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Foreword

I am very pleased to announce that, beginning with content published in 2015, *Studies in Agricultural Economics* is included in the Thomson Reuters™ Web of Science™ Core Collection. The journal has met the high standards of an objective evaluation process by the global leaders in scientific indexing that takes into account, among other criteria, peer review, timely publishing, novel content, international diversity and citation impact. In Web of Science, *Studies in Agricultural Economics* will benefit from cover-to-cover indexing, cited reference indexing, subject category assignment, and indexing all authors and addresses.

This news represents a milestone in the continuing development of the journal. This year, *Studies in Agricultural Economics* published 23 papers, of which eight are by Hungarian authors, nine are from elsewhere in Europe and six are from outside Europe. By contrast, in 2010 14 papers were published, of which 13 were by Hungarian authors and one came from elsewhere in the European Union. The greater diversity of the journal's content is reflected in the contributions to this issue.

This issue starts with an impact assessment in Albanian agriculture by Skreli, Imami, Jámbor, Zvyagintsev and Çera. This shows that the government subsidy scheme had a net positive impact on areas planted with olives and grapevines, and on part-time on-farm employment, but that no significant net impact was observed regarding farm size and crop yields. They recommend that new support schemes should be anticipated by an in-depth market outlook.

In the context of increasing interest in renewable energy sources, including biofuels, Potori and Stark assessed the influence of crude oil futures on new crop sunflower seed futures in Hungary. Their results suggest that standard cointegration analysis may not be appropriate for multiannual price series of agricultural commodities with strong seasonality in production because it will not capture the periodical shocks in supply and demand.

Noting that environmental management is an increasingly critical criterion in the allocation of farm subsidies, Mészáros, Hufnagel, Balázs, Bíró, Jancsovszka, Podmaniczky and Sipos describe the development and field testing of the 'Green-point system' of farm environmental performance indicators. Farms in Hungary performed best for *plant protection* and *diversity of crop production*, while *nutrient management* is the most critical area.

In the first of two papers from Poland, Chmieliński and Karwat-Woźniak report that the socio-demographic structure of the farming population is still favourable and the educational level of farming family members has been improving. However, hidden unemployment in the countryside adversely affects restructuring and modernisation processes in agricultural holdings. Employment on family farms has a decreasing role in reducing the imbalance in the rural labour market in Poland.

Gospodarowicz finds that similar levels of technical or social infrastructure are associated with a significantly higher level of economic development in urban and urban-rural *gminas* (municipalities) than in rural *gminas*. Sustainable development is largely the result of institutional factors related to infrastructure. It is therefore advisable to move away from a purely redistributive approach towards targeted territorial support of the development potential of municipalities.

Pitter, Jóźwiak, Martos, Kaló and Vokó evaluate whether health technology assessment methodology is suitable for quantitative decision support in food safety risk analysis. They suggest that cost-utility analysis could better serve the priority settings in food safety risk management than the currently (rarely) applied cost-benefit analysis. The shared methodology would pave the way to the integration of health and food policies.

This issue concludes with two papers from Ethiopia on the topic of environmental management. Ahmed analysed the relationships between the adoption by maize farmers of different input-intensive technologies and natural resource management practices. Both positive and negative relationships were identified. Educational level of the household, family size and other factors are shown to influence farmers' decisions to adopt a technology or practice.

Finally, Geta, Mezgebo and Zeleke measured the willingness of urban and rural households to pay for improved drainage basin management, and the factors affecting households' willingness to pay. They conclude that that any drainage basin management system needs to consider the monthly income, location, sex, initial bids, occupation, marital status and educational level of the affected households.

AKI's intention is to further develop *Studies in Agricultural Economics* as a good quality, regional, English language journal that publishes original research and other material on agricultural economics and rural development, and which is available in both printed and electronic formats. I look forward to receiving your papers for publication in future issues of the journal.

Andrew Fieldsend
Budapest, November 2015

Engjell SKRELI*, Drini IMAMI*, JÁMBOR Attila, Dmitry ZVYAGINTSEV*** and Gentjan ÇERA***

The impact of government subsidies on the olive and vineyard sectors of Albanian agriculture

This study analyses the impact of government subsidy schemes on farm production capacity, technical efficiency and use of idle production factors (land and labour) in the olive and vineyard sectors of Albanian agriculture. The paper uses a quasi-experimental design by applying a propensity score matching method based on a structured survey conducted in 2013. The results show that the government subsidy scheme had a net positive impact on areas planted with olives and grapevines, and on part-time on-farm employment. On the other hand, no significant net impact was observed regarding farm size and crop yields. This is the first time that such an in-depth impact assessment of government subsidies in the agriculture sector has been carried out in Albania, thus the results will be useful both for scientists and policy makers in agriculture and rural development.

Keywords: agricultural subsidies, impact assessment, propensity score matching

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Introduction

Analysing subsidies has always been an issue of debate in agricultural economics. On the one hand, subsidies provide incentives to enable changes that cannot otherwise happen. On the other hand, agricultural economists are sceptical regarding the effectiveness of agricultural subsidies, often considering them too expensive, poorly targeted, distortive and path dependent (Baltzer and Hansen, 2011).

Although agricultural policy programmes are hard to evaluate for several reasons (e.g. conflicting objectives, lack of clear goals, indirect effects, political interests etc.), many empirical studies have analysed the effects of agricultural policies on farm structures (Ahearn *et al*., 2005; Kim *et al*., 2005; Feichtinger and Salhofer; 2013). Despite the obvious importance of the topic in agricultural policy making, Ahearn *et al*. (2005) conclude that "our understanding of how government policies have affected the structure of agriculture, or how future policies could be designed to promote specific outcomes, remains limited" (p.1182).

In line with the diversity of agricultural policy programmes, empirical studies analysed different aspects of government subsidies in agriculture. Baltzer and Hansen (2011), for instance, analysed large scale *input* subsidy programmes in Sub-Saharan Africa and concluded that the popularity of these subsidies is mainly due to their political attractiveness rather than economic superiority. Banful (2011) went further, suggesting that political powers 'watered down' the effectiveness of fertiliser subsidy programmes in Ghana. By contrast, Huang *et al*. (2011), analysing the impact of China's agricultural subsidies, found that input subsidies appear to be non-distorting in terms of producer decisions.

Rada and Valdes (2012) showed that the benefits of agricultural research have been most rapidly adopted by the most efficient farms, while other public policies including rural credit and infrastructure investments, favoured 'average' producers. Minviel and Latruffe (2014) found that targeted investment subsidies were positively associated with farm's technical efficiency, while Bojnec and Latruffe (2013) found that agricultural subsidies reduced the technical efficiency of Slovenian farms but improved their profitability. Zhu and Lansink (2010) analysed the impact of European Union (EU) Common Agricultural Policy (CAP) subsidies on the technical efficiency of crop farms in selected EU Member States and also found mixed results.

Ciaian and Swinnen (2006) analysed the *welfare effects* of agricultural subsidies in the ten Member States that joined the EU in 2004 by analysing their land markets and found land-related payments ineffective and distortive. In an overview on the influence of agricultural support on agricultural land prices, Feichtinger and Salhofer (2013) concluded that a considerable share of farm subsidies were absorbed by the land owners rather than by the operating farmers.

Kaditi (2013) analysed the impact of the CAP reforms on *farm labour structure* in Greece and found that agricultural support measures negatively affected demand for both family and hired labour. The paper also found that structural labour adjustments were the result of farm characteristics such as farm size and location. In their analysis of the effects of the 2003 reform of the CAP on Irish farmers' off-farm labour market decisions, Hennessy and Rehman (2008) found that decoupling of direct payments was likely to increase the probability of farmers participating in the off-farm employment market and that the amount of time allocated to off-farm work would increase.

Brady *et al*. (2009) analysed the impact of decoupled direct payments on *biodiversity* and landscape and found that eliminating the link between support payments and production had only limited negative consequences for the landscape. They suggested that these effects could be offset by strengthening (CAP Pillar II) agri-environmental schemes. Mayrand *et al*. (2003), investigating the environmental impacts of U.S. agricultural subsidy programmes, showed that higher subsidies had led to an intensification of agricultural production which is detrimental to environmental sustainability. In addition, they concluded that in most countries agricultural support remained largely concentrated on market price support and output/input-based payments, which are the most environmentally harmful categories of subsidies. Harvey and Hubbard's (2013) analysis of the political economy of animal welfare programmes found them to be inefficient. The authors suggested that conventional arguments for government interventions are misleading.

There is considerable criticism of the present policy systems, especially the major ones such as the CAP and the U.S. Farm Bill. Most authors find that most current agricultural subsidies are inefficient and out-dated, though there is no consensus how to reform them (see e.g. Chau and de Gorter, 2005; Harvey and Jambor, 2011; Tangermann, 2011).

Overall, the empirical findings are rather mixed. On the one hand, agricultural policy programmes have succeeded in raising farmers' use of inputs, productivity and incomes. On the other hand, they have been extremely expensive. Subsidies have tended to benefit those who are relatively well off and farmers have become dependent on continued government support.

In the above context, this article analyses the impact of Albanian agricultural subsidies on farm development and decision making. It adds to the existing literature in three ways: (a) it uses an up-to-date survey dataset; (b) it tests the effectiveness of agricultural subsidies in one country; and (c) it analyses agricultural subsidies in a country aiming to join the EU. To the best of our knowledge, it is the first time that such an in-depth analysis has been carried out for Albania.

This study focuses on the olive and vineyard sectors which are among the most important and fastest growing agri-food sectors in Albania. Olive production has increased significantly in recent years, from 27,600 tonnes in 2007 to about 100,000 tonnes in 2012. Since then, there has been a marked expansion of plantings stimulated by national support schemes and the number of olive tree production areas has increased by approximately 60 per cent. Grape production has also increased significantly, by almost one third compared to 2007 (MARDWA, 2014). Both sectors have absorbed significant government subsidies – they were the most important sectors that were targeted by the first subsidy support measures.

Hypotheses

Based the foregoing, the following hypotheses are advanced:

1. *Government subsidy has a positive impact on production capacity.* Standard microeconomic theory suggests that reduction in investment costs will lead to increased production capacity. Stiglitz's (1987) argument of subsidy 'incentive' supports the idea that subsidies in agriculture inevitably influence the behaviour to allocate effort and other resources to agriculture. Whereas 'early' agricultural programmes tend to encourage agricultural production growth, recent versions tend to decouple support from production levels (Anderson *et al.*, 2013; Anderson and Valenzuela, 2013). In this respect, we assume Albania's agricultural policy to be at the 'early' stage.
2. *Government subsidy will result in improved technical efficiency.* According to the empirical literature, the impact of subsidy on technical efficiency – output maximisation for unit of input – is rather mixed (Zhu and Lansink, 2010; Rada and Valdes, 2012; Bojnec and Latruffe, 2013; Minviel and Latruffe, 2014). Our results can contribute to the inconclusive debate on the impact of subsidy on technical efficiency.
3. *Government subsidy encourages land and labour use.* One of the justifications of trade protection for developing countries is that higher domestic prices will lead to an upward movement of the production possibility frontier as a result of bringing idle resources, namely land and labour, into the economic cycle. This is actually a 'second best' policy that solves the problem indirectly (Krugman and Obstfeld, 1994). Though investment subsidy is also a 'second best' policy (government supports farmers to increase the area planted without intervening directly in the land and labour market), it is closer to the 'problem source' and is therefore expected to motivate farmers to use idle resources. Furthermore, in Albania, a large share of agriculture land has not been subject to formal property registration (Zhllima and Imami, 2012), which makes access to finance and loan very difficult (lack of collateral). Thus, (in addition to loan guarantees) subsidies can be an important way of enabling such farmers to fund investments, which in turn can allow the use of idle land and labour as well as contribute to an increase in production capacity (hypothesis 1).

Methodology

Propensity score matching procedure

Quasi-experimental design using a propensity score matching (PSM) method was used to create two similar groups from a randomly-selected sample, one composed of subsidised farmers (treated group) and another composed of non-subsidised farmers (control group).

Conceptually, PSM is based on the counterfactual approach. From a pool of treated and control group subjects, PSM permits observations on treated subjects that are (on average) similar to the control group subjects on as many criteria as possible with the exception of the treatment itself. Following the work of Rosenbaum and Rubin (1983, 1985), Rubin and Thomas (1996), Sekhon (2011), and Ho *et al.* (2011), PSM has become an increasingly popular approach to estimate causal effects in impact evaluation.

PSM is a three-stage process. The *first stage* entails estimating the propensity score, which is the probability of receiving treatment conditional upon observed independent variables or covariates. This probability is found by regressing membership in the treated versus control group (dependent variable) on a set of observed independent (covariates or predictors) variables by means of a logit or probit regression.

In the propensity score procedure using logit regression, our dependent variable was 'S_2008', which is a dummy/binary variable taking the value 1 for farmers who have received government subsidy in 2008 and 0 for the ones not having received subsidy during the same year. The independent variables or covariates that were used to regress the membership to treatment versus control group are described in Table 1.

Table 1: Independent variables or covariates used in the logistic regression.

Variable	Type	Unit of measurement
Age of household head (HH)	Scale	Years
No. of family members working on the farm	Scale	Persons
Educational level of household head	Ordinal	1 = no education; 2 = elementary school (four years); 3 = mandatory school (nine years); 4 = agricultural high school; 5 = general / technical high school; 6 = university
Farm size in 2008	Scale	Dynyms*
Experience of HH head in the chosen activity	Scale	Years
Type of employment	Dummy	1 = farming as main employment, 0 = other employment as main employment
Sector dummy	Dummy	1 = vineyard; 0 = olives
County (qark**)	Dummy	1 = Fier; 0 = Shkodër

* One dynym is equal to 1000 m²
** A qark is a local government unit in charge of regional planning and development.
Source: own composition

The nearest neighbour matching procedure of MatchIt software (Ho *et al*., 2011), an R package was used to create two similar groups. Several matching procedures were run (simple matching, matching using 'caliper' 0.25[1], matching without caliper with replacement in control groups at ratio 2 (allowing matching of one control member for two treatment group members), and matching with replacement and caliper 0.25) before choosing the second as the one which better balances treated and control group.

The second stage is matching the treated subjects to the control subjects in such a way that the two groups are similar for all covariates represented by the propensity score measure. In general this entails matching treated with control individuals using similar propensity scores. Various algorithms are available for the matching procedure, including nearest neighbour matching with replacement and without replacement (one treated case for one control case), radius matching, kernel matching, stratification matching and others.

An important tool to assess whether covariate balance has been achieved is the standardised absolute bias, which is calculated as absolute bias:

$$Absolute\ bias = \frac{\bar{X}_{treated} - \bar{X}_{control}}{\sqrt{\frac{S^2_{treated} + S^2_{control}}{2}}} \quad (1)$$

where $\bar{X}_{treated}$ and $\bar{X}_{control}$ are the means of a given covariate for the treated and the control subject, respectively. Likewise, $S^2_{treated}$ and $S^2_{control}$ are the respective standard deviations of the given covariate. Rosenbaum and Rubin (1985) have suggested that differences greater than 20 per cent should be regarded as unacceptable.

Two groups of 100 farmers – each one treated and one control – were formed by matching the propensity scores. The remaining 56 farmers, nine subsidised and 47 non-subsidised, were excluded from the analysis. Table 2 summarises the similarity of treated and control groups before and after matching.

Table 2: Statistics for the similarity of treated and control groups of farmers before and after using the *m.out_caliper 0.25* matching procedure**.**

	Before matching	After matching
Number of observations	256	200
Mean absolute bias	0.08	0.03
Maximum absolute bias	0.29	0.12
N variables with absolute bias > 0.15	2	0
Mean difference significant at p < 0.05	0	0

Source: own calculations

Table 3: Dependent and independent variables used to measure net treatment effect.

Concept	Dependent variable	Independent variable	Unit of measurement
Government subsidy	-	Subsidy in 2008	Dummy variable, taking the value 1 for treated farmers and 0 for control farmers
Production capacity	Area under olives and vineyards (2012)	Area under olives and vineyards (2008)	Dynyms
Technical efficiency	Yield per hectare (2012)	Yield per hectare (2008)	Tonnes
Farm size	Area per farm (2012)	Area per farm (2008)	Dynyms
Part-time on-farm employment	Part-time farmers (2012)	Part-time farmers (2008)	Number of farmers

Source: own composition

Members of the two groups of 100 farmers are similar in terms of average age of household head (55.5 years for the control group cf. 56.5 for the treatment group). Although the number of family members working on the farm is slightly higher for the control group (2.35) than for the treated group (2.30), the difference is not statistically significant. Similarity is also observed in terms of education – the median value for both groups is 4 (corresponding to agriculture high school) and the distribution through the different education levels is similar. The average farm size around 15 dynym for both groups. The experience in farming is slightly lower for the control group (26.7 years) than for the treated group (29.5 years) but the difference is statistically not significant. The groups are also similar in terms of main employment with on-farm self-employment being the most frequent main employment. In terms of sectors, 109 farmers are olive farmers and 91 farmers are vineyard farmers. The allocation of farmers by qark is equal for both the control and treated groups.

The *third stage* entails measuring the net treatment effect. We do so by running simple linear regressions to find out whether the subsidy has had any statically significant impact (Oakes and Feldman, 2001; Onur, 2006) on the considered outcomes. The linear regression takes the form:

$$Y = \alpha + b_1 X + b_2 T + \varepsilon \quad (2)$$

where Y is the post-score of an outcome variable, α is the estimated intercept, X is the pre-test score of the same variable, and T is a dummy variable taking value 1 for treatment

[1] Caliper, the allowed difference in propensity score, is expressed in standard deviations of average propensity scores.

and 0 for control group. The b_2 coefficient associated with T (Treatment) provides a measure of net treatment effect.

Four regressions were run to measure net treatment effects of government subsidy on production capacity, technical efficiency, farm size and part-time on-farm employment. The dependent variables are represented by data for 2012 while the independent variables are represented by subsidy in 2008 and data for 2008 (Table 3).

Data

A face-to-face survey of 119 vineyard farmers and 137 olive farmers was conducted in 2013 using a structured questionnaire that was tested and accordingly adjusted before being used for data collection. For practical reasons, our analysis was confined to two counties (Shkodër and Fier) out of 12 that made up Albania at that time. The sectors and areas were selected on the basis of three criteria: (a) amount of government subsidy – Shkodra and Fier have both received significant financial support for establishing olives and vineyards, and the money allocated to these sectors in these counties has been substantial – that to olives has been more than half (55 per cent) of all such funding in Fier and slightly less than one third (32 per cent) in Shkodër; (b) sector potential to reveal at least some impact in the four years from 2008 to 2012; and (c) regional representativeness, considering counties from both southern (Fier) and northern (Shkodër) Albania.

Communes and village selection was based on frequency of supported beneficiaries using the information provided by the Ministry of Agriculture, Food and Consumer Protection (MAFCP). Beneficiaries (subsidised farmers) were selected randomly based on lists provided by the Regional Department of Agriculture (extension service) while non-beneficiaries (non-subsidised farmers) were identified using a quasi-random selection, following a random route procedure. Interviews were conducted by well-trained postgraduate students of the Agricultural University of Tiranë. Their work was facilitated by MAFCP staff (extension experts). The research team technically supervised the whole process, including the survey implementation.

Results

In this section, hypothesis 1 (effect of government subsidy on production capacity) is operationalised as area planted with olives and vineyards, hypothesis 2 (effect on technical efficiency) as olive and vineyard yields per hectare, and hypothesis 3 (effects on land and labour use) as farm size and on-farm employment.

Government subsidy and area planted with olives and vineyards

Government subsidy has had a clear, positive impact on the area planted with olives and vineyards. The net treatment effect of subsidy is 4.39 dynyms (Table 4); this difference is statistically significant as informed by t statistic and related p-value associated with Subsidy_2008.

In 2008 the average planted area per farm, 2.5 dynyms for subsidised farmers and 3.2 for the non-subsidised farmers, was rather similar for the two groups. The subsidy has clearly affected the area planted by subsidised farmers: in 2012 it was 11.0 dynyms, or more than four times larger than in 2008. There was also an increase in the planted area of non-subsidised farmers but at a significantly lower level; it only doubled during the studied period to reach 7.2 dynyms in 2012. Government subsidy also had a clear impact on increasing the number of olive trees and this was in line with the finding that the area under olives and vines had increased.

An average Albanian farm is small (1.2 ha, according to MARWDA, 2014), agricultural land is often not fully utilised and thereby there is presently a lack of economies of scale. The significant net positive impact of government support on the olive and vineyard areas highlights the opportunity for farmers to benefit from emerging economies of scale.

Government subsidy and olive and vineyard yields

Government subsidy did not have a statistically significant impact on crop yield per hectare. The B coefficients associated with Subsidy_2008 for both the olive and vineyard sectors are statistically insignificant (Table 5).

Table 4: Impact of government subsidy on area planted with olives and vineyards.

Model	Unstandardised coefficients		Standardised coefficients	t	Significance
	B	Std. error	Beta		
(Constant)	4.40	0.99		4.43	0.00
Area planted with olives and vineyards in 2008	0.88	0.14	0.39	6.09	0.00
Subsidy 2008	4.39	1.24	0.22	3.51	0.00

Dependent variable: area planted with olives and vineyards in 2012
Source: own calculations

Table 5: Government subsidy impact on yields per hectare of olives and vineyards.

Activity	Model	Unstandardised coefficients		Standardised coefficients	t	Significance
		B	Std. error	Beta		
Olives	(Constant)	1.29	0.95		1.35	0.17
	Yield in 2008	0.86	0.10	0.64	8.58	0.00
	Subsidy in 2008	0.81	1.28	0.04	0.63	0.52
Vineyards	(Constant)	7.62	5.95		1.28	0.20
	Yield in 2008	1.97	0.48	0.42	4.09	0.00
	Subsidy in 2008	2.43	7.49	0.03	0.32	0.74

Dependent variable: yield in 2012
Source: own calculations

In 2012, subsidised farmers produced 3.1 t ha^{-1} of olives and 13.1 t ha^{-1} of grapes, while non-subsidised farmers produced 3.8 t ha^{-1} and 21.1 t ha^{-1} respectively. Although there has been positive development in terms of increasing yields per hectare for both groups, no significant net effect of subsidy was found. This missing net impact of government subsidy on crop yields per hectare may be explained if considered jointly with an analysis on technology adoption. Subsidised famers, as a rule, used common technology in terms of cultivars, plant protection materials, pesticides and machinery, including sprayers (Skreli and Imami, 2013).

The olive cultivar mix in Albania has undergone major changes during the social and economic transition period. New intensive cultivars have been introduced and the olive cultivar mix is quite modern. In anecdotal cases 'treated' farmers have introduced new cultivars, but the difference between subsidised and non-subsidised farmers is not significant. The grape cultivar mix needs improvement however, particularly when it comes to those intended for wine production. The government subsidy impact in terms of grape cultivar mix remains limited.

The impact of government subsidy on the introduction of drip irrigation[2] has been negligible when compared to the level of investment in drip irrigation technology by the non-subsidised group (Skreli and Imami, 2013). While one in four non-subsidised farmers have introduced drip irrigation in olive and grape orchards, the share of subsidised farmers who have introduced drip irrigation is only is 16 per cent – a substantially lower figure.

Commonly-available plant protection materials and fertilisers are used both by subsidised and non-subsidised farmers, with only a limited number having reported using any new types of pesticides or fertiliser, but not necessarily belonging to the subsidised group of farmers. The agricultural machinery, including spraying technology, is very similar for both subsidised and non-subsidised farmers, and again it is common technology.

Overall, the impact of government subsidy on the introduction of new technology has been weaker than the impact of own money spent by farmers to create new olive and grape production areas. It could be argued that such a phenomenon stems from 'moral hazard' – farmers tend to consider the soundness of the investment less when they do not have to pay the full cost of it. Qualitative information suggests that, in some cases, farmers do not provide the necessary services to the new plantings after obtaining the subsidy and in a few extreme cases they even completely abandon the new plantings (Skreli and Imami, 2013).

Government subsidy and farm size and on-farm employment

Government subsidy had no impact on farm size; the net impact represented by the coefficient B associated with Subsidy_2008 (0.30 dynym) is statistically insignificant and the p-value of 0.41 suggests however that the result may be due to chance (Table 6).

Table 6: Government subsidy impact on farm size.

Model	Unstandardised coefficients		Standardised coefficients	t	Significance
	B	Std. error	Beta		
(Constant)	0.36	0.38		0.95	0.34
Farm size in 2008	0.98	0.01	0.96	51.68	0.00
Subsidy in 2008	0.30	0.37	0.01	0.81	0.41

Dependent variable: farm size in 2012
Source: own calculations

Table 7: Government subsidy impact on part-time, on-farm employment.

	Unstandardised coefficients		Standardised coefficients	t	Significance
	B	Std. error	Beta		
(Constant)	0.63	0.14		4.37	0.00
Part time farmers in 2008	0.80	0.06	0.65	12.40	0.00
Subsidy in 2008	0.36	0.19	0.10	1.89	0.05

Dependent variable: part time farmers in 2012
Source: own calculations

The two groups had similar farm sizes in 2008: 15.0 dynyms for the subsidised farmers and 14.9 dynyms for their non-subsidised counterparts. While farm size for non-subsidised farmers increased by 0.09 dynyms over the period 2008-2012 (15.1 dynyms in 2012), it increased by 0.39 dynyms for subsidised farmers (15.4 dynyms in 2012), or a net difference of 0.3 dynyms. However, the differences are statistically insignificant and can be interpreted as indicating a lack of impact of government subsidies on farm size.

Although there are signs of an active land rental market, this has not affected farm size. In a limited number of cases (6 per cent of farmers), subsidised farmers have rented land to establish olive and grape production areas. The area rented is between 0.5 ha and 2.3 ha. Qualitative information from the field interviews supports the idea that the land rental market is an opportunity with land managed by rural communes. The rental of private land for establishing new olive and grape production areas is a rather unlikely option given that land ownership titles are perceived to be insecure.

Since reported full-time, on-farm employment is anecdotal, only the results of part-time on-farm employment[3] are discussed below. Government subsidy has had a substantial significant impact on increasing on-farm part-time employment (Table 7).

The two groups of farms had similar values in terms of part-time employment per farm in 2008: 0.74 part-time farmers for non-subsidised farmers and 0.99 part-time farmers for subsidised farmers. While subsidised farms employed on average 1.80 part time employees, non-subsidised farmers employed only 1.23 employees. Although there was an increase in part-time on-farm employment for both groups, that for the subsidised group was significantly higher than for the non-subsidised group, the net difference being 0.36 part-time employees per farm. The results by sector suggest that the increases in part-time on-farm employment for both the olive and vineyard sectors were significant, with slightly higher values for the vineyard sector.

[2] Although drip irrigation is not nowadays considered an innovation, its incidence is still limited and therefore it is considered a new technology.

[3] Part-time workers in the olive and vineyard sectors deal mainly with some specific operations such as land tilling, pruning and fruit picking. Based on expert assessment, 'part time' in the considered sectors may be converted to at most 0.25 AWU.

Discussion

This paper analyses the outcomes and possible impact of Albanian farm subsidy schemes using a quasi-experimental design by applying PSM method. The results show that the government subsidy scheme had a clear net impact on increasing areas under olive and grape production. The positive impact on area planted with olives and vines had not affected farm size, however. Furthermore, the impact of subsidies on part-time on-farm employment was positive, while its impacts on technology adoption and crop yield per hectare were not significant.

Our results are generally in line with the majority of the cited literature, showing that agricultural subsidy programmes have a rather mixed impact. We found that Albania's agricultural subsidy policy had a direct impact on production capacities (area and production), suggesting an 'early stage' for the Albanian agricultural sector. The results regarding impact on technical efficiency are in line with those of Minviel and Latruffe (2014) and Zhu and Lansink (2010), who found mixed relationships between agricultural subsidies and efficiency. As expected, subsidy positively affects part-time on-farm employment but no significant impact was found in terms of bringing idle land into the economic cycle, contrary to what we hypothesised.

Supporting investment in new fruit production areas became part of the Albanian policy agenda only recently, starting from 2008. Impact evaluation of the scheme in 2012, only four years from its start, is an important limitation of the study. Despite the assumption that this is a sufficient time frame for the scheme to have an impact, we are aware that that only partial impacts are discussed and analysed. This is due to the fact that although intensive olives and vineyards enter production by the third year, they only reach full production by the sixth or seventh year. The results most affected by this limitation are yields per hectare and the least are area planted with olives and vineyards, and employment. Another limitation of the study is the small sample size which is likely to lead to higher margins of error. Furthermore, despite our balanced selection of counties (south and north), random selection of communes and quasi-random selection of farmers prompts caution about generalising the results at the country level. On the other hand, given the lack of baseline data, the study looks at the selected indicators only in retrospect, meaning using self-reported data from farmers related to their performance in recent years.

Our research findings can be relevant for government agencies and other stakeholders which have engaged or plan to engage in investment support schemes in the Albanian agriculture sector. It is recommended the government continues its support for creating new fruit production areas. Given the small average farm size, Albanian agriculture needs support to establish commercial farms and the current scheme is an effective way to link small farms with markets. A measure which is an investment support scheme is superior to output/price support – it is less trade distortive and has a lower negative budget impact. Caution should be made of the complex effect in the longer run, however. As the domestic market may saturate for different products, further increased production may cause a sharp decline in sales prices which can make the farmers' financial situation worse off. Therefore, support schemes for given agricultural activities should be anticipated by an in-depth market outlook.

Support to investment in labour-intensive industries, if well designed, tends to affect farm income and employment generation positively. Our study results support that there is a significant increase in part-time on-farm employment, meaning that the subsidy scheme has had a positive impact in terms of addressing the hidden unemployment problem which is a critical one for Albanian agriculture.

Our survey data suggest that a large proportion of farmers have not mobilised any additional resources after benefiting from government subsidies and new technology adoption has been limited. The study findings may be used to encourage the government to introduce conditionality – to use subsidy to meet more than one policy objective. Recommended policy objectives to be followed are new technology adoption and financial resource mobilisation.

While the rental market of private land is dysfunctional, anecdotal evidence suggests that farmers rent the commune-managed land for establishing new fruit production areas. The government may therefore design a policy to promote the use of commune-managed land for this purpose. The policy mix should consider reducing local government discretion in renting out the land, designing incentives for local government based on land transactions, and providing bonus points in file evaluations in case of local government managed land rented, to mention only a few possible measures.

Skreli and Imami (2013) found that for 25 per cent of subsidised farmers, investment is equal or close to the level of the government subsidy, meaning that no additional resources are mobilised. Additionally, the impact of subsidies in introducing new technologies is significantly lower than the impact of farmers' own money. Based on these facts it is argued that a 'moral hazard' problem is associated with government subsidy. More in-depth investigation is however suggested in order to better understand this phenomenon.

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Do crude oil prices influence new crop sunflower seed futures price discovery in Hungary?

The oil produced from sunflower seed is primarily used for human consumption. It can substitute for other edible vegetable oils, such as rapeseed oil, processed into biodiesel in the European Union. This paper assesses the influence of crude oil futures on new crop sunflower seed futures in Hungary during the growing seasons of sunflower by applying standard cointegration analysis for the period 2004-2013. Tests were performed for the entire period and each sunflower growing season. For comparison, the influence of Paris rapeseed futures on sunflower seed futures was also assessed. The contrasting estimations for the global and seasonal characteristics of the variables suggest that standard cointegration analysis may not be appropriate for multiannual price series of agricultural commodities with strong seasonality in production because it will not capture the periodical shocks in supply and demand. The results are briefly discussed from the aspect of the fundamentals of the sunflower seed market.

Keywords: price cointegration, sunflower seed, crude oil, growing seasons

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Introduction

Throughout the 2000s, particularly after the sharp rise in oil prices in 2008, public and private interest in diversifying energy sources intensified remarkably. The reasons for this included volatility in the prices of petroleum products, the finite nature of fossil fuels and increasing environmental concerns, especially related to greenhouse gas emissions. Also, more emphasis was placed on novel ways to add value to agriculture and to promote growth poles which could deliver 'green' jobs in non-carbon intensive sectors of the economy. These factors reinforced interest in renewable energy sources, including biofuels (UNCTAD, 2014). Global production of biofuels increased dynamically, primarily due to policies that stimulated the use of fuel ethanol and biodiesel. The emerging biofuels market generated significant demand for some agricultural commodities, especially food crops, including oilseeds, strengthening the linkages between agricultural commodity markets and fossil fuel markets, and between different agricultural commodity markets (FAO, 2008).

The European Union (EU), initially a leader in biofuels legislation, accounted for around 40 and 45 per cent respectively of global production and consumption of biodiesel in 2013 (calculations based on F.O. Licht, 2015). The EU started to implement biofuel-related targets in 2003 with Directive 2003/30/EC. This Directive set indicative biofuel penetration targets of 2 per cent by the end of 2005 and 5.75 per cent by the end of 2010. By 2020, on the basis of the Renewable Energy Directive (RED) 2009/28/EC, the EU aims to have 10 per cent of the energy used in transport in every EU Member State come from renewable sources including biofuels.

Biodiesel is a nontoxic and biodegradable renewable fuel. Conventional or 'first generation' biodiesel is produced from vegetable oils (i.e. rapeseed oil, soybean oil, palm oil etc.), used cooking oils and animal fats through transesterification. In the transport sector, biodiesel is used in its pure form or blended with fossil diesel fuel. In the EU, the global leader both in rapeseed production and crushing, the biodiesel industry relies primarily on rapeseed oil as feedstock. Recently, however, the share of rapeseed oil in the feedstock mix has decreased from 73 per cent in 2010 to 58 per cent in 2013, mostly due to the increasing use of hydrotreated palm oil and recycled vegetable oils (Flach *et al*., 2014), the latter counting double in the RED target in many EU Member States. In 2013, the 5.6 billion litres of rapeseed oil processed by the EU biodiesel industry represented around half of the total output of the EU Member States.

Although sunflower seed has the highest oil content (up to 55 per cent) among oilseeds, its suitability for biodiesel production is limited by the high content of linoleic acid (Lewandowski, 2013). Sunflower oil is primarily used for human consumption and it has applications in the cosmetics industry too. According to the European Biomass Industry Association, only around 1-2 per cent of the biodiesel produced in the EU is derived from sunflower seed oil.

World sunflower seed production is characterised by strong seasonality. As the statistics of Oil World (ISTA Mielke GmbH) show, in recent years more than three quarters of the global crop were harvested during September and October. The largest producers in the Northern Hemisphere include the EU, Ukraine, Russia, China, Turkey and the United States. Since its accession to the EU in 2004, Hungary has been one of the major sunflower seed producing Member States in the EU, ranking fourth after France, Romania and Bulgaria[1] during the period 2004-2013. The country has been a net exporter of sunflower seed, and of both raw and edible sunflower oil, mainly to other EU Member States. Hungary is the only country in the EU where sunflower seed futures are traded.

Since sunflower oil can substitute for other edible vegetable oils processed into biodiesel in significantly larger quantities, the sunflower seed market could be interlinked with the crude oil market indirectly. Therefore, we hypothesised that crude oil futures prices influence new crop sunflower seed futures price discovery in Hungary. Despite the wide literature on the relationship between agricultural commodity and fossil fuel prices, only a very small number of authors have considered sunflower seed or sunflower oil in

[1] Romania and Bulgaria accessed the EU only in 2007.

their analysis. For sunflower seed, these include Nazlioglu and Soytas (2011) showing neutral impacts of low-frequency monthly crude oil prices in Turkey for the period January 1994 to March 2010. For sunflower oil, these include Yu *et al*. (2006) finding no influence of weekly crude oil prices on sunflower oil prices quoted in Hamburg for the period January 1999 to March 2006, and Hassouneh *et al*. (2011) providing evidence of a single cointegration relationship among weekly crude oil, biodiesel and sunflower oil prices in Spain for the period November 2006 to October 2010.

To test our hypothesis, we applied standard cointegration analysis for a multiannual time period but were also interested in examining the strength of the possible linkage between these markets in the individual growing seasons of sunflower as these often exhibit, by nature, substantial changes in the market fundamentals. For comparison, the influence of Paris rapeseed futures on sunflower seed futures was also assessed.

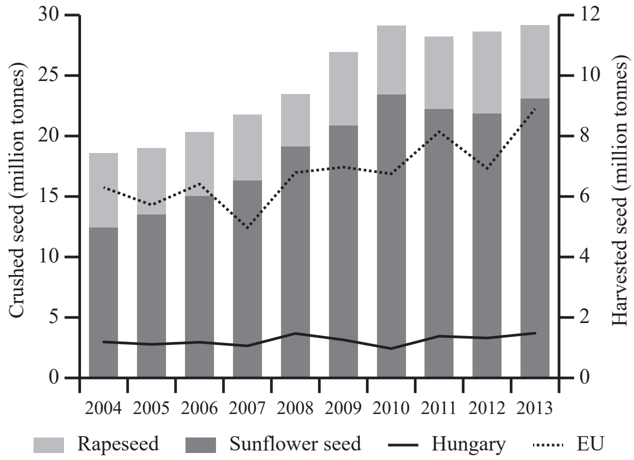

Figure 1: Sunflower seed production of Hungary and the EU-27 during the period 2004-2013, and EU-27 crushing of rapeseed and sunflower seed in the 2003/04-2012/13 crop years (October-September) which include the sunflower growing seasons (April-October).

Data sources: Hungarian production data: Hungarian Central Statistical Office; other data: Oil World (ISTA Mielke GmbH)

Methodology

Statistical methods

To assess the influence of crude oil and rapeseed futures on new crop sunflower seed futures prices in Hungary, firstly the Augmented Dickey-Fuller test (ADF) (Dickey and Fuller, 1979) and the Kwiatkowski-Phillips-Schmidt-Shin test (KPSS) (Kwiatkowski *et al*., 1992) were applied for the entire 2004-2013 period and each individual sunflower growing season to verify whether the price series used were integrated. (Individual variables, which permanently change due to many developments, are integrated when their differences of order d are stationary, and $d > 0$.) Secondly the Johansen Maximum-Eigenvalue test for cointegration (Engle and Granger, 1987; Johansen, 1988) was performed for the entire 2004-2013 period and each individual sunflower growing season where the ADF test and the KPSS test provided strong evidence that the particular price series were integrated. (Individual variables are cointegrated when a long-run equilibrium relationship represented by some linear combination of them exists.)

Recent applications of the Johansen test for assessing the possible linkages between energy and agricultural commodity markets include Natanelov *et al*. (2013) for crude oil, ethanol and maize, Pala (2013) for crude oil and the FAO food price index, and Harri *et al*. (2009) for crude oil, agricultural commodities and exchange rates. All these studies provide evidence for the existence of a long-run equilibrium relationship between crude oil prices and some of the agricultural commodity prices. In general, the standard cointegration test is often performed for fragments of longer time periods where breaks are usually adjusted to the occurrence of certain macroeconomic phenomena (see e.g. Natanelov *et al*., 2013; Pala, 2013). However, we are not aware of any attempt to use this method while splitting the time series according to the production seasons of the agricultural commodity involved in the analysis.

The standard cointegration test was considered appropriate to test the equilibrium relationship since it provides more robust results than other more advanced techniques in the case of seasonal segmentation of the data. We refrained from the use of models which recognise the presence of structural breaks in order to avoid over-segmentation of the time series, as well as of threshold cointegration techniques due to the possible complexity of the SETAR-based approach.

Our calculations were made using version 3.1.1 of the R software; for the ADF, the KPSS and the Johansen tests version 0.10-32 of the *tseries* package and version 1.2-8 of the *urca* were applied, respectively.

Data

Relevant seed production and crushing data for the period 2004-2013 are presented in Figure 1. During this period, the average sunflower seed production per year of Hungary was 1.24 million tonnes, which represented an 18.3 per cent share of the total EU output. The 2010 season saw the lowest level of production in Hungary since EU accession with 970 thousand tonnes, representing 80.1 per cent of the average for the preceding five years, i.e. 2004-2009. Total crushing of rapeseed and sunflower seed in the EU increased from 18.6 million tonnes in the 2002/04 crop year (October-September) to a peak of 26.9 million tonnes in the 2009/10 crop year, thereafter remaining fairly constant.

For the analysis, the daily closing price series of November sunflower seed futures listed at the Budapest Stock Exchange (BÉT) Grain Section, of November Brent crude oil futures listed at the Intercontinental Exchange (ICE), and of November rapeseed futures listed at the Paris Bourse (MATIF) were used from the first exchange trading day in April until the expiry of the November Brent crude oil futures around the middle of October for the period 2004-2013[2].

In Hungary, sunflower is sown in April, and this is when expectations regarding the new crop begin to be formed.

[2] The choice of 2004 as the first year of the time period for the analysis is justified by the fact that Hungary adopted the EU mechanisms of agricultural market regulation fully upon its accession to the EU on 1 May 2004.

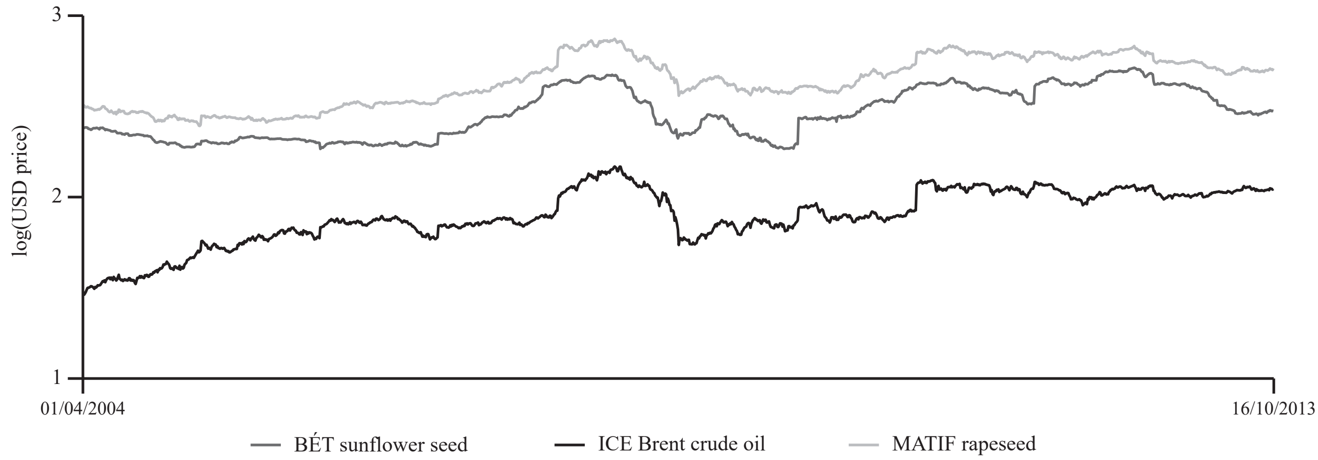

Figure 2: The daily log-price series of BÉT sunflower futures for November delivery, ICE Brent crude oil futures for November delivery and MATIF rapeseed futures for November delivery converted to USD per tonne or barrel equivalents in the sunflower growing seasons (April-October) during the period 2004-2013.

Note: weekends are excluded from the x axis
Source: own calculations

The sunflower harvest ends around the middle of October, thus the price series used cover sunflower growing seasons adequately. In respect of sunflower seed futures (and rapeseed futures too), by using only one contract, in this case the November contract price series instead of the continuous front month price series, the data are clean of the usual seasonal drop in prices when old crop futures switch (often asynchronously between the different markets) to new crop futures (normal backwardation). Furthermore, the November contract price series of sunflower seed represent the anticipated harvest time price of the new crop only little distorted by the cost of carry.

Missing data for exchange trading holidays not longer than one day were linearly interpolated, and weekends were excluded from the series. Thus the number of days for the individual growing seasons (n1-n10) analysed varied from 140 to 143, and totalled 1,412 (N) for the period 2004-2013. All prices were converted to their USD per tonne or barrel equivalents using the official daily exchange rates published by the European Central Bank and then, to avoid problems of scale, further converted to their natural logarithms (Figure 2).

Results

The ADF test and the KPSS test verified that the price series used were I(1) or I(2) for the entire 2004-2013 period and most of the individual sunflower growing seasons (Tables 1 and 2). Following the ADF test results, no cointegration tests were performed for the ICE and BÉT pairs of price series in 2006 and in 2013, and also for the MATIF and BÉT pairs of price series in 2006.

The results of the Johansen test (Table 3) suggest the existence of a long-run equilibrium relationship between ICE Brent crude oil futures for November delivery and BÉT sunflower seed futures for November delivery during the sunflower growing seasons of the period 2004-2013 at the 5 per cent significance level. This finding supports the hypoth-

Table 1: Values of the ADF and KPSS statistics for the daily log-price series of BÉT sunflower futures for November delivery, ICE Brent crude oil futures for November delivery, and MATIF rapeseed futures for November delivery converted to USD per tonne or barrel equivalents for the entire 2004-2013 period, and each individual sunflower growing season (April-October).

Time period	BÉT		ICE		MATIF	
	ADF	KPSS	ADF	KPSS	ADF	KPSS
Apr 2004 to Oct 2013 (N = 1,412)	-1.34	0.53	-2.07	2.41	-1.39	1.09
Apr 2004 to Oct 2004 (n1 = 140)	-1.55	0.19	-1.88	0.25	-2.63	0.08**
Apr 2005 to Oct 2005 (n2 = 141)	-0.56	0.53	-1.80	0.27	-2.62	0.49
Apr 2006 to Oct 2006 (n3 = 140)	-4.07*	0.13**	-1.50	0.56	-2.23	0.40
Apr 2007 to Oct 2007 (n4 = 142)	-1.82	0.42	-1.66	0.16	-2.53	0.45
Apr 2008 to Oct 2008 (n5 = 143)	-1.04	0.71	0.10	0.70	-0.73	0.67
Apr 2009 to Oct 2009 (n6 = 142)	-2.08	0.47	-1,96	0.38	-2.71	0.35
Apr 2010 to Oct 2010 (n7 = 140)	-1.74	0.46	-1.94	0.42	-1.88	0.34
Apr 2011 to Oct 2011 (n8 = 140)	-1.83	0.40	-3.23	0.07**	-2.77	0.27
Apr 2012 to Oct 2012 (n9 = 141)	-1.06	0.25	-1.59	0.60	-2.09	0.32
Apr 2013 to Oct 2013 (n10 = 143)	-0.88	0.35	-4.12*	0.23	-1.27	0.30

For testing the null hypothesis, the 'constant with linear trend' statistics of the ADF and KPSS tests were used. The optimal lag parameters were calculated by R based on the Akaike information criterion
ADF critical values: -3.96 (1%); -3.41 (5%); -3.12 (10%)
KPSS critical values: 0.22 (1%); 0.15 (5%); 0.12 (10%)
* Indicates rejection of the null hypotheses at 5 per cent significance level (ADF null hypothesis: the time series have unit root)
** Indicates acceptance of the null hypotheses at 5 per cent significance level (KPSS null hypothesis: the time series are stationary)
Source: own calculations

Table 2: Values of the ADF and KPSS statistics for the differentiated daily log-price series of BÉT sunflower futures for November delivery, ICE Brent crude oil futures for November delivery and MATIF rapeseed futures for November delivery converted to USD per tonne or barrel equivalents for the entire 2004-2013 period, and each individual sunflower growing season (April-October).

Time period	BÉT		ICE		MATIF	
	ADF	KPSS	ADF	KPSS	ADF	KPSS
Apr 2004 to Oct 2013 (N = 1,412)	-25.13*	0.11	-25.89*	0.15	-26.98*	0.25
Apr 2004 to Oct 2004 (n1 = 140)	-7.34*	0.23	-7.73*	0.29	-5.82*	0.08
Apr 2005 to Oct 2005 (n2 = 141)	-4.89*	0.64**	-8.22*	0.04	-8.51*	0.11
Apr 2006 to Oct 2006 (n3 = 140)	-5.39*	0.23	-6.12*	0.28	-7.99*	0.29
Apr 2007 to Oct 2007 (n4 = 142)	-7.14*	0.08	-6.32*	0.19	-3.60*	0.25
Apr 2008 to Oct 2008 (n5 = 143)	-6.73*	0.76**	-5.83*	1.27**	-6.06*	0.92**
Apr 2009 to Oct 2009 (n6 = 142)	-3.67*	0.27	-6.69*	0.16	-8.93*	0.09
Apr 2010 to Oct 2010 (n7 = 140)	-11.67*	0.15	-4.02*	0.27	-4.17*	0.38
Apr 2011 to Oct 2011 (n8 = 140)	-3.54*	0.10	-10.28*	0.19	-9.18*	0.22
Apr 2012 to Oct 2012 (n9 = 141)	-7.24*	0.45	-7.61*	0.19	-8.14*	0.24
Apr 2013 to Oct 2013 (n10 = 143)	-9.25*	0.30	-7.89*	0.31	-9.20*	0.28

For testing the null hypothesis, the 'without trend and drift' statistics of the ADF and KPSS tests were used. The optimal lag parameters were calculated by R based on the Akaike information criterion
ADF critical values: -2.58 (1%); -1.95 (5%); -1.62 (10%)
KPSS critical values: 0.74 (1%); 0.46 (5%); 0.35 (10%)
* Indicates rejection of the null hypotheses at 5 per cent significance level (ADF null hypothesis: the time series have unit root)
** Indicates rejection of the null hypotheses at 5 per cent significance level (KPSS null hypothesis: the time series are stationary)
Source: own calculations

Table 3: Statistics of the Johansen Maximum-Eigenvalue test for cointegration of the daily log-price series of BÉT sunflower futures for November delivery versus ICE Brent crude oil futures for November delivery and MATIF rapeseed futures for November delivery converted to USD per tonne or barrel equivalents for the entire 2004-2013 period, and each individual sunflower growing season (April-October).

Time period	ICE	MATIF
Apr 2004 to Oct 2013 (N = 1,412)	18.56	10.45
Apr 2004 to Oct 2004 (n1 = 140)	12.80	7.65
Apr 2005 to Oct 2005 (n2 = 141)	4.53	11.30
Apr 2006 to Oct 2006	-	-
Apr 2007 to Oct 2007 (n4 = 142)	20.02	19.87
Apr 2008 to Oct 2008 (n5 = 143)	14.35	10.69
Apr 2009 to Oct 2009 (n6 = 142)	14.08	12.07
Apr 2010 to Oct 2010 (n7 = 140)	13.87	17.02
Apr 2011 to Oct 2011 (n8 = 140)	13.23	12.48
Apr 2012 to Oct 2012 (n9 = 141)	11.43	17.32
Apr 2013 to Oct 2013 (n10 = 143)	-	19.35

Critical values: 20.20 (1%); 15.67 (5%); 13.75 (10%)
Source: own calculations

esis that crude oil prices influence new crop sunflower seed futures price discovery in Hungary. However, as opposed to this global characteristic of these two price series, Brent crude oil and sunflower seed futures were estimated as being cointegrated only in the 2007 sunflower growing season, also at the 5 per cent significance level. This implies that crude oil prices influence new crop sunflower seed futures price discovery only occasionally, under special circumstances.

In contrast to the above, the same test revealed the lack of a long-run equilibrium relationship between MATIF rapeseed futures for November delivery and BÉT sunflower seed futures for November delivery during the sunflower growing seasons of the period 2004-2013 (Table 3). Again, as opposed to this global characteristic of these two price series, rapeseed and sunflower seed futures were estimated being cointegrated in the 2007, 2010, 2012 and 2013 sunflower growing seasons, in all cases at the 5 per cent significance level. Consequently, it would be inappropriate to conclude that no cointegration relationship exists between these markets when MATIF rapeseed futures (with more liquidity than BÉT sunflower seed futures) could have served well for cross hedging price risks associated with sunflower seed production, processing and trade in Hungary in almost half of the growing seasons for which the cointegration test was performed.

Discussion

From the aspect of sunflower seed market fundamentals, the seasonal cointegration between ICE Brent crude oil futures for November delivery and BÉT sunflower seed futures for November delivery in 2007 coincided with a record low in sunflower seed production in the EU-27 of 4.97 million tonnes (Figure 1). This represented a 22.6 per cent drop compared to 2006, and it fell short of the 2004-2006 average by 19.1 per cent. Whether this exceptional decline in supply impacted on this particular price relationship indeed needs further exploration.

In respect of the seasonal cointegration between MATIF rapeseed futures for November delivery and BÉT sunflower seed futures for November delivery, we note that sunflower seed production in the EU-27 decreased compared to the previous year not only in 2007 (by 1.44 million tonnes or 22.5 per cent) but also in 2010 and 2012 (by 0.22 million tonnes or 3.2 per cent, and 1.21 million tonnes or 14.9 per cent respectively). Another common feature of these sunflower growing seasons was that total crushing of rapeseed and sunflower seed increased in the crop years (October-September) which included these particular growing seasons (Figure 1).

A logical argument would be that an anticipated decline in sunflower seed supply paralleled by a growth in the combined current domestic demand of the two principal oilseeds produced in the EU apparently strengthens the seasonal connection between sunflower seed and rapeseed markets. Interestingly, 2005 is out of line here. Although sunflower seed production declined by 0.58 million tonnes or 9.2 per cent in the EU-27 (taking into account Bulgaria and Romania which accessed the EU in 2007, too) compared to 2004, and the combined current domestic demand of rapeseed and sunflower seed increased during the 2004/05 crop year, MATIF rapeseed futures and BÉT sunflower seed futures were not cointegrated. This finding, however, could be explained by the 0.68 million tonnes decrease in sunflower seed crushing in 2004/05.

Finally, 2013 was quite different from 2007, 2010 and 2012: all-time record quantities of sunflower seed were harvested in the EU-27 (8.90 million tonnes, representing a 28.4 per cent increase compared to 2012, and exceeding the 2004-2012 average by 35.8 per cent), in Ukraine (10.94 million tonnes, or +30.5 per cent over the previous year) and in Russia (10.20 million tonnes, or +27.8 per cent over the previous year). These outputs contributed to the global production of sunflower seed surging to an unprecedented 43.25 million tonnes in the 2013/14 crop year (estimates by ISTA Mielke, 2015). During the sunflower growing season, the global oilseed and grain market was also anticipating new highs in the production of rapeseed and soybeans, as well as of wheat and maize for the 2013/14 crop year[3]. The general downward movement of prices may have caused the seasonal cointegration of rapeseed futures and sunflower seed futures again.

The contrasting estimations for the global and seasonal characteristics of the variables indicate the weakness of the applied standard cointegration test when performed for the multiannual price series of an agricultural commodity with strong seasonality in production, namely it will not capture the periodical shocks in supply and demand. This can lead to misinterpretations of the test results: the existence of a long-run equilibrium relationship may be accepted with most of the individual growing seasons actually lacking the equilibrium, and vice versa. The Johansen test for cointegration assumes that the cointegrating vector is constant during the time period analysed. However, in reality, when prices of agricultural commodities with strong seasonality in production are cointegrated with prices of other commodities in certain growing seasons, the cointegrating vector representing the equilibrium relationship may be different in each of these time periods due to the substantial changes in the market fundamentals. This aspect may deserve further research because of the expected increase in the volatility of crop production and prices caused by increasing climate variability in the future.

Although our results indicate the weakness of the applied standard cointegration test, they still have some policy implication. Namely, that policies based on the assumption of the long-run presence of a certain degree of linkage between energy markets and the market of food products which substitute for other food products used as energy feedstock, and between food products used as energy feedstock and their substitutes for food exhibiting strong seasonality in production, would require to be flexible in order to be effective. The periodical shocks in the supply and demand of these agricultural commodities deserve consideration as they may substantially influence the strength of market interlinkages from one production season to the next.

[3] ISTA Mielke (2015) estimated the global production of rapeseed in 2013/14 to be 69.62 million tonnes (+8.7 per cent compared to the previous crop year) and that of soybeans to be 281.92 million tonnes (+5.9 per cent). USDA (2015) estimated the global production of wheat to be 716.82 million tonnes (+8.8 per cent) and that of maize to be 988.70 million tonnes (+13.9 per cent).

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Farm-level environmental performance assessment in Hungary using the Green-point system

Faced with society's increasing expectations, the European Union's Common Agricultural Policy uses environmental management as an increasingly critical criterion in the allocation of farm subsidies, with a shift in focus from production and area-based subsidies to payments for supplying public goods. There is an increasing demand to assess the ecological and environmental performance of farms as public money spent on provision of environmental services requires justification. The objective of this research is to strengthen the basis of the concept of farm-level environmental performance assessment. Firstly we give an overview of indicator-based sustainability assessment tools. Even though there are several different tools developed globally, and the themes and indicators for the assessment of environmental performance are very similar, there are significant differences in terms of data survey among them. Secondly we describe the development and field testing of the 'Green-point system' developed in Hungary. This system is able to measure the environmental performance of farms and their value/capability of providing public goods and sustaining ecosystem services through a framework of farm enterprise calculations and assessments. The Green-point system fits well into the stream of yet scarce approaches and efforts, which in several European countries aim to introduce and strengthen the so-called result-based agri-environmental schemes alongside the currently rather dominant management-based approaches.

Keywords: agroecosystems, diagnosis, environmental impact assessment, evaluation methods, indicators, sustainability

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Introduction

Agricultural market competitiveness is dependent on its production efficiency and the quality of its products relative to environmental capacity and the status and quality of natural resources. Since the 1960s, intensification of agricultural production has caused increasing environmental pollution, driving much research on the environmental impacts of agriculture (e.g. Wauchope, 1978; Ryden *et al*., 1984). More recently, the loss of biodiversity, soil erosion, deterioration of water quality and the decrease in soil organic matter have received increasing attention (e.g. Pimentel and Kounang, 1998; Kätterer and Andrén, 1999). To protect and enhance the European Union's (EU) rural heritage, the Common Agricultural Policy (CAP) aims to head off the risks of environmental degradation and enhance the sustainability of agro-ecosystems by promoting agricultural practices that preserve the environment by means of a relatively complicated system of regulations and subsidies (Tangermann, 2011).

Conducting farm-level sustainability assessments has several benefits. They provide measurable results and assessment for farmers and also offer the possibility to benchmark farmers against each other once regional anonymous databases are created. They contribute to increasing farmers' awareness of possible environmental improvements and support farm management decisions. Assessment tools can provide baseline information for policy support systems and to result-based agri-environmental schemes. However, there is still relatively little experience with authentic evaluation of environmental success in farming. Development and implementation of suitable assessment tools raise several questions such as what indicators should be used to express agri-environment relationships on a farm in a way that facilitates improved management; how can environmental improvement be documented using appropriate indicators; what indicators have been developed already and how useful are they for farmers and advisors; and how should the set of indicators be defined such that sustainability assessment is the least complex to complete but still provides useful evaluation.

The objective of our work is to strengthen farm-level assessment of environmental performance. Firstly, we give an overview of the importance of indicators as tools for assessing sustainability with a focus on the criteria that make an indicator appropriate for farm-level environmental evaluation. Secondly, we describe the development of the 'Green-point system' indicator set for Hungarian agriculture. Thirdly, we present the results of the farm and field-level testing of these indicators.

Indicators as the basis of assessments

The term 'indicator' has been defined as 'a variable which supplies information on other variables which are difficult to access and which can be used as a benchmark to take a decision' (Gras *et al*., 1989). Indicators should have three dimensions: systemic, temporal/spatial and ethical. *Systemic* means that they are required to assess the economic, environmental and social aspects of agriculture. *Temporal and spatial* indicate the purpose to assess the effects that are likely to occur over time and in space, and *ethical* refers to the sustainability which is founded on a system of values such as the need to conserve the natural and human heritage, or at least to use it as sparingly as possible (Zahm *et al*., 2006).

During the *Results-based agri-environment schemes* conference in 2014 (IEEP, 2014), participants concluded that

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indicators used for this purpose should be (a) clearly linked to objectives (e.g. ecosystems, specific habitats or particular species); (b) reliable (based on adequate evidence) measures of the overall desired outcome, which must be appropriate to context and location; (c) set within a simple framework with common payment triggers – perhaps with two or three hierarchical levels; (d) relatively easy to identify and survey (hence cost-effective); (e) linked to wider goals and user needs (e.g. RDP Monitoring and Evaluation Framework indicators); (f) cheat proof; and (g) acceptable to farmers.

Thus, the development of indicators that can measure the sustainability of an agricultural production system is a complex task. The main question is how to translate the concept of sustainability into operational terms at an individual farm level. During the past 25 years, several different approaches have been developed for assessing aspects of farm-level agricultural sustainability. Pacini *et al*. (2004) used a model to compare the economic, agronomic, technical and environmental results for the MacSharry and the Agenda 2000 reforms. Van Passel *et al*. (2007) constructed an economic model to analyse the impact of managerial and structural farm characteristics on farm sustainability. Others (Bechini and Castoldi, 2009; Thomassen *et al.*, 2009) applied economic and environmental indicators to evaluate farm sustainability. Singh *et al*. (2009) and Binder *et al*. (2010) compared and analysed different sustainability methods by means of literature review. Fumagalli *et al*. (2011) calculated agro-environmental and economic indicators to evaluate farm sustainability and also compared current and alternative management scenarios. Carmona-Torres *et al*. (2014) developed a multifunctional farm-level performance assessment, comparing the current and alternative farming techniques.

However only a few operational applications have been described in the literature (i.e. the Ökopunkte scheme in Degenfelder *et al*., 2005; MOTIFS in Meul *et al*., 2008; DIALECTE in Pointereau *et al*., 2012; MESMIS in Ripoll-Bosch *et al*., 2012; and SMART in Jawtusch *et al*., 2013 and in Schader *et al*., 2014). The development of such tools is considered by many authors (e.g. Hansen, 1996; van der Werf and Petit, 2002; IEEP, 2014) as a method to support the implementation of sustainable agriculture. Each uses a set of indicators to express the degree of environmental impact of a farm based on the use of external inputs in relation to the production and/or the use of specific management practices.

The results of indicator-based assessments should be applicable at several levels: for research purposes, for policy makers and as a source of information for the general public. These different groups have different needs. The research community focuses on the methodologies being internally consistent and the data comparable. Policy makers prefer indicators of sustainable development which are clear, unambiguous and helpful to strategic and applied policy making (Hanley *et al*., 1999). As Meadows (1990) points out, ordinary people need to be informed if their environment and quality of life are deteriorating, about whether this trend is expected to continue, and how such a situation be reversed.

The most important stakeholder group of these sustainability assessments are farmers as they use directly the results of evaluations. As evaluations provide measurable results, farmers can do a year-to-year comparison of their own farming practices from the sustainability point of view or they can benchmark their activities against other farmers. These analyses can lead to better management decisions and can extend farmers' knowledge.

Methodology

Our research focuses on the development of the Green-point system for evaluating the environmental performance of Hungarian farms. This was carried out within the framework of the *Terradegra* project coordinated by the Agricultural Research Centre of the Hungarian Academy of Sciences. The main objective of the *Terradegra* project was to provide IT background and database for research services on the environmental load of agriculture and on the environmental condition of soil for the Soil Degradation Subsystem (SDS) of the National Environmental Information System. For the purposes of the research, farms representing all types of agricultural activities from across Hungary were selected. Data were gathered to monitor the effect of agriculture on the environment by defining the most important indicators of soil degradation. During the development and testing of the indicator system these data were used to calculate the Green-points of farms and to analyse statistically our sample.

Development of the Green-point system indicator set

As there has been no previous experience of evaluating the environmental performance of Hungarian farms, the Green-point system is derived mainly from the French DIALECTE system. However, owing to the fact that French and Hungarian farming practices are different, instead of a simple translation of the French tool, some modifications were required. Adaptation of the DIALECTE system had already started before the *Terradegra* project. The DIALECTE indicator set was tested on different pilot areas on a small number of farms. Based on the results, modifications were suggested by the experts participating in the projects. These modifications were done on three levels: (a) some indicators were modified: by keeping the focus area of the given indicator, the concept of measurement was changed; (b) maximum available points were modified in certain cases; and (c) new indicators were introduced to guarantee more precise measurement of farm sustainability in Hungary.

In the Green-point system each indicator is assigned a maximum score. The results of a surveyed farm are calculated through an algorithm based on the management practice of that particular farm. There are two levels of scoring: the field (or plot) and the farm level. While some indicators are broken down to field level, some others are defined only at the farm level. For example, average field size, and the diversity of crop production are only relevant at the farm level. The farm-level scores are based on field-level scores. Some farm-level indicators were calculated by weighting the field-level results with the size of relevant plots while others (for example indicator 16) were calculated by a different algorithm as described below. By running the collected data through specific algorithms to obtain the score of individual indicators, the total score of the farm in the Green-point system could be derived.

Thus the Green-point system is a quantitative evaluation method applicable for each land-use and farming type. Indicators are used to describe the intensity and the environmental effect of the farm. The system enables the user to compare the performance of farms, or within the same farm, the performance of different economic years. This approach motivates the farmer by focusing on the environmental achievements of the farm. The system is to enhance diversity (at farm and at species level), a minimised use of chemicals and artificial inputs, and the application of management methods that are similar to the traditional and extensive ones.

Field testing of the indicator set

Representative sampling of the farms was done based on the database of the Hungarian Central Statistical Office (KSH) General Agricultural Census (GAC), 2010. In the GAC the KSH recorded several parameters per farm and also categorised these 26,557 farms by applying a representative multiplier (indicating the size and the production volume of the farm). This methodology was worked out by KSH and the data of the categorised farms were passed to the *Terradegra* project team. Following this the project team identified the farm types which were characteristic on the national and (NUTS 3 level) county levels.

As the GAC contains several farming-related parameters, the three most important parameters indicating the farming intensity and the environmental impact of a farm were defined: (a) amount of fertiliser applied (kg ha^{-1}); (b) proportion of area where pesticides were used (%); and (c) amount of organic manure applied (t ha^{-1}). For each of the three parameters the 26,557 farms in the GAC were divided into five sub-categories (Table 1). Based on these parameters a three letter code was attached to each farm, where each code/letter (A-E, F-J and K-O, respectively) referred to one parameter. Using the representative multiplier, it showed us the characteristic farm types at national and county levels. The result of this classification was the identification of the most typical farm types and their proportion in each county, which ensured the representativeness of farm selection.

Data were collected by county experts with different professional backgrounds (soil experts, plant protection experts etc.) using a specially-developed questionnaire. Participants answered simple multiple-choice questions and entered on special data sheets the numerical values of certain parameters that clearly define the intensity of management. These answers defined (directly or indirectly) the results of different indicators. The scale of data collection was the largest homogenous area unit, i.e. a plot in the cases of arable and grasslands. There were two (spring and autumn 2011) surveys on two levels (farm and field). Complete data sets were collected on more than 2600 fields of 260 farms and a database was compiled for all examined indicators for the previous three economic years (2008/09, 2009/10 and 2010/11).

Methods of statistical analysis

Firstly, the contribution of each indicator to the total field- and farm-level scores was calculated. The percentages of farms with zero points and highest points for each indicator were used to illustrate the variability in the environmental performance of the farm sample. In addition, the relative contribution of six indicator groups to the variance in the data, and the impacts of four newly-developed indicators on the total scores, were assessed.

Secondly, owing to concerns about the appropriateness of the weightings given to each indicator in the total score, the scales of the 17 indicators were standardised (the achieved points were divided by the maximum available points). The standardised indicators were evaluated from two aspects. On the one hand, a correlation matrix was applied, and this was followed by a cluster analysis (paired group method). On the other hand, the environmental sustainability of the sample farms was assessed from the scores of the indicator groups. A one-way ANOVA test (with Tukey pairwise post hoc test) was carried out to identify significant differences.

Results

Indicators and their calculation methods

The Green-point system indicator set is composed of 17 indicators with a maximum total score of 90 (Table 2). The set is composed of six groups (A-E): four indicators of nutrient management, two of soil protection, three of natural landscape elements, one of plant protection and water management, three of energy consumption and four of diversity of crop production. Of these 17 indicators, seven indicators remained unchanged from DIALECTE, in six cases the weightings or calculation methods were changed, while four indicators (*length of field boundary with hedge*, *area affected by water management*, *irrigation*, and *external services*) were completely new. Thirteen are field-level indicators, all of which have farm-level versions, and four are farm-level only indicators. A further indicator (*crops cultivated*) is only used as background data for calculating different farm-level indicators.

Table 1: Parameters used to categorise the 26,557 farms in the General Agricultural Census 2010 database.

Amount of fertiliser applied (kg ha^{-1})		Proportion of area where pesticides were used (%)		Amount of organic manure applied (t ha^{-1})	
Value range	No. farms	Value range	No. farms	Value range	No. farms
0	11,854	0	7,138	0	19,401
0< ≥200	4,042	0< ≥50	3,240	0< ≥10	2,850
200< ≥500	7,797	50< ≥100	10,955	10< ≥30	2,579
500< ≥700	1,271	100< ≥200	3,655	30< ≥50	1,158
>700	1,593	>200	1,569	>50	569

Source: own composition

Table 2: The parameters of the Green-point system indicators structured by indicator group.

No.	Indicator name	Unit of measurement	Max points	Level of usage*	Modification
A. Nutrient management					
1	Nitrogen balance	Active substance, kg ha^{-1}	10	Fi+Fa	As DIALECTE
2	Phosphorus balance	Active substance, kg ha^{-1}	10	Fi+Fa	Weighting changed
3	Potassium balance	Active substance, kg ha^{-1}	10	Fi+Fa	Weighting changed
4	Use of organic manure	kg ha^{-1}	5	Fi+Fa	As DIALECTE
B. Soil protection					
5	Winter land coverage	Percentage of total area	4	Fi+Fa	As DIALECTE
6	Non-ploughed areas	Percentage of total area	4	Fi+Fa	As DIALECTE
C. Natural landscape elements					
7	Length of field boundary with hedge	Percentage of total length	4	Fi+Fa	New indicator
17	Average plot size	ha	5	Fa	As DIALECTE
8	Area affected by water management	Yes/no	2	Fi+Fa	New indicator
9	Territory of land elements	Percentage of total area	5	Fi+Fa	Calculation method changed
D. Plant protection					
10	Frequency of pesticide use	Area of application (ha)	6	Fi+Fa	As DIALECTE
E. Energy consumption					
11	Irrigation	Yes/no	2	Fi+Fa	New indicator
12	Fuel consumption	l ha^{-1}	3	Fi+Fa	Calculation method changed
13	External services	Yes/no	1	Fi+Fa	New indicator
F. Diversity of crop production					
14	Crops cultivated	ha	-	(a)	-
15	Proportion of legumes in crop structure	Percentage of total area	0	Fa	Weighting changed
16	Proportion of cereals and maize	Percentage of total area	5	Fa	Weighting changed
18	Diversity of crop structure	Percentage of crop area	10	Fa	As DIALECTE

* Fi = farm; Fa = farm; (a) used indirectly for farm-level calculations
Source: own composition

Field-level indicators

Nitrogen, phosphorus and potassium balances (indicators 1-3) are calculated by subtracting the amount of active substance removed from the amount of active substance applied. One part of the information required for the calculation of the applied active substance is directly available from the famers. The other part requires a calculation based on the type and the amount of fertiliser applied on the field. The per-hectare amount of active substance removed is obtained by multiplying the crop yield with a crop specific N/P/K coefficient. Surplus nitrogen is maximised at 50 kg ha^{-1}, no points are given above this. The maximum score is 10 if the surplus is zero, otherwise the logic of the calculation is that the lower the surplus values, the higher the scores. The algorithm is similar for P and K, but the limit is 30 kg ha^{-1}.

Use of organic manure (indicator 4) compares the amount of active substance applied with manure to the total amount of active substance. To obtain the indicator score, manure quantity and type are needed. The algorithm takes these data and an N/P/K coefficient from a background table to calculate the amount of active substance applied with manure per unit of area. The figures obtained are then compared to the total amount of N/P/K applied (including artificial fertilisers) on the field. To get the final score, the average proportion of active substances (N/P/K) applied with manure is multiplied by the maximum potential score (5 points). When only manure was applied as a fertiliser, the maximum score is automatically given.

Winter land coverage (indicator 5) is scored according to crop type (winter wheat, multi-year lucerne, temporary grassland etc.). Four points are awarded when the whole area has winter coverage and the minimum score is 0 for not having any cover. As regards to *non-ploughed areas* (indicator 6), only direct sowing, set aside and other areas that are not ploughed can be rewarded with 4 points. For *length of field boundary with hedge* (indicator 7), the percentage of total length with hedge is multiplied by the highest possible score (4 points) and then with a multiplier of 1.5; however the final score cannot be higher than 4 points.

Area affected by water management (indicator 8) is a simple yes/no question, with a score of 2 points if there are areas under water management and 0 if there are not. In terms of territory *of land elements* (indicator 9), five points are awarded when less than 10 per cent of the field is covered with landscape features (e.g. small lakes, forest belts etc.), and the maximum score (10 points) is given if the proportion is higher than 10 per cent. For *frequency of pesticide use* (indicator 10) the number of pesticide applications is multiplied by the size of the field[6] and then with a multiplier, which is 1 for herbicides, 2 for fungicides and 3 for pesticides. The interim score is obtained by dividing the sum of sub-results by the size of the field. When the interim score is above 13, the final score is zero. When it is below 13, then the maximum score (6 points) is divided by 15 and multiplied by the interim score to get the final score.

Irrigation (indicator 11) is another simple yes/no question. The indicator scores 2 points if there is irrigation and 0 if there is not. The amount of water per area unit is not considered in this calculation. For *fuel consumption* (indicator 12), the Green-point system divides the fuel consumption on a given field with the total area of the field to obtain the specific (per hectare) consumption. If the result is at least 150 l ha^{-1}, the score is 0; between 100 to 150, the score is 1;

[6] If a pesticide was applied three times on the same field, we calculate with 300 per cent of the territory of that field. Above this we apply the multiplier of 3.

between 50 to 100, 2 points are given; and, for results below 50 litres, 3 points are granted. *External services* (indicator 13) is also a simple yes/no question. The indicator scores 1 point if the farm relies on any external service and 0 if it does not.

For *crops cultivated* (indicator 14), only interim points are given, since these data are only needed for farm-level calculations. For grain crops, maize and legumes the interim score equals the size of the field. When there is an annual or multi-year crop on the field, the interim score is obtained by multiplying the field size with 0.1. When there is undersowing on the area, the multiplier is 0.2; whereas for temporary grassland the multiplier is 0.3.

Farm-level indicators

Although most of the indicators are calculated directly from field-level indicators 1-13 (but weighted by the size of relevant area), an additional four indicators are only applied at the farm level.

Proportion of legumes in crop structure (indicator 15) is calculated from the interim scores of the field-level *crops cultivated* data. Relevant field-level interim results are summed and then divided by the total area of the farm. To get the final score this fraction is multiplied by 5 points. The algorithm is the same for the *proportion of cereals and maize* (indicator 16). Finally, the *average plot size* (indicator 17) is calculated. Where this is above 10 hectares, the score is 0; values between 5 to 10 hectares are reduced by 5 and the result is extracted from the maximum available score (5 points); for values under 5 hectares, a maximum score of 5 points is given.

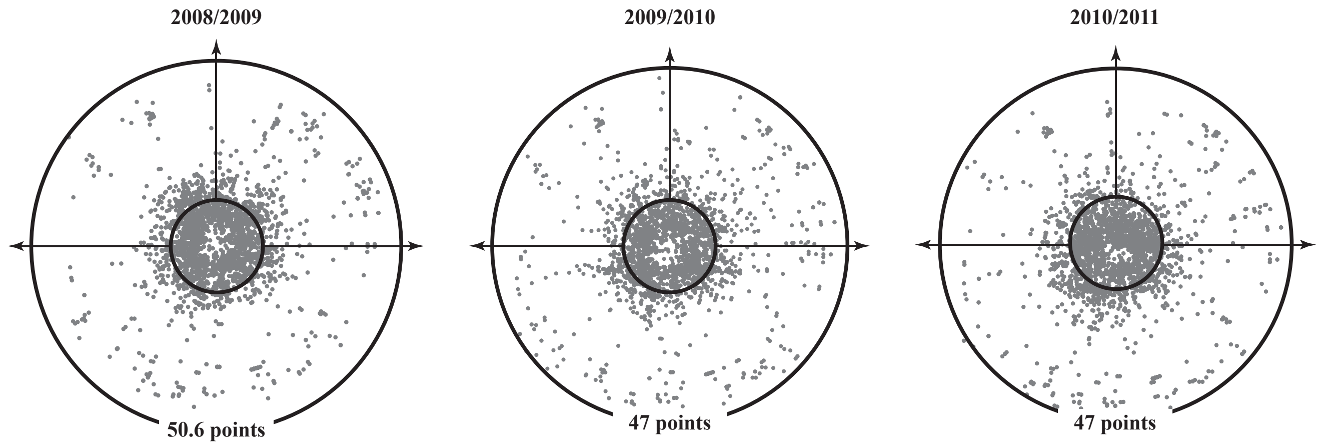
For *diversity of crop structure* (indicator 18), we sum the number of different types of crops cultivated (including grasslands and pastures), and this figure is divided by the number of plots. This is multiplied by the maximum score (10 points). In the second part of the calculation, the percentage of grass coverage is calculated for the total farm size. Multiplying the maximum 10 points with this percentage, the second interim score is obtained. The final score, which should not exceed 10 points, is the sum of these two interim scores.

Field testing of the indicator set

Field results

The field-level scores of the three economic years are shown in Figure 1. The inner circle represents the annual average value, whereas the outer circle shows the maximum value of that year. The maximum possible score at the field level is 60 points, and the field with the best performance reached 50.6, i.e. 84.6 per cent of the maximum. While this particular figure is relatively high, the average values are low, about 23 per cent of the total score. There was no significant difference between the performances of the three years. Probably this is due to the fact that management methods and other relevant parameters are likely to have remained unchanged from year to year.

We examined the influence (weight) and proportion of each indicator within the total score of a particular field and calculated the average importance of each indicator. Four indicators (out of 14) accounted for 76 per cent of the total performance of fields. The indicator with the biggest effect is *frequency of pesticide use* (indicator 10), which accounted for 39 per cent of the total score, followed by *fuel consumption* (indicator 12), *non-ploughed areas* (indicator 6) and *length of field boundary with hedge* (indicator 7) which accounted for 16, 12 and 10 per cent respectively. The first three of these indicators were drawn from DIALECTE (although in the case of indicator 12 the calculation method was changed), while the fourth is a completely new indicator developed by us. The remaining ten indicators accounted for less than a quarter of the total performance of fields.

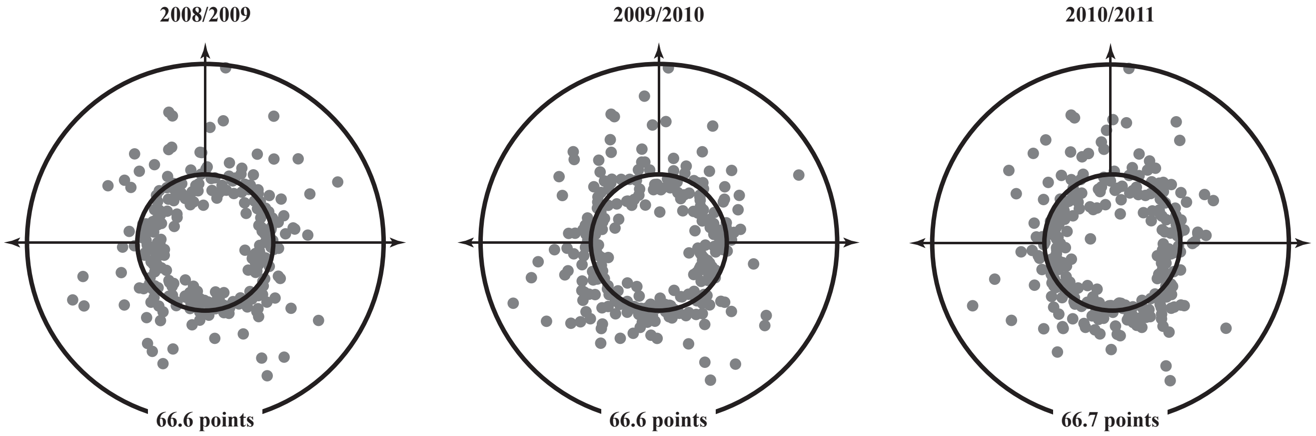


Number of fields: 2665
Maximum: 50.6
Minimum: 1.0
Average: 13.8
Deviation: 9.7
Relative deviation: 70.6%

Number of fields: 2663
Maximum: 47.0
Minimum: 0.6
Average: 14.5
Deviation: 10.0
Relative deviation: 69.0%

Number of fields: 2665
Maximum: 47.0
Minimum: 1.0
Average: 14.0
Deviation: 9.7
Relative deviation: 69.5%

Figure 1: Green-point field-level scores for three economic years.
Source: own data



2008/2009	2009/2010	2010/2011
Number of fields: 260	Number of fields: 260	Number of fields: 260
Maximum: 66.6	Maximum: 66.6	Maximum: 66.7
Minimum: 13.0	Minimum: 13.4	Minimum: 9.4
Average: 26.3	Average: 27.2	Average: 29.4
Deviation: 8.6	Deviation: 8.7	Deviation: 8.2
Relative deviation: 32.7%	Relative deviation: 31.9%	Relative deviation: 31.0%

Figure 2: Green-point values of three economic years at farm level.
Source: own data

Farm results

At farm level, the pattern of distribution and the difference between economic years at farm level are similar to those shown on field level (Figure 2). The maximum possible score at farm level is 90 points. The average score was 33 per cent, and even the maximum scores were barely above two-thirds of that figure. The relative deviation was even lower.

The distribution of the most significant indicators is more diverse at farm level than at field level. Of the 17 indicators, seven accounted for an average of 75 per cent of the total score. These indicators are the *diversity of crop structure* (indicator 18; 20 per cent), *frequency of pesticide usage* (indicator 10; 16 per cent), *proportion of cereals and maize* (indicator 16; 11 per cent), *territory of land elements* (indicator 9; 8 per cent), *fuel consumption* (indicator 12; 7 per cent), *nitrogen balance* (indicator 1; 6 per cent) and *non-ploughed areas* (indicator 6; 6 per cent). The results also show that the difference between the relative weights of these highlighted indicators is lower than the same figures at field level.

The data were also analysed according to indicator group. According to the raw data, *nutrient management* (group A) and *natural landscape elements* (group C) had the biggest effects on the variance of the environmental performance of farms (Table 3).

These results are reflected in the distributions of scores across the farms. In the cases of indicators 5, 8, 11 and 13 more than 80 per cent of farms scored zero each year (Table 4), although three of these were simply scored 'yes/no'. This means the farms have the least favourable effect on the environment as regards *winter land coverage, area effected by water management, irrigation* and *external services*. In terms of *non-ploughed areas* and *frequency of pesticide usage* (indicators 6 and 10), more than 10 per cent of the farms scored very highly (meaning that more than 10 per cent of the farms have the most favourable effect in these areas).

Among the four new indicators, *length of field boundary with hedge* (indicator 7) has the highest effect (4.3 per cent on average) on the overall farm-level scores (Table 5).

Table 3: Share of variance by indicator group from raw data and standardised data.

	Indicator group	Raw data	Standardised data
A	Nutrient management (1-4)	71.9	13.5
B	Soil protection (5,6)	6.2	28.1
C	Natural landscape elements (7-9, 16)	13.5	11.0
D	Plant protection (10)	4.1	33.0
E	Energy consumption (11-13)	1.5	10.6
F	Diversity of crop production (14, 15, 17)	2.8	3.8

Source: own data

Table 4: Share of farms achieving the most and least (zero) favourable possible scores per indicator for each individual year (per cent).

Indicator number*	2008/2009		2009/2010		2010/2011	
	least	most	least	most	least	most
1	25	3	22	3	25	3
2	38	4	33	4	37	3
3	53	4	48	4	47	3
4	67	0	65	0	61	0
5	85	5	85	5	85	6
6	23	11	21	10	23	12
7	28	0	28	0	28	0
8	87	1	85	1	87	1
9	28	10	27	9	27	10
10	5	12	6	10	5	10
11	87	2	91	1	89	2
12	8	19	7	18	7	19
13	90	10	90	9	90	10
14	-	-	-	-	-	-
15	52	0	46	0	47	0
16	10	4	10	4	9	5
17	54	24	56	25	55	24
18	237	1	235	1	235	1

* For indicator names see Table 2
Source: own data

Table 5: Proportion of total farm-level scores accounted for by the four new indicators (per cent).

	Length of field boundary with hedge (7)	Area affected by water management (8)	Irrigation (11)	External services (13)
Minimum	0.0	0.0	0.0	0.0
Maximum	15.9	11.1	11.1	5.2
Mean	4.3	0.4	0.4	0.4
Standard deviation	4.2	1.3	1.4	1.2

Source: own data

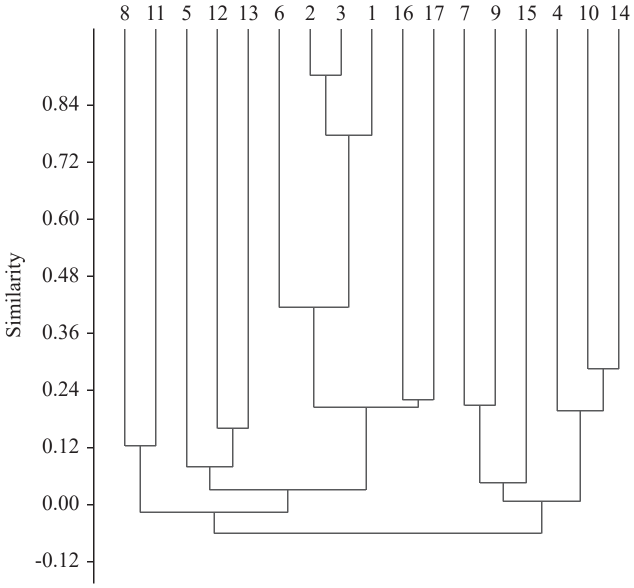


Figure 3: Hierarchical classification of the 17 standardised indicators calculated with cluster analysis (paired group method).
Source: own composition

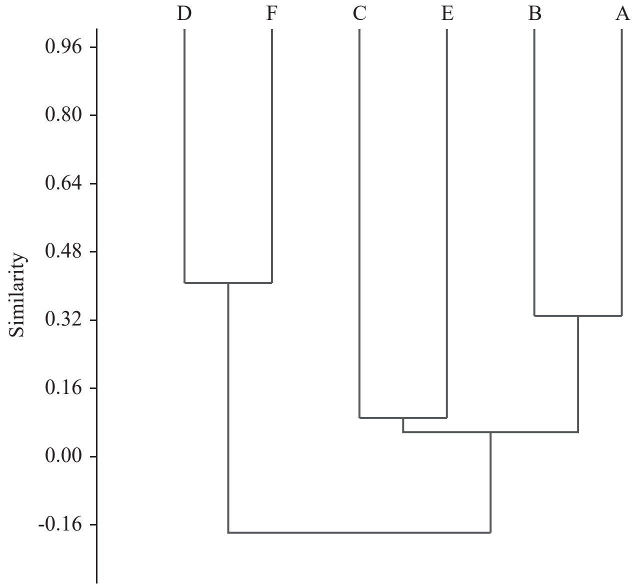


Figure 4: Correlation based cluster analysis of the standardised data of indicator groups A-E.
Source: own composition

Analysis of standardised data

Linear correlation and rank correlation were used on the farm-level data to compare the results of the original calculation method (raw data) and the standardised-balanced summing method (standardised data). Both the linear (0.79) and rank (0.83) correlations were significant and positive, and were significantly different from zero (for linear correlation: p=1.21 *10 ad-57; for rank correlation: p=2.28 *10 ad-67). This means that farms that scored highly using the raw data also scored highly when applying the standardised data.

By applying correlation as a distance function (in similarity form), cluster analysis was used to create a hierarchical classification of the 17 standardised indicators (Figure 3). Zero or negative similarity index values mean that indicators are not similar, whereas a positive value indicates similarity between indicators. Similarity between indicators is shown by horizontal lines. Indicators 1, 2 and 3 are much more strongly related than any other variable pairs and a hiatus is visible in the distribution of correlation values. Indicators 7 and 9, 12-13 and 14-15 also form separate clusters. To overcome these issues, indicators within the six indicator groups A-E were totalled and divided by the number of indicators in the group. These group average values were summed so that the parameters influenced the final indicator values of farms equally. The relationships between the six indicator groups were examined by correlation matrix and correlation-based cluster analysis. All correlations were below 0.45 (Table 6).

Table 6: Correlation matrix of the six indicator groups.

	A	B	C	D	E	F
A	-	5.56E-08	0.010	0.057	0.812	9.45E-14
B	0.329	-	0.864	7.84E-08	0.337	2.89E-10
C	0.160	-0.011	-	0.568	0.152	0.249
D	-0.118	-0.326	0.036	-	0.390	9.65E-12
E	0.015	0.060	0.089	-0.054	-	0.146
F	-0.440	-0.378	-0.072	0.406	-0.090	-

For indicator group names and constituent indicators see Table 2
Source: own calculations

The correlation-based cluster analysis reveals the most similarity between indicator groups A and B (*nutrient management* and *soil protection*) and groups D and F (*plant protection* and *diversity of crop production*). This would seem reasonable as the first two groups are soil-related and the second two are focusing on the produced plants (Figure 4). The one-way ANOVA test shows that there is no significant difference in the average values between the indicator groups B and C, B and E, and C and E, meaning that from these aspects the performance of Hungarian farms are similar. However, all other indicator groups are significantly different from each other. The environmental sustainability the sampled farms with respect to each of the six indicator groups is illustrated in Figure 5. The closer the value is to 1, the higher is the sustainability.

As with the indicator group raw data, the shares of variance in the farm-level scores of the indicator group standardised data were calculated (Table 3). With the elimination of the bias originating from the weighting of the indicators, the variance was influenced mainly by indicator groups A (*nutrient management*), B (*soil protection*) and D (*plant protection*).

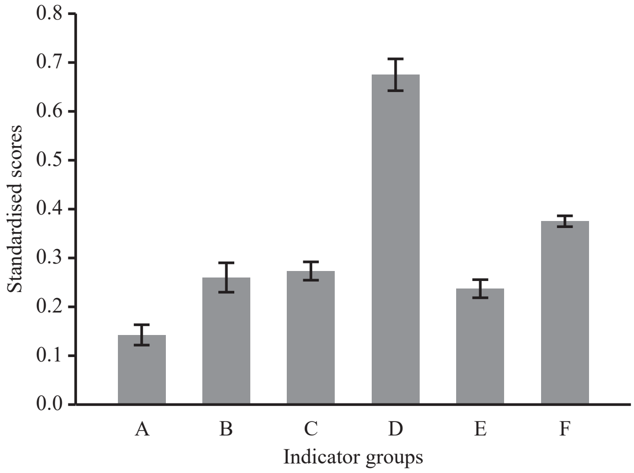


Figure 5: Environmental sustainability of a sample of Hungarian farms according to six indicator groups using standardised data.
Error bars indicate ± 1 SE
Source: own composition

Discussion

The results suggest that the average environmental performance of the farms in our sample is relatively low. This assessment applies both to the field (where the average is 14.1, i.e. 23 per cent of the total available points) and farm (the average of 27.6 is just 33 per cent of the total) scores. Farms scored the highest for *plant protection* and *diversity of crop production*, meaning that their activities are the least environmentally destructive in these areas. The most critical area is *nutrient management*, whereas *soil protection*, *natural landscape elements* and *energy consumption* show average results.

However, the relative weighting of individual indicators can be just as important in determining the apparent level of sustainability as the actual choice of indicators. The Green-point system is still under development and it may be that imperfect weighting is the explanation behind our results. For this reason, the data were standardised to eliminate the influence of weighting. After comparing the standardised and the raw data, differences among the most determinant indicators and indicator groups were outlined. For the raw data, 75 per cent of the variance was determined by two indicator groups (A and C, including six indicators), whereas for the standardised data this level of variance was covered by five indicator groups (D, B, A and C, including eleven indicators). This difference highlighted that standardisation proved to be useful and reconsideration of indicator weightings might be needed.

The standardisation of data is also important for the further development of the tool: while the general analysis of the results allows the comparison of farms; the analysis of standardised data enables researchers to evaluate the system itself. By applying these two approaches in parallel, efficient further development can be achieved.

The testing of the applicability of the new indicators was also essential. The focus areas of these new indicators were selected based on international experiences. Even though similar indicators of different assessment tools are calculated in different ways, the topics they try to evaluate overlap. The new indicator of *irrigation*, for example, is one of the indicators of SMART and it was also added to the new indicator set of DIALECTE. However in the Swiss tool, irrigation similar to the indicator of *water management* is covered by more than one indicator. The indicator *length of field boundary with hedge* is of high importance in the English agri-environmental measures such as Entry Level Stewardship, Organic Entry Level Stewardship and High Level Stewardship, and it proved to be an important indicator of the Green-point system as well as it has a considerable effect on the variance of both the standardised and raw results.

Another important consideration is the scale used for evaluation. Figures presented in Table 4 revealed that the use of a yes/no scale is not recommended in the long run as it can distort the results. However it can be justified during the testing phase of a new indicator, since it still can show the relevance of the topic on which the indicator is focusing.

The necessity of individual indicators was analysed by checking the correlations between indicators. There was a strong and positive correlation between indicators 1, 2 and 3. This shows that it is not necessary to use all three indicators when assessing the nutrient management. It is enough to use only one of them (probably N), as the inclusion of three such similar indicators (with a total of 30 points) can considerably shift the proportion of the weight of indicator groups relative to each other.

To verify our results we compared them with macro-level data. Macro indicators are quite different from micro indicators but still some overlap was found between the Green-point indicators and the sustainable development indicators of KSH (KSH, 2013). KSH applies two macro-level indicators measuring sustainability (nutrient balance for N and P) which are comparable to the Green-point system's indicators. The patterns of our nutrient balance indicators over the period 2008-2011 are in line with the trends of the relevant macro indicators of KSH.

Although we did not analyse specifically the applicability of our tool for different farming systems, it can be stated that the indicators of the Green-point system, in their present form, are mainly suitable for assessing crop production farms. Some of the indicators are not appropriate in the case of specialised farms (e.g. plantations, agro-forestry systems, nurseries, apiaries), therefore such farms are at a disadvantage as regards collecting green points. Animal husbandry farms face similar drawbacks in this respect as indicators for these activities are missing.

Therefore we consider it important for the future to complement the current indicator set with new indicators which enables the Green-point system to assess the environmental performance of all farming systems in Hungary. Such a complete – perceived impact measuring – system could lead to the elaboration of a real impact measuring indicator system, which can expected to be the future basis of the distribution of agricultural subsidies in the CAP.

Acknowledgement

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Changes in population and labour force in family farming in Poland

This paper discusses changes in population and labour in family farming in Poland. We analyse the size and socio-demographic characteristics of the farming population, the degree of utilisation of own labour resources on the farm and the assessment of labour inputs in family farming. Our research uses data from IERiGŻ-PIB field studies as well as general statistics. In comparison to the European Union as a whole, the socio-demographic (education and age) structure of the farming population in Poland is relatively favourable. There has been a significant reduction in the share of persons working exclusively on the family farm while the share of those with off-farm employment has increased. Around 500,000 persons who are not registered as unemployed and may be considered as redundant from the point of view of farming activities and represent hidden unemployment. We conclude that employment on family farms has a decreasing role in reducing the imbalance in the rural labour market in Poland.

Keywords: agriculture, farm structure, off-farm employment

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Introduction

Economic development can result in a reduction in the economic significance of agriculture, in terms of a decreasing share in Gross Domestic Product (GDP). Such a trend is increasingly visible in the Polish economy, despite the increase in agricultural production (Mrówczyńska-Kamińska, 2008). As a result, in 2013 the agricultural sector accounted for just 3.4 per cent of Poland's GDP (GUS, 2014). Nonetheless, this figure is still almost double the average figure for the European Union (EU) which was 1.8 per cent in 2012 (Nurzyńska, 2014). The continuing impact of the agricultural sector on the general economic and social situation in Poland is illustrated by its relatively large significance in the employment structure of the rural population (Chmieliński, 2013) and the livelihood strategies of rural households (Sikorska, 2006; Karwat-Woźniak, 2012).

Currently the biggest challenge in the economic sphere is the competitiveness of the agri-food sector, which must make more efficient use of its production potential (especially land and labour resources). Labour productivity is low and the excessive number of workers engaged in agriculture is an important factor hindering economic change in the sector. Implementing the desirable structural changes mostly involves the activation of concentration processes in the agrarian structure, the reduction in the number of persons employed in agricultural production and the improvement of labour productivity (Cramer *et al*., 2001). The activation of such processes has been hampered not only by macroeconomic conditions, particularly labour market imbalance, but also by the socio-demographic characteristics of the farming population. Therefore, the problem of off-farm employment in rural areas has become increasingly important, particularly for farming families (Gardner and Rausser, 2001). There is a need to diversify the economic activities of the farming population in order to improve the competitiveness of agriculture, increase income levels and implement the multifunctional development of agriculture and rural areas (this entails the provision of both commodity and non-commodity goods and services by farms to society, such as landscape, employment, rural viability etc. as well as creation of strong rural non-farm economy).

In farming, replacement of land with capital is becoming more significant (Johnson, 2002) and, as a consequence, the impact and significance of the area of cultivated land in determining the production results of farms are decreasing (Woś, 1998). To a relatively larger extent, land is becoming the environment and space of agricultural production rather than a production factor (Woś, 2001). However, under the conditions of Polish agriculture, especially from the perspective of particular agricultural manufacturers, the area of land used still, to a great extent, determines both the scale of production and the profitability of agricultural activities (Zegar, 2009a). This means that under conditions of high fragmentation in terms of area, an increase in the farm's area may considerably affect the economic situation[1]. Achieving a reasonable level of concentration of agricultural land is also desired from the point of view of the protection of natural resources and sustainable agricultural development (Wrzaszcz and Zegar, 2014). In this case, the development of the agricultural sector in Poland is strongly linked to processes of land concentration, especially within individual[2] (family) farms (Zegar, 2009b).

Concentration processes in agriculture also determine the increasing requirements of the recipients of agricultural products, especially regarding the size of product batches. The necessity for farmers who aim to at least maintain their level of income from agriculture to increase their scale of production is also more and more evident. This requirement should also be related to trends of relative decrease in prices of agricultural products[3] which, as a matter of principle, is a universal regularity and results in the decrease in profitability of agricultural production.

Since modern production technologies are inherently

[1] A study by Karwat-Woźniak (2009) proved that in Polish conditions, an increase in the area of cultivated land by 1 ha increases the farm's opportunity to move to a higher production group by 3-4 per cent.

[2] Despite certain conceptual differences, we use terms: family farms and individual farms interchangeably.

[3] In 2012, as compared to 1995, the index of prices of products purchased by farmers amounted to 317.4 per cent, while a similar index regarding products sold by farmers amounted to only 240.6 per cent. As a result, the index of prices (price scissors) of products sold by farmers to products purchased for the purposes of agricultural production at that time amounted to 73.4 per cent, (75.7 per cent - when it comes to products purchased for production purposes) which means that the prices of products sold by farmers were increasing 25 per cent slower than the prices of products purchased by them (GUS, 2013).

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Table 1: Changes in land structure of family farms in Poland by size, 2002 and 2010.

Specification	Year	Total	Size groups (ha of agricultural land)					
			1-5	5-10	10-15	15-30	30-50	≥ 50
Structure of farms	2002	100.0	58.7	21.9	9.4	7.8	1.6	0.8
	2010	100.0	55.2	22.5	9.8	8.6	2.3	1.6
Change in number of farms in the period 2000-2010 (%)		-20.1	-25.9	-17.6	-16.6	-10.7	13.7	42.1

Data source: GUS (2013)

labour-saving, the economic strength of farms is increasingly dependent on the existing skills of farm managers and their ability to acquire new skills (Terluin and Post, 2000). At the same time, the potential to increase the non-agricultural economic activities of farming family members depends on their educational level since improved qualifications make off-farm employment more likely, thereby reducing agricultural employment as well as the number of redundant persons on the farm (that represent hidden unemployment in the agricultural sector)[4].

In this paper we investigate whether land the concentration process in Polish agriculture is being followed by changes in farm structure and the socio-demographic characteristics of the farming population as well as in labour relations (inputs). Increasing the area of farms and optimisation of farm labour are autonomous processes and reflect the internal development forces present in agriculture. The outcome of these trends from the macroeconomic perspective are structural transformations in agriculture (Tomczak, 2005) that determine the future competitiveness of the agri-food sector in Poland and in countries with similar farm structures. We hypothesise that land concentration is followed by improvement in labour quality and rationalisation (optimisation) of the use of own labour resources. At the same time, we argue that, apart from registered unemployment, a significant number of farming family members may be considered redundant from the point of view of farming activities (and represent hidden unemployment in the agricultural sector). We try to apply subjective and objective criteria to identify the scale of this phenomenon.

Methodology

Our research findings are based on various sources of available data, the main empirical material being the results of the regular field surveys conducted by the Institute of Agricultural and Food Economics – National Research Institute (IERiGŻ-PIB) in Warszawa, mostly from the 1996, 2000, 2005 and 2011 studies. The survey covers all agricultural holdings with more than 1 ha of agricultural land at the disposal of natural persons, namely individual agricultural farms, being in fact family farms (Zegar, 2008), located in 76 villages across Poland. Those locations were deliberately selected to make the size of the analysed farms proportional to the actual area structure, both at the national level and across regions. The surveyed units accounted for around 1 in 500 of all family farms, and in 2011 survey their number was approximately 3,300. The survey questionnaire was designed to collect a great variety of detailed information, not only on the features of the farms, but also on their demographic characteristics, the educational level, economic activities of managers and their family members.

The large number of farms included in the analysed sample, the wide range of collected material and the application of the same research method each year, which was the precondition for the continuity and comparability of data, has enabled a multidimensional analysis of labour in family farming. Empirical data from field studies used in the analysis concerned the economic year or the status at its end. These were, accordingly, 1999/2000, 2004/2005 and 2010/2011, which are referred to below as the years 2000, 2005 and 2011.

The empirical material from field studies was combined with selected Polish Central Statistical Office (GUS) data from the 2002 and 2010 National Agricultural Censuses.

Results

Changes in farm structure and processes of land concentration

During the pre-EU accession period and the first years of Poland's membership of the EU, relatively large structural changes took place in Polish rural areas and agriculture. In the period 2002-2010 the number of individual farms, which includes entities with an area of more than 1 ha of agricultural land, decreased from 1,951,700 to 1,558,400, an average loss of 2.5 per cent each year (Table 1).

The changes in the numbers of farms varied according to their area (Table 1). The number of entities with up to 30 ha of agricultural land decreased, with the largest loss (26 per cent) occurring in the group of farms with up to 5 ha of agricultural land. These latter farms usually could not provide sufficient work and livelihood for an average agricultural family but, despite these changes, they continue to constitute the most numerous community (55 per cent of all individual farms). Different trends can be seen for farms with at least 30 ha of agricultural land which are capable of further economic development. In total, the number of entities in this group increased by 24 per cent. The increase was even higher in the group of farms with 50 ha or more. However the share of the total agricultural area of the larger farms remains small: in 2010 the share of individual farms with at least 30 ha of agricultural land was 3.9 per cent, while for farms of 50 ha and larger the figure was 1.6 per cent.

The analysis of changes in the structure of land use by family farms shows that the slight decrease (from 13.6 to 13.4

[4] Hidden unemployment is the underestimation of unemployment levels in labour statistics, where only those who are 'actively looking for work' are counted as unemployed. Rural labour markets are 'tight', i.e. characterised by imperfect information and high transaction costs (Hurst *et al*., 2005). There is a tendency for those who are redundant on the farm to give up looking for off-farm jobs, and to work on the farm for less time that they would like.

Table 2: Structure of agricultural land use by family farms in Poland by size, 2002 and 2010.

Specification	Year	Total	Size groups (ha of agricultural land)					
			1-5	5-10	10-15	15-30	30-50	≥ 50
Structure of agricultural land use	2002	100.0	18.6	20.3	14.9	21.1	9.5	15.6
	2010	100.0	16.3	18.7	13.8	20.3	10.1	20.8
Change in the period 2002-2010 (%)		-1.5	-13.6	-9.4	-9.2	-5.5	4.2	31.5

Data source: GUS (2013)

million ha) in the total area of agricultural land at their disposal was accompanied by large differences in this process between area groups (Table 2). In the period 2002-2010 the area of agricultural land occupied by the group of entities of up to 30 ha fell by 9 per cent. Despite the decrease, however, in 2010 farms of up to 5 ha arable land still accounted for 16 per cent of the total area of agricultural land in individual farms (c.f. 19 per cent in 2002). By contrast, the area of land at the disposal of farmers with farms of 30 ha of agricultural land and more increased by 19 per cent. The share of agricultural land in entities with the possibility to meet the conditions of growing competition increased from 25 to 31 per cent.

Socio-economic characteristics of the farming population

According to IERiGŻ-PIB field studies, in 2011 the demographic structure of the group living on family farms continued to be favourable (Table 3). However, although in that year the population aged 18-44 represented the largest group (40.6 per cent), in comparison with 1996 there was a significant increase (from 18.4 to 25.4 per cent) in the share of other working age persons (aged over 44) and a decline (of over 10 percentage points) in the pre-working age population. The post-working age population has remained virtually unchanged. This shows that rural areas may be affected by problems related to the ageing population in the future.

Performance assessments of agricultural holdings in a competitive environment frequently raise the issue of the relatively low educational level of the farming population.

Table 3: The age structure of the population from family farms in Poland, 1996-2011, per cent.

Year	Pre-working age[a)]	Working age[b)]		Post-working age[c)]
		Age of mobility[d)]	Age of non-mobility[e)]	
1996	27.8	38.4	18.4	15.4
2000	26.1	39.2	20.1	14.6
2005	22.1	40.0	22.7	15.2
2011	17.6	40.6	25.4	16.4

Economic age groups according to GUS: a) persons aged 17 or under; b) women aged 18-59 and men aged 18-64; c) women aged 60 or over and men aged 65 or over; d) persons aged 18-44; e) women aged 45-59 and men aged 45-64

Data sources: IERiGŻ-PIB field studies 1996, 2000, 2005 and 2011

It results from years of young people's career choices, unfavourable for agriculture. Furthermore, involvement in work on the family farm has often been dependent on the family situation rather than on actual qualifications.

Over the period 2000-2011 there was an improvement in the educational level of members of farming families in Poland, with regard to general education (Table 4). Higher values were observed for all levels of post-primary education, but the improvement was particularly evident in the case of higher education (up from 2 to 12 per cent), as well as for secondary (technical secondary school and high school) and post-secondary education (up from 17 to 31 per cent). Despite those positive changes, in 2011 more than 26 per cent of farming family members continued to have only general education at primary level, whereas 30 per cent graduated from basic (two/three-year) vocational school (Polish: *zasadnicza szkoła zawodowa*). However, between 2000 and 2011 there was also an increase in the share of persons with non-agricultural education, up from less than 43 to 55 per cent. At the same time, the share of persons who completed agricultural (both vocational and higher) education remained virtually unchanged, at around 13-14 per cent.

Along with those changes, the diversification of the economic activity of the farming population in Poland has notably strengthened. This was largely due to increasing employment opportunities in Poland and abroad. As a result, 57.4 per cent of the working members of farming families in 2011 were engaged only in their own agricultural activity and 13.0 per cent exclusively off their family farm (Table 5). Over the period 1996-2011, the share of the employed from farming families combining their economic activity with working on and off their units – although previously stable – increased slightly, from 22.8 to 29.6 per cent.

Table 5: Workplace of the population aged 15 or over from family farms in Poland, 1996-2011, per cent.

Year	Working exclusively on the farm	Combining on-farm and off-farm employment	Having only off-farm jobs
1996	74.0	22.8	3.2
2000	72.4	23.4	4.2
2005	66.3	24.1	9.6
2011	57.4	29.6	13.0

Data sources: IERiGŻ-PIB field studies 1996, 2000, 2005 and 2011

Table 4: The educational level of the working age population from family farms (including persons aged 15 or over who have completed their education) in Poland, 2000-2011, per cent.

Year	General education				Vocational education	
	Primary	Basic vocational	Secondary and post-secondary	Higher	Agricultural	Other
2000	41.4	39.3	17.1	2.2	14.4	42.6
2005	33.9	37.5	23.3	5.0	15.0	48.2
2011	26.4	30.1	31.5	12.0	13.2	54.9

Data sources: IERiGŻ-PIB field studies 2000, 2005 and 2011.

Transformations in the structural distribution of the population by place of work were continuous in nature and clearly intensified after 2000. They indicate that a growing number of people from farming families have begun actively to seek employment alternatives, often completely giving up work on a family farm. There are trends on agricultural holdings to rationalise employment and hire only the human resources that are needed. This process is illustrated by the decreasing number of family members engaging in farm work. This is also confirmed by the declining importance of family farming as a place of economic activity for the rural population and especially as an exclusive place of work.

In 2011 the majority (87.0 per cent) of economically-active farming family members aged 15 or over continued to work in their agricultural holdings, this being the only place of employment for over half of them (57.4 per cent). Nevertheless, the share of people contributing to work on their own farm during the period 1996-2011 decreased on average by 0.7 percentage points per year, while the share of people from farming families engaged in work on a farm declined on average by 1 percentage point per year over the period 2000-2011. As regards those working only in a family agricultural holding, the corresponding rates were about 1.1 and 1.4 percentage points, respectively.

Furthermore, our research shows that the drop in the population engaged only in agricultural activity also led to changes in terms of the amount of work performed (Figure 1). These the share of permanent, full-time farm workers fell from 64.2 in 1992 to 39.9 per cent in 2011 and this was accompanied by a substantial increase (from 6.9 to 26.8 per cent) in the share of those seasonally or occasionally engaged in agricultural activity. This was associated mainly with a lower level of involvement of the youth, women and post-working age people in family agricultural activity, reflecting the rationalisation processes in labour use. During the period 1992-2011 there were no major changes in the share of permanent farm workers who worked fewer than 8 hours a day (down from 28.9 to 33.3 per cent).

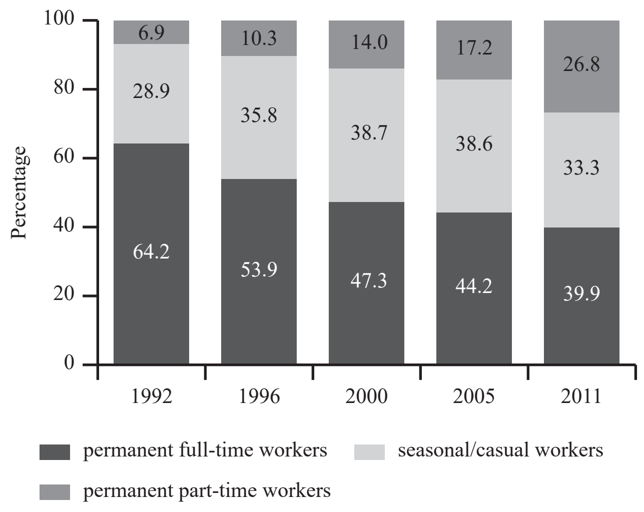

Figure 1: On-farm employment of the population from family farms in Poland, 1992-2011, per cent.

Data sources: IERiGŻ-PIB field studies 1992, 1996, 2000, 2005 and 2011

Changes in the economic activity of the farming population, particularly the declining importance of a family farm as a place of economic activity for its residents, are also reflected in decreasing agricultural labour inputs. In accordance with data from field studies, the period 2000-2011 witnessed another decline in agricultural labour inputs similar to that seen in the final decade of the 20th century. Between 2000 and 2011 this value dropped from 15.3 to 10.0 AWU per 100 ha of agricultural land, i.e. by 34.6 per cent (Table 6). This means that over this period the rate decreased on average by 3.1 percentage points per year, compared to 2.6 percentage points in the period 1992-2011.

The relatively high propensity in Poland to rationalise employment on family farms which has been observed after 2000 can be primarily attributed to:

- An increase in the advancement of land concentration. Data from field studies show that the average area of an agricultural holding grew on average by 1.3 per cent per year (from 8.5 to 9.7 ha of arable land) in the period 2000-2011 compared to 0.9 per cent in the years 1992-2000.
- An increase in the number of large farms. The share of holdings of 30 ha or more among the holdings surveyed was 5.6 per cent in 2011, compared to 4.2 per cent in 2005, 2.9 per cent in 2000, 2.1 per cent in 1996 and just 1.1 per cent in 1992.
- Improved technical infrastructure of farms, especially machinery and equipment enabling comprehensive mechanisation of agricultural production, whose emerging effects reduced the demand for labour. Data from field studies show that the share of well-equipped households with tractors increased from 16 to 33 per cent between 2000 and 2011. This also confirms advances in mechanisation in the entire manufacturing process. At the time, the number of holdings with a set of machines allowing for mechanisation of the whole technological process increased by almost 25 per cent. These changes took place almost three times faster than throughout the 1990s.

Table 6: Labour inputs of the population from family farms in Poland, 1992-2011.

Year	Annual Work Units (AWUs)				Change (1992=100)			
	Total per		Including own work per		Total per		Including own work per	
	farm	100 ha agricultural land	farm	100 ha agricultural land	farm	100 ha agricultural land	farm	100 ha agricultural land
1992	1.50	20.0	1.45	19.5	100.0	100.0	100.0	100.0
1996	1.42	17.2	1.37	16.6	94.7	86.0	94.5	85.1
2000	1.33	15.3	1.27	14.7	86.7	76.5	86.7	75.4
2005	1.19	12.4	1.13	11.8	79.3	62.0	77.9	60.5
2011	0.96	10.0	0.93	9.7	64.0	50.0	64.1	49.7

Data sources: IERiGŻ-PIB field studies 1992, 1996, 2000, 2005 and 2011

These transformations were also stimulated by increased opportunities for economic migration, mainly to the EU-15 Member States.

The decline in labour inputs in individual agricultural holdings was due to a drop in labour inputs of family members, as family labour force dominated total labour inputs in agricultural activity. In general, the significance of hired labour remained minor. These trends are confirmed by both general statistical data and the results of the IERiGŻ-PIB field studies. Moreover, after an increase (from 2.3 to 5.0 per cent) between 1992 and 2005 in the share of external labour force in total agricultural labour inputs in the individual agricultural holdings surveyed, the trend reversed. In 2011, the share dropped to 3.7 per cent.

Hidden unemployment in family farming

Our survey findings allow the application of objective criteria to the identification of the category of redundant persons, and thus the rate of hidden unemployment in family farming in Poland. We measure this phenomenon using two different approaches: the farm managers' opinions about the number of family members redundant in farming and the objective working time criterion. The criterion of unutilised working time was considered the most appropriate tool to determine the scale of this phenomenon. The group of individuals considered redundant included all working-age persons who worked only or mostly on the family farm, engaged in agricultural activities for three months per year or fewer, and also in the case of longer working periods, but involving no more than three hours a day.

According to the working time criterion, redundant persons accounted for 20 per cent of the total working age farming population, this being larger than the figure derived on the basis of the farm managers' assessments, which was slightly more than 7 per cent (Figure 2). In all size groups of agricultural holdings the differences between the two measures were relatively large: in all cases the share of redundant persons identified according to the farm managers' assessment was less than half the figure determined on the basis of the working time criterion. Therefore, in addition to registered unemployment (mostly concerning the non-farming population) of about 0.9 million residents of the countryside in mid-2011, approximately 500,000 persons may be considered as redundant from the point of view of farming activities (which represents an estimate of hidden unemployment in the agricultural sector).

Discussion

Our results show that the decline in the number of family farms in Poland has accelerated significantly. The rate of loss of individual farms during the period 2002-2010 (2.5 per cent on average each year) was approximately double that of the previous decade (Sikorska, 2013). In addition, field studies show that the tendency to liquidate farms was strengthened after Poland's accession to the EU. According to these data, the period 2005-2011 witnessed the loss of 55 per cent more farms on average each year than the years 2000-2005 (Karwat-Woźniak, 2012). Taking into account the fact that changes in the area structure are usually evolutionary, the recorded decrease in the number of farms is significant and indicates progress in the rationalisation of agricultural structures, the professionalisation of economic activities in the rural population and, most importantly, creates the possibilities of a more effective use of agricultural land and a better use of the economies of scale to improve the competitiveness of Polish family farms (Sikorska and Karwat-Woźniak, 2012).

Changes in the number of family farms have been paralleled by processes of land concentration. The dynamics of land concentration is the result of numerous factors, and the analysis of the intensity of this process in particular time periods demonstrates that they were mainly related to the general economic conditions and their impact on the non-agricultural job market situation as well as the economic situation in agriculture. This thesis is reflected, among others,

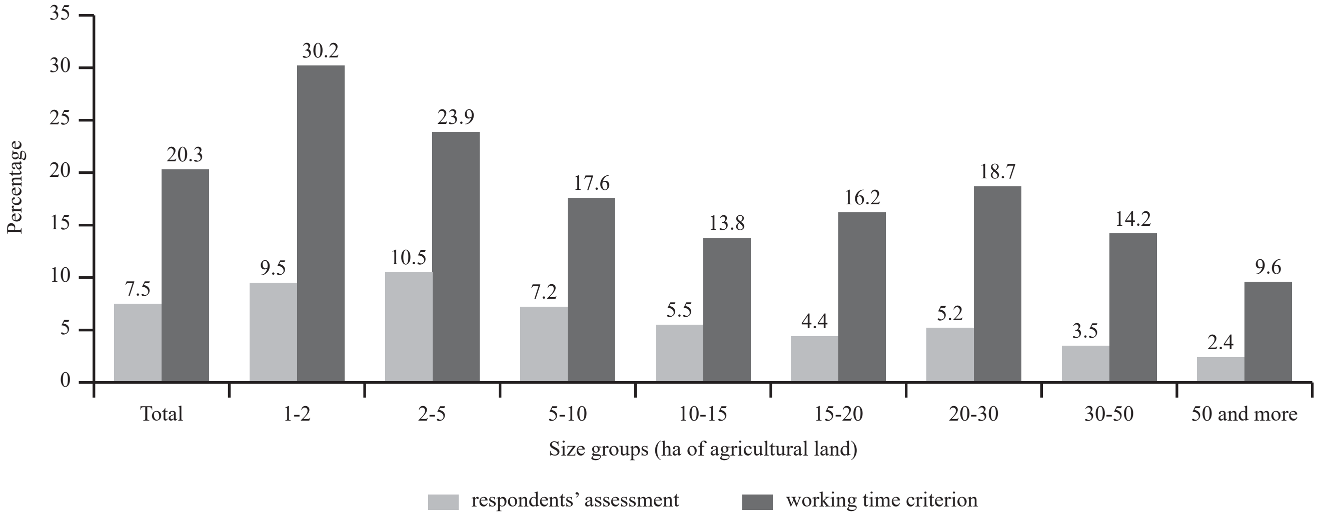

Figure 2: Share of redundant persons in the working age population from family farms in Poland by farm size, 2011, according to respondents' assessments and working time criterion, per cent.

Data source: 2011 IERiGŻ-PIB field study in a clear strengthening of the process following Poland's accession to the EU which resulted in the increase in the profitability of agricultural production. At the same time, the requirements of EU markets resulted in the need to introduce technological changes to the process of manufacturing agricultural raw materials, to increase the scale of production and improve product quality. These factors, as well as EU subsidies directly related to the area of cultivated land, and EU funds for projects related to the development of rural and agricultural areas, changed the attitude of Polish farmers regarding the land area of owned farms. These attitudes were also affected by the situation on the agricultural land market as well as the possibilities of being employed outside agriculture.

As a result, the average area of an individual farm in Poland increased on average by 3.2 per cent per year in the period 2005-2011. As compared to previous years, this increase should be considered very high. In 1990-2005 an average area of an individual farm increased by nearly 1.4 per cent annually (in the period 2000-2005 – by 0.9 per cent). But the average farm area is still much smaller than that which can create the conditions of competitiveness (Zegar, 2009a), and several times smaller than in countries with which Polish farms compete due to the assortment of production, for example Germany (40.6 ha). Polish agriculture is still characterised by one of the worst area structures of agricultural farms in Europe, as well as an unfavourable structure of use. In terms of the area structure of farms, the only other EU Member States similar to Poland are Italy, Lithuania and Portugal. In Member States characterised by the most optimal area structure (Denmark, Ireland, Germany) the share of farms to up to 5 ha of agricultural land did not exceed 10 per cent and they disposed of no more than 1 per cent of all agricultural area.

However, the possession of land by family farms in Poland is being systematically improved. This tendency is reflected in the increase of the average farm area. From the beginning of the transition period (1990) to 2013 the average area of a statistical individual farm increased from 6.3 to 9.3 ha, namely by 47.6 per cent, and thus the average annual increase amounted to 2.1 per cent. Furthermore, it should be noted that the structure of land use by entities from particular size groups is more significant than the structure of farms in the assessment of structural changes and their impact on the competitive potential (Poczta, 2013). It is the structure of land use that determines the average production conditions in a particular country (Sadowski *et al*., 2013).

The share of agriculture in the GDP of Poland declined from 7.2 per cent in 1990 to 3.3 per cent in 2001 (Ziętara, 2003). Therefore, the problem of off-farm employment in rural areas became increasingly important during the first decade of transition, particularly for farming families. Our study shows that the diversification of the economic activity of the farming population has notably strengthened. This was largely due to increasing employment opportunities in Poland and abroad. As a result, we observe a drop in the number of working members of farming families engaged only in their own agricultural activity and significant increase of those working exclusively off their family farm.

The relatively high propensity to rationalise employment which was observed after 2000 can be primarily attributed to an increase in both the advancement of land concentration and in the number of large farms, as well as the improved technical infrastructure of farms, especially machinery and equipment enabling comprehensive mechanisation of agricultural production, whose emerging effects reduced the demand for labour. Additionally, labour outflows from Poland not only facilitated a drop in the supply of labour, but also stimulated the creation of new jobs, which was associated with the growing demand as regards families whose members were emigrants (Rosiek, 2007; Chmieliński, 2013).

From our results we can also conclude that the socio-demographic structure of the farming population in Poland is still favourable and that the educational level of farming family members has been improving, although it continues to be rather low compared to that of the population. Owing to the complexity of the issue of labour resources and inputs in family farming, this topic represents a major determinant of successful restructuring of the agricultural sector in Poland. Economic activity of the farming population and alternative income sources for farming families are both important elements and prerequisites of rural development. Multiple activities are becoming increasingly widespread (Kaleta, 2005), which determines increased significance of non-agricultural education in rural development. At the same time, owing to technological progress, knowledge and the ability to make use of it, has been gaining in importance as the basis for economic activity, including agricultural activities. This means that both the diversification of income sources and economic efficiency of agricultural holdings are closely related to the quality of human capital, primarily determined by the educational level (Gall *et al*., 2003).

On the other hand, hidden unemployment in the countryside, even if favourable for the state in the short term (by lowering official unemployment rates), adversely affects restructuring and modernisation processes in agricultural holdings, thus in the whole sector (McLaughlin, 2013). The living costs of persons who are redundant in terms of production activities, as well as of those actually unemployed, are incurred by farming families, not by the state. It is negatively reflected in the economic performance of agricultural holdings and the level of agricultural investment expenditure.

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Social and technical infrastructure development of municipalities (*gminas*) in Poland

This paper presents the institutional and spatial determinants for the development of social and technical infrastructure in municipalities (*gminas*) in Poland. According to the empirical results, there are significant differences between various types of *gminas* in terms of the level of development of technical and social infrastructure. Similar levels of technical or social infrastructure are associated with a significantly higher level of economic development in urban and urban-rural *gminas* than in rural *gminas*. Spatially, the position of *gminas* in relation to larger settlement centres and communication routes affects the development of technical infrastructure to a greater extent than social infrastructure. The relationship between infrastructure development and selected economic and social characteristics of municipalities is a feedback loop in which the relative wealth of a local administrative unit stimulates the development of the infrastructure while at the same time benefiting from this fact. This means that the present use of European Union Structural Funds for the development of infrastructure does not contribute to closing the gap in development. Sustainable development is largely the result of institutional factors related to infrastructure. It is therefore advisable to move away from a purely redistributive approach in this regard to targeted territorial support of the development potential of municipalities.

Keywords: sustainable development, technical infrastructure, social infrastructure, municipalities, rural development

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Introduction

The main objective of this paper is to identify and assess empirically the current institutional and spatial characteristics and determinants of the development of technical and social infrastructure of municipalities (*gminas*)[1] in Poland and their impact on sustainable development in these administrative entities. Institutional structures are systemic and dynamic in nature, and interact with socio-economic processes, strengthening or weakening sustainable development. The research hypothesis was formulated around the assumption that within institutional structures the public sector represented by the local administration is an important proponent of sustainable development, but that its impact is significantly affected by spatial factors.

Infrastructure can be classified differently – by emphasising its technical, economic, social, institutional and innovative attributes. For the purposes of this study it is defined according to A. Ginsbert-Gebert (cited by Jarosiński, 2003) as a system of devices and institutions that perform ancillary social, economic or technical functions in relation to other spatial systems. The considerations are limited to the analysis of technical and social infrastructure. The technical infrastructure includes *inter alia* roads, gas pipelines, water supply systems, drainage networks, facilities and devices for environmental protection (sewage disposal systems etc.), whereas the social infrastructure fulfils the educational, cultural and health needs of the population. Infrastructure is thus a spatial set of facilities and institutions that induces efficient operation of enterprises and households and is essential in the spatial development of local systems. It influences the formation of human, social and cultural capital and the opportunities for economic initiatives, attraction of external capital, modernisation opportunities for growth of agricultural production, the standard of living and the generation of multifunctional and sustainable rural development. It also determines the opportunity for *gminas* to progress in civilisational terms, to increase territorial cohesion and to reduce the distance between their inhabitants.

The importance of infrastructure in local development gained attention in the late 1980s with the evolution of the theory of regional development (Blakely, 1989; Krugman, 1998) predominantly conditioned by endogenous resources, *inter alia* physical capital and 'soft' factors such as human, social and cultural capital. Theoretical works (e.g. Schultz, 1976; Lucas, 1988; Reich, 1996; Romer, 2000) highlighted the importance of intangible factors in the development of the near area (rural or urban). Infrastructure is closely related to the area for which it performs its tasks, as a specific resource associated with the territory, and the organisation of the process of investing in infrastructure takes the form of a network. In addition to the territorial dimension, the development thereof consists of organisational, cognitive, normative, economic and environmental aspects.

Rural development is closely linked to the development of infrastructure. In the process of rural development, infrastructure is one of the elements supporting the economic activity and determines its scope, structure and spatial distribution. This applies also to increases in agricultural productivity (Pinstrup-Andersen and Shimokawa, 2006). The level of infrastructure may determine the attractiveness or unattractiveness of the region, and thus provide opportunities and barriers to its further development. Infrastructure as a factor activating socio-economic progress is also one of the important determinants of the living conditions of the population. In the initial phase of development of the infrastructure it attracts people, and later people become the stimulus for further development of infrastructure. Measures aimed at attracting entrepreneurs can only succeed if they are connected with the improvement of technical and social

[1] The Polish system of local self-government is organised in three layers with 16 regions (*voivodships*) that correspond to the EU NUTS 2 level, 379 middle level (*poviats*) entities and 2478 municipalities (*gminas*) as the lowest level of local authorities. Entities at each layer are organisationally and financially independent. Neither *voivodships* nor *poviats* have any control over *gminas* (LAU 2), which are administratively and financially independent, having their own sources of income, development strategies and elected authorities. Particular emphasis is placed on the *gmina* as the most important tool of decentralisation and reorientation on local needs.

infrastructure, creating the appropriate economic environment, appropriate for business (Naldi *et al*., 2015).

The infrastructural services are provided separately and jointly by the public, private and NGO sectors, with the most important role being played by the former. In Poland the State should alleviate the disparities in socio-economic development. Self-governments (*gminas*) are therefore primary owners of the infrastructure and depending on their financial capabilities are attempting to create favourable access to its services. *Gminas* are responsible for disbursement of budget funds to finance the infrastructural equipment and facilities. As the owners of most of the infrastructural equipment, territorial self-governments generate more favourable conditions for the recipients of infrastructural services than other owners. They do not perceive profitability as a primary task, but develop infrastructure towards comprehensiveness and complementarity of devices, hoping that this will improve the conditions for socio-economic development.

Infrastructure development requires an appropriate local investment policy that is aimed at increasing the attractiveness and credibility of a *gmina* as a place of residence and job creation, which in turn determines the opportunities for its further development. The areas that are well equipped with infrastructure accumulate various resources. Perroux (cited by Domański, 2006) refers to such areas as 'motoric units', where infrastructural devices attract investments from other economic fields, whereas Myrdal (1958) calls them 'core areas' where factors promoting the economic development and producing multiplier effects are concentrated. The concept of core areas also appears in Hirschman (1958).

Local authorities have the ability to use aid (primarily European Union (EU) funds obtained under the Rural Development Programme, a Regional Operational Programme and the Human Capital Operational Programme) for infrastructural development which is only available to local governments. The willingness of local communities to contribute their own financial resources to the cost of construction or extension of infrastructure is limited, and it usually happens for smaller projects such as the modernisation of a road. In such a situation, the development of the local economy (reducing unemployment and employment in agriculture, improving the living conditions of the population and increasing the professional and spatial mobility of the population) determine the State aid and search for extra-budgetary funds for infrastructural development.

Kołodziejczyk (ed., 2012) presented evidence for the dependence of socio-economic development in Poland on the level of infrastructural development. Related empirical studies carried out using Polish data in various regions of the country (e.g. Salamon, 2006; Krakowiak-Bal, 2007; Piszczek, 2010; Baran, 2011; Kłos, 2012; Wasiluk, 2013) have shown significant correlations between the level of development of local infrastructure and the economic, financial, social and demographic characteristics of local administrative units. In this paper, empirical analysis allowed the determinants of the institutional development of the technical and social infrastructure to be verified as a key factor for the sustainable development of rural areas in Poland.

Methodology

A heterogeneous statistical data set for the period 2005-2012 of the entire population of *gminas* in Poland was employed. Empirical analysis involved three steps. In the first step the development of individual elements of infrastructure in municipalities was examined, taking into account their types. Subsequently a synthetic index – as a composite measure of technical and social infrastructure development – was developed, serving as a basis for further calculations and spatial mapping. Based upon the calculated measures, in the final step a causality assessment was carried out, aiming at establishing the determinants of sustainable infrastructure development. The calculated measures were confronted with selected financial and organisational characteristics of the municipalities. Quantitative approaches included descriptive statistics and Pearson correlation coefficients. Data were supplied by Polish Statistical Office, GUS (the Regional Data Bank - *Bank Danych Regionalnych*).

In Poland, the distinction between rural, urban and urban-rural municipalities was introduced for the purpose of national territorial division in the Regulation of the Council of Ministers on 15 December 1998 entitled *On the detailed arrangements for implementing, using and sharing national official register of territorial division of the country and related responsibilities of the government and the local government units* (Journal of Laws [Dziennik Ustaw] 1998.157.1031 with amendments). According to § 2 points 6 to 8 of the Regulation, an urban *gmina* (304 in Poland) is a municipality with the status of the city, a rural *gmina* (1563) is a municipality in which there are only villages and an urban-rural *gmina* (611) is a municipality in which at least one of the settlements has the status of the city.

As explained above, infrastructure is defined as a system of devices and institutions that perform ancillary functions in relation to other spatial systems. Owing to significant differences in the spatial distributions of indicators, it was not possible to assess the infrastructure of rural areas by considering just one element. Instead, this was done using the synthetic index, a measure of development defined by Hellwig (1972). This is a taxonomical approach based upon a Euklidean distance of a set of characteristics from an artificially constructed limit; a higher level of the statistics correspond to a higher level of technical or social development.

In a very concise description of the estimation path, each *gmina* can be attributed to a point P in n-dimensional space, such that $P_i(x_{ij})$ is an array of characteristics x where $i=1,\dots,n$; $j=1,\dots,m$, i=*gmina*, j=descriptive variable, n=number of *gminas*, and m=number of variables. Each variable x is subsequently normalised $x_{ij} \rightarrow z_{ij}$. The identification of the development pattern follows with: P_0=an artificial point in the space with coordinates: $z_{01}, z_{02}, \dots, z_{0n}$ where $z_{0j}=\max(z_{ij})$ or $z_{0j}=\min(z_{ij})$. The distance between $P_i(x_{ij})$ and P_0 is computed as $c_{i0} = \sqrt{\sum_{i=1}^{n}(z_{ij} - z_{0j})^2}$ and finally the synthetic measure for each *gmina* is estimated as: $d_i = 1 - \frac{c_{i0}}{c_0}$

where $c_0 = \overline{c} + 2_{S_0}$ and $\overline{c}$=the arithmetical mean of the distance between *gmina* and pattern, and S_0=the standard deviation of the distance between *gmina* and pattern.

Synthetic values are determined in reference to the population mean, which in Poland in the case of both technical and social infrastructures amounts to 100. Higher values indicate a higher level of development of a given type of infrastructure in the *gmina*. For technical infrastructure, the estimation was based on elements such as the density of metalled roads, the length of the water supply system, sewage disposal system and gas network, while the evaluated elements of social infrastructure included the density of the network of educational institutions at different levels of education, and the numbers of health centres and cultural institutions.

Results

Level of development of technical infrastructure in municipalities

Water supply and sewage disposal systems are still the facilities with the highest degree of variation between the *gminas* (Table 1). In 2012, the water supply network density in rural *gminas* amounted on average to about 93 km, in urban-rural *gminas* about 90 km and in urban ones 327 km per 100 km^2. The values for the sewerage network were 32, 35 and 299 km respectively. The development of the water supply and sewerage networks in the examined *gminas* translated into an increase in the share of population served by the networks in relation to the total population in the period 2005-2012, in the case of water supply network on average by 1.5 per cent a year, and for the sewerage system by 1.3 per cent.

There are still *gminas* that have no water supply and sewerage networks. In 2012, 0.6 per cent of *gminas* had no water supply network, 8.2 per cent had no sewerage system, and these were mainly rural *gminas* (70 per cent). The density of sewerage systems featured much greater disparities than water supply networks. In 2012, the coefficient of variation for water supply networks in urban *gminas* was 47.6 per cent, in rural ones it was 62.2 per cent and in urban-rural ones 65.4 per cent. The equivalent values for sewerage networks were 56.6 per cent, 158.3 per cent and 107.5 per cent respectively. A comparison of the amount of supplied water and discharged sewage shows that in urban *gminas* it is currently 70 per cent of the water supply, in rural ones it amounts to 21 per cent and in urban-rural ones to 32 per cent. There were also large differences between *gminas* in 2012 in terms of inhabitants served by sewage treatment plants: 64 per cent in urban *gminas*, 17 per cent in rural ones and 34 per cent in urban-rural ones. The costs of rural infrastructure, both at the investment stage as well as due to ongoing maintenance, are generally much higher in rural than in urban areas because of the dispersed settlements. As a result, access to rural infrastructure components is still much worse than in urban areas.

Level of development of social infrastructure in municipalities

Within the *gminas* there was a significant reduction in the number of social infrastructure institutions between 2005 and 2012. One of the main factors that determines spatial distribution of pre-school education is the number of children aged 3-6. The share of this age group in the total population amounts to around 6.1 per cent in urban *gminas*, 6.3 per cent in urban-rural ones and 5.3 per cent in rural ones. As the number of kindergartens decreases, the number of children covered by pre-school education falls: in 2012, the number of children in pre-school institutions equalled 77.1 in urban *gminas*, 62.3 in urban-rural ones and 58.1 in rural areas per 1,000 children aged 3-6 (Table 2). In the period 2005-2012, there were also changes in the primary education: approximately 4 per cent of schools in urban *gminas*, 8 per cent of schools in rural-urban ones and 11 per cent rural ones were closed. Hence, within rural areas the spatial availability of basic educational institutions decreased.

Table 1: Characteristics of the technical infrastructure in different types of *gminas* in 2012.

Characteristic	Technical infrastructure				
	average	min	max	coefficient of variation	median
	Urban municipalities				
Inhabitants using the water supply (%)	93.3	38.2	99.7	10.5	96.4
Inhabitants using sewerage (%)	81.8	24.8	99.8	18.3	87.1
Inhabitants using gas installations (%)	60.4	0.0	99.4	57.2	75.9
Length of the sewerage network (km per 100 km^2)	299	6	913	56.6	295
Length of the water supply network (km per 100 km^2)	327	7	773	47.6	329
	Rural municipalities				
Inhabitants using the water supply (%)	76.0	0.0	99.9	27.3	82.4
Inhabitants using sewerage (%)	27.1	0.0	99.5	77.8	24.7
Inhabitants using gas installations (%)	15.1	0.0	97.1	162.3	0.0
Length of the sewerage network (km per 100 km^2)	32	0.0	448	158.3	15
Length of the water supply network (km per 100 km^2)	93	0.0	518	62.2	85
	Urban-rural municipalities				
Inhabitants using the water supply (%)	83.4	0.0	99.5	18.1	87.6
Inhabitants using sewerage (%)	47.8	2.4	96.8	40.9	48.3
Inhabitants using gas installations (%)	30.9	0.0	96.6	93.2	27.7
Length of the sewerage network (km per 100 km^2)	35	0.8	343	107.5	23
Length of the water supply network (km per 100 km^2)	89	0.0	438	65.4	81

Data source: GUS

Table 2: Characteristics of the social infrastructure in different types of *gminas* in 2012.

Characteristic	Social infrastructure				
	average	min	max	coefficient of variation	median
			Urban municipalities		
Kindergartens per 100 km^2	36.3	0.9	161.5	74.9	30.6
Kindergartens per 10,000 inhabitants	3.0	0.7	15.5	42.4	2.8
Clinics per 100 km^2	74.7	0.0	290.2	71.0	63.7
Clinics per 10,000 inhabitants	6.1	0.0	14.8	39.4	5.7
Middle schools per 100 km^2	21.5	0.9	80.0	63.7	20.0
Libraries per 100 km^2	14.2	0.9	66.7	68.1	12.0
Libraries per 10,000 inhabitants	1.4	0.3	7.4	62.7	1.2
Children in kindergartens per 1,000 children	77.1	2.8	912.6	137.8	44.9
Primary schools per 10,000 children	70.7	14.3	215.5	48.9	67.1
Children in primary schools per 1,000 children	97.3	59.5	124.2	6.6	97.8
Children in secondary schools per 1,000 children	96.5	40.8	186.7	11.3	97.3
			Rural municipalities		
Kindergartens per 100 km^2	2.2	0.0	42.9	136.6	1.2
Kindergartens per 10,000 inhabitants	2.9	0.0	17.9	81.1	2.5
Clinics per 100 km^2	2.5	0.0	28.0	120.1	1.7
Clinics per 10,000 inhabitants	3.6	0.0	18.5	53.8	3.3
Middle schools per 100 km^2	1.8	0.0	26.3	95.3	1.3
Libraries per 100 km^2	2.5	0.0	21.1	79.5	2.0
Libraries per 10,000 inhabitants	3.9	0.0	14.4	51.4	3.6
Children in kindergartens per 1,000 children	58.1	0.0	1601.6	135.7	40.7
Primary schools per 10,000 children	73.0	0.0	239.1	47.4	69.4
Children in primary schools per 1,000 children	97.3	0.0	172.0	10.0	98.3
Children in secondary schools per 1,000 children	95.8	0.0	182.1	15.4	97.3
			Urban-rural municipalities		
Kindergartens per 100 km^2	3.1	0.0	42.2	136.0	1.7
Kindergartens per 10,000 inhabitants	2.6	0.0	11.4	53.0	2.3
Clinics per 100 km^2	4.4	0.0	40.3	107.4	2.9
Clinics per 10,000 inhabitants	4.1	0.0	13.3	45.4	3.9
Middle schools per 100 km^2	2.1	0.2	14.8	96.1	1.5
Libraries per 100 km^2	2.6	0.0	17.4	82.1	2.1
Libraries per 10,000 inhabitants	2.8	0.0	8.0	50.4	2.6
Children in kindergartens per 1,000 children	62.3	0.0	3115.9	253.5	37.1
Primary schools per 10,000 children	74.2	0.0	240.0	50.0	71.8
Children in primary schools per 1,000 children	94.8	0.0	150.5	17.3	97.4
Children in secondary schools per 1,000 children	93.8	0.0	228.7	20.7	96.6

Data source: GUS

Generally, the average indicators of availability of social infrastructure are at a level higher than the median, which indicates a high concentration of such facilities in some *gminas* (Table 2).

Synthetic measures of technical and social infrastructure development

The overall level of infrastructure development in a *gmina* in the period 2005-2012 was assessed using the composite measure developed by Hellwig (1972). There are large disparities in the development of technical and social infrastructure between the types of *gminas* and their size measured by the number of inhabitants (Table 3).

A much higher level of social and technical infrastructure occurred in urban *gminas* and *gminas* with a higher population regardless of the type. Therefore, it can be concluded that from the point of view of the development and operation of these facilities, it is the population in a *gmina* that counts. This can be interpreted on the basis of certain theories on regional and local development, including the growth pole theory and gravity model (Perroux, Hirschman), where development is correlated mainly with the population potential and its demographic structure. Major differences in the level of development of the technical infrastructure were observed in the urban *gminas* rather than the urban-rural and rural ones, as evidenced by the coefficient of variation. However, as regards the technical infrastructure in urban *gminas*, as the population increased, these differences declined whereas in rural and urban-rural *gminas* they increased. For social infrastructure, major differences occur between urban-rural and rural *gminas* rather than between urban ones. Once again, it confirms a higher concentration of social infrastructure institutions in cities.

When comparing the 2005 and 2012 coefficients of variation in individual types of *gminas*, a decrease in these indicators for social infrastructure and a slight increase in the case of technical infrastructure can be seen. It results, on the one hand, from the closure of numerous social infrastructure institutions because of a demographic low but, on the other hand, from increased financial potential to develop technical infrastructure facilities.

Table 3: Composite ratio of technical and social infrastructure according to the type and size of *gmina*.

Type of *gmina* and no. inhabi-tants (000)	Technical infrastructure				Social infrastructure			
	measure of development		coefficient of variation		measure of development		coefficient of variation	
	2005	2012	2005	2012	2005	2012	2005	2012
Urban-rural	***94.0***	***93.4***	***20.4***	***23.0***	***87.2***	***86.8***	***60.6***	***53.6***
< 5.0	79.7	77.2	12.1	14.5	114.4	92.8	56.5	22.6
5.0-7.5	82.6	81.4	13.9	15.7	86.2	71.8	38.2	68.1
7.5-15.0	90.1	89.2	16.4	18.0	82.5	80.8	32.5	46.8
15.0-30.0	101.2	101.2	17.6	20.9	84.9	99.2	34.4	56.2
> 30.0	126.1	127.1	17.9	20.4	109.7	108.8	62.9	36.3
Rural	***82.2***	***82.5***	***26.9***	***29.9***	***80.0***	***89.5***	***47.3***	***35.2***
< 2.5	64.8	63.7	23.5	23.2	89.8	89.3	32.2	51.2
2.5-5.0	76.7	75.0	19.3	21.4	83.2	90.4	47.5	38.3
5.0-10.0	81.6	81.3	24.8	26.4	77.6	87.3	44.5	33.5
10.0-15.0	96.3	99.4	29.3	31.0	79.4	92.5	59.6	31.8
> 15.0	111.8	114.5	36.4	35.6	80.2	98.2	43.7	26.5
Urban	***203.4***	***203.0***	***33.2***	***31.1***	***227.9***	***179.7***	***60.6***	***33.6***
< 10.0	136.2	138.0	36.9	38.2	180.2	138.3	62.4	42.7
10.0-20.0	186.3	187.2	32.6	30.9	194.2	167.1	43.3	37.9
20.0-50.0	228.5	222.6	28.3	25.8	229.0	185.6	36.5	29.3
50.0-100.0	228.2	230.9	25.9	24.0	292.9	199.4	91.8	25.5
> 100.0	229.4	227.7	18.3	16.4	268.5	214.3	24.5	22.9

Data source: GUS

Table 4: Definitions of five groups of *gminas* in terms of their level of infrastructure development.

Group name	Range of values ($\bar{x}$ - average, δ_x - standard deviation)
Very low	$x_i < \bar{x} - 0.9 * \delta_x$
Low	$\bar{x} - 0.3 * \delta_x > x_i \geq \bar{x} - 0.9 * \delta_x$
Average	$\bar{x} + 0.3 * \delta_x > x_i \geq \bar{x} - 0.3 * \delta_x$
High	$\bar{x} + 0.9 * \delta_x > x_i \geq \bar{x} + 0.3 * \delta_x$
Very high	$x_i \geq \bar{x} + 0.9 * \delta_x$

Source: own calculations

Spatial characteristics of infrastructure development

From the analysis of the level of infrastructure development, by taking into account the average value of the synthetic index and the standard deviation from the mean, five groups of *gminas* were identified (Table 4). Clear differences in the level of development of both technical and social infrastructure can be observed between individual NUTS 2 regions (*voivodeships* or *województwa*) and within regions. As regards the diversity of infrastructure development, the differences between the *gminas* are larger in terms of social rather than technical infrastructure, both at the local and the regional scales. The highest diversity in terms of technical infrastructure occurs in Małopolskie and Śląskie *voivodeships* (in the far south) and the lowest in the central Kujawsko-Pomorskie and Łódzkie *voivodeships* (Figure 1), and for social infrastructure in Opolskie and Małopolskie *voivodeships* (again in the south), and Świętokrzyskie (south) and Pomorskie (north) *voivodeships* respectively (Figure 2).

Very high levels of development of technical and social infrastructure are evident in about 80 per cent of urban *gminas* (such as Gdańsk, Poznań and Warszawa) but only in 3.1 per cent of rural *gminas*. Rural and urban-rural areas had the highest shares of *gminas* with low and average levels of development. This confirms that, in general, the level of infrastructure development is much lower in rural and urban-rural *gminas* than in urban *gminas*. However, the position of *gminas* in relation to larger settlement centres and communication routes affects the development of technical infrastructure to a greater extent than social infrastructure. As far as social infrastructure is concerned, *gminas* within the hinterland of a city have a lower level of infrastructure development, the cities become then the main centres of concentration of infrastructural facilities.

From the coefficients of variation for infrastructure it can be concluded that there is a clear polarisation of the phenomena. This applies in particular to the social infrastructure in urban-rural and rural *gminas* with bigger populations. It may mean that a higher coefficient of variation results from

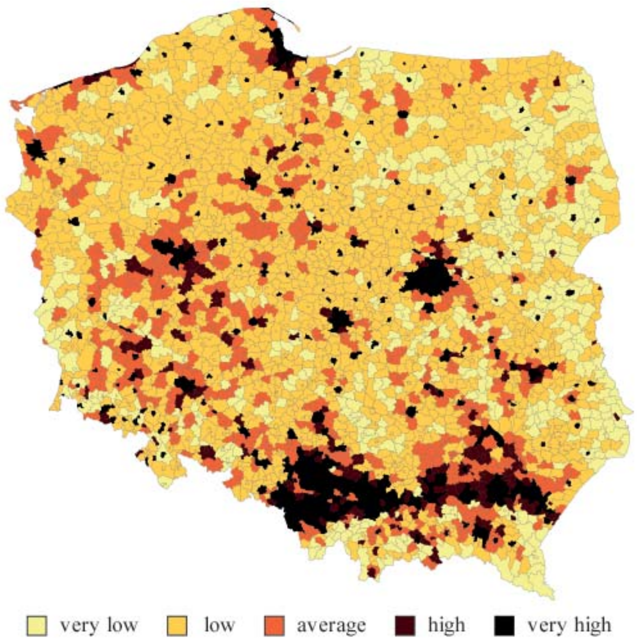

Figure 1: Level of technical infrastructure development of *gminas* in 2012.

For the definitions of the five groups of *gminas* see Table 4
Data source: GUS

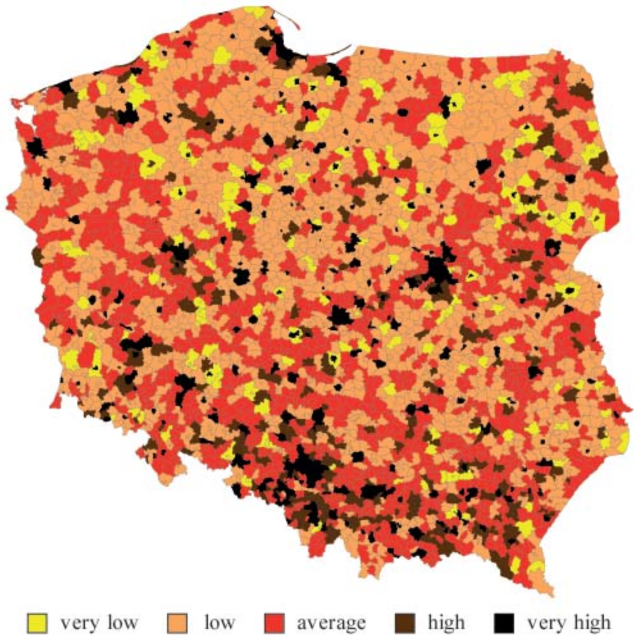

Figure 2: Level of social infrastructure development of *gminas* in 2012.
For the definitions of the five groups of *gminas* see Table 4
Data source: GUS

the different rates of development of these areas. The result can be regarded as empirical evidence for the validity of assumptions of the theory of polarisation (Hirschman, 1958), according to which the increase comes from the core, resulting in the polarisation process. In this sense, spatial polarisation means the concentration of resources in selected (core) entities and is characteristic of the early stages of economic development, or areas undergoing economic transformation.

Budgetary determinants of infrastructure development

In Poland, the investment policy on infrastructure is a domain of activity of *gmina* self-government, and its effectiveness depends on the knowledge of the needs and available financial resources. Obtaining more EU funds by richer *gminas* might lead to further marginalisation of the *gminas* that are lagging behind as far as development is concerned and to increased distance between them. In 2012, EU funds represented about 6.6 per cent of total income of all *gminas*; in rural *gminas* it was about 6.7 per cent, in urban-rural ones 6.6 per cent and in urban ones 6.3 per cent (Table 5). However, a much higher percentage of urban *gminas* (22.2 per cent) had such funds amounting to over 7 per cent of their budget than rural *gminas* (17.3 per cent) or urban-rural ones (18.0 per cent). Most *gminas* – about 27 per cent (in each category group) – obtained EU funds amounting to 3-5 per cent of their budget. A high impact on obtaining such funds, confirmed in this study by a high Pearson correlation coefficient (r = 0.59), is exerted by the amount of own income in a *gmina*.

It was however not observed that the share of such funds in the total income of *gminas* is affected by the population of a *gmina*. The highest Pearson correlation coefficient of the overall evaluation of the level of development of the technical infrastructure was found in the case of own income per inhabitant (r = 0.56) and the share of capital expenditure in total expenditure of *gminas* (r = 0.61). However, in 2010, 41 per cent of the *gminas* had an own income per inhabitant below the average, i.e. below PLN 700, and in 49.1 per cent of *gminas* the share of capital expenditure in their total expenditure was below the average, i.e. approximately 17 per cent. This suggests that about 50 per cent of the examined *gminas* cannot develop their infrastructure due to their financial situation.

Similarly to the EU funds in the budget of *gminas*, the share of capital expenditure in the total expenditure of *gminas* increased in the period 2009-2011, followed by a slight decrease in 2011, in all types of *gminas* (annual data not shown). In the period 2006-2012, in the structure of expenditure of the *gminas*, capital expenditure accounted for 20.4 per cent on average (Table 5). Studies have shown that the *gminas* with a less favourable financial situation also proved to be active in terms of investment. In this case, there was also a tendency for this ratio for different types and sizes of *gminas* to become similar with the influx of EU funds. The relationship between the share of EU income in the *gmina* budget and the share of capital expenditure in the total expenditure measured by the Pearson correlation coefficient is statistically significant (r = 0.72).

Discussion

When analysing the availability and changes in water supply and sewerage systems in Polish *gminas*, Kołodziejczyk (2012a) observed that more advantageous changes in water supply systems occurred in *gminas* that obtained more EU funds, in *gminas* with fewer inhabitants, and which were rather rural than urban-rural. As far as sewerage networks were concerned, such changes occurred in *gminas* with a higher population, but also in rural *gminas* and in *gminas*

Table 5: Shares of income from EU funds and capital expenditure in total expenditure, according to the type and size of *gmina*.

Urban-rural			Rural			Urban		
No. inhabitants (000)	**Income, 2012 (%)**	**Expenditure* (%)**	**No. inhabitants (000)**	**Income, 2012 (%)**	**Expenditure* (%)**	**No. inhabitants (000)**	**Income, 2012 (%)**	**Expenditure* (%)**
< 5.0	4.7	19.4	< 2.5	7.0	19.5	< 10	7.1	19.6
5.0-7.5	7.5	21.0	2.5-5.0	7.4	19.8	10-20	7.1	20.3
7.5-15.0	7.2	20.8	5.0-10.0	6.6	20.2	20-50	5.2	20.6
15.0-30.0	5.7	19.9	10.0-15.0	5.5	22.0	50-100	5.6	18.0
> 30.0	5.1	21.9	> 15.0	4.2	21.4	> 100	7.4	21.8
All *gminas*	6.6	20.6	All *gminas*	6.6	20.3	All *gminas*	6.3	20.1

*Average of the period 2006-2012
Data source: GUS

with a higher share of EU funds. Owing to the high cost of infrastructural investments, not every *gmina* is able to cover fully the expenses on the basis of their own income. The downward trend in recent years in the share of own income in the total income of *gminas*, from 45 per cent in 2005 to 42 per cent in 2012, makes the financial situation of local authorities uncertain, it does not guarantee stability of own sources of income. Therefore, under-investment of infrastructure grows in accordance with the reported needs and becomes a barrier to the initiation of development processes within some areas (Kołodziejczyk, 2012b).

The relationships of rural infrastructure with the population system are reciprocal in nature. On the one hand, population and how the population is distributed in space affect the overall level of development of infrastructure; on the other hand, the level of development of infrastructure impacts on the number and structural changes taking place in the population system. The comparison of the density of population within rural areas with the synthetic measure of infrastructure development showed a strong correlation. What should be pointed out in particular is the strong dependence in the case of social infrastructure ($r=0.64$). Because social infrastructure services are point-based, they have to be used at the place where they are provided, and therefore their distribution should be proportionate to the number of inhabitants and space. The correlation is different in the case of rural areas remaining under the influence of cities. The concentration of population is not promoted by an appropriate development of social infrastructure. In such a case, the cities are the main centres of concentration of infrastructure. This is a conscious decision of local authorities (distribution of infrastructure investment projects in large centres) due to the scarcity of financial resources. Large centres also exhibit more bottom-up initiatives, and social pressure on the authorities are much more developed – as regards the allocation of funds in such localities.

As rural areas are subject to numerous negative impacts and pressures arising predominantly from the unfavourable demographic situation, there is an urgent need to modernise the existing technical infrastructure in order to ensure the implementation of the new needs of the local community, *inter alia*, appropriate level of mobility and ensuring proper care for the elderly. Technical infrastructure is important not only within the area of administrative unit where the investment is located, but also for the neighbouring units.

As regards social infrastructure development, the area of social services is still treated by many government and self-government politicians as a secondary element that needs to be addressed after the resolution of the major economic problems. The significant decrease in the number of kindergartens (by about 14 per cent) and preschool education establishments (by about 11 per cent) in Poland may be particularly dangerous. Owing to the reduced availability and accessibility of such institutions, it will result in fewer educational opportunities for children from rural areas and might also contribute to a reduction in population growth. Similarly, the declining share of expenditure from the budget of *gminas* on culture and art in recent years has also caused the regression of traditional culture media, such as libraries, community centres, youth clubs and sports clubs. However, new forms of cultural activity are becoming more and more popular owing to mobile devices such as computers with Internet access. According to the GUS, access to the Internet within rural areas is provided to around 42 per cent of households, compared to 69 per cent in the cities.

There are significant differences between various types of *gminas* in terms of the impact of the level of development of technical and social infrastructure on individual aspects of sustainable development. The same levels of technical or social infrastructure contribute to a significantly higher level of economic development in urban and urban-rural *gminas* than in rural *gminas*. A low level of infrastructure development in *gminas* in 2012 was associated with a significant deterioration in the socio-economic situation in 2012, in particular in rural *gminas* in comparison with 2005. Given that in 2012, *gminas* with a very low or low level of development of their technical infrastructure accounted for about 50 per cent of all *gminas*, and for the social infrastructure for about 52 per cent, there is no reason for optimism about their future economic and social development. Sustainable development is largely the effect of institutional determinants of infrastructure. Therefore, it is necessary to depart from the redistributive approach in this regard towards the territorially-oriented support for the development potential of *gminas*.

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Next steps to evidence-based food safety risk analysis: opportunities for health technology assessment methodology implementation

Food safety risk analysis and health technology assessment (HTA) are two different paradigms sharing multiple common features. Decision makers in both fields have the responsibility to promote the health of society deciding on intervention opportunities based on disease burden, intervention feasibility, effectiveness and cost, equity and ethical considerations. The evolution of HTA in the last two decades has resulted in the establishment and widespread use of quantitative tools to support and justify evidence-based decisions. In contrast, decision making in the food safety domain is still a qualitative process rendering ad hoc weights to all aspects considered. This review evaluates whether HTA methodology is suitable for quantitative decision support in food safety risk analysis. We conclude that cost-utility analysis (CUA) could better serve the priority settings in food safety risk management than the currently (rarely) applied cost-benefit analysis (CBA), considering either broad resource allocation or specific safety measure decisions. Development of multi-criteria decision analysis tools could help the introduction of consistent and explicit weighting among cost and health impacts, equity and all other relevant aspects. Cost-minimisation and cost-effectiveness analyses would be relevant for ‘threshold’ and ‘as low as reasonably achievable’ approaches to single food safety risk assessments, respectively. Assuming a future widespread use of HTA methodology in the food safety paradigm, a vision of integrated healthcare, food safety and nutritional policy emerges, with the re-evaluation of budgets and resources of these large systems in a rational and socially acceptable way.

Keywords: foodborne disease, cost-utility analysis, MCDA, health technology assessment, risk analysis, priority setting

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Introduction

In the field of food chain safety, decision makers have a responsibility to promote the health of plants, animals and humans, and to protect the national and international economy. For that purpose, decisions should be made on different intervention opportunities, based on the risk analysis framework defined first by FAO/WHO (2006). However, during this process, not only the risk (or burden) of the diseases, but intervention feasibility, effectiveness and cost, equity and ethical considerations also play increasingly important roles. In this respect, food safety risk analysis and health technology assessment (HTA) in healthcare system development are analogue paradigms. The aim of this paper is to identify those elements of HTA methodology suitable for quantitative decision support in food safety risk analysis.

The different methodologies for ranking the risks related to feed/food safety and nutritional hazards, on the basis of their anticipated human health impact, assessed by Van der Fels-Klerx *et al.* (2015) show a large variability in application, emphasising that each tool has its optimal purpose of use. The decision making process in the food chain safety domain uses many quantitative tools, especially during risk assessment, however the decision making as a whole is still mostly a qualitative process that applies ad hoc weights to all aspects considered. Interestingly, the practice of multi-aspect HTA decision making has changed a lot in the last two decades, resulting in the establishment and widespread use of sophisticated quantitative approaches to support and justify evidence-based decisions (Bodrogi and Kaló, 2010).

In this paper, we overview the current status of foodborne pathogen ranking, explain the role of full economic evaluation and multi-criteria decision making in HTA with implications for food safety risk management, and discuss the opportunities and barriers of risk-benefit evaluations in food safety decisions.

Pathogen burden ranking for food safety risk prioritisation: from DALY to QALY

The burden of domestic foodborne diseases in the United States (U.S.) due to various pathogens has been systematically re-assessed by Scallan *et al*. (2011a, 2011b), providing new point estimates with 90 per cent credible intervals on the number of illness episodes, hospitalisations and deaths caused by 31 main pathogens (including bacteria, viruses and parasites). They found that no specific pathogens were recognised in the majority of illnesses, hospitalisations and deaths due to U.S. domestic foodborne diseases. Considering the cases with known pathogens, most illnesses were caused by norovirus (58 per cent), while non-typhoidal *Salmonella* species were the leading cause of hospitalisation (35 per cent) and deaths (28 per cent). Ranking the pathogens according to their disease burden strongly depends on how the disease burden is measured. For example, *Listeria monocytogenes* is responsible only for a negligible number of annual illness episodes as compared with other pathogens, but is ranked among the top three causes of domestic foodborne disease-related deaths. The annual health burden of domestically acquired foodborne illnesses in the U.S. (incidence of illnesses, hospitalisations and deaths) was estimated by Mead *et al*. (1999) and Scallan *et al*. (2011a, 2011b). Note that the different methods do not allow trend analyses between the

Mead and the Scallan studies.

Estimation of the overall disease burden of particular pathogens requires an integrated approach with appropriate weights for mild cases, hospitalisations and acute deaths. Moreover, disease burden calculations should also consider the potential long-term consequences, such as increased risk of Guillain-Barré syndrome after *Campylobacter* infections, haemolytic uremic syndrome with or without end-stage renal disease after *E. coli* O157 and Shiga toxin producing *E. coli* (STEC) non-O157 infections, or newborn complications after listeriosis and toxoplasmosis (Hoffmann *et al*., 2012; Scharff, 2012; Batz *et al*., 2014). The new incidence estimates published by Scallan *et al.* (2011b) elicited a series of updated estimations on overall domestic foodborne disease burden due to particular pathogens in the U.S. Scharff (2012) calculated the total cost of illness as the sum of costs of physician care, hospitalisation, pharmaceuticals, cost of productivity loss and the value of statistical life for fatal cases, also considering long-term consequences. Decreased quality of life as captured by *quality adjusted life years* (QALY) loss (health utility decrements of 0.492 during hospitalisation and 0.311 during illness episode) was also monetised and included in the enhanced cost of illness model. Hoffmann *et al.* (2012) integrated the new incidence estimates of Scallan *et al.* (2011b) with a thorough literature review and reconsidered the disease outcome trees (symptoms, severity, duration and likelihood of health outcomes) for 14 key pathogens in the U.S. Symptom definitions were scored along the five domains of EQ-5D and new, health state-specific utility decrement data were generated and reviewed by clinical experts of foodborne diseases. Updated disease outcome trees were then used to estimate the total cost of illness (sum of medical costs, productivity loss and value of premature mortality) and total QALY loss (including decreased life quality and disease related mortality). The cost of illness and QALY loss are not additive in this study because both capture the burden of premature mortality. In a recent paper, the same team published new estimates on QALY loss for the same 14 key pathogens, with slightly reduced QALY losses in *Cryptosporidium* and Shiga toxin producing non-O157 *E. coli* infections (Batz *et al.,* 2014).

Ranking of foodborne pathogens by their disease burden is part of a new risk-ranking model of the Food Safety Research Consortium, with the intention of attributing pathogen-specific disease burden and costs to categories of food vehicles, based on outbreak data and expert judgment (Batz *et al*., 2004; Hoffmann *et al.,* 2007). The ultimate goal of this work is to support priority setting and resource allocation for food safety, in two contexts (Batz *et al*., 2005). The first context ('Purpose 1' or 'High level/Strategic priority setting') is broad resource allocation, i.e. which of many possible pathogens or pathogen-food pairs pose the greatest concern to public health and therefore deserve priority attention for intervention or further analysis. This level of prioritisation intends to support programmes or agencies during strategic planning, developing annual work plans or annual budget requests. The second context ('Purpose 2' or 'Decision on risk management options') is to support the choice of specific risk management actions and strategies with respect to a particular hazard. This latter context may also utilise the results of foodborne pathogen attribution to key food sources, by focusing the attention to the critical elements and steps in the food supply chain.

In parallel with the work in the U.S., the estimation of foodborne disease burden is the subject of intensive research worldwide with the intention of ranking foodborne pathogens and food pathogen-food pairs to guide foodborne disease-related policy decisions. The systematic estimation of the numbers of illnesses, hospitalisations and deaths for 30 foodborne pathogens in Canada have been recently published (Thomas *et al*., 2013), and the attribution of selected pathogens to food sources was also approached (Davidson *et al*., 2011). The World Health Organization continues its programme to quantify the global burden of foodborne diseases in *disability-adjusted life years* (DALY), recently initiating four pilot country studies in Albania, Japan, Uganda and Thailand (Kuchenmüller *et al.,* 2013). Country-specific research papers on disease burden of a single (Tariq *et al*., 2011; Fürst *et al*., 2012; Verhoef *et al*., 2013) or a couple of specific foodborne pathogens (Lindqvist *et al*., 2001; Van den Brandhof *et al*., 2004; Kemmeren *et al*., 2006; Haagsma *et al*., 2009; Lake *et al.*, 2010; Ruzante *et al*., 2010; Havelaar *et al.*, 2012) also report on the health burden of foodborne diseases as captured in DALY metrics. An exception in this respect is the work of Shin *et al*. (2010), quantifying the Korean health burden of foodborne pathogens as QALY loss estimates. Unfortunately, this group failed to report pathogen-specific burden of disease data.

Although both DALY and QALY are population health metrics describing morbidity and mortality simultaneously in a single number, they were developed with different intentions and are not interchangeable. DALY was developed to describe health at population level, without the aim of responsiveness to slight health changes at individual level. In contrast, the primary aim of developing the QALY methodology was to support the evaluation of medical interventions (Gold *et al.,* 2002). Since QALY became the dominant, almost exclusively used, health denominator in health technology assessment, the authors argue that cost-utility analyses in food safety risk analysis shall also adopt QALY for the standard quantification of the health impacts of food safety policies. Applying QALY as a universal health currency could facilitate the comparison of effectiveness and cost-effectiveness of health and food safety policies, describing their health effects in a common language.

Full economic evaluation in HTA, with implications for food safety risk management

Once the expected health benefits of a planned new technology are quantified, the next step is to compare the health benefits with the economic impacts of the intervention. In HTA, the standard approach is a full economic evaluation which has two criteria: (a) the selection of a policy-relevant comparator (which can be an already-applied intervention or the lack of any intervention (watchful waiting), depending on the current state of the art); and (b) both the costs and health gain must be examined. In other words, full economic evaluations compare at least two alternative technologies by examining both economic impacts and health consequences (Drummond *et al*., 1997). There is abundant literature on the full economic evaluations of health technologies. In contrast, published full economic analyses on food safety risk management (or risk analysis in the broader sense) measures are sparse. However, recent food safety publications tend to pay more and more attention to health quality beyond costs and mortality, providing important input and allowing for future full economic analyses. The Scharff (2012) study monetised the hospitalisation- and illness-related health losses in its enhanced cost of illness model. The extensive work described in Hoffmann *et al*. (2012) and Batz *et al*. (2014) opened the door for full economic analyses of risk management measures against 14 investigated foodborne pathogens, providing detailed disease outcome trees and QALY loss estimates. What is still missing is the identification of appropriate alternative intervention measures for comparison, with data on their expected effect on disease incidence, and information how the disease outcome trees would be changed by these interventions.

Health and cost data for a full economic evaluation can be generated in three parallel ways in HTA. *Randomised interventional studies* may collect data with high internal validity, although these studies are typically limited in size and duration, and their protocol may limit meaningful economic data collection (e.g. reduction in the number of outpatient visits cannot be evaluated in a study with protocol-specified regular investigator visits). *Naturalistic studies* provide information on a larger and less standardised population, with higher external validity. However, health outcomes may be subject to confounding in these studies due to the lack of randomisation, and conducting naturalistic studies for new health care technologies can hardly be implemented before approval on their market authorisation, pricing and reimbursement. A third line of evidence generation in HTA is *economic modelling*, with decision tree, Markov and discrete event simulation models as the most frequently applied techniques. In economic models, clinical data from randomised clinical trials and naturalistic studies or any other data sources are synthesised, enabling the model to project intermediate clinical and economic results to longer time horizons, and thus estimate the potential long-term value of the assessed technology. For comparison, multiple relevant data sources are available for food safety risk analysis. Short-term data of high scientific quality and internal consistency can be gathered, for example in statistically planned and evaluated experiments in the laboratory or in fieldwork (an analogue of randomised controlled clinical trials in HTA). Naturalistic, large-scale uncontrolled data are also available, for example from the analysis of the practices of different countries. There is also a need for risk management decisions on long-term and expensive programmes ex ante, without available data on their real-world effectiveness and cost-effectiveness – justifying the use of economic modelling in the evaluation of the planned measures as part of the food safety risk analysis process. The estimation of foodborne disease burden between 2020 and 2060 in the Netherlands (Bouwknegt *et al*., 2013), or the microsimulation of households behaviour to assess the impact of food safety policies on society (Stefani, 2008) are mentioned here as food safety modelling examples.

Full economic analyses in HTA are classified to cost-minimisation, cost-effectiveness, cost-utility and cost-benefit analyses, according to the measurement units of health gain. The relevance of these analyses in the food safety risk analysis process is summarised in Table 1.

Although cost-benefit analyses, which can aggregate and thus compare in monetary values any kind of food safety measures with each other or with non-health related investment options, have the widest scope, the validity, reliability and acceptance of converting health benefits into monetary values are low (Cowen, 1998; Bodrogi and Kaló, 2010). Therefore, cost-utility analyses should be preferred over cost-benefit analyses whenever appropriate. Such analyses can aggregate and thus compare any kind of food safety measures, including measures against different risks, or multiple risks in a comparative risk approach (for example (FAO/WHO, 2006), the possible loss of nutritional benefits if people eat less fish in order to avoid methylmercury; or the possible increase in cancer risks where chlorinated water is used to minimise pathogens in food during processing). Cost-utility analyses do not monetise health losses and benefits, but convert them into QALY changes – circumventing the uncertainties and ethical disputes about the monetary value of health. Another advantage of cost-utility analysis is that it emphasises the relevance of a thorough health impact assessment. Accordingly, cost-utility analysis would be the preferred method of economic assessment for broad

Table 1: Types of full economic analyses in health technology assessment, with their proposed applicability in food safety risk analysis.

Type of analysis	Unit of health gain	Applicability in HTA*	Applicability in food safety risk analysis
Cost-minimisation	Not specified (equal health gain)	Comparison of medical procedures with equal health gain.	Compare two measures both achieving the ALOP, or the respective FSO in a threshold approach.
Cost-effectiveness	Natural units	Comparison of medical procedures with non-equal health gain measurable in the same health dimension.	Compare two measures against the same risk in an ALARA approach.
Cost-utility	QALY	Comparison of any medical procedures.	Compare any kind of food safety measures and/or healthcare interventions (prioritisation among health-related investments).
Cost-benefit	Monetary value	Comparison of any medical and non-medical procedures and investment options.	Prioritisation of health-related versus not health-related investments.

* Source of information: Bodrogi and Kaló (2010)
Key: ALARA: as low as reasonably achievable; ALOP: appropriate level of protection; FSO: food safety objective; QALY: quality adjusted life years
Note: for all four types of analysis, the unit of costs is 'monetary value'
Source: own composition

resource allocation ('Purpose 1' prioritisation in Batz *et al*., 2005); whereas the selection of an optimal measure against a specific risk could rely on cost-utility, cost-effectiveness or cost-minimisation analyses, depending on the determination of the Appropriate Level of Protection and the occurrence of multiple risks or health consequences.

Systematic application of the above discussed full economic evaluations could contribute to the development of more rational and transparent food safety systems, with improved allocation effectiveness.

Multi-aspect decisions in food safety risk management and in HTA

Risk ranking tools, like the ranking of hazard-food combinations in a national context, are acknowledged scientific approaches in the framework of food safety risk analysis (FAO/WHO, 2006). However, the decision on a particular measure against a specific risk does not rely solely on the magnitude of the risk. It also needs to assess carefully the feasibility, effectiveness and cost of potential interventions, as well as their expected public health benefits (Batz *et al*., 2005; FAO/WHO, 2006). These considerations are also valid for broad resource allocation decisions and the planning of food safety programmes (Hoffmann, 2010; Hoffmann *et al.*, 2012; Scharff, 2012). Assessment of health burden, intervention feasibility, effectiveness and costs allows the risk managers to select risk management measures which reach their targets, are cost-effective and are not over-restrictive. Risk managers shall also consider stakeholder equity, ethical considerations and potential consequences on other risks (for example, decreases in the availability or nutritional quality of foods, or increasing burden of currently well-controlled pathogens upon redistribution of food safety resources to key pathogens). Although cost-benefit analysis is a mandatory element of food safety policy decisions in some countries, it typically does not cover all relevant aspects, e.g. quality of life (Ragona and Mazzocchi, 2008) and is believed to have frustrating uncertainty in its parameter estimates (Irz, 2008). Hence, balancing between health burden, costs and expected benefits of intervention measures, considering different stakeholder perspectives, and dealing with the expected impact on food trade, trust of society in the food chain, and effects on economy is essentially a qualitative process. Accordingly, the selection of the implemented risk management options is fundamentally a political and social decision at present (FAO/WHO, 2006).

As a response to this challenge in health technology assessment, multi-criteria decision analysis (MCDA) tools have been developed to cover all important aspects of decision making with standardised weights. The quantitative result of a full economic analysis is typically an important component of the multi-criteria decision process, but equity, ethical and socio-cultural aspects are also covered with relevant weights, in an objective and transparent manner.

Developing appropriate MCDA tools to support evidence-based, objective risk management decisions, incorporating full economic analyses of the considered measures, is a future opportunity for international and national food safety policies. Previous steps in this direction include a multi-criteria decision support tool with integrated presentation of cost-benefit analysis and other criteria for food safety priority setting focusing on food-pathogen pairs (Caswell, 2008). Another example is the institution of Impact Assessment in the UK, which combines the findings of a full economic analysis with multiple other aspects of assessment (Irz, 2008) without the quantitative integration of all findings.

Opportunities and barriers to using HTA methodology in food safety risk management decisions

Frequently cited arguments against risk-benefit evaluations in food safety risk management decision processes include the issues of uncertainty in model parameters (Irz, 2008), unpredictable effects of risk management measures on stakeholders' behaviour (FAO/WHO, 2006; Ragona and Mazzocchi, 2008), and the technical and theoretical difficulties with calculation and monetisation of health benefits (Cowen, 1998; Irz, 2008).

Uncertainty is an inherent part of all ex ante impact analyses and is appropriately managed in the health technology assessment process by deterministic or probabilistic sensitivity analyses – which are quantitative tools also available for food safety risk management. It is claimed that the level of uncertainty is especially high in food safety risk analysis. For example, the lack of long-term human data on the biological effect of reduced levels of chemical contaminants does not allow reasonable assumptions on the expected health impact (Irz, 2008). Risk management measure concepts without reasonable assumptions on their effectiveness may be premature to implement (unless a precautionary approach is considered). Assumptions with a weak basis call for additional risk assessment exercises, sensitivity analyses in the full economic evaluation, representation of uncertainty in the decision process (preferably via an MCDA tool) and regular monitoring during practical implementation to adjust the assumptions and the full economic evaluation to the real-world experience.

Unpredictable effects of risk management measures on stakeholders behaviour is not considered to be a valid argument against risk-benefit analyses, because communication between all involved stakeholders is at the heart of risk analysis, with equally emphasised importance of risk management, risk assessment and good risk communication (FAO/WHO, 2006).

Cost-benefit analyses have their limitations, but are probably the most appropriate currently-used approach to the assessment of food safety interventions (Irz, 2008). A recent U.S. News Opinion Economic Intelligence comment also emphasises the distinguished thesis that more funding and more regulations do not automatically result in better health and food safety, and calls for well-done, peer-reviewed cost-benefit analyses of future regulations, as well as for retrospective review of similar regulations done in the past to show their effectiveness (Williams, 2014).

Although QALY are used routinely in health technology assessment, the integrated evaluation of environmental-related health risks traditionally uses alternative approaches (e.g. willingness to pay, or cost of disease (Hammitt, 2002; Scallan *et al.*, 2011b; Hoffmann *et al.*, 2012). The health burden of foodborne diseases is typically quantified in DALY, as summarised in the first section of this paper. Recently-published work in the U.S. (Hoffmann *et al.*, 2012; Scharff, 2012; Batz *et al.*, 2014) represent a breakthrough in this respect, providing updated, scientifically-sound disease outcome trees with disease state-specific estimates of QALY losses for 14 key foodborne pathogens. These pieces of information open the door for cost-utility analyses to enter the field of food safety risk management, avoiding the need to monetise the calculated health losses. The systematic use of cost-utility analyses is encouraged both for broad resource allocation and for evaluation of alternative measures in food safety risk management.

Full economic analyses followed by an MCDA tool provide an established, objective and transparent methodology for multi-aspect health technology and policy assessment. The application of the same methodology is an opportunity for the development of evidence-based, transparent food safety risk management. One could object to this approach in that it would further increase the information burden and unnecessary bureaucracy. However, even without the uptake of the proposed quantitative methodology, most probably the same pieces of information are considered by risk managers, but on an ad hoc basis (Caswell, 2008). The proposed integration of HTA methodology into the food safety risk analysis process is shown in Figure 1.

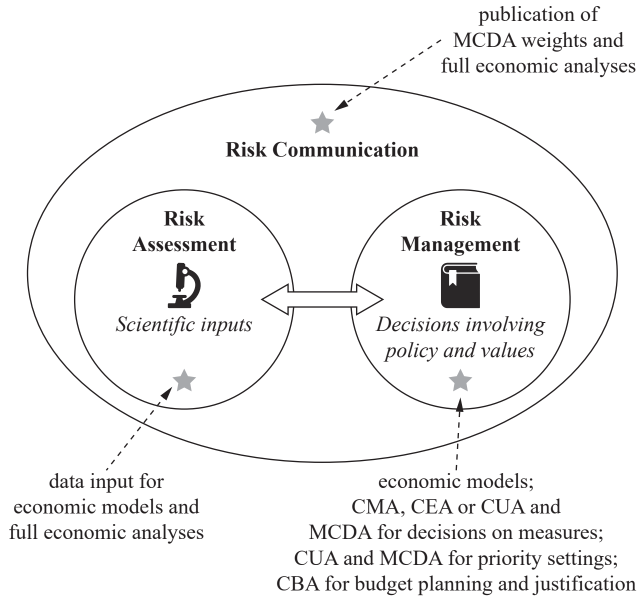

Figure 1: Place of health technology assessment tools in the food safety risk analysis process.

CBA: cost-benefit analysis; CEA: cost-effectiveness analysis; CMA: cost-minimisation analysis; CUA: cost-utility analysis; MCDA: multi-criteria decision analysis
Source: adapted from FAO/WHO (2006)

Conclusion: a vision of an integrated, evidence-based health and food policy

Sharing the established methodological tools of health technology assessment with food safety risk analysis would be a reasonable achievement. Moreover, the shared methodology would pave the way to the integration of health and food policies. According to this vision, cost-utility analyses of health and food policies would support the broad resource allocation between these policies, investing public expenditure in these fields proportionally to their expected health benefits. And within these policies, the selection of technologies, interventions and any policy measures would be supported by full economic analyses without health gain monetisation (i.e. cost-utility, cost-effectiveness and cost-minimisation analyses), together with the country-specific development of MCDA tools to deal explicitly and transparently with all relevant aspects of policy decisions. This would lead to systematic and evidence based food safety decision process along the whole risk analysis framework, with increased transparency, ensuring better and more justifiable decisions with higher societal values and gains.

Setting up priorities between diseases caused by specific foodborne pathogens is clearly a necessary and straightforward approach. However, it must be remembered that most domestic foodborne pathogen related diseases, hospitalisations and deaths have consistently failed to be linked to a specific pathogen in the U.S. (Mead *et al.*, 1999; Scallan *et al.*, 2011a). Moreover, foodborne pathogens are by far not the only causes of foodborne diseases: food safety risk analysis activities must face also the risks due to food additives and contaminants (e.g. mercury and dioxins, natural toxins such as aflatoxins, residues of pesticides and veterinary drugs) as well as physical risks (Mead *et al.*, 1999; FAO/WHO, 2006). Accordingly, the issue of broad resource allocation in food safety risk management shall not be restricted to the prioritisation among known foodborne pathogens.

In a wider context, let us consider the borders between food safety and nutritional policy. Beyond foodborne infections and toxicity, the qualitative and quantitative characteristics of food consumption also have tremendous impact on life quality and expectancy. Excess intake of calories, saturated and trans fats, free sugar and sodium, as well as low consumption of vegetables and fruits contribute significantly to rising rates of chronic diseases including hypertension, heart disease, stroke, diabetes and obesity (Nolte and McKee, 2008; DHHS, 2013). On the other hand, under-nutrition is an important burden in low income countries. Assuming an integrated food safety and nutritional policy, the overall ambition is not only to prevent foodborne infections and toxicity, but in a more global sense to promote health by any means targeting the proper consumption habits of safe food by society. In fact, food safety and nutrition policies are strongly interlinked at high-level decision making in the European Union at DG SANTE and in the European Food Safety Authority. In the U.S., the FDA Food Program has a dedicated sub-programme for better health through nutrition and labelling strategies (DHHS, 2013). Further steps to this integration might include the cost-utility analysis of food safety and nutritional policies to support optimal broad resource allocation across these fields. Apparently, this is not the practice at present.

Healthcare, nutrition policy and food safety risk analysis are closely interlinked by their health promoting aspect. Patients with acute foodborne infections may later be faced with chronic consequences, such as renal failure after STEC infection, Guillain-Barré syndrome after *Campylobacter* infection, or hepatocellular cancer due to aflatoxin contamination in nuts. Patients with excess calorie intake have increased risk of type II diabetes, which is one of the largest burdens on current healthcare budgets in developed countries. Development of improved therapies should logically shape the prioritisation among nutritional risk factors. On the other hand, appropriate investments in food safety and nutritional policies may help to avoid significant health loss and healthcare expenditures. Accordingly, food safety and nutritional policies and interventions form two particular 'classes' of health technologies.

Consumption of specific nutrients or vitamins is part of medical therapy in some cases; examples include vitamin D and calcium in postmenopausal osteoporosis, or glucosamine and chondroitin in osteoarthritis. There are precedents for HTA analysis of the proposed nutritional practice in these cases, as reviewed for example in Black *et al*. (2009). These examples, together with the recently-published systematic data on QALY impact of key foodborne infections, are encouraging that the evolution of quantitative HTA methodology in recent decades may contribute to the improvement of evidence-based food safety and nutritional policies. Allocative effectiveness of budget planning would theoretically benefit from performing relative cost-utility analyses of these large systems, redistributing healthcare, nutritional policy and food safety investments in a rational and socially acceptable way. Quantitative health technology evaluation methodology could also support consistent and transparent decision making on specific intervention measures within food and nutritional policies. The proposed next steps in this direction include the development of country-specific cost-utility analyses of currently implemented and potential alternative/additional intervention measures against the most important foodborne pathogens, followed by the integration of the analysis results into the decision making in the specific risk management processes.

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Musa Hasen AHMED*

Adoption of multiple agricultural technologies in maize production of the Central Rift Valley of Ethiopia

The improvement of agricultural productivity using technology is an important avenue for increasing output, reducing poverty and tackling land degradation. However, there is disagreement about which type of technology is most appropriate for smallholders. While some promote the need for natural resource management practices and low external input, others advocate the need for input intensification. This study has examined the nature of the relationship that exists between the two broad categories by using fertiliser and certified seed as input-intensive technologies and manure and soil conservation as natural resource management practices. Alongside this, the paper has also identified the factors that facilitate and impede the probability of those technologies being adopted.

Keywords: maize, technologies, technology mix, adoption, multivariate probit

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Introduction

About ninety per cent of the world's poor live in rural areas and almost all of them rely on agriculture for their food, income and employment (Collier, 2007). Thus, growth of farm productivity is widely understood to be a prerequisite for broad economic development in those areas (Tiffen, 2003; Sanchez *et al.,* 2009). In Africa, however, the sector is mainly in the hands of small-scale farmers who use traditional methods and tools of production. The growth of the agricultural sector in the continent has lagged behind both economic and population growth even during the years 2001-2010, which was a period globally perceived as a 'decade of growth' (Diao *et al*., 2012). Particularly in Sub-Saharan Africa (SSA), productivity has not increased considerably (Shisanya *et al*., 2009; Pretty *et al*., 2011). The region has the lowest land and labour productivity rates in the world (Henk and Kofi, 2003). It is the only developing region not to have experienced significant declines in undernourishment and about one third of the people in the region are food insecure (Graaff *et al.,* 2011). SSA is the only region in which the share of people living in extreme poverty is still as high as it was 30 years ago (WB, 2013).

Ethiopia remains one of the poorest countries in the world. According to World Bank data, in 2010, food aid was equivalent to 13 per cent of its national output and in 2014 nearly 30 per cent of households in the country were in extreme poverty. The country receives more food aid than any other country in the world (Kirwan and Margaret, 2007), and the depth and intensity of food insecurity are high (Bogale and Shimelis, 2009; Zegeye and Hussien, 2011).

In the country, agriculture contributes about 41 per cent of GDP, employs 83 per cent of total labour force and contributes 90 per cent of exports (EEA, 2012). Yet the use of low capital-intensive technologies results in low productivity and income that constrain farmers' capacity (Dinar *et al*., 2008). As indicated by Taffesse *et al.,* (2012), 96 per cent of the cultivated land in the country is managed by smallholder farmers, the majority of whom own less than one hectare. Thirty-six per cent of Ethiopian farming households are engaged in subsistence farming, living on less than USD 2 per day. This means they can only afford low mechanisation implements that are small and use human power (MoA, 2014). In addition to human muscle, oxen-draft is the main source of power for land preparation and planting, and this has created complementarities between crop and livestock production for centuries. Yet achieving higher and sustained agricultural productivity growth remains one of the greatest challenges facing the nation (Spielman *et al.,* 2010; Ahmed *et al,* 2014).

One way to increase agricultural productivity is through wider adoption of farming technologies, and such measures have been shown to have positive impacts on income, food security and poverty reduction (Alene *et al*., 2009; Asfaw *et al*., 2011; Kassie *et al*., 2011). Technology adoption can also improve nutritional status (Kumar and Quisumbing, 2010); lower food prices (Karanja *et al*., 2003) and reduce the risk of crop failure (Hagos *et al.,* 2012). However, especially in Africa, adoption rates of agricultural technologies remain quite low (Spielman *et al.,* 2010). There is also disagreement about which type of technology is most appropriate to the small farm sector (Priscilla *et al*., 2014). While some believe low external input approaches are most fitting for African smallholders (IAASTD, 2009), others such as Pingali (2007) advocate the need for input intensification.

Low external input strategies involve different agronomic practices, such as soil and water management practices and use of organic manure (Priscilla *et al*., 2014). Such agricultural production systems are expected to enhance sustainability while maintaining productivity that protects natural resources and the provision of public goods. Input intensification strategies, on the other hand, place higher emphasis on the use of certified seeds, mineral fertiliser, irrigation and other productivity-enhancing inputs. They argue that owing to negative soil nutrient balances caused by continuous cultivation with little or no addition of nutrients, enhanced food crop production in SSA is critically dependent on external nutrient inputs (Cobo *et al.,* 2010; Sanchez, 2002).

There is also a strategy that calls for integrated soil fertility management since agricultural intensification cannot occur unless certified seed, organic inputs and mineral fertiliser are combined and used with good agricultural practices adapted to local conditions (Place *et al.,* 2003; Vanlauwe *et al.,* 2010). In fact, these two strategies are not incompatible and they might be combined to increase production and productivity. For instance, Teklewold *et al.* (2013) indicated that the adoption of cropping system diversification, conservation tillage and modern varieties increases income from maize production. Kassie *et al.* (2015) also indicated that combining conservation agriculture with certified seeds and other external inputs could lead to positive synergistic effects. Furthermore, Mucheru-Muna *et al.* (2007) showed that significant yield benefits can be achieved through the combined application of organic matter and fertilisers compared to either resource applied alone. In general, there is no single approach that will work in every situation and the suitability of these technologies varies under different conditions (Priscilla *et al.*, 2014). Therefore, more research is required to show comparative evidence of what really works under which conditions.

Although numerous studies (e.g. Feleke and Zegeye, 2006; Beshir *et al.,* 2012; Wolka, 2014) have been conducted in Ethiopia to examine the adoption of agricultural technologies, most of them have looked at the adoption of technologies in isolation, while farmers typically adopt multiple technologies as complements, substitutes or supplements. By focusing on single technologies, such studies ignore the possibility that the choice of technologies to be adopted may be partly dependent on earlier technology choices (Teklewold *et al.,* 2013). The purpose of this study was therefore to identify the nature of the relationship that exists between the input-intensive technologies and natural resource management practices that have been adopted by smallholder maize-producing farms in the Central Rift Valley of Ethiopia. For this study, certified seed and fertiliser were considered as input-intensive technologies and manure and soil conservation practices were considered as natural resource management. Alongside this, the paper also analysed the factors that jointly facilitate and impede the probability of adopting productivity enhancing technologies.

Methodology

Description of study areas

In Ethiopia, maize accounts for the largest share of production by volume and is produced by more farms than any other crop (Chamberlin and Schmidt, 2012). CSA (2012a) indicated that about nine million smallholders were involved in maize production in the 2011/12 production season. It is primarily produced and consumed by the small-scale farmers predominantly in the mid-and low-altitude, sub-humid agro-ecologies (Dawit *et al.,* 2008). Maize is also one of the most important food sources in the country. From 1960 to 2009, the dietary calorie and protein contributions of maize have increased by around 20 and 16 per cent, respectively (Shiferaw *et al.,* 2013). According to FAO data, in 2013 the dietary calorie and protein contribution of maize had reached 398 KCal/day and 9.2 g/day, respectively.

During the 2011/12 production season, maize covered about 2.05 million ha of land at the national level, equivalent to 21.4 per cent of the total area covered by all cereals (CSA, 2012a). Of this area, 30.6 per cent was sown with certified seed varieties, and 23.3 and 27.7 per cent had utilised organic and inorganic fertiliser, respectively. The total output of maize in the same year at national level was 60.7 tonnes, i.e. 32.3 per cent of the total cereal production in that year. The productivity of maize in the same year was the highest among cereals with 2.95 t/ha which was an improvement of 32.5 per cent over 2006/07. Within this period, maize seed use has increased by 135 per cent, and application of inorganic and organic fertiliser to the maize crop increased by 82.3 per cent and 19 per cent respectively.

This study was undertaken in Arsi-Negele district, which is one of the major maize producing areas in the Central Rift Valley of Ethiopia. Geographically, it is situated at 7°09'-7°41' N and 38°25'-38°54' E. The study area covers three agro-ecological zones (low, mid and high land) based on annual mean temperature, rainfall, altitude and vegetation (ICRA, 2002). The temperature of the area ranges from 16°C to 25°C and annual rainfall ranges between 500-1150 mm. The topography of the area is a gentle slope or flatter. Some parts of the highlands in the study area are covered by natural forest, bush and shrub. The main crops grown in the area include wheat, maize, *teff*, barley, sorghum, onion and potato. Annual crops accounted for 95 per cent of all croplands in the district. *Andosol* soil type covers about 52.2 per cent of the district, while *nitosols* cover the remaining 47.8 per cent. The rainfall of the area is bimodal, with a short rainy season occurring from February to April and the main rainy season from June to October. The short rainy season allows farmers to grow potato early and later plant cereals, specifically wheat. Livestock are an important component of the farming system and a source of intermediate products in the district.

The area is intensively cultivated and private grazing land is unavailable. Communal pasture and straw from crops are the main source of feed for livestock production. According to CSA (2012b), the district has 303,223 inhabitants of which 150,245 are male and 152,978 are female.

Data sources and collection methods

A combination of purposive and random sampling techniques was employed to obtain a sample of respondents for this study. A two-stage random sampling technique was then applied to select sample households. In the first stage, three *Kebeles*[1] were randomly selected from Arsi Negelle district. In the second stage, 130 household heads were selected randomly using probability proportional to size. The analysis was conducted at plot-level since farmers may adopt certain technologies on some of their plots but not on others. Accordingly, plot-level data were collected from 148 plots managed by 130 randomly selected maize producers. The data were collected by means of a semi-structured questionnaire. The schedule was first pre-tested and, based on the result of the pre-test, some modifications were made to the questionnaire before the execution of the formal survey. Enumerators who are familiar with the study area, who can understand the local language and who have prior experience in data collection were recruited.

[1] *Kebele* is an administrative hierarchy in Ethiopia. The country is a federal state of regions where every region is structured into zones and zones are divided into districts. Every district is again divided into *kebeles*.

Econometric model

Since the adoption decision is inherently multivariate, attempting univariate modelling excludes useful economic information contained in interdependent and simultaneous adoption decisions (Dorfman, 1996). Therefore, this paper employs a multivariate probit model (MVP). The MVP technique simultaneously models the influence of the set of explanatory variables on each of the different practices while allowing for the potential correlation between unobserved disturbances, as well as the relationship between the adoptions of different practices (Belderbos *et al.*, 2004; Yu *et al.*, 2008; Kassie *et al.*, 2009). One source of correlation may be complementarity (positive correlation) or substitutability (negative correlation) between different practices (Belderbos *et al.*, 2004). Positive correlation also occurs if there are unobservable farmer-specific characteristics that affect several decisions but that are not easily captured by measurable proxies. Failure to capture unobserved factors and interrelationships among adoption decisions regarding different practices will lead to bias and inefficient estimates (Greene, 2008).

The observed outcome of technology adoption can be modelled following random utility formulation. Consider the j^{th} household ($j=1,...,N$) which is confronting a decision on whether or not to adopt the available productivity enhancing technologies on plot $p\,(p=1,...,P)$ over a specified time horizon. Let U_i represent the benefits to the farmer from the traditional production system, and let U_k represent the benefit of adopting the k^{th} productivity enhancing technology: ($k=F, S, C, M$) representing choice of fertiliser (F), certified crop variety (S), soil conservation (C) and manure application (M). The farmer chooses to adopt the k^{th} technology on plot p if $Y^*_{jpk} = U^*_k - U_i > 0$.

The net benefit Y^*_{jpk} that the farmer gains from k^{th} technology on plot p is a latent variable determined by observed and unobserved characteristics:

$$Y^*_{jpk} = X'_{jpk}\beta_k + u_{ip} \qquad (k=F, S, C, M) \tag{1}$$

where X_{jp} represents observed household, socioeconomic, institutional and plot characteristics; u_{jp} represents unobserved characteristics; K denotes the type of technology available and β_k denotes the vector of parameter to be estimated. Using the indicator function, the unobserved preferences in equation (1) translate into the observed binary outcome equation for each choice as follows:

$$Y_k = \begin{cases} 1 \text{ if } Y^*_{jpk} > 0 \\ 0 \text{ otherwise} \end{cases} \qquad (k=F, S, C, M) \tag{2}$$

In the MVP model, the error terms jointly follow a multivariate normal distribution (MVN) with zero conditional mean and variance normalised to unity where (u_F, u_S, u_C, u_M)~MVN(0, Ω) and the symmetric covariance matrix Ω is given by:

$$\Omega = \begin{pmatrix} 1 & \rho_{FS} & \rho_{FC} & \rho_{FM} \\ \rho_{SF} & 1 & \rho_{SC} & \rho_{SM} \\ \rho_{CF} & \rho_{CS} & 1 & \rho_{CM} \\ \rho_{MF} & \rho_{MS} & \rho_{MC} & 1 \end{pmatrix} \tag{3}$$

The off-diagonal elements in the covariance matrix represent the unobserved correlation between the stochastic components of the different types of technologies (Teklewold *et al.,* 2013). This formulation with non-zero off-diagonal elements permits for correlation across the error terms of several latent equations, which represent unobserved characteristics that affect the choice of alternative technologies.

Results

Dependent variables

The dependent variable for this study was the type of technology adopted from the set of: fertiliser, certified seed, manure and soil conservation practices. Improved maize seed was adopted on about 70 per cent of the plots and mineral fertiliser was applied on 78.4 per cent of the plots. Meanwhile, the adoption of manure and soil conservation technologies was below 50 per cent. Out of the total plots, 48.7 per cent applied manure and 35 per cent soil conservation practices.

Independent variables

The mean age of the sample respondents was 42.3 with the range from 22 to 70 (Table 1). On average, the sample respondents have cultivated maize for more than 20 years. The mean educational level of the sample households was grade 4.3 and about 35 per cent of the respondents were capable of reading and writing though they did not attain formal education. Regarding socioeconomic variables, the family size of the sampled households varies from 1 to 13 with a mean of 5.7. The mean livestock holding of the sampled households in terms of tropical livestock unit (TLU)[2] was 8.7 and the area of cultivated land ranges from 0.5 to 7.0 hectares with an average size of about 2 hectares.

As regards institutional variables, 29 per cent of the total sample households surveyed reported that they have received credit. The mean distance from the nearest market to the homestead was 3.7 kilometres. Sixty-three per cent of respondents indicated that they have social responsibilities such as religious, administrative and/or community leadership roles. The frequency of extension contact ranges from 12 to 52 times with an average contact of 22.9 times per year. Currently, extension service is mostly provided by the public sector, operating in a decentralised manner where extension is implemented at the district level (Davis *et al*., 2009).

Concerning the plot characteristics, the mean plot size was 0.54 ha and, on average, the plots are 1.03 km away from the homestead. Around 37 per cent of the plots were fertile and, in the perception of the farmers who managed them, 32.7 per cent of them were sloppy. About 12 per cent of plots were either rented or shared. In Ethiopia, all rural land is owned by the state and part of this land is allocated to farmers on a use-right basis. The rural land reform policy strictly prohibits the transfer of land by sale. Therefore, farmers in the area get additional land mainly through two informal arrangements: sharecropping and hiring.

[2] To see how TLU is calculated, please refer to Annex 1.

Table 1: Characteristics of the sample households.

Variable	Mean	Std. error	Min	Max
Household characteristics				
Age of the head of household (HH, years)	42.3	11.1	22	70
Educational level (grade)	4.3	3.3	0	12
Maize production experience (years)	20.6	10.3	2	50
Socioeconomic characteristics				
Off/nonfarm activity = 1 if HH is engaged in off/non-farm activity; 0 otherwise	0.22	0.41	0	1
Family size (persons)	5.7	2.2	1	13
Livestock owned (TLU)	8.7	6.0	0	81
Area of cultivated land (ha)	1.9	1.4	0.5	7.0
Annual farm income (ETB)	11,543	23,295	1,200	214,460
Institutional characteristics				
Extension contact (number of times per year)	22.9	14.4	12	52
Distance from home to market (km)	3.7	1.9	0.1	9.0
Cooperatives membership = 1 if the HH is member; 0 otherwise	0.11	0.31	0	1
Social responsibility = 1 if HH has social responsibility; 0 otherwise	0.63	0.49	0	1
Credit utilisation = 1 if HH used credit; 0 otherwise	0.29	0.46	0	1
Plot characteristics				
Plot size (ha)	0.54	0.27	0.13	1.00
Soil fertility = 1 if HH perceives the plot is fertile; 0 otherwise	0.37	0.49	1	2
The slope of the plot = 1 if HH perceives the plot is flatter; 0 otherwise	0.33	0.47	2	3
Plot ownership = 1 if HH owns the plot; 0 otherwise	0.88	0.41	0	4
Distance from the plot to home (km)	1.03	0.89	0.01	5.00

Source: own data

Nature of the relationship between the technologies

The results of the correlation coefficients of the error terms from the MVP are significant for any pairs of equations ($p < 0.000$) and they are statistically different from zero in four of the six cases (Table 2), confirming the appropriateness of the MVP specification. The result shows that the likelihoods of households to adopt fertiliser, manure, certified seed and soil conservation practices were 78.1, 47.6, 70.4 and 35.0 per cent respectively. It also shows that the joint probability of using all technologies was 11.6 per cent and the joint probability of failure to adopt all technologies was 3.8 per cent. The results of correlation coefficients[3] of the error terms indicate that there is positive (complementarity) and negative correlation (substitutability) between different technologies.

The simulated maximum likelihood estimation results indicated that there were positive and significant relationships between household decision to adopt fertiliser and manure, fertiliser and certified seed; and certified seed and soil conservation. The results also show that there were negative and significant relationships between adoption of manure and fertiliser and certified seed. The relationship between fertiliser and manure is plausible because both technologies deliver nutrients to the soil and the complementarily of certified seed and fertiliser is expected, especially in commercialised farms.

The result shows that there is no clear demarcation between technologies and farmers might combine input intensification and natural resource management or they might substitute each other as in the case of fertiliser and manure. This might be due to the nature of plurality of the role of extension workers in the country. In Ethiopia, extension workers are the main source of information for smallholder farmers regarding most of farming activities. They advise and consult farmers about the importance of certified seed, chemical fertilisers, compost, crop rotation, row planting and soil and water conservation simultaneously.

[3] A different but related approach is to estimate a probit model for the adoption of each technology, where adoption dummies for all the other technologies are used as right-hand-side variables. The result is presented in Annex 2.

Table 2: Correlation matrix of the technologies from the multivariate probit model.

	Fertiliser	Manure	Improved seed	Soil conservation
R_{Manure}	-0.626***			
$R_{Improved\ seed}$	0.662***	-0.248*		
$R_{Soil\ conservation}$	0.188	-0.185	0.497***	
Predicted probability	0.781	0.476	0.704	0.350
Joint probability (success)	0.116			
Joint probability (failure)	0.038			
Log likelihood	-254.44			
Likelihood ratio test of Rhoij = 0, $P > \chi^2(6)$	0.000			

***, ** and * significant at 1%, 5% and 10% probability level, respectively
Source: own calculations

Determinants of farmers' choice of adaptation strategies

Although farmers adopt a combination of technologies, there are a number of factors that can influence their decision to choose a particular technology. This section has identified the variables which determine the adoption of various technologies using MVP (Table 3). Eighteen explanatory variables, of which nine were dummy and nine continuous, were included in the model. The selection of those explanatory variables for the model was done through literature review.

Among plot-level variables, plot ownership was positively related to soil conservation and negatively with certified seed. The positive relationship indicates soil conservation is more likely to be implemