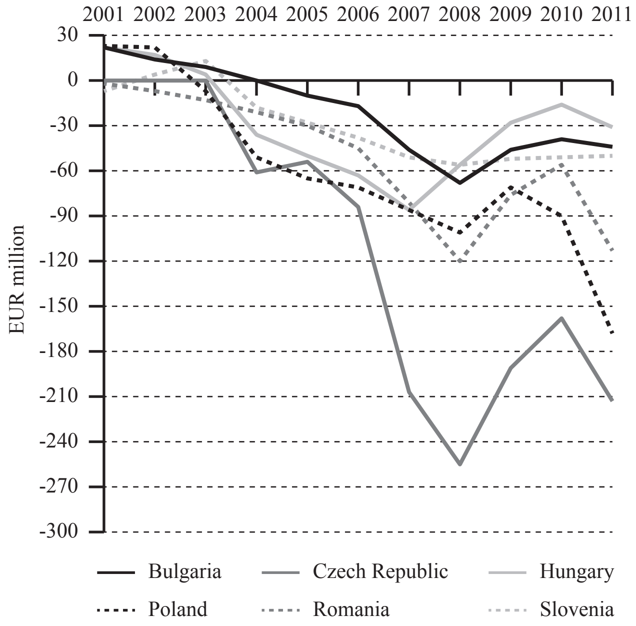

Figure 2: The trade balance in beverages, spirits and vinegar of six Central and Eastern European countries with the EU-15 in the period 2001-2011.

Source: authors' own calculations based on Eurostat data

and the smallest in 2010. By comparing these results with Figure 1, it becomes apparent that the decline in the CEEC fruit spirits trade with the EU-15 following EU enlargement played just a minor role in the overall decrease in the overall beverages, spirits and vinegar trade balance.

When analysing the main EU-15 trading partners in fruit spirits of the six CEECs, a high concentration becomes evident. Three EU-15 Member States account for 90 per cent of the fruit spirits trade of the six CEECs, with Germany being the major trading partner in most cases (Table 1). Concentration has not changed significantly since EU accession.

Competitiveness of the CEEC fruit spirits trade

In the analysis of the competitiveness of the fruit spirits trade of the six CEECs with the EU-15, all four Balassa-indices show similar results for each country. In general, all countries except Hungary and Poland (the latter not having a PGI fruit spirit) had a revealed comparative advantage and all were competitive in the EU-15 beverages market in the period 2001-2011 (Table 2). Standard deviations are normal (except for Romania in some cases), indicating only small changes between years. However, in addition to the overall picture, it is evident that the values for Hungary and Poland are fundamentally lower than those for other countries analysed, indicating that individual country performances differed significantly.

An analysis of price and quality competition over time shows similar results. Two-way fruit spirits trade with the EU-15 – which was decisive in the period analysed – was ultimately unsuccessful in terms of quality and price (Table 3). It is apparent that a growing number of fruit spirits became unsuccessful with respect to price and quality competition following EU accession, while the share of successful competition has been diminishing over time. One-way trade in some years was caused by the lack of exports from some of the CEECs.

As to analysis by country, Bulgaria and Czech Republic show signs of successful price and quality competition, in many cases, while other countries analysed can, in the majority of the cases, be characterised by unsuccessful price and quality competition (Table 4). Compared to 2001, when fruit spirits in three of the six countries were competitive in the EU-15 beverages markets, all products except for those coming from the Czech Republic had become uncompetitive by 2011. Slovenia is a good example of having a PGI product and being uncompetitive in both quality and price terms, while the Czech Republic is an exception as it does not possess any PGI fruit spirits but is competitive in some years.

Table 1: Concentration by country of the fruit spirits trade of six Central and Eastern European countries with the EU-15 in 2003 and 2011 (per cent).

Exports				Imports			
2003		2011		2003		2011	
Country	Share	Country	Share	Country	Share	Country	Share
Germany	60	Austria	53	Germany	50	Germany	60
Austria	19	Italy	29	Spain	28	Italy	24
Italy	17	Germany	11	Italy	18	France	6

Source: authors' own calculations based on Eurostat data

Table 2: Revealed comparative advantage of fruit spirits of six Central and Eastern European countries in the EU-15 beverages market, 2001-2011.

Denomination	Average, 2001-2011				Standard deviation, 2001-2011			
	B	RTA	lnRXA	RC	B	RTA	lnRXA	RC
Revealed comparative advantage, if:	> 1	> 0	> 0	> 0				
Bulgaria	2.84	2.64	0.52	2.39	2.64	2.61	1.25	1.55
Czech Republic	5.32	4.52	1.27	2.00	4.77	4.57	0.99	1.09
Hungary	0.52	0.15	-0.98	0.06	0.46	0.73	0.87	1.82
Poland	0.09	-0.04	-3.75	-1.56	0.15	0.18	1.89	2.14
Romania	6.08	5.43	0.38	1.16	12.39	12.22	1.85	1.41
Slovenia	3.20	2.40	0.52	0.84	2.69	2.52	1.59	1.60

Source: authors' own calculations based on Eurostat data

Table 3: Fruit spirit trade between six Central and Eastern European countries and the EU-15 with regard to price and quality competition, 2001-2011.

Percentage (%)	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
One-way trade	0.00	0.09	0.09	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00
Two-way trade	1.00	0.91	0.91	1.00	1.00	0.82	1.00	1.00	1.00	1.00	1.00
Category A: successful price competition	0.40	0.25	0.25	0.33	0.33	0.00	0.00	0.20	0.00	0.33	0.00
Category B: unsuccessful price competition	0.20	0.25	0.25	0.00	0.33	0.33	0.60	0.40	0.50	0.17	0.33
Category C: successful quality competition	0.20	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Category D: unsuccessful quality competition	0.20	0.25	0.50	0.67	0.33	0.67	0.40	0.40	0.50	0.50	0.50

Source: authors' own calculations based on Eurostat data

Table 4: GP-indices in the fruit spirits trade of six Central and Eastern European countries.*

GP-index	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Bulgaria	D	D	A	A	A	B	D	A	D	A	D
Czech Republic	A	A	D	D	B	-	-	-	B	A	C
Hungary	C	-	-	A	B	-	B	B	D	B	B
Poland	-	-	-	D	D	-	B	D	B	D	D
Romania	B	C	B	D	A	D	B	B	B	D	B
Slovenia	A	B	D	D	D	D	D	D	D	D	D

* A = successful price competition, B = unsuccessful price competition, C = successful quality competition, D = unsuccessful quality competition
Source: authors' own calculations based on Eurostat data

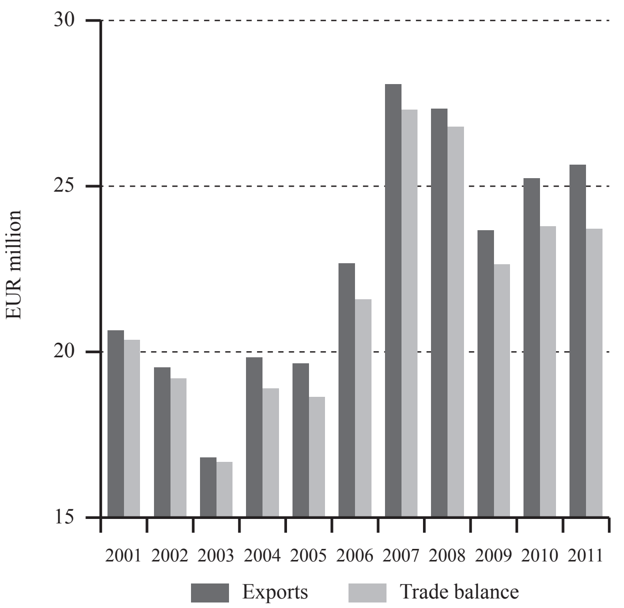

Figure 3: Italian grappa exports to, and trade balance with, the EU-15.
Source: authors' own calculations based on Eurostat data

Competitiveness of grappa: the Italian case

It can be asked how these results compare with those of a well-known PGI fruit spirit produced in an EU-15 Member State (Appendix 3). Is the competitiveness of all fruit spirits negative in Europe or there are exceptions? As an illustrative example, the Italian grappa was selected and its competitiveness was tested by the same indicators. The trade balance of grappa with EU-15 markets was significantly positive (EUR 16-28 million in 2001-2011), in contrast to CEEC fruit spirits (Figure 3). Moreover, the Italian grappa trade balance shows an increasing trend, rising from EUR 20 million in 2001 to EUR 24 million in 2011.

The Italian grappa is more competitive than the CEEC fruit spirits in the EU-15 beverages market and is also competitive in terms of price and quality (Table 5). It had a revealed comparative advantage in all years analysed by the B and lnRXA index, while RTA and RC indices were negative in most cases. A comparison of these results with those of the CEEC fruit spirits suggests that export-based indices for grappa are higher, although import-based ones are lower, which might simply result from the fact that imports are more likely to be influenced by policy interventions. Standard deviations were relatively low for grappa except for the RTA index, indicating slight changes between years in values of respective indices.

Table 5: Revealed comparative advantage and GP-indices of Italian grappa in the EU-15 beverages market, 2001-2011.

	Denomination				
	B	RTA	lnRXA	RC	GP-index*
2001	13.02	0.27	2.57	0.02	A
2002	12.61	-2.06	2.53	-0.15	A
2003	10.15	-3.89	2.32	-0.32	C
2004	10.03	-59.08	2.31	-1.93	C
2005	11.15	-71.61	2.41	-2.00	C
2006	12.98	-52.04	2.56	-1.61	C
2007	13.83	-18.23	2.63	-0.84	C
2008	13.29	-8.38	2.59	-0.49	C
2009	11.68	-36.46	2.46	-1.42	C
2010	12.51	-52.58	2.53	-1.65	C
2011	13.28	-46.49	2.59	-1.50	C
Average	12.23	-31.87	2.50	-1.08	n.a.
Standard deviation	1.30	26.14	0.11	0.74	n.a.

* for the interpretation of the GP-index, see Table 3
Source: authors' own calculations based on Eurostat data

However, the GP-index of the Italian grappa is much more favourable than that of the CEEC fruit spirits: in 2001 and 2002 grappa was price competitive, while from 2003 to 2011 grappa was successful in quality competition. This suggests that the positive trade balance of the Italian grappa in the EU-15 was associated with high prices for exports and low prices for imports. The results clearly indicate that the Italian grappa outperforms the CEEC fruit spirits in competitiveness in the EU-15 beverages market although both have a PGI in their labels.

Discussion

Our analyses reveal some clear trends in the fruit spirits trade with the EU-15 of the six CEECs. Firstly, it is observable that the CEECs imported more beverages and fruit spirits than they exported, resulting in a negative trade balance. Secondly, in the vast majority of cases the CEEC fruit spirits experienced unsuccessful price and quality competition after EU enlargement, meaning that the CEECs exported fruit spirits at a reasonably low price, and imported them at a high price. Consequently, the perceived quality of fruit spirits was not in line with their prices. What is the background to these changes?

First of all, the opening of national agri-food markets to EU competition has led to a marked increase in regional imports of high value-added and price-competitive processed products, while exports continue to be the more easily substitutable bulk agri-food products. Processed products from the EU-15 are much more price competitive in the national market than are regional raw materials in EU-15 markets (Jámbor and Hubbard, 2012).

Another important factor has been the tough adjustment to new market conditions. EU membership has made the CEECs part of a large, competitive market. On the one hand, this market offers tremendous opportunities for their agricultural sectors; on the other hand, they are faced with significantly increased competition in their domestic markets and the trade figures indicate a rather limited ability so far to withstand these competitive pressures (Csáki and Jámbor, 2010). The subsidy policy of competitors is also important as a cause. The traditionally high agricultural subsidies of the EU-15 have distorted the competitiveness of agri-food products imported by the region after EU accession.

Meeting future challenges requires that this situation be acknowledged within agricultural policy making, respecting the production of unique national/regional products. Targeted policies for PGI/PDO producers are needed such as the protection of the name of the produce, the enhancement of proper marketing strategies and the enhancement of competitiveness of PGI/PDO producers. It is of utmost importance to retain the original name of PDO products but this is often not a simple procedure. In the case of *feta* cheese, for instance, it took a long legal process until Greece secured the exclusive right to produce this well known product; while Germany, France and Denmark were able to manufacture it only using different denominations. The issue regarding the *Tokaj* PDO wine is still on the agenda between Hungary and Slovakia; so far there is no agreement on the usage of this denomination.

It is clear that PDO products are seen as having a relevant business value. Several researchers have shown that European consumers are becoming aware of the geographical indication system and are familiar with the logos but the main concept (high quality based on origin) is still very unclear even in Southern Europe where geographical indication products such as grappa look back on a long tradition (Bureau and Valeschini, 2003). The introduction of a common European logo for wines and alcoholic drinks may help consumers to recognise the special characteristics of these high quality products which would be realised in higher prices, and thus be beneficial for the whole sector (Belletti *et al*., 2007).

But the most important question is how to improve the trade balance of the CEEC PGI fruit spirits with the EU-15. This issue is a complex one that raises many other questions for economists working in different areas (marketing, agriculture, food etc.) Further research is needed to better understand the patterns behind these changes and to create a long-term strategy for the sector. However, the problem is not unsolvable as the Italian example indicates.

Conclusions

This paper has analysed the competitiveness of products with PDO as realised through the fruit spirit trade of six CEECs with the EU-15 beverages markets and has drawn a number of conclusions. Firstly, the majority of the studied CEEC fruit spirits was both competitive and had a comparative advantage in the EU-15 beverages market in the period 2001-2011, although the competitive positions have continuously declined since EU accession. Secondly, the analysis suggests that two-way fruit spirit trade with the EU-15 was ultimately unsuccessful in quality and in terms of price, although there are significant differences in the performances of individual countries. Thirdly, the results show that the CEEC are losing market positions in their traditional fruits spirit sector in the EU-15 beverages market in spite of the fact that the majority of these products have a geographical indication. Fourthly, the comparison of the competitiveness of the CEEC fruit spirits with the Italian grappa indicate that the latter outperforms CEEC fruit spirits in competitiveness in the EU-15 beverages market, although both have a PGI in their labels. Further research is needed to understand trade patterns in the CEEC region and to find out how to improve the competitiveness of CEEC fruit spirits in the EU-15 markets.

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Appendix 1: Spirits distilled from fruits with PGI status in four Central and Eastern European countries, and the year in which PGI status was awarded.

Spirit	Country of origin	Spirit	Country of origin
Szatmári szilvapálinka (2003)	Hungary	Ţuică Zetea de Medieşu Aurit (2005)	Romania
Kecskeméti barackpálinka (2003)	Hungary	Ţuică de Valea Milcovului (2005)	Romania
Békési szilvapálinka (2003)	Hungary	Ţuică de Buzău (2005)	Romania
Szabolcsi almapálinka (2003)	Hungary	Ţuică de Argeş (2005)	Romania
Gönci barackpálinka (2008)	Hungary	Ţuică de Zalău (2005)	Romania
Pálinka (2008)	Hungary	Ţuică Ardelenească de Bistriţa (2005)	Romania
Bošácka slivovica (2003)	Slovakia	Horincă de Maramureş (2005)	Romania
Brinjevec (2008)	Slovenia	Horincă de Cămârzana (2005)	Romania
Doljenski Sadjevec (2008)	Slovenia	Horincă de Seini (2005)	Romania
Slivova rakya from Troyan (2005)	Bulgaria	Horincă de Chioar (2005)	Romania
Kaysieva rakya from Silistra (2005)	Bulgaria	Horincă de Lăpuş (2005)	Romania
Kaysieva rakya from Tervel (2005)	Bulgaria	Turţ de Oaş (2005)	Romania
Slivova rakya from Lovech (2005)	Bulgaria	Turţ de Maramureş (2005)	Romania
Pălincă (2008)	Romania		

Source: EU (2008)

Appendix 2: The classification of spirits distilled from fruits according to the Eurostat trade database with eight digit breakdown (CN8).

Code	Description
22089033	Plum, pear or cherry spirit, in containers holding <= 2 l
22089038	Plum, pear or cherry spirit, in containers holding > 2 l
22089048	Spirits distilled from fruit, in containers holding <= 2 l (excluding plum, pear or cherry spirit and calvados)
22089051	Spirits distilled from fruit, in containers holding =< 2 l (excluding plum, pear or cherry)
22089071	Spirits distilled from fruit, in containers holding > 2 l (excluding spirits distilled from grape wine or marc, plum, pear or cherry)

Source: Eurostat

Appendix 3: The classification of grappa according to the Eurostat trade database with eight digit breakdown (CN8).

Code	Description
22082026	Grappa, in containers holding <= 2 l
22082086	Grappa, in containers holding > 2 l

Source: Eurostat

Isaac ABUNYUWAH*

Implications of conceptual and data complexities on time-series econometric applications in market integration analysis

This article demonstrates and highlights the conceptual limits of current empirical market integration (MI) time series models (threshold models) and their implications on market efficiency and competitive equilibrium conclusions. The complexities and diversities that characterise the analysis of the concept of market integration are evaluated within the framework of Enke-Samuelson-Takayama-Judge (ESTJ) spatial equilibrium theory. The efficiency and competiveness implications drawn from MI models are limited by how the data generation process (DGP) is influenced by equilibrium conditions, by the tradability restrictions of the inter-markets relationships and by the presence of unobserved transactions costs. However, empirical applications scarcely address these limitations. Two sets of synthesized data with varying levels of non-linear complexity implied by alternating equilibrium conditions are generated to demonstrate conceptual limits of current threshold models in market integration analysis. Inconsistent conclusions that linear representations imply for threshold propagated DGP will also apply for conclusions derived from threshold models if markets are characterised by switching equilibria conditions.

Keywords: market integration, switching equilibria, threshold models, transactions costs.

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Introduction

The concept of market integration (MI) has received considerable treatment in both classical and applied economics literature. The concept is fundamentally based on market equilibrium theory in its static version of market competitiveness and structural conditions on the one hand and arbitrage processes in the dynamic framework on the other. Economic efficiency and welfare issues have underpinned many market reforms and arguments for free market economic policies in many countries (Baulch, 1997; Barrett and Li, 2002; WTO, 2006). The importance of understanding the functional structure of markets for the appropriate design and assessment of market policies cannot be overstated.

In a dynamic framework time series tools of varying levels of non-linear complexity have been applied in MI analysis to infer the extent and degree to which markets are integrated (see for example Brorsen *et al*., 1985; Kinnucan and Forker, 1987; von Cramon-Taubadel, 1998; Wohlgenant, 1999; Abdulai, 2000; Goodwin and Piggott, 2001; Meyer, 2004; Fackler and Tastan, 2008; Stephens *et al*., 2008; Moser *et al*., 2009; Butler and Moser, 2010). Based on the adjustment dynamics, these models have attempted to address issues of price transmission asymmetries, structural breaks, trend, transaction costs and threshold cointegration. Under specific model assumptions the nature of these adjustment processes have been used to draw conclusions and implications for market efficiency, levels of competition and market integration.

From a structural perspective, market integration in a spatial (and temporal) equilibrium setting has been demonstrated to be complex (see Spiller and Wood, 1988; Sexton *et al*., 1991; Baulch, 1997; McNew and Fackler, 1997; Barrett and Li, 2002 among others). Here the roles various concepts, such as tradability, contestability, efficiency, transactions costs, market imperfections, time trend and data scarcity, play in inter-markets equilibrium processes and outcomes have been demonstrated. These have also studied how individual concepts or their combined effects affect market integration outcomes and associated modelling implications. In a static regime switching framework, these authors have comprehensively evaluated the MI concept within competitive equilibrium conditions following the Enke, 1951, Samuelson, 1952, and Takayama and Judge, 1971 (ESTJ) market equilibrium theory through parity bound models (PBM)[1].

Though notable improvements have been seen in the time series applications with the application of cointegration tools, error correction models and threshold extensions, the price transmission econometric models still do not provide a comprehensive framework for market integration analysis, as demonstrated through the ESTJ spatial equilibrium theory, especially the PBM. The econometric time-series models tend to be restrictive or tend to address a particular type of inter-market equilibrium condition by assuming *a priori* market integration, or by assuming threshold limits conditional on transactions costs. Where market inter-relationships are characterised by alternating equilibrium conditions over time, as one would expect in many developing markets where market imperfections and inefficiencies exist, parameter estimates and conclusions derived from these types of time-series models can be misleading.

Although this conceptual concern has remained in the literature for over three decades, methodological limitations and their implications on MI conclusions in the context of market structure, data complexity and equilibrium theory are scarcely discussed and addressed in empirical applications of the time series models. Inconsistent conclusions that linear representations imply for threshold autoregressive (TAR) propagated data generating processes (DGP) will also apply for conclusions derived from TAR models if markets are characterised by switching equilibria conditions. This study systematically demonstrates these limits to TAR models with synthesised data generated from two varying levels of non-linear complexity. A general non-linear modelling structure is suggested as a sensible and practical alternative.

[1] A few recent studies (e.g. Stephens *et al*., 2008 and Moser *et al*., 2009) in the dynamic frame have included some components of the basic PBM structure.

The market integration concept

From the literature and empirical work, the concept of market integration has been identified as an indicator of a process of market inter-relationships, evidenced by tradability and the resultant co-movements of market prices in particular, or by an outcome of inter-market process, gauged by arbitrage conditions and the resulting competitive equilibrium.

Market integration analysis has been carried out within the framework of the ESTJ spatial equilibrium model. In general, the model assesses markets inter-connectedness within the concepts of tradability, market equilibrium and efficiency. In its basic setting, Enke (1951) defines trade functions and transportation costs for regions that trade in homogenous goods whereby each region constitutes a single and distinct market separated but not isolated by transportation cost per unit. A state of equilibrium exists between spatially separated markets if conditions for regional producer (supply), consumer (demand) and location price equilibrium are met. Samuelson (1952) showed how this equilibrium process could be formulated into mathematical linear programming problem and illustrated how the maximisation of the objective function could be solved by iterative methods. Following Samuelson's model, Takayama and Judge (1971) reformulated the problem into a quadratic programming setting.

In MI analysis the level of tradability, as might be dictated by trade restrictions, market competition and the cost of arbitrage, determines the level of efficiency and integration of the markets under consideration. From Barrett (2005), tradability signals the transfer of excess demand from one market to another, as captured in actual or potential physical flows, while market efficiency requires the minimisation of inter-market transfer costs and quasi rents from binding quotas in addition to the attainment of competitive spatial equilibrium (Barrett, 2001).

Based on ESTJ spatial equilibrium theory in general one of three consistent long run market conditions applies based on tradability restrictions and arbitrage conditions. These are:

$$E\{P_{At}\} = P_{Bt} + \tau_{ABt} \quad (1)$$

$$E\{P_{At}\} < P_{Bt} + \tau_{ABt} \quad (2)$$

$$E\{P_{At}\} > P_{Bt} + \tau_{ABt} \quad (3)$$

where E is the expectation operator, P_{At} is the price in market A in time t, and τ_{ABt} is the transactions cost involved in trading from market B to A in time t. From the theory, if we take P_{Bt} and τ_{ABt} as given, then P_{At} is expected to be at least equal to P_{Bt} since in this setting, market A is importing from B (see Spiller and Wood, 1988; Sexton *et al*., 1991; Baulch, 1997; Barrett and Li, 2002; Negassa and Myers, 2007 for detailed model characterisation).

In equation (1) competitive equilibrium and perfect integration conditions hold (Baulch, 1997; Barrett and Li, 2002). From (2) the negative expected profit to arbitrage means no attractive opportunities exist for marketing intermediaries to trade and exploit. From Barrett and Li (2002), this is consistent with a spatial competitive equilibrium for non-trading activities (segmented competitive equilibrium) while in equation (3) there exist positive expected returns to inter-market trade, signalling foregone arbitrage opportunities or failed-arbitrage (Fackler and Goodwin, 2001; Park *et al*., 2002). Here markets are characterised by an imperfectly competitive equilibrium in which positive marginal profits to arbitrage are unexploited owing, for example, to oligopsonistic or oligopolistic behaviour or to binding quantitative restrictions on trade (Baulch, 1997; Barrett and Li, 2002). The theory implies that in the long run markets may be characterised by switching equilibria (multiple equilibria in time space) in the following form:

$$R_t^* = \begin{cases} v_t + \upsilon_t & R_t^* > 0 \quad \text{Regime 2} \\ v_t \quad \text{if} & R_t^* = 0 \quad \text{Regime 1} \\ v_t - \upsilon_t & R_t^* < 0 \quad \text{Regime 3} \end{cases} \quad (4)$$

where R_t^* is the difference between two market prices at time t, given transactions cost, υ_t represents unexploited rent or costs which can be attributed to market imperfections, trade restrictions or segmentation. The v_t error component describes perfect integration conditions where rent levels do not significantly differ from zero and as such are represented by a normally distributed error. In short, the equilibrium theory in effect implies that switching techniques are required to capture market integration dynamics within the various equilibrium conditions if they alternate over the time period under consideration.

The parity bound model (PBM) has been applied in the above framework with varying levels of non linear restrictions while TAR models have been developed in the dynamic framework to address non-linearities imposed by transaction costs. Thus, from a price transmission stand point (threshold modelling), transaction costs constrain price transmission and the exhaustion of arbitrage opportunities to a given threshold. If transaction costs play a role in the adjustment process then integrated markets are characterised by TAR models (see Tong, 1983; Tsay, 1989; Balke and Fomby, 1997; Goodwin and Piggott, 2001 for detailed exposition). In general, TAR models can be represented as follows:

$$R_t = \beta R_{t-1} + u_t \quad (5)$$

where R_t represents the price differentials ($P_{At} - P_{Bt}$) or rent; u_t is a white noise error term; and beta is a parameter that indicates the extent to which price differentials adjust in the period that follows a price shock. Two forms of TAR effects are identified, the band-TAR and the equilibrium TAR. In the former case when arbitrage or rent levels significantly fall or exceed cost of arbitrage or a given margin, market forces lead to the correction of that deviation only to the lower or upper bound of the threshold band respectively. In the equilibrium TAR however, the adjustments or corrections move into the threshold band, towards where the equilibrium point lies. That is, unlike the usual TC-based TAR effects, a form of adjustment activities can also occur within the band (see Balcombe *et al*., 2007 for methodological perspective of the two TAR forms).

For threshold effect (b-TAR), imposed by transaction costs, the following relationship holds between changes in price differentials and previous values:

$$\Delta R_t = \begin{cases} \rho_1(R_{t-1} - \tau_1) + u_1 & \text{if } \infty > R_{t-1} \geq \tau_1 \\ \rho_0 R_{t-1} + u_2 & \text{if } \tau_1 > R_{t-1} > \tau_2 \\ \rho_1(R_{t-1} + \tau_2) + u_3 & \text{if } \tau_2 \geq R_{t-1} > -\infty \end{cases} \quad (6)$$

where R_{t-1} represents the lag of price differentials (rent), $\rho = \beta - 1$, τ_i stands for transactions costs and ρ_i depicts regime specific adjustment parameter. Compared to the complete equilibrium model defined in equation (4), the TAR models imply a particular scenario of inter-market relations where in the long run all profit to trade is zero, that is, equation (1) above or assuming threshold cointegration effects. The ESTJ theory however, postulates that three long run market equilibrium conditions are possible: whether in the long run arbitrage rent is greater, equal or less than the inter-market transactions cost, whether or not trade actually occurs.

If equilibrium conditions alternate between these regimes, TAR models that do not incorporate regime switching beyond the threshold band will underestimate parameter values for periods of market integration phase. Hence, as noted above, inconsistent conclusions that linear representations will imply for TAR propagated DGP will also apply for conclusions derived from TAR models if markets are characterised by switching equilibria conditions. For instance, asymmetries and price irreversibility/stickiness may be implied while in fact the markets might be characterised by alternating equilibrium conditions driven by policy changes, inefficient market institutions or inter-markets segmentations that result from seasonal bumper harvests of many developing markets.

Synthesised market data

Price differentials are generated based on the above ESTJ theoretical framework and reflect the *process* of integration by taking into account the time series characteristics of the data. Thus, when tradability holds price transmission is implied, at least conditional on transactions costs. The base model for the TAR evolves from the perfect market integration condition as specified in equation (1), which translates into (5) in time series settings. Two data sets were used for the demonstration. One set comes from a purely transaction costs (TC) based TAR propagated data generating process while the other adds another layer of non-linear complexity imposed by inter-market segmentation as implied by equations (2 and 3) above. The first set was utilised to highlight the strengths of the TAR models when the non-linear complexity is imposed by transaction costs on the adjustment process in the inter-market relationship. The resultant series is denoted as series *A*, where $\rho_1 = -0.78$ at expectation, ($\beta_1 = 0.22$) and presented in Figure 1 as a simple non-linear series. This means that when trade occurs rent is fully and quickly exhausted and as such price differentials revert to TC (τ) bounds. To focus on real inter-market conditions beyond normal TC-created autarky conditions we specify $\tau_1 = \tau_2 = 8.3$, indicating symmetric structure; with 1.0 innovation (u) variance and ρ_0 set at 0 at expectation (thus, $\beta_0 = 1$), which defines random walk process within the threshold band. To exemplify the strengths and limits of current TAR models we have concentrated on the dynamics that associate with inter-markets equilibrium processes as dictated by various levels of market efficiency or inefficiency. In effect, the complexity that a trend component in the time series can impose on TAR modelling, especially on transaction costs (see van Campenhout, 2007) and the latter's non-constant implications, are not included in this demonstration. This was done to avoid dampening the strengths of classical TAR models in identifying transactions cost motivated threshold effects.

The second data set is characterised by relatively complex non-linear processes that reflect switches between inter-markets conditions within the equilibrium structure identified

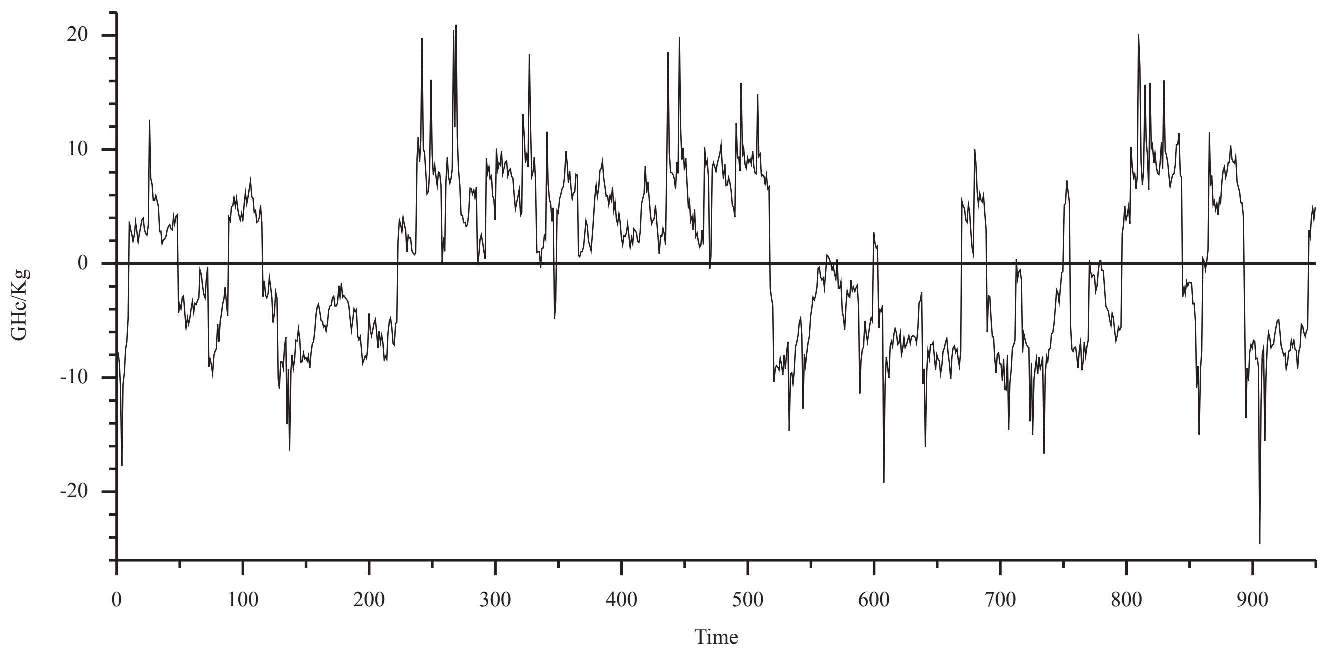

Figure 1: Simple non-linear price differentials series (Series *A*)

Source: Author's own construct (with OX).

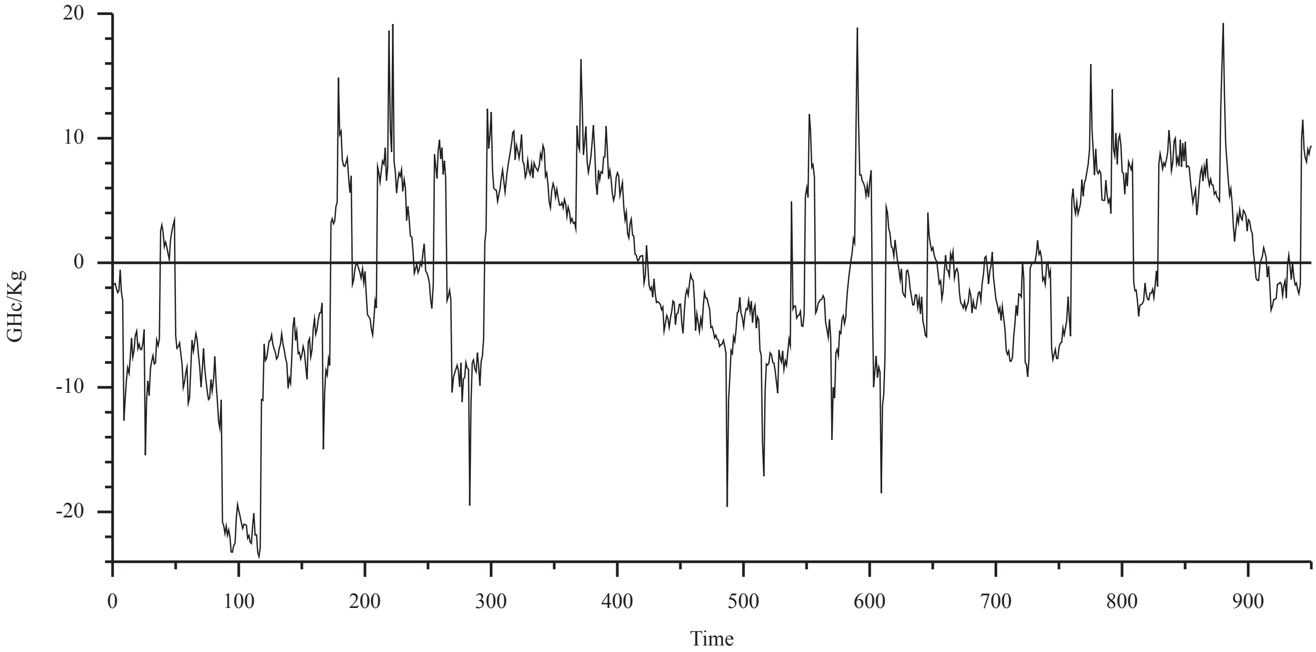

Figure 2: relatively complex non-linear price differentials series (Series *B*)
Source: Author's own construct (with OX).

in equations (1) to (4). Unlike series *A,* regime changes that follow the theoretical implications of arbitrage behaviour under imperfect or segmented market equilibrium conditions were imposed. This series is denoted as series *B* (Figure 2). Here, ρ_1 was set to negative 0.78 (beta = 0.22) for tradability periods beyond the threshold point of 8.3 with normally distributed errors with variance one as in the perfect integration case considered above. In addition, two periods of 'stylised' imperfect/segmented market conditions were fixed around time points (71:115 and 621:675). In these periods $\rho_1 = 0$ was implied to reflect inter-market segmentation periods. Again, trend and non-constant TC were not included in the series for reasons noted above.

Results

In this section we analyse these two series using the b-TAR as time series MI measurement tool. In typical TAR applications the transactions cost levels are not known but estimated from the model. Given these data sets, we imposed the usual economic assumptions that drive MI assessment models on the DGP and employed the b-TAR tools. The TAR model as defined in equation (6) is applied to the above data sets. We utilised general SETAR set up with the Markov-switching package (MSVAR) of Krolzig (1998) on OX 3.2 platform.

The analysis from b-TAR models for series *A* is presented in Table 1. The results from the null (linear AR) model are presented in the second column, while estimates from the b-TAR model are shown in the third column.

The test for the presence of threshold effects against the null of linear representation strongly favours the former as indicated by the likelihood ratio (LR) statistic and highly significant p-value for Davies statistic. The estimated threshold points of (-7.84 and 7.73) for series *A* under estimate the true threshold points of 8.3 in absolute terms, but when the innovations variance is taken into account the differences are not significant. The mean values and their associated standard errors for the series also point to same direction. The estimated values for rho (ρ_1 and ρ_0) strongly point to rapid adjustment process that characterises the series when the threshold point is exceeded (ρ_1 = -0.8647 (0.078) and -0.8087 (0.086) for regimes 1 and 3 respectively); and near random walk process within the threshold band as rho for this regime (ρ_0 = -0.0367 (0.020)) does not differ significantly from zero. From the second column, however, the TAR effect has blurred the rapid adjustment phases in the linear representation with indication of strong persistence in the inter-markets relationship (ρ = -0.086 (0.013)). Thus the strength of TAR models in this respect is clear.

The results from series *B* are presented in Table 2. Here, critical issues with general TAR models are highlighted,

Table 1: TAR analysis for simple non-linear relations (Series *A*)

Variable	Linear Model	B-TAR Model		
		Regime 1	Regime 2	Regime 3
Treshold point		R_1 ≤ -7.84	-7.84 ≤ R_1 ≤ 7.73	R_1 ≥ 7.73
Constant	0.0110 (0.092)	-7.8179 (0.796)	0.0009 (0.099)	7.4794 (0.884)
R(t-1)	-0.0860 (0.013)	-0.8647 (0.078)	-0.0367 (0.020)	-0.8087 (0.086)
Reg Probabilities	1.0000	0.1423	0.6986	0.1591
LR (Davies)		173.583 (0.000)***		

***,**,* represent significance levels under 1, 5 and 10%
Source: Own Analysis with MSVAR 3.1

Table 2: TAR Estimates of Complex Non-linear Series (Series *B*)

Variable	Linear Model	B-TAR Model		
		Regime 1	Regime 2	Regime 3
Treshold point		R_1 ≥ 7.68	7.68 > R_1 > -5.67	R_1 ≤ -5.67
Constant	0.0769 (0.043)	5.6156 (0.901)	-0.0647 (0.090)	-0.0726 (0.432)
R(t-1)	-0.1860 (0.018)	-0.6390 (0.091)	-0.0168 (0.022)	-0.0583 (0.038)
Reg Probabilities	1.0000	0.1380	0.6080	0.2540
LR (Davies)		79.30(0.000)***		

***,**,* represent significance levels under 1, 5 and 10%
Source: Own Analysis with MSVAR 3.1

when there are relatively complex inter-market processes and the data are generated by a mixture of threshold and switching market equilibrium conditions.

Like series *A*, the null of linear representation is again rejected as indicated by the LR and the Davies statistics. To evaluate the presence of TAR, it is expected that the adjustment process in some periods is governed by threshold effects as a result of TC constraints where rho (ρ_1) should not differ significantly from zero to reflect random walk nature of the price differentials within the threshold band. The intermediate regime, regime 2, is clearly characterised by strong persistence implied by TAR representation.

From regime 3, however, unlike the simple non-linear data set considered in Table 1, the impact of the complex data set has significantly understated the threshold point (-5.73). More importantly, in contrast to the *perfect* integration system considered above, the strong rent correction implied by periods of perfect integration (-0.8647 (0.078) and -0.8087 (0.086) for regimes 1 and 3 respectively for series *A*) is blurred by the strong persistence that characterises segmented inter-markets phases that do not follow any threshold process in series *B* within regimes 1 and 3 (-0.6390 (0.091) and -0.0583 (0.038)) respectively. This is more pronounced for regime 3 where the majority of the observations under segmentation periods fell beyond the threshold point. Again, from Table 2, both estimated threshold and adjustment parameters indicate that the system is characterised by strong asymmetries even though no asymmetric constraints were imposed.

Discussion

In general these results from the SETAR models with respect to series *B* do not point to strong conclusion for TC-based threshold effects where rent correction parameter (ρ_1) values for regimes 1 and 3 are expected to be high in absolute terms. As explained under the theoretical concepts above, complete market integration conceptualisation alters the threshold space with an additional layer of non-linear complication. In this respect the three state b-TAR model would not produce estimates that a pure TC-based threshold DGP will suggest.

These complications suggest that when a mixture of TAR and switching inter-market conditions ensue, threshold models may miss the true inter-markets dynamics that govern the system. The results presented above show that asymmetric conclusions reached by many MI studies that do conduct other institutional assessment for their causes may have merely come from complex inter-market DGP *vis-à-vis* inherent weakness of current time series models. Meyer and Cramon-Taubadel (2004) have raised mis-specification issues in explaining asymmetric adjustments. Moreover, depending on the nature of non-linear complexity that governs the DGP the estimated adjustment parameters and levels of threshold constraints derived from TAR specifications can be misrepresentations of the true equilibrating structure if switching inter-markets equilibrium conditions hold. Recent survey and meta-analysis of price transmission coefficients from studies that have been conducted in the sub-Sahara African markets by Amikuzuno and Ogundari (2012) point to same conclusion demonstrated above. It was shown that price transmission coefficients in the primary studies that applied the PBM tended to be more likely to have higher (about 0.20 units) estimated coefficients than those that do not use this method. That is, higher rates of rent correction in our TAR formulation. Their study also found that studies that tested for units roots were more likely to obtain lower estimates of price transmission coefficients (about 0.13 units lower) than studies which did not test for unit roots. Clearly, time series data that generate rent series which are characterised by switching inter-markets segmentation and integration have a higher probability of testing for units roots.

The above analyses of the simple and complex non-linear sets in the context of ESTJ equilibrium conditions point to the fact that the TAR assessment tools for MI analysis have their particular strengths. However, the nature of the true underlying data generation process, resulting from inter-market rent dynamics may not follow the threshold effects as the model assumes. Additional non-linear attributes and dynamics can lead to different results and conclusions if they are not taken into account.

Conclusions

Time series econometric tools have dominated market integration and price transmission analysis in the applied economics and commodity markets literature. However, while market inter-relationships in time space can be characterised by switching equilibria conditions (implied by the market integration concept) and are taken into account in PBM applications, studies that utilise time series econometric models scarcely discuss and accommodate these. As a reminder, this study has demonstrated through market equilibrium theory and synthesised data the non-linear complications that are imposed on MI tools and their implications for MI conclusions. The consequences of representing the true data generation process with different model specification assumptions on market integration processes are illustrated by the application of two different data sets with various levels of non-linear complications. Methodologically, shortfalls and strengths of the SETAR models as the main current frontier of time series applications in MI analysis have been demonstrated under specific inter-markets equilibrium conditions.

It is suggested that hierarchical models or sample splitting methods (see Abunyuwah, 2008; van Campenhout, 2009) that are applicable in other complex non-linear modelling fields should be explored to accommodate the complete equilibrium structure along the PBM. In sample splitting procedure for instance, the complications imposed by threshold effects and the threshold band in particular, can be addressed by concentrating out the transaction costs component of the data/series so that the alternating adjustment processes imposed by switching equilibrium conditions can be assessed by regime switching methods for dynamic models. The broadness of the concept demands that each market analysis with respect to methods and data must be supported by institutional analysis as a guide to attaching socio-economic significance to significant econometric results.

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TAKÁCS-GYÖRGY Katalin*, LENCSÉS Enikő and TAKÁCS István***

Economic benefits of precision weed control and why its uptake is so slow

Innovation in agriculture ensures the widespread use of the most up-to-date technology. One such technology is precision crop protection, which meets the requirement of environmental and economic sustainability. The applicability of precision crop protection has been verified by several studies and in practice, but its uptake is very slow. Examining the economic relationships between potential savings and pests at the European Union level, this paper shows that the savings in pesticide use following the adoption of precision plant protection can be 30,000 tonnes (calculated using the current dose levels) per annum. If approximately 30 per cent of the crop producing and mixed farms larger than 16 ESU apply this new technology, the environmental burden will be reduced by 10-35 per cent. From a survey of 72 Hungarian farmers we found a positive correlation between the size of the farm and the adoption of precision farming technology, and those farmers in the survey that had implemented precision crop production estimated that the consequent change in income had been positive. Thus, at a certain farm size and farming intensity, precision crop production is a real, environmental friendly farming strategy option, through which each farm can generate an income that covers at least the economic conditions of simple production. By encouraging environmentally friendly farming practice, precision crop production can meet the requirements of the proposed green component of Pillar 1 of the Common Agricultural Policy for the period 2014-2020.

Keywords: greening, precision farming, pest control, technology uptake.

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Introduction

Precision farming is a holistic system, a technology that allows target oriented treatments, thus managing the spatial and temporal variability within an ecosystem, by applying spot treatment applications. It has been shown that the implementation of precision crop production can result in savings in the use of pesticides, while savings can also be expected regarding fertiliser use, depending on the objective of production. (Godwin *et al.* 2003; Timmermann *et al.* 2003; Swinton 2005; Dillon and Gandonou 2007; Chavas 2008; Guthjar *et al.*, 2008). Precision crop production is compatible with ecological, economic and social sustainability. Social sustainability means the sustainability of food, energy and industrial production, and compliance with economic criteria in terms of the producer, as well as the sustainability of the environment.

The application of precision technology in crop production may ensure more efficient production for the grower along with a lower environmental impact. Precision farming could result in less agrochemical being distributed in the environment, and it also could be one of the basic pillars of efficient agriculture while large-scale production structure, investments, organisational structures and operational mechanisms remain. Earlier studies estimated 20-60 per cent pesticide savings owing to precision plant protection and 0-30 per cent savings in fertiliser use depending on the yield homogeneity (Lowenberg-DeBoer and Swinton, 1997; Batte and van Buren, 1999; Pecze, 2006; Rider *et al*., 2006). Also, for the producer this method of farming can be a tool for reducing the risks associated with production. With the appropriate implementation and combination of technological elements in crop production, the uncertainty of crop yield can be reduced and the reliability of the farmer's income can be increased (Auernhammer, 2001; Takács-György, 2008a; Chavas, 2008). Accuracy is necessary during the correct application of precision technology, but often this is a factor that obstructs its use on farms (Arnholt *et al*., 2001; Sinka, 2009).

One of the less examined areas of the economic relationships of precision crop production is precision crop protection. On the basis of several years of plot-level trials, real savings in agrochemical use (60 per cent) resulting from using spot treatments of precision weed control are reported by Hall and Faechner (2005). Other authors (e.g. Gutjahr *et al*., 2008) stress that actual agrochemical savings do not necessarily mean similar levels of cost savings. Using simulation model examinations that considered also the economic impact of locally specified weed control, Toews (2005) estimated that the income difference can be between EUR -25 and EUR +40 per hectare compared to the treatment of the entire surface. This difference is also affected by the distribution of weed cover, sowing shifts, agrochemical costs and weed competence. In spite of the fact that the technical-technological resources for producers are available, crop protection is the least used among the existing precision crop production components; yield mapping, precision fertilising and lime management are more frequently used (Timmermann *et al.*, 2003; Jensen *et al*., 2012; Lencsés, 2012).

Earlier studies have shown that the conversion to precision crop production is limited by the need for additional investment and the availability of labour (Weiss, 1996; Lambert and Lowenberg-DeBoer, 2000; Godwin *et al*., 2003; Takács *et al*., 2008; Takács-György, 2008b). However, the design of additional equipment does not mean a disproportionate investment burden. In spite of approaching the twentieth anniversary of precision farming technology, it is still in the early adoption stage. Precision farming, as an innovation in agriculture, can be considered as 'technology push' innovation. The cooperation of several different actors in the food chain is necessary in the case of precision technology, although the process is different from the market-focused technology development system proposed by Fenyvesi and Erdeiné Késmárki-Gally (2012). Generally, farms cultivating bigger areas of land with a mixed structure use rather more elements of precision technology than do their smaller farm counterparts (Takács-György, 2008a; Jensen *et al*., 2012). Only five per cent of farms applied at least one precision element of technology in the United Stares in 1998, on farms larger than 1200 ha (McBride and Daberkow, 2003), while Swinton and Lowenberg-DeBoer (2001) reported that only 1-5 per cent of Austrian, Brazilian, Danish, English and German farmers used precision technology in 2001. Over 400 farmers (one per cent of the farms registered in the Farm Accountancy Data Network (FADN)) applied precision technology in Denmark, of which 80 per cent were bigger than 200 ha, but only ten used more than one element (Pedersen *et al*., 2010). When the costs of data collection are included in the costs of extension, the frequency of precision services was extended in the United States not only on large farms (Griffin and Lowenberg-DeBoer, 2008). The results of Jacobsen *et al*. (2011) also illustrated the low percentage of farms using more than one precision element and underlined that farmers applying precision technology are bigger farms. Reichardt and Jürgens (2009) reported a low and moderate adoption of precision farming in Germany and emphasised the need to improve the official advisory service.

The question is, what can be the role of precision crop production in meeting the requirements of the proposed green component of Pillar 1 of the European Union's (EU) Common Agricultural Policy (CAP) for the period 2014-2020, which is intended to encourage environmentally friendly farming practice? Under the proposals, farmers carrying out organic production will automatically be entitled to complementary subsidies (EC, 2011). According to Wolf and Buttel (1996), precision farming is an abiotic factor, which is the ultimate tool for the reform of agricultural production. Precision crop production clearly belongs to this type of alternative farming strategy.

In order to determine the type and intensity of farming that is most suitable for the environment, the losses and the negative consequences of pests and diseases for environmental and human health should be considered. Based on different calculations, yield losses caused by pests (biotic stress) can be significant, up to 40 per cent of the potential yield. Of this, yield losses caused by weeds are 10-12 per cent; those caused by pathogenic organisms are 18-20 per cent, and those caused by insects account for 8-10 per cent (Auernhammer, 2001). However, the demand of society to reduce the use of pesticides, both in terms of the quantities applied and the frequency of use, can be satisfied in a number of ways (Smith and Reynolds, 1966; Lambert and Lowenberg-DeBoer, 2002; Szentpétery *et al*., 2005).

There are many direct and indirect economic (agricultural policy) means of reducing the use of crop protection chemicals. The tax on these chemicals in itself does not reduce their use if it is not paired with the compensation of revenues (Falconer and Hodge, 2000). Skevasa *et al*. (2012) confirmed through the use of models that, in contrast to taxes on pesticides, the low toxicity pesticides, pesticide quotas and the support of environmentally friendly R&D results can reduce agrochemical use. From studies of French vineyards, Lescot *et al*. (2011) have found that both environmental taxes and green subsidies can contribute to the returns on precision means. They have also concluded, however, that the ratio of shifting and the number of applied elements was low within the examined group. The poor financing situation and the high indebtedness of farms (owing to the financial crisis) were highlighted among the possible reasons.

Our research objective was to estimate, taking into account the considerable capital demand involved in shifting to precision crop production, as well as the advanced technical expertise that is necessary and the changing management tasks, the size of area on which precision agrochemical use can be introduced, how much agrochemical can be saved and what changes will result in the competitive position of the producers. The aim of this paper is to examine, firstly, the potential role of precision crop production in the reduction of environmental burden and, secondly, why its uptake is so slow in spite of its confirmed environmental and economic benefits. We advance two hypotheses:

- H1: If an appropriate number of farms shift to precision crop protection, measureable amounts of pesticides can be saved at the EU-25 level, and thus the objectives of greening can be reached by using precision technology;
- H2: Higher scale of farming and higher qualifications of farmers can enhance the expansion of precision crop production.

Methodology

Estimation of savings in pesticide applications

The starting point of our research was that, at the EU-25 (i.e. excluding Romania and Bulgaria) level, conversion to precision crop production of a specified area of the farm can result in considerable savings. These savings can be related primarily to crop protection, which also means a reduction in the environmental burden. Our calculations are based on Farm Structure Survey (FSS) data (Eurostat, 2009). It was a starting condition of our research that arable farms and mixed farms would switch to precision farming only if they are above a certain size, because of the additional equipment required for the technology adoption.

In the EU, 240,000 farms belong to the 16-40 ESU class, covering 4.2 million hectares, 139,000 farms belong to the 40-100 ESU class, cultivating 5.9 million hectares, and the number of farms over 100 ESU is 77,000, which together cover 11.3 million hectares. Our assumption was that farms above 100 ESU are able to switch to precision crop production by making their own investments based on their farm size and production level, while farms within the 16-40 and 40-100 ESU size classes can convert by using shared machinery.

The degree of savings in relation to the number of converted farms and the intensity of production (agrochemical use) was examined by scenario analysis. Based on the literature examining the penetration of the elements of precision plant production (Jacobsen *et al*., 2011; McBride and Daberkow, 2003), the proportions of farms converting to precision farming were set at 15, 25, and 40 per cent using pessimistic, neutral and optimistic scenarios, respectively. The expected savings in pesticide use, 25, 35 and 50 per cent were determined from the literature (Batte and van Buren, 1999; Pecze, 2006; Rider *et al*., 2006; Chavas, 2008).

Table 1: Nitrogen fertiliser and agrochemical use in selected groups of European countries in 2008.

Country	Nitrogen (t km^{-2})	Pesticide (t km^{-2})
EU-15	6.0	0.23
OECD	2.2	0.07
HU	5.8	0.17
Countries characterised by higher rates of chemical use		
BE	10.6	0.69
NL	13.4	0.41
DE	10.5	0.17
Countries characterised by median rates of chemical use		
CZ	6.8	0.10
DK	7.4	0.11
UK	5.9	0.19
FR	7.5	0.28
IE	8.1	0.05
PL	6.3	0.07

Source: Source: OECD (2008)

The estimations were made for crop production and mixed farms according to countries and groups on the basis of different levels of agrochemical use. Thus the above questions were separately examined for the EU-25, Hungary, the group of Belgium, the Netherlands and Germany (high levels of agrochemical use), as well as the group of the Czech Republic, Denmark, the United Kingdom, France, Ireland and Poland (Table 1). The estimation model of cost savings was:

$$C_{n,m} = p_m \cdot \sum_{k=1}^{c}\sum_{j=1}^{b}\sum_{i=1}^{a} h_{i,j,k}^{y} \cdot \overline{c}_{n,m,i,j,k}^{y}$$

where:

$C_{n,m}$: total savings of n cost type in m model variant at EU and country group level [EUR];

p_m: average degree of n cost type savings in m model variant, Pesticide cost savings: p_1=25%, p_2=35%, p_3=50% [%];

m: serial number of model variant;

n: cost type (*1*= pesticide cost);

i: economic size unit category in FADN database, $i \in [1,a]$, a=max(6); examined economic size unit categories: 16-40 ESU, 40-100 ESU, (4) 16 - <40 ESU, (5) 40 - <100 ESU, (6) >= 100 ESU;

j: type of activity in FADN database, $j \in [1,b]$, b=max(8); examined types of activity: (1) Field crops, (8) Mixed;

k: member countries of the EU, $k \in [1,c]$, c=25 (2006), c=27 (2009);

y: reference year of data in FADN database, $y \in [1989,2009]$; examined years: 2006, 2009;

$h_{i,j,k}^{y}$: number of represented farms in FADN database in y year, in i economic size unit category, in j type of activity, in k member country [holdings];

$\overline{c}_{n,m,i,j,k}^{y}$: average value of n type of cost in FADN database in y year, in i economic size unit category, in j type of activity, in k member country [EUR/holdings];

Survey of Hungarian farmers

In the spring and summer of 2011, 72 crop producer farmers attending agricultural shows at Gödöllő (n=25), Agárd (n=14), Siófok (n=20) and other places (n=13) took part in a structured interview survey designed to explore the extent and awareness of precision crop production. The questions asked concerned the features of farms (size, type and machinery), the elements of precision crop production applied, and the circumstances and reasons of their introduction. Farmers could choose from the following precision farming technology elements: row tracking, soil sampling with GPS, precision fertilising (on-line or off-line), precision weed management (on-line or off-line), precision plant protection (on-line and off-line), precision sowing, yield mapping etc. Farmers who so far have rejected precision crop production were asked why this is and under what conditions would they consider converting.

The sample included farmers from all NUTS2 regions of Hungary, namely West Transdanubia (10%), Central Trandanubia (30%), South Trandanubia (8%), Central Hungary (13%), North Hungary (11%), North Great Plain (18%) and South Great Plain (10%). In terms of farm size, 25% were under 4 ESU, 13% were between 4 and 8 ESU, 33% were between 8 and 16, and 30% were over 16 ESU. The average age of respondents was 48 years.

Cramer V tests were used to determine if the age of the farmer and the amount of cultivated land were correlated with the uptake of precision crop production. The significant difference level was five per cent.

Results

Macroeconomic and environmental benefits of precision plant protection

At the EU-25 level, depending on the percentage of pesticide savings achieved, the estimated amount of pesticide savings is 5.7-11.4 thousand tonnes if 15 per cent of the farms convert to precision plant protection, 9.5-13.1 thousand tonnes if 25 per cent convert, while in the best case scenario, the savings can be between 15.2 and 30.4 thousand tonnes (Table 2).

Table 2: Expected savings in pesticide use owing to the introduction of precision plant protection (EU-25).

			Farms converting to precision plant protection (%)		
			15	25	40
16-100 ESU	Converted area (000 ha)		5,334	8,887	14,219
	Pesticide savings (t)	25%	2,925	3,574	7,799
		30%	4,095	3,950	10,919
		50%	5,849	4,900	15,598
>100 ESU	Converted area (000 ha)		5,624	9,373	14,997
	Pesticide savings (t)	25%	2,771	4,618	7,389
		30%	4,095	6,465	10,344
		50%	8,190	9,235	14,777
Total	Converted area (000 ha)		10,956	18,260	29,216
	Total pesticide savings (t)	25%	5,695	8,192	15,188
		30%	8,190	10,415	21,263
		50%	11,391	14,135	30,375

Note: Assuming 2.4 kg ha^{-1} pesticide use (EU-25; OECD database)
Source: own calculations based on EUROSTAT data from 2009

Table 3: Estimated pesticide cost savings by crop producing and mixed farms converting to precision plant protection in the EU-25 and selected groups of European countries (million EUR).

Country group	Farm group 16–100 ESU Median savings				Farm group 100 ESU Median savings			
	25%	30%	50%	Percent (%)	25%	30%	50%	Percent (%)
EU-25	854.1	1,195.7	1,708.1	100.0	820.0	1,148.0	1,640.0	100.0
HU	24.6	34.4	49.1	2.9	22.0	30.9	44.1	2.7
BE+NL+DE	221.9	310.7	443.8	26.0	232.5	325.5	465.0	28.4
CZ+DE+UK+FR+IE+PL	487.8	683.0	975.7	57.1	472.5	661.5	945.0	57.6

Source: own calculations based on FADN data from 2009

Assuming constant yield, owing to the site-specific treatment, the realised savings in pesticide active ingredients can be 8-10 per cent of the amount used previously. At the same time, at the farm level, the savings will also reduce the material costs, as well as the competitiveness of the farm and its role in reducing the environmental burden.

The total production cost for farms in the EU-25 above 16 ESU amounted to EUR 30,479 million in 2009. The total pesticide costs reached 18.7 per cent of this. Considering the possible scenarios of shifting to precision crop production, and assuming the above prevalence on pesticide costs, between EUR 1,674.1 and EUR 3,348.1 million of savings can be achieved at the EU-25 level due to the adoption of precision pest control (Table 3).

Between 0.6 and 6.2 per cent of savings in farm-level production costs can be attributed to the precision use of pesticides. The total pesticide costs are 14.8 per cent of the total costs in the group of countries (BE+NL+DE) that use more agrochemicals. The savings on production costs can be between EUR 5.590 and EUR 57.770 million, which can dramatically improve the competitiveness of the sector.

The results from macro-level models support the fact that precision plant protection can have an important role in environmental burden reduction, alongside other elements of technological development in agriculture.

By proving the first hypothesis (H1), we can state that by promoting the switch to precision technology the greening objectives of the CAP can be reached.

Uptake of precision crop production: what is it like?

Thirty-one of the interviewed farmers reported that they used use precision farming technology and 41 stated that they did not. Most farmers use only one element of precision farming technology. Row tracking was the most frequently applied technique (35.5 per cent), then net-like soil sampling (22.6 per cent), followed by precision fertilisation (19.4 per cent) and precision crop protection (16.1 per cent) and precision soil cultivation (9.7 per cent). The other elements were mentioned only by one farmer in the survey (Table 4).

The cross-correlation examined the effects of the most important farm parameters (amount of cultivated land, income, age of farmers, education) on the adoption of precision farming technology. There was a moderate but significant positive correlation between the area of cultivated land and the adoption of precision farming technology (Cramer V=0.36 α=0.01). With the age of the farmers adopting precision crop production there was a also moderate, positive correlation (Cramer V=0.31 α=0.03). The farmers using more elements of precision technology come from the middle-aged category (40-65 years), while none of the older farmers (over 65 years old) applied precision technology. While these results are based on a relatively small sample size, they agree with those of Kutter *et al.* (2011). There were no significant correlations between the income of farms, the highest education level of farmers and the adoption of precision farming technology.

Among the changes expected from the implementation of precision farming, the reduction of environmental burden from crop production was mentioned most frequently by the interviewees, followed by the additional income, the size of which was estimated to be between 5 and 15 per cent by 63 per cent of the respondents. The reduction in agrochemical use was the third most frequently mentioned consequence. On the basis of cross-table analysis there was a positive, medium strength relationship (ϕ = 0.25, five per cent significance level) between the implementation of precision crop production and the estimation of changes in incomes. The reasons given for the low uptake of the technology included the low awareness level, the negative approach of management and the positive correlation (ϕ =0.35) with the increase of the farm area.

From among the reasons given in the survey for the slow uptake of precision technology we were able to prove the first part of our second hypothesis (H2), namely that the higher scale of farming can enhance the expansion of precision crop production.

Table 4: Frequency of use of elements of precision farming amongst Hungarian farmers in 2011.

Element of precision technology	Farms applying an element of precision technology (%)		Median proportion of farm area using precision farming technology (%)
	of total sample (n=72)	of farms using of precision technology only (n=31)	
Row tracking	15.3	35.5	100
Net-like soil sampling	9.7	22.6	58
Precision fertilising	8.3	19.4	76
Precision crop protection	6.9	16.1	71
Precision soil cultivation	4.2	9.7	75
Yield mapping	1.4	3.2	100
Aerial remote sensing	1.4	3.2	100
Precision weed control	1.4	3.2	n.d.
Precision sowing	1.4	3.2	100
Remote sensors	-	-	-
Weed mapping	15.3	35.5	100

Source: own survey using structured interviews

Discussion

The expansion of precision crop production is still in its early phase. The process can be characterised from the uptake point of view of innovation, based on Rogers (1962); our typology for the uptake is as follows:

1. During its introduction precision crop production had a relative advantage compared to the general technologies used in crop cultivation, which would have allowed for relatively rapid growth;
2. In terms of compatibility, precision farming can be considered less compatible. This is due to the fact that farmers are characterised by different levels of knowledge and skills, by a mistrust in the new technology and by their different farm sizes and financial opportunities. If support from consultants for the introduction of the new technology is missing, the uptake process will be slow;
3. The application of precision crop production is not easy to understand, it requires much attention, precise work and a wide range of information;
4. Relevant industry players and suppliers affected in the application and marketing of the technology are dominant with regards to the application and cognition;
5. With the introduction of precision technology some of the available benefits are directly observable, such as material savings, improvements in cost-effectiveness, together with the additional costs and expenses. The indirect effects, however, such as reduction of environmental burden and improvements in food safety, are less evident. While the measurable positive returns remain unclear to the farmer, and the risks remain high, even in the presence of a good financial background, the spread of the technology is slow.

The adoption of more elements of precision plant production technology is slow across the world (Godwin *et al*., 2003; Pecze, 2006; Griffin and Lowenberg-DeBoer, 2008; Pedersen *et al*., 2010; Lencsés, 2012). The results of our survey suggest that the slow uptake of some elements of the technology can be partly explained by the problematic questions of shifting, which state that the role of expertise and precision will increase in the converted farms, the documentation and tracking of the procedures that will be required and not all the actors will view this positively, the production costs will often be higher and the returns on extra investment are not always ensured. In these cases all kinds of cooperation and strategic collaborations among the farmers, extension services and providers are important in the adoption of new technology, such as the forms of joint machine use (e.g. machinery rings). The significance of relational capital as the basis of knowledge based growth is greater within small and medium-size enterprises' innovational cooperation (Takács, 2000; Husti, 2009; Welbourne and Pardo-del-Val, 2009; Macieczjak, 2012; Vuylsteke and Van Gijseghem, 2012). It is important to highlight the role of these forms of cooperation because the individuals make their decisions on the adoption of new technologies on the basis of information coming through these channels (Csizmadia, 2009).

The benefit of the transition to precision pest management is proven, since spot treatments will result in real savings in the use of plant protection materials, depending on the area infected by pests. In all cases where there is heterogeneity within the field, and a high number of those spots, plant protection treatments can be omitted without suffering significant economic damage. The model calculations underlying this showed that precision crop protection can result in significant savings in agrochemical use at the macroeconomic level. Similar positive economic and social results in Danish farms were reported by Jensen *et al*. (2012) through an increase in the farmers' income and reductions in fuel consumption and pesticide use. As regards to agrochemical use, after shifting to precision crop production in the EU-25 countries, presuming an optimistic scenario and in the case of the reasonable use of the currently applied substances, 30 thousand tonnes less pesticide would be required for the currently produced yield. If the proportion of converted farms is around 30-60 per cent, the 10-35 per cent reduction in substance use compared to the intensive, entire surface treatment technology would reduce the environmental burden to a similar degree at the national economy level. In this case individual utility and social utility coincide. The yield uncertainty can be reduced during the production of food and industrial raw materials, as it helps traceability in food chains and improves the predictability both at farm and national level.

Precision crop production, as an environmentally friendly farming practice, can be one of the means of enhancing the green component of Pillar 1 of the CAP proposed for the period 2014-2020. The greening impact, i.e. the decreasing substance use measured in agrochemicals, can be greater than the savings reached by leaving the land fallow, because this practice prefers marginal areas where agrochemical use is originally lower. Farmers who leave their land fallow perform more intensive production on their other land in order to compensate for the yield losses. This process occurred within the United States agriculture before the turn of the millennium (Knutson, 1993). We agree with those who call attention to alternative solutions in the discussions of the CAP proposals and do not exclude the acceptance of innovation outputs (technique, technology and organisation) in the CAP system (Groupe de Bruges, 2012).

To force and promote the uptake of precision farming one tool can be – as a new element, an indirect assistance – putting the application of precision technology into the tools of the CAP greening component.

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Comparison between the United States and Poland of consumers' perceptions of organic products

The paper aims at exploring further the potential of organic agriculture by increasing the knowledge about consumers' perceptions of organic products. The United States (Florida) and Poland are interesting examples in which the level of organic market development varies and this allows us to test whether consumer perceptions of organic food products vary with market development. A survey was conducted amongst students at the University of Florida (United States) and at the Warsaw University of Life Sciences-SGGW (Poland). The results obtained from an online survey were analysed through econometric modelling. The model used for this study was the ordered probability model, which was used to compare the frequency of organic consumption between the United States and Polish students. The findings indicate that students from the two countries have different perceptions of organic products. The less the market is developed (such as in Poland), the more important is basic knowledge about the products. With a higher level of market development (for example in the United States), consumers already have this basic knowledge about the products, such as origin or organic label, and are more focused on their qualities, such as taste or variety. These differences should be taken into account by states when developing policies on organic agriculture and healthy eating generally, and during the formulation of marketing strategies by companies interested in the growth of the organic market.

Keywords: consumer perception, organic farming, organic market

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Introduction

This paper focuses on the differences in consumers' perceptions of organic products between Poland and the United States in relation to the level of organic market development in terms of sales and availability of organic products. Balogh (2007) highlighted the differences between the United States and Europe in terms of consumer habits and wider food supply trends. He presents data that show that the proportion of overweight and obese consumers is much higher in the former than in the latter, but that the proportion is increasing more rapidly in Europe. Four possible solutions are suggested to obesity as an endemic social disease. One of these is to purchase organic products instead of buying food products processed from traditionally produced agricultural raw material.

There are many differences in terms of the level of development of organic markets between the United States and Poland. Differences in growth are evidenced by the monetary value of both markets. In 2009, the value of the organic market in the United States was expected to reach USD 23 billion (EUR 16.1 billion) (USDA, 2011). This accounts for approximately 2.5 per cent of total food sales in the United States. In the European Union (EU) sales of organic products were approximately EUR 19.6 billion in 2010. At the same time the largest market for organic products was Germany with a turnover of EUR 6 billion, followed by France (EUR 3.4 billion) and the UK (EUR 2 billion) (Willer and Kilcher, 2012). The value of the Polish organic market reached USD 143.1 million (EUR 100 million) in 2009 (PMR, 2010) suggesting that the level of development is still low. The organic market constitutes only about 0.2 per cent of the total food market. It results in low availability and variety of organic products. Organics in Poland can be also characterised by high prices. In terms of the per capita consumption of organic food, in 2010 it reached EUR 65.0 in the United States, which was almost twice as much as the EU average (EUR 33.7), while in Poland it was less than EUR 1.0. The highest per capita consumptions of organic food in 2010 were observed in Switzerland (EUR 153.0) and in Denmark (EUR 142.0) (Willer and Kilcher, 2012).

Previous studies show that the perception of organics varies among consumers. Most studies on consumer attitudes state that organic products are considered as safer, healthier and more environmentally friendly. Consumers' perceptions of organic food and quality of organic products are positive – they have good feelings about organic products (Magnusson *et al*., 2001; Conner, 2004; Monaco *et al*., 2007; Zhao, 2007; Kihlberg and Risvik, 2007; Pellegrini and Farinello, 2009). They often perceive organics as having better taste, freshness, appearance and colour (Hoefkens *et al*., 2009). However in the literature there is an ongoing debate concerning healthiness and safety of organic food (Żakowska-Biemans, 2011). Some researchers conclude that organic foods are healthier while others find that this is not the case (Grankvist and Biel, 2001; Williams, 2002; Naspetti and Zanoli, 2006; Monaco *et al*., 2007; Azurra and Paola, 2009). There are no clear data which can show higher content of nutrients in organic or conventional products (Williams, 2002; Magkos *et al*., 2003). There are also no clear differences in sensory characteristics between conventionally and organically grown organic products. Many studies state that the nutrient content and sensory characteristics depends mostly on the region, soil type, crop variety, climate, or post-harvest practices, and not on whether or not chemicals are used in production (Bonti-Ankomah and Yiridoe, 2006; Żakowska-Biemans, 2011).

It was reported that consumers have different willingness to pay (WTP) for organic products. The WTP of those who join the consumer market of ecological goods is basically determined by the solvency (income) of consumers (Takács and Takács-György, 2012). In general, WTP decreases with increase of premium price. But at the same time prices for organic products can increase with preferred specific attributes, e.g. freshness. Further, it is difficult to determine which products that have higher price premiums attract consumers more (Bonti-Ankomah and Yiridoe, 2006). However the most significant barriers to purchasing organic products were the price premiums and the lack of availability of organic products (O'Donovan and McCarthy, 2002; Hill and Lynchehaum, 2002; Hughner *et al*., 2007; Aertsens *et al*., 2009; Żakowska-Biemans, 2011). Studies also reported that women are more willing to buy organic food products. This is understandable because women are more often responsible for purchasing food for the household and know more about nutrition and food safety (O'Donovan and McCarthy, 2002; Pellegrini and Farinello, 2009; Aertsens *et al*. 2009). Studies show also a correlation between level of income and willingness to buy organic products (Aertsens *et al*., 2009).

Balogh (2007) noted that in the United States a third generation of convenience products has already appeared with the dual aim of delivering convenience and health. Although in Europe consumption 'philosophy' accepts the importance of convenience, greater emphasis is placed on natural origin, freshness and traditional recipes. This illustrates the importance of consumer perception on food market development and it might be assumed that these perceptions are the most acute amongst the most highly educated groups in society. Thus our research on the consumer perception of organic products was carried out among one such group, namely university students.

Methodology

The demand for organic food was analysed by asking respondents about the frequency of consumption of organic products. Data were collected using an online survey instrument (online questionnaire) among students at the University of Florida (UF) in Gainesville, United States and at Warsaw University of Life Sciences – SGGW (WULS), Poland. The survey was administered in both countries during April and May 2011.

At UF, the questionnaire was sent to three groups using a convenience sampling method. The majority of students (81 per cent) were from the College of Agricultural and Life Sciences. Other colleges included Liberal Arts and Sciences (11 per cent), Business Administration, Engineering, Health and Human Performance, Law, Medicine, Pharmacy and Public Health and Health Professions. Most of the respondents (97 per cent) were pursuing their Bachelor's degree.

At WULS, the questionnaire was sent to students also using a convenience sampling method. The majority of students (95 per cent) were from the Faculty of Economic Sciences. Other faculties included Faculty of Veterinary Medicine, Faculty of Wood Technology, Interfaculty Studies of Regional Planning, Interfaculty Studies of Commodity Science and Faculty of Applied Informatics and Mathematics. Most of the students were pursuing their Master's degree (55 per cent). However 45 per cent of respondents were pursuing their Bachelor's degree.

These data were then used to conduct an ordered probit model to determine the independent variables which influence a respondent's frequency of consumption of organic products (the dependent variable). In this paper the approach used to estimate models with a dependent variable which is ordinal but not continuous is the ordered response model. The ordered probit model (ordered probability model) is used to determine the independent variables which influence a respondent's frequency of consumption of organic products. The ordered probit model relies on the idea of a continuous metric which underlies the ordinal responses observed in the analysis (Equation 1).

$$Y^* = X'\beta + \varepsilon \qquad (1)$$

Y^* is a continuous variable which is a linear combination of a set of predictors, X. Additionally ε represents a disturbance term that has a normal distribution. β represents the vector of regression coefficients which we want to estimate.

In the model used to analyse consumption of organic food by students, there are unknown threshold parameters Y^* (i = 0, 1, 2), with y values specified as:

Y = 0 if consumers do not consume organic food products
Y = 1 if consumers consume organic products monthly
Y = 2 if consumers consume organic products weekly
Y = 3 if consumers consume organic products daily

Y^* will be estimated with other parameters. In the situation where there is an intercept coefficient in the model, parameter $Y0^*$ is normalised to a value 0 and k–1 additional parameters will be estimated with Xs.

The probabilities of observing Y, given X are written as (Equation 2):

$$Prob(Y = n) = \varnothing(\mu_n - \beta X') - \varnothing(\mu_{n-1} - \beta X'), n = 0,1,2, \quad (2)$$

where ∅ is the normal density function.

The marginal effects of the independent variables on the probabilities are also observed. They vary from the values of the coefficients estimates. The marginal effects are related to the values of all independent variables (Equation 3).

$$\frac{\partial Prob(Y = n)}{\partial X} = [\varnothing(\mu_{n-1} - \beta X') - \varnothing(\mu_n - \beta X')] \times \beta \qquad (3)$$

The ordered probability model is used to compare the frequency of organic consumption between American and Polish students. The dependent variable for the ordered probability model is the frequency of consumption of organic food products. The model uses several socioeconomic, demographic and habit independent variables (Table 1). SPSS and LIMDEP were used to compute the model.

The model contains variable *country*, which describes the effect of the respondent's country on the frequency of consumption of organic products. Variables with the 'I' symbol represent the interactions related to specific variables between countries. In other words, it means that there are possible differences or similarities in case of specific variables between countries which can be significant to the consumption frequency of organic products.

Results

The ordered probability model was used to investigate the consumption of organic food products. Frequency of consumption was calculated on the basis of a question that asked the respondents how often they eat organic food products. The assumption is made that consumption of organic foods less than once per month is equivalent to not consuming organic food at all. Observations with missing information were deleted leaving 349 usable observations. The results of the ordered probit analysis were explanatory, with the model making correct predictions 68.5 per cent of the time compared to the naïve prediction of 60.2 per cent. The results of the ordered probability analysis revealed interesting information (Tables 2 and 3). Variables are reported as statistically significant at a confidence level of 90 per cent or greater. Statistical results are divided into four parts: (a) personal characteristics and lifestyle; (b) purchase frequency habits of organic food products; (c) knowledge and beliefs about organic farming; and (d) attitudes towards purchase and consumption of organic food products.

Personal characteristics and lifestyle

Demographics and other variables related to the person's lifestyle were included in the model. The students were asked several questions related to the opinion about their eating behaviour. Students in both countries said they will eat organic food less frequently if they said that the food they eat can influence their health. However, American students, who indicated they do not want to give up foods they like to eat, even if they are not healthy foods, were 11.9 per cent more likely to consume organic food more frequently. First may mean that they appreciate, for example, the taste of organics so they include these foods in their diet. For Polish students this variable was not statistically significant which may mean that reasons other than taste influence their consumption of organics.

Respondents were also asked about their diet on the day before taking the survey. Students reported which of different types of foods they ate in the previous day. Those who ate less healthy foods the previous day eat organics less frequently. However, those who did eat healthy foods the previous day were more likely to consume organic foods more frequently. This held true for respondents in both countries. Polish respondents who ate more healthy foods on the day before are 7.7 per cent (1.0 per cent in case of U.S. students) more likely to consume organics more frequently.

Purchase frequency habits of organic food products

To consume, organic products have to be purchased. Students indicated several places where they buy organics. The places like *supermarket*, *organic food stores*, *direct sales on the farm* and *farmers' market* were statistically related in the decision to consume organic products in both countries. In the United States, the retail market consists mainly of large supermarket chains. In Poland, a large proportion of respondents indicated they do their primary shopping in small grocery stores or at farmers' markets, which are very common. With the further development of organic markets in Poland a higher significance of supermarkets as the source of organic products is expected. The possibility to find organics in supermarkets may grow the consumption of organics due to an increase in their availability, popularity, assortment and possible lower price for consumers.

Knowledge and beliefs about organic farming

Some differences related to the beliefs and knowledge about organic farming and organic food products between the American and Polish students were observed. Students were asked how much they think they know about organic farming. A positive relationship between this opinion and the frequency of consumption of organic food was found only for American students. This indicates that students in the United States who believe they know more about organic production are 14.9 per cent more likely than an average person to consume organic food more frequently.

Polish and American students were also evaluated on how much they actually know about organic farming in general. This variable was statistically related to the consumption frequency of organic products. Students in Poland are 8.8 per cent more likely to consume organics more frequently if they have better knowledge about organic farming. This relationship shows that in Poland, where the level of organic market development is still very low (compared to the United States), there is still great potential for organic production. More knowledge may also translate into higher consumption of organic foods and further development of the organics market in Poland. The relationship had been expected to be similar as well for the American students, but in the United States, the relationship is weak and opposite. It may mean that knowledge of organics can be not pro-organic for the American students so it may create a negative image of organic farming.

Attitudes towards purchase and consumption of organic food products

Among the reasons for consumption, there were different relationships to the frequency of consumption of organic food for students from the two countries. Polish students were 14.1 per cent more likely to eat organic food if they stated they consume these products because they are something new. Students from the United States presented an opposite attitude. This can be explained by the fact that organic food is still not common in Poland. In the case of United States, organic foods exist in almost all supermarkets and do not catch people's attention as something 'new'.

Another factor which influenced the decision to buy organic food was significant only for American students. Students from the United States said that they buy organic because they want to support organic farmers. Respondents in the United States may support organic farmers because they assume they are small, local farmers and the support goes directly to them, which may often not be true. Polish consumers, knowing that organic farmers in Poland receive financial subsidies, may pay less attention to the income of organic farmers while purchasing organic food.

The purchasing factor *synthetic pesticides are not allowed in production* did not behave in the manner expected. The literature suggests that organic foods being produced without synthetic pesticides are one of the drivers for buying organic products (Hoefkens *et al*., 2009). This analysis suggests that in both the United States and Poland other factors have more of an impact on the frequency of consumption of organic products. The purchasing factor *organic farming is environmentally friendly* had a significant impact on the frequency of consumption of Polish and American students, but in opposite ways. The fact that organic farming may positively affect the environment was a convincing reason for Polish students to consume organics more frequently. In this case they are 25.1 per cent more likely to consume organics more frequently. American students who said organic farming was environmentally friendly were not motivated enough to purchase organic products for that reason. At the same time purchasing factors such as *organic food has better quality* and *organic products are healthier* did not influence statistically the frequency of consumption of organic food.

Some differences between American and Polish students were found in the case of barriers for purchasing organics. The higher cost of organic products had an impact on the decision to buy organics less frequently, but only for Polish students. Polish students were 14.5 per cent more likely to consume organics less frequently if they say that *cost* is the barrier for purchasing organic products. This may be explained by the lower income of Polish students in comparison to students in the United States. It is interesting that American students are even more likely to buy organic if they are aware of the higher costs for organics. This situation may be explained by better financial situation of American students. At the same time they may find a higher price for organic as paying for some additional value or attributes of organic food in which they believe in. They may also be more aware about these attributes than students in Poland. It is also worth mentioning that the low level of development of the organic market in Poland may create much higher prices of organic products than in the United States. In general, as a result of the increase in supply, a decrease in price takes place (Takács *et al*., 2003). So with further development of the organic market, prices for organic products in Poland should be more stable and their variety may increase.

Students in both countries would buy organics more frequently if the variety was bigger. This problem is especially important in Poland where the market is still not developed. Also interesting is the fact that the availability of organic products as the barrier did not influence the consumption frequency of organics. It was expected that students, especially in Poland, would react to the lack of availability of organic products by indicating that they purchase less frequently. One of the explanations may be that variable for *variety* is substituting for the variable *availability*, so the lack of availability is seen more as a lack of variety. This may mean that students from both countries would consume organics more frequently if a greater variety of organics is easy available for purchasers.

However, students in the United States and Poland did present different attitudes in terms of the relationship between frequency of consuming organics and ease of finding organic products in their area. This variable did not behave in the manner expected in case of Polish respondents. They consume organics less frequently if they say that it is easy to find these products in their area. It may be that people who consume organics less frequently do not have an idea about lack of availability of organic products. In other words, only the people who are interested in consumption of organics know how difficult is to find these products in Poland. In the survey only 30 per cent of Polish students admitted that it is easy for them to find organic products in their area. At the same time students in the United States are 8.9 per cent more likely to consume organics more frequently if they say they do not have problems finding organic products in their area. This is what was generally expected. In the questionnaire more than 70 per cent of the American students said it is easy to find organics in their area.

In the survey respondents were also asked at what price difference (WTP) they would select organic food products in comparison to conventional products. In general, students in both countries would pay around 10 per cent more for organic products. The model also investigated the relationship between the country of the respondents and the consumption frequency of organics. Based only on the country variable there are not any significant differences between the United States and Poland in terms of the frequency of consumption of organics.

Discussion

This paper focuses on the differences in consumers' perceptions of organic products between Poland and the United States in relation to the level of organic market development in terms of sales and availability of organic products. Students from the United States and Poland have different perceptions about organic products. Some of these differences may be explained by the different level of development of the organic market in the two countries.

The organic market in the United States can be characterised by a higher level of development than in Poland. Organic products are common and available in most of the supermarkets. American students did not find the price for organics as a barrier to purchase. They may consider the higher price for organics as paying for some additional attributes of organics in which they believe in. These attributes and qualities may be considered as one of the main reasons for purchasing organics in the United States. This corresponds with previous research which has found that quality characteristics (especially taste) are the main drivers of demand for organics in the United States (Caswell, 2001).

The lack of development of organic market in Poland was observed as respondents rated the availability of organic products as low. Potential consumers of these products have to face higher prices of organics, probably resulting in the lower popularity of these products. However, general knowledge about organic food was high and was similar to the knowledge of American students. In addition to consuming organics more frequently because they see them as new, innovative products, Polish students also increased their consumption if they felt organic production was good for the environment. It does appear there is potential for consumer demand as the students were excited about the new products and new production method as a potential alternative to conventional agriculture. They may consider themselves as potential buyers of organics. As knowledge had a significant and positive impact on consumption of organic foods, it seems that education and increases in awareness would help further development of organic market in Poland.

The importance of education suggests that the results of our study on students may not necessarily be applicable to the wider population. Probit models are often used for examinations related to consumer perception, also in case of organic products. Dettmann and Dimitri (2007) for example sought to find out which demographic factors influence the purchase of organic vegetables. In this case the probit model was a part of the Heckman model and it examined the household's choice to buy organic vegetables as a function of different demographic factors. They found that race, educational level and household income consistently influenced the odds of purchasing organic vegetables. Briza and Wardb (2009) focused on the responses of Spanish consumers regarding their state of knowledge about organic foods products. They showed that awareness and consumption of organic products is influenced by consumer demographic characteristics, knowledge of enriched foods and price perceptions. Factors impacting on both awareness and consumption were explored using simulation methods and the coefficients from the logit and probit models.

Our findings generally support the results obtained by other authors with regard to both American (Dahm *et al*., 2009; Ming, 2009) and Polish students (Kowalczyk-Vasilev *et al*., 2011). They show that, in general, more knowledge can be translated into higher consumption of organic foods and further development of the organics market. Our research, by contrast, found that for the American students more knowledge of organics can be translated into not pro-organic. These results might suggest a loss of confidence in organic foods in well developed markets.

In the context of the different stages of development of the organic market in Poland and the United States, the paper has provided evidence about different attributes that can play an important role in consumers' perception of organic food in these markets. The less the market is developed (such as in Poland), the more important is basic knowledge about the products such as origin or organic label. With a higher level of market development (for example in the United States), consumers already have this basic knowledge about the products and are more focused on their qualities such as taste or variety. These differences should be taken into account by states when developing policies on organic agriculture and healthy eating generally, and during the formulation of marketing strategies by companies interested in the growth of the organic market.

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Table 1: Variables used in the ordered probit model.

Variable	Definition of variable	Coding
Freqcons	Frequency of consumption of organic food	= 0 if consumers do not consume organic food products = 1 if consumers consume organic products monthly = 2 if consumers consume organic products weekly = 3 if consumers consume organic products daily
Gender	Gender	Female = 1, Male = 0
GenderI	Interaction of gender and country	= 0 if Country = PL = Gender if Country = US
Eatbehav1	Eating behaviour - My food choices affect my health	Ranges from 1 to 5
Eatbehav1I	Interaction of "Eating behaviour - My food choices affect my health" and country	= 0 if Country = PL = Eatbehav1 if Country = US
Eatbehav2	Eating behaviour - I always choose the healthiest option, even if it is more expensive	Ranges from 1 to 5
Eatbehav2I	Interaction of "Eating behaviour - I always choose the healthiest option, even if it is more expensive" and country	= 0 if Country = PL = Eatbehav2 if Country = US
Eatbehav3	Eating behaviour - I have control of my health no matter what I eat	Ranges from 1 to 5
Eatbehav3I	Interaction of "Eating behaviour - I have control of my health no matter what I eat" and country	= 0 if Country = PL = Eatbehav3 if Country = US
Eatbehav4	Eating behaviour - I don't want to give up the foods that I like	Ranges from 1 to 5
Eatbehav4I	Interaction of "Eating behaviour - I don't want to give up the foods that I like" and country	= 0 if Country = PL = Eatbehav4 if Country = US
Yestgood	Good diet on the day before the survey	Ranges from 0 to 5
YestgoodI	Interaction of "good diet on the day before the survey" and country	= 0 if Country = PL = Yestgood if Country = US
Yestbad	Bad diet on the day before the survey	Ranges from o to 5
YestbadI	Interaction of "bad diet on the day before the survey" and country	= 0 if Country = PL = Yestbad if Country = US
Country	Country – Poland or the United States (FL)	Poland (PL) = 0, United States (US) = 1
Superm	Place where individual purchase organic food- supermarket	Ranges from 1 to 5
SupermI	Interaction of "supermarket" and country	= 0 if Country = PL = Superm if Country = US
Orgstore	Place where individual purchase organic food - organic food store	Ranges from 1 to 5
OrgstoreI	Interaction of "organic food store" and country	= 0 if Country = PL = Orgstore if Country = US
Directorg	Place where individual purchase organic food - direct sales from a farm	Ranges from 1 to 5
DirectorgI	Interaction of "direct sales from a farm" and country	= 0 if Country = PL = Directorg if Country = US
Farmarkt	Place where individual purchase organic food - farmers markets	Ranges from 1 to 5
FarmarktI	Interaction of "farmers markets" and country	= 0 if Country = PL = Farmarkt if Country = US
Subjknow	Subjective knowledge (opinion) of individual about organic farming and organic products	Ranges from 1 to 5
SubjknowI	Interaction of "subjective knowledge" and country	= 0 if Country = PL = Subjknow if Country = US
Objknow	Objective knowledge of individual about organic farming and organic products	Ranges from 1 to 8
ObjknowI	Interaction of "objective knowledge" and country	= 0 if Country = PL = Objknow if Country = US
Factdifferent	Factor for purchasing organic products - It's something different	Ranges from 1 to 5
FactdifferentI	Interaction of factor "It's something different" and country	= 0 if Country = PL = Factdifferent if Country = US
Factsupport	Factor for purchasing organic products - I am supporting organic farmers	Ranges from 1 to 5
FactsupportI	Interaction of factor "I am supporting organic farmers" and country	= 0 if Country = PL = Factsupport if Country = US
Factqualit	Factor for purchasing organic products - Organic food has better quality	Ranges from 1 to 5

Variable	Definition of variable	Coding
FactqualitI	Interaction of factor "Organic food has better quality" and country	= 0 if Country = PL = Factqualit if Country = US
Factpest	Factor for purchasing organic products - Synthetic pesticides are not allowed in production	Ranges from 1 to 5
FactpestI	Interaction of factor "Synthetic pesticides are not allowed in production" and country	= 0 if Country = PL = Factpest if Country = US
Facthealth	Factor for purchasing organic products - Organic products are healthier	Ranges from 1 to 5
FacthealthI	Interaction of factor "Organic products are healthier" and country	= 0 if Country = PL = Facthealth if Country = US
Factenvir	Factor for purchasing organic products - Organic farming is environmentally friendly	Ranges from 1 to 5
FactenvirI	Interaction of factor "Organic farming is environmentally friendly" and country	= 0 if Country = PL = Factenvir if Country = US
Barravail	Barrier for purchasing organic products - Availability	Ranges from 1 to 5
BarravailI	Interaction of barrier "Availability" and country	= 0 if Country = PL = Barravail if Country = US
Barrcost	Barrier for purchasing organic products - Cost	Ranges from 1 to 5
BarrcostI	Interaction of barrier "Cost" and country	= 0 if Country = PL = Barrcost if Country = US
Barrvariet	Barrier for purchasing organic products - Insufficient variety	Ranges from 1 to 5
BarrvarietI	Interaction of barrier "Insufficient variety" and country	= 0 if Country = PL = Barrvariet if Country = US
Barrinfo	Barrier for purchasing organic products - Too little information	Ranges from 1 to 5
BarrinfoI	Interaction of barrier "Too little information" and country	= 0 if Country = PL = Barrinfo if Country = US
Easyfind	Level of difficulty to find organic products	Easy = 1 Difficult = 0
EasyfindI	Interaction of "level of difficulty to find organic products" and country	= 0 if Country = PL = Easyfind if Country = US
Primary	Variable which states if individual is the primary shopper in the household or not	Primary shopper = 1 Not primary shopper = 0
PrimaryI	Interaction of "Primary" and country	= 0 if Country = PL = Primary if Country = US
WTP	Willingness to pay of the individual for organic products	Ranges from 0 to 3
WTPI	Interaction of "willingness to pay" and country	= 0 if Country = PL = WTP if Country = US

Table 2: Ordered probability model results.

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z	Mean of X
Freqcons	-4.651	2.109	-2.205	0.027	
Gender	0.154	0.421	0.367	0.713	0.593
GenderI	-0.242	0.456	-0.532	0.594	0.404
Eatbehav1	-0.669	0.189	-3.539	0.000	4.323
Eatbehav1I	0.574	0.221	2.597	0.009	3.255
Eatbehav2	0.281	0.201	1.399	0.161	2.842
Eatbehav2I	-0.239	0.218	-1.095	0.273	2.071
Eatbehav3	-0.178	0.161	-1.105	0.269	2.891
Eatbehav3I	0.140	0.178	0.787	0.431	2.171
Eatbehav4	-0.235	0.164	-1.429	0.153	3.613
Eatbehav4I	0.315	0.189	1.664	0.096	2.730
Yestgood	0.202	0.062	3.232	0.001	9.409
YestgoodI	-0.176	0.070	-2.521	0.011	6.839
Yestbad	-0.052	0.091	-0.570	0.568	7.292
YestbadI	0.026	0.100	0.259	0.795	5.438
Country	2.154	2.315	0.930	0.352	0.733
Superm	0.348	0.125	2.780	0.005	2.908
SupermI	0.241	0.141	1.708	0.087	2.174
Orgstore	-0.361	0.174	-2.076	0.037	1.664
OrgstoreI	0.544	0.194	2.802	0.005	1.237
Directorg	0.387	0.117	3.292	0.001	1.398
DirectorgI	-0.332	0.163	-2.034	0.041	0.916
Farmarkt	0.269	0.136	1.978	0.048	2.057
FarmarktI	-0.365	0.167	-2.183	0.029	1.237
Subjknow	-0.074	0.185	-0.401	0.688	2.762
SubjknowI	0.393	0.203	1.929	0.053	1.985
Objknow	0.232	0.125	1.846	0.064	5.805
ObjknowI	-0.304	0.135	-2.257	0.024	4.186
Factdifferent	0.372	0.181	2.048	0.040	2.753
FactdifferentI	-0.453	0.197	-2.298	0.021	2.020
Factsupport	-0.209	0.193	-1.084	0.278	3.240
FactsupportI	0.437	0.216	2.026	0.042	2.438
Factqualit	0.140	0.286	0.489	0.624	3.810
FactqualitI	-0.108	0.312	-0.346	0.729	2.744
Factpest	-0.498	0.316	-1.574	0.115	3.742
FactpestI	0.496	0.333	1.492	0.135	2.681
Facthealth	0.450	0.330	1.364	0.172	3.885
FacthealthI	-0.225	0.352	-0.638	0.523	2.793
Factenvir	0.665	0.260	2.553	0.010	3.810
FactenvirI	-0.860	0.282	-3.043	0.002	2.776
Barravail	-0.057	0.215	-0.268	0.788	3.498
BarravailI	0.049	0.232	0.213	0.831	2.527
Barrcost	-0.383	0.207	-1.844	0.065	4.226
BarrcostI	0.402	0.232	1.728	0.084	3.088
Barrvariet	-0.332	0.201	-1.655	0.098	3.111
BarrvarietI	0.210	0.224	0.935	0.349	2.249
Barrinfo	0.116	0.209	0.556	0.578	3.303
BarrinfoI	-0.083	0.228	-0.366	0.714	2.375
Easyfind	-0.837	0.415	-2.017	0.043	0.601
EasyfindI	1.063	0.455	2.337	0.019	0.521
Primary	1.232	0.718	1.716	0.086	0.914
PrimaryI	-1.183	0.774	-1.528	0.126	0.676
WTP	0.282	0.210	1.342	0.179	3.785
WTPI	-0.293	0.221	-1.323	0.186	2.773

Table 3: Summary of marginal effects for ordered probability model.

Variable	Y=00	Y=01	Y=02	Y=03
Freqcons	.0000	.0000	.0000	.0000
Gender	-.0585	.0264	.0305	.0016
GenderI	.0921	-.0422	-.0475	-.0024
Eatbehav1	.2527	-.1114	-.1344	-.0070
Eatbehav1I	-.2171	.0957	.1154	.0060
Eatbehav2	-.1062	.0468	.0565	.0029
Eatbehav2I	.0903	-.0398	-.0480	-.0025
Eatbehav3	.0676	-.0298	-.0359	-.0019
Eatbehav3I	-.0531	.0234	.0282	.0015
Eatbehav4	.0890	-.0392	-.0473	-.0024
Eatbehav4I	-.1192	.0525	.0634	.0033
Yestgood	-.0765	.0337	.0407	.0021
YestgoodI	.0667	-.0294	-.0354	-.0018
Yestbad	.0197	-.0087	-.0105	-.0005
YestbadI	-.0098	.0043	.0052	.0003
Country	-.7114	.4250	.2698	.0167
Superm	-.1315	.0579	.0699	.0036
SupermI	.1365	-.0602	-.0726	-.0038
Orgstore	-.1462	.0644	.0777	.0040
OrgstoreI	-.1018	.0449	.0541	.0028
Directorg	-.0912	.0402	.0485	.0025
DirectorgI	-.2057	.0907	.1094	.0057
Farmarkt	.1258	-.0554	-.0669	-.0035
FarmarktI	.1380	-.0608	-.0734	-.0038
Subjknow	.0281	-.0124	-.0149	-.0008
SubjknowI	-.1485	.0655	.0789	.0041
Objknow	-.0878	.0387	.0467	.0024
ObjknowI	.1152	-.0508	-.0612	-.0032
Factdifferent	-.1405	.0619	.0747	.0039
FactdifferentI	.1714	-.0755	-.0911	-.0047
Factsupport	.0792	-.0349	-.0421	-.0022
FactsupportI	-.1654	.0729	.0879	.0046
Factqualit	-.0530	.0234	.0282	.0015
FactqualitI	.0408	-.0180	-.0217	-.0011
Factpest	.1883	-.0830	-.1001	-.0052
FactpestI	-.1877	.0827	.0998	.0052
Facthealth	-.1703	.0751	.0905	.0047
FacthealthI	.0851	-.0375	-.0452	-.0023
Factenvir	-.2513	.1108	.1336	.0069
FactenvirI	.3251	-.1433	-.1728	-.0089
Barravail	.0218	-.0096	-.0116	-.0006
BarravailI	-.0187	.0082	.0099	.0005
Barrcost	.1447	-.0638	-.0769	-.0040
BarrcostI	-.1519	.0670	.0808	.0042
Barrvariet	.1256	-.0554	-.0668	-.0035
BarrvarietI	-.0793	.0350	.0422	.0022
Barrinfo	-.0440	.0194	.0234	.0012
BarrinfoI	.0316	-.0139	-.0168	-.0009
Easyfind	.2993	-.1048	-.1817	-.0128
EasyfindI	-.3880	.1663	.2081	.0136
Primary	-.4557	.3144	.1367	.0047
PrimaryI	.3919	-.0856	-.2786	-.0277
WTP	-.1067	.0470	.0567	.0029
WTPI	.1108	-.0488	-.0589	-.0030

Vesna D. JABLANOVIĆ*

Agricultural monopolistic competitor and the Pigovian tax

A monopolistically competitive agricultural market structure has some features of competition and some features of monopoly. Monopolistic competition has the following attributes: (a) many sellers; (b) product differentiation; and (c) free entry. In the long-run equilibrium, price equals average total cost, and the agricultural firm earns zero economic profit. The aim of this paper is to construct a relatively simple chaotic long-run monopolistic competitor's agricultural output growth model that is capable of generating stable equilibria, cycles or chaos. A key hypothesis of this work is based on the idea that the coefficient $\pi = \frac{d+m}{(\alpha-1)b\left(1+\frac{1}{e}\right)}$ plays a crucial role in explaining local stability of the monopolistic competitor's agricultural output, where d is the coefficient of the marginal cost function of the agricultural monopolistic competitor; b is the coefficient of the inverse demand function; a is the coefficient of average cost growth; m is the Pigovian tax rate; and e is the coefficient of the price elasticity of demand.

Keywords: monopolistic competition, agriculture, long-run, equilibrium conditions, the Pigovian tax rate, chaos

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Introduction

Monopolistic competition has characteristics of both competition and monopoly. Similar to competition, monopolistic competition has many firms, and free exit and entry. Similar to monopoly, the products are differentiated and each company faces a downward sloping demand curve. Monopolistic competition refers to a market situation with a relatively large number of sellers offering similar and differentiated products.

Food products are increasingly heterogeneous as firms are able to create and market branded products. As agricultural firms turn to new branded product development to defend market share, Boland *et al*. (2012) suggest that many of these industries arguably resemble monopolistically competitive industries. The subject of their study, prunes in the United States, is an example that is consistent with firms operating under monopolistic competition. There are several firms operating in the marketplace, there are no barriers to entry, prunes are sold as a successful brand, and demand curves are downward sloping.

According to Adam Smith (1776), the 'invisible hand' of the marketplace leads self-interested buyers and sellers in a market to maximise the total benefit that society can derive from a market. But market failures can still happen. When a transaction between a buyer and a seller directly affects a third party, the effect is called an externality. Namely, an externality refers to the uncompensated impact of one person's actions on the well-being of a bystander. It is a direct effect of the actions of one person or firm on the welfare of another person or firm, in a way that is not transmitted by market prices.

Externalities cause markets to be inefficient, and thus fail to maximise total surplus. In other words, negative externalities cause the socially optimal quantity in a market to be less than the equilibrium quantity. On the other hand, positive externalities cause the socially optimal quantity in a market to be greater than the equilibrium quantity.

In this theoretical framework, we can say that the quantity produced and consumed in the agricultural market equilibrium is efficient in the sense that it maximises the sum of producer and consumer surplus. However, if an agricultural firm contributes to air, land or water pollution (a negative externality), then the cost to society of producing agricultural products is larger than the cost to the producer. For each unit of agricultural output produced, the social cost includes the private costs of the producers plus the cost to those bystanders adversely affected by the pollution.

The government can internalise an externality by imposing a tax on the agricultural producer to reduce the equilibrium quantity to the socially desirable quantity. Internalising an externality involves altering incentives so that people take account of the external effects of their actions. When externalities are significant and private solutions are not found, government may attempt to solve the problem through: (a) command and control policies (these usually take the form of regulations that forbid or require certain behaviours); and (b) market-based policies (government uses Pigovian taxes and subsidies to correct the effects of a negative externality). In other words, public policies for externalities are: (a) regulation; (b) taxes and subsidies; (c) assign property rights; and (iv) pollution permits.

Linear analysis used in the theory of economic growth presumes an orderly periodicity that rarely occurs in an economy. In this sense, it is important to construct deterministic, nonlinear economic dynamic models that elucidate irregular, unpredictable economic behaviour. Chaos theory is used to prove that erratic and chaotic fluctuations can arise in completely deterministic models. Chaotic systems exhibit a sensitive dependence on initial conditions: seemingly insignificant changes in the initial conditions can produce large differences in outcomes. This is very different from stable dynamic systems in which a small change in one variable produces a small and easily quantifiable systematic change. Thus chaos embodies three important principles: (a) extreme sensitivity to initial conditions; (b) cause and effect are not proportional; and (c) nonlinearity.

Chaos theory started with Lorenz's (1963) discovery of complex dynamics arising from three nonlinear differential equations leading to turbulence in the weather system. Li and Yorke (1975) discovered that the simple logistic curve can exhibit very complex behaviour. Further, May (1976) described chaos in population biology. Chaos theory has been applied in economics by Benhabib and Day (1981, 1982), Day (1982, 1983, 1994), Grandmont (1985), Goodwin (1990), Medio (1993), Lorenz (1993) and Jablanovic (2011, 2012a, 2012b, 2012c), among many others. A number of nonlinear business cycle models use chaos theory to explain the complex motion of the economy.

The agricultural economics literature does not have any examples of the externalities analysis in an industry typified by monopolistic competition. The aim of this paper is to develop a theoretical framework of how externalities can influence long-run agricultural monopolistic competitor equilibrium. This is done by constructing a relatively simple chaotic long-run monopolistic competitor's agricultural output growth model that is capable of generating stable equilibria, cycles or chaos.

The model

In the model of the monopolistically competitive agricultural firm take the inverse demand function:

$$P_t = a - bQ_t \tag{1}$$

where P is the monopolistic competitor's agricultural price; Q is the monopolistic competitor's agricultural output; and a and b are coefficients of the inverse demand function.

Marginal revenue (line MR in Figure 1) is:

$$MR_t = P_t\left[1 + \left(\frac{1}{e}\right)\right] \tag{2}$$

where MR is marginal revenue; P is the monopolistic competitor's agricultural price; and e is the coefficient of the price elasticity of demand.

Further, suppose the quadratic marginal cost function for the monopolistically competitive agricultural firm is:

$$MC_t = c + dQ_t + fQ_t^2 \tag{3}$$

where MC (curve MC in Figure 1) is marginal cost; Q is the monopolistic competitor's agricultural output; and c, d and f are coefficients of the quadratic marginal cost function.

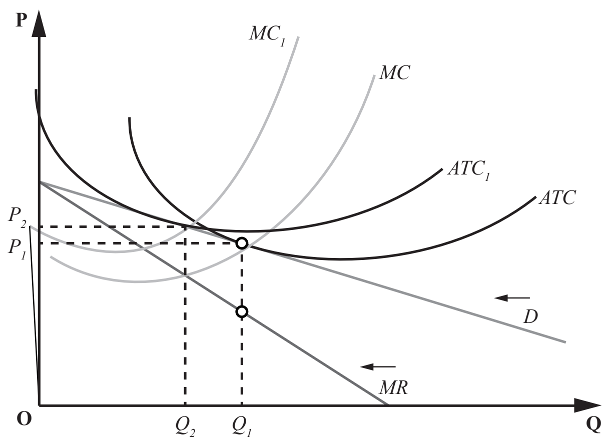

Figure 1: Long-run profit maximisation and new long-run equilibrium of a monopolistically competitive agricultural firm and the new marginal cost curve which includes the Pigovian tax.

Because of the externality, the cost to society of producing an agricultural product is larger than the cost to the agricultural producer. For each unit of agricultural output produced, the social cost includes the private costs of the agricultural producer plus the costs to those bystanders adversely affected by the water, land or air pollution. The marginal social costs take into account the external costs imposed on society by the producer. An agricultural producer would take the costs of pollution into account when deciding how much agricultural product to supply because the Pigovian tax now makes him/her pay for these external costs.

It is supposed that the Pigovian tax is:

$$T_t = mQ_t \tag{4}$$

where T is the Pigovian tax; Q is the agricultural output; and m is the Pigovian tax rate. In this sense, the marginal cost function for the agricultural monopolistic competitor is:

$$MC_t = c + (d + m)Q_t + fQ_t^2 \tag{5}$$

where MC (curve MC_1 in Figure 1) is the marginal cost; Q is the agricultural output; c, d and f are coefficients of the quadratic marginal private cost function; and m is the Pigovian tax rate.

The long-run equilibrium of agricultural monopolistically competitive industry generates two equilibrium conditions. Firstly, a monopolistic competitor maximises profit by producing the quantity at which marginal revenue equals marginal cost. Thus the profit-maximising condition is that:

$$MR_t = MC_t \tag{6}$$

In an agricultural monopolistically competitive market, price exceeds marginal cost because profit maximisation requires marginal revenue to equal marginal cost and because the downward-sloping demand curve makes marginal revenue less than the price. Equivalently, equation (7) expresses price directly as a mark-up over marginal cost, i.e.:

$$P_t = \frac{MC_t}{\left(1 + \frac{1}{e}\right)} \tag{7}$$

The second condition, price (P) equal to average cost (ATC):

$$P_t = ATC_t \tag{8}$$

means that each agricultural firm in the industry is earning only a normal profit. Economic profit is zero and there is no economic loss.

In accordance with (7) and (8) we obtain (curve ATC in Figure 1):

$$ATC_t = \frac{MC_t}{\left(1 + \frac{1}{e}\right)} \tag{9}$$

Further:

$$ATC_{t+1} = ATC_t + \Delta ATC \tag{10}$$

i.e.:

$$(1-\alpha)ATC_{t+1} = ATC_t \quad (11)$$

Substituting (7) and (8) in (11) gives (curve ATC_1 in Figure 1):

$$(1-\alpha)P_{t+1} = \frac{MC_t}{\left(1+\frac{1}{e}\right)} \quad (12)$$

Substituting (1) in (12) gives:

$$(1-\alpha)(a-bQ_{t+1}) = \frac{MC_t}{\left(1+\frac{1}{e}\right)} \quad (13)$$

Firstly, it is supposed that a = 0 and c =0. By substitution one derives:

$$Q_{t+1} = \frac{d+m}{b(\alpha-1)\left(1+\frac{1}{e}\right)}Q_t - \frac{f}{b(1-\alpha)\left(1+\frac{1}{e}\right)}Q_t^2 \quad (14)$$

Further, it is assumed that the long-run agricultural monopolistic competitor's output is restricted by its maximal value in its time series. This premise requires a modification of the growth law. Now, the long-run agricultural monopolistic competitor's output growth rate depends on the current size of the long-run monopolistic competitor's output, Q, relative to its maximal size in its time series Q^m. We introduce q as $q = Q/Q^m$. Thus q ranges between 0 and 1. Again we index q by t, i.e. write q_t to refer to the size at time steps t = 0, 1, 2, 3, ... Now the growth rate of the long-run agricultural monopolistic competitor's output is measured as:

$$q_{t+1} = \frac{d+m}{b(\alpha-1)\left(1+\frac{1}{e}\right)}q_t - \frac{f}{b(1-\alpha)\left(1+\frac{1}{e}\right)}q_t^2 \quad (15)$$

This model given by equation (15) is called the logistic model. For most choices of α, b, d, f, m and e there is no explicit solution for (15). Namely, knowing α, b, d, f, m and e and measuring q_0 would not suffice to predict q_t for any point in time, as was previously possible. This is at the heart of the presence of chaos in deterministic feedback processes. Lorenz (1963) discovered this effect - the lack of predictability in deterministic systems. Sensitive dependence on initial conditions is one of the central ingredients of what is called deterministic chaos.

This kind of difference equation (15) can lead to very interesting dynamic behaviour, such as cycles that repeat themselves every two or more periods, and even chaos, in which there is no apparent regularity in the behaviour of q_t. This difference equation (15) will possess a chaotic region. Two properties of the chaotic solution are important: firstly, given a starting point q_0 the solution is highly sensitive to variations of the parameters α, b, d, f, m and e; secondly, given the parameters α, b, d, f, m and e the solution is highly sensitive to variations of the initial point q_0. In both cases the two solutions are for the first few periods rather close to each other, but later on they behave in a chaotic manner.

The logistic equation

The logistic map is often cited as an example of how complex, chaotic behaviour can arise from very simple non-linear dynamic equations. The logistic model was originally introduced as a demographic model by Pierre François Verhulst. It is possible to show that iteration process (Figure 2) for the logistic equation:

$$z_{t+1} = \pi z_t(1-z_t), \pi \in [0,4], z_t \in [0,1] \quad (16)$$

is equivalent to the iteration of growth model (15) when we use the following identification:

$$z_t = \frac{(\alpha-1)f}{(1-\alpha)(d+m)}q_t \qquad \pi = \frac{d+m}{(\alpha-1)b\left(1+\frac{1}{e}\right)} \quad (17)$$

Using (15) and (17) we obtain:

$$z_{t+1} = \frac{(\alpha-1)f}{(1-\alpha)(d+m)}q_{t+1} =$$
$$= \frac{(\alpha-1)f}{(1-\alpha)(d+m)}\left[\frac{d+m}{(\alpha-1)b\left(1+\frac{1}{e}\right)}q_t - \frac{f}{(1-\alpha)b\left(1+\frac{1}{e}\right)}q_t^2\right] =$$
$$= \frac{f}{(1-\alpha)b\left(1+\frac{1}{e}\right)}q_t - \frac{(\alpha-1)f^2}{(1-\alpha)^2 b(d+m)\left(1+\frac{1}{e}\right)}q_t^2$$

On the other hand, using (15) and (16) we obtain:

$$z_{t+1} = \pi z_t(1-z_t) =$$
$$= \left[\frac{d+m}{(\alpha-1)b\left(1+\frac{1}{e}\right)}\right]\left[\frac{(\alpha-1)f}{(1-\alpha)(d+m)}\right]q_t\left\{1-\left[\frac{(\alpha-1)f}{(1-\alpha)(d+m)}\right]q_t\right\} =$$
$$= \frac{f}{(1-\alpha)b\left(1+\frac{1}{e}\right)}q_t - \frac{(\alpha-1)f^2}{(1-\alpha)^2 b(d+m)\left(1+\frac{1}{e}\right)}q_t^2$$

Thus we have that iterating

$$q_{t+1} = \frac{d+m}{b(\alpha-1)\left(1+\frac{1}{e}\right)}q_t - \frac{f}{b(1-\alpha)\left(1+\frac{1}{e}\right)}q_t^2$$ is really

the same as iterating $z_{t+1} = \pi z_t(1-z_t)$ using

$z_t = \frac{(\alpha-1)f}{(1-\alpha)(d+m)}q_t$ and $\pi = \frac{d+m}{(\alpha-1)b\left(1+\frac{1}{e}\right)}$.

It is important because the dynamic properties of the logistic equation (16) have been widely analysed (Li and Yorke, 1975; May, 1976).

It is obtained that:

(i) For parameter values 0 < π < 1 all solutions will converge to z = 0;
(ii) For 1 < π < 3.57 there exist fixed points the number of which depends on π;
(iii) For 1 < π < 2 all solutions monotonically increase to z = (π – 1) / π;
(iv) For 2 < π < 3 fluctuations will converge to z = (π – 1) / π;

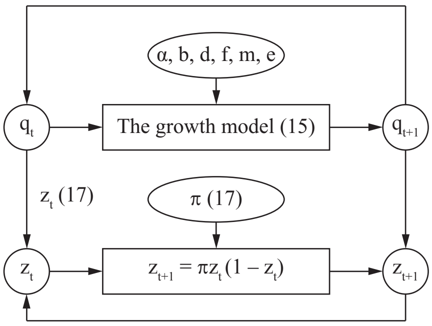

Figure 2: Two quadratic iterators running in phase are tightly coupled by the transformations indicated.

(v) For $3 < \pi < 4$ all solutions will continuously fluctuate;

(vi) For $3.57 < \pi < 4$ the solution becomes ‘chaotic’ which means that there exist a totally aperiodic solution or periodic solutions with a very large, complicated period. This means that the path of z_t fluctuates in an apparently random fashion over time, not settling down into any regular pattern whatsoever.

Conclusion

This paper suggests the use of the simple chaotic model of a profit maximising agricultural monopolistic competitor in predicting the long-run fluctuations of the agricultural monopolistic competitor’s output. The model (15) has to rely on specified parameters α, b, d, f, m and e, and an initial value of the long-run monopolistic competitor’s output, q_0. But even slight deviations from the values of these parameters and the initial value of the long-run agricultural monopolistic competitor’s output show the difficulty of predicting a long-term behaviour of the long-run agricultural monopolistic competitor’s output, q_0. A key hypothesis of this work is based on the idea that the coefficient $\pi = \dfrac{d+m}{(\alpha-1)b\left(1+\frac{1}{e}\right)}$ plays a crucial role in explaining local stability of the long-run agricultural monopolistic competitor’s output where d is the coefficient of the marginal cost function of the agricultural monopolistic competitor; b is the coefficient of the inverse demand function; α is the growth coefficient of the average cost, m is the Pigovian tax rate and e is the coefficient of the price elasticity of demand. The quadratic form of the marginal cost function of the agricultural monopolistic competitor is an important ingredient of the presented chaotic long-run monopolistic competitor’s output growth model (15).

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Extended summary

KESZTHELYI Szilárd and PESTI Csaba

Results of Hungarian FADN Farms 2011

The Hungarian Farm Accountancy Data Network (FADN) system consists of 1537 individual and 388 corporate sample farms. These farms are representative of the approximately 106 thousand Hungarian agricultural commodity producers in terms of farm type, economic size and legal form. The Research Institute of Agricultural Economics (AKI) is responsible for the continuous operation, central data processing, publishing and dissemination of information, and development of the system, and for maintaining contacts with the European Union. Each year valuable micro-economic data are collected on the costs and incomes of the farms in the framework of FADN. The results of this work are published annually by AKI in book form. The publication 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.

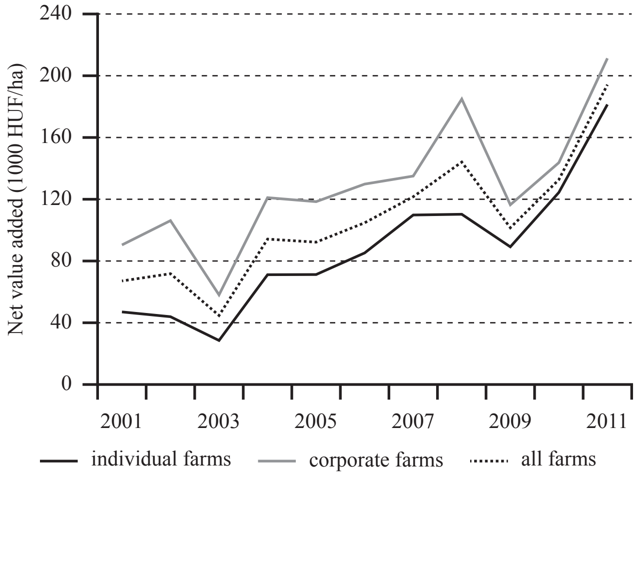
The book starts with a short introduction. This is followed by a descriptive section that defines the economic terms and indicators used and describes the method of deriving the economic results in agriculture. The next section deals with the profitability and the change in assets in the Hungarian agricultural sector as a whole. The results from individual and corporate farms are then described separately in different chapters, focusing on the factors influencing profitability. In the final chapter the development of land prices and land rental fees are studied across the different FADN regions of Hungary.

The book is supplemented in the annexes with 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 of the book can be summarised as follows.

The increase in profitability of the agricultural sector following the decline in 2009 has further continued. Net value added in 2011 has reached a new peak of HUF 194.6 thousand per hectare, this being a 47 per cent increase over 2010 (Figure 1). The main cause of this significant improvement in 2011 was a concurrent increase in yields and prices. Costs went up by just 16 per cent. Bigger subsidies have also contributed to the growing profits. While the profits of individual farms increased by 71 per cent, in the case of corporate farms the rate of growth was 139 per cent – more than double – of the previous year's figure.

Figure 1: Net value added per one hectare for individual, corporate and all farms in Hungary, 2001-2011.



Profits have increased for all farm types except for field and indoor vegetables producers, due to the scare across Europe over cucumbers contaminated with *E. coli*. The highest increase was detected for wine producers and grape growers as well as for beef and sheep herders.

Across all farms, investments increased by 31 per cent while the accumulation of assets (net investment) grew nearly five times (HUF 16.3 thousand per hectare) but still did not reach the level of 2009. The recovery in investments was mainly induced by the significant growth in purchases of machinery and other technological equipment (64 per cent) but money was also put into buildings (27 per cent) and breeding animals (23 per cent). Unfinished investments have presented only moderate (5 per cent) growth. The level of investments – as in every year – is closely related to the availability of investment subsidies. The sum of investment subsides per hectare has risen by 7 per cent since 2010.

Investments in individual farms increased by 1.8 times and amounted to HUF 54.9 thousand per hectare meaning that in 2011 real technological developments took place. Investments in corporate farms have also increased and amounted to HUF 113.6 thousand per hectare. This amount was more than double the value of the individual farms.

The effects of the financial crisis on agriculture are still noticeable. Despite growing incomes, credit lending has fallen further. Investments have been financed by own sources at a growing rate.

The increase of land prices continued in 2011. The price of arable land went up by 13 per cent – well above the inflation rate – to HUF 534.8 thousand per hectare. In connection with that, land rental fees also grew, by 15.2 per cent. For renting one hectare of arable land in 2011, farmers had to pay on average HUF 30.8 thousand.

The findings of this book are mainly targeted at agricultural policy makers and researchers, but can also be of value to producers.

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.

JUHÁSZ Anikó, JANKUNÉ KÜRTHY Gyöngyi, KŐNIG Gábor, STAUDER Márta and TUNYOGINÉ NECHAY Veronika

Effects of the production of private label goods on the food retail trade and its suppliers

Agroeconomic Book, published 2010

The rapid proliferation of private labels can be viewed as a symbol of tension which displays all of the typical elements of competitive struggle between the buyers and suppliers in the food supply chain. Our secondary research aimed to collect and analyse the theoretical and empirical knowledge about the private label brand success story and also to describe the present situation with the help of statistical tools. Our primary research focused on understanding the strategy and views of food retailers and suppliers about private labels.

FEKETE Géza and KISS György (eds)

Production data for the major Hungarian food products, 2010

Agroeconomic Information, published 2012

This publication presents data, for a wide selection of products, on the food processing industry's production costs and sales income in 2010 compared to the previous year. Firstly the price changes for the major food product groups are briefly summarised and secondly tabular data for individual food products are presented. These data show that in 2010 the production costs of meat products generally decreased. This is generally true for all products as the manufacturers aimed to reduce their production costs while trying to maintain or increase the sales price. But in the meat industry product group in 2010 there were mainly sales price reductions as well. In the poultry, dairy, and milling and baking industries, as well as the production of pasta products, increases in raw material costs, and more or less in total production costs too, compared to the previous period, can be observed. The results usually varied between products within sectors, with the exception of the milling industry, for example, where poorer results were associated with all of the products for which data are presented. However, a positive example is the production of pasta. As in 2009, all presented products produced a profit, but in addition in 2010 these profits were increased.

BÉLÁDI Katalin and KERTÉSZ Róbert

The cost and income situation of the major Hungarian agricultural products in 2010

Agroeconomic Information, published 2012

This publication examines the cost and income situation of the major agricultural products in 2010 on the basis of data from the farms of the Hungarian FADN system. The processed data concerns the so-called 'determinant producer farms' that provide the dominant part of domestic production. In addition to the mean data this book includes the results of different farming groups. The changes in the cost and income situation of arable crops, horticultural products (fruit and vegetables) and livestock products are analysed in separate chapters. Due to the extremely wet weather conditions the agricultural sector suffered serious damage and the average yield of arable crops and horticultural products generally decreased. In the case of arable crops the higher price mostly did not compensate for the increased unit cost that resulted from the yield losses. Despite this, owing to subsidies the per-hectare profit of enterprises significantly increased in the case of arable crops compared to 2009. The average sales price of fruit and vegetable products also increased in line with the increasing unit production cost, and almost all of the fruit and vegetable products realised an increased profit. In case of livestock products only the price of hens' eggs did not provide a margin of income over the costs of production, in contrast with the other major livestock products, all of which achieved a profit in 2010.

Studies in Agricultural Economics

Information for authors

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Audience

Researchers, academics, policy makers and practitioners in agricultural economics and rural development, especially in eastern central and south eastern Europe.

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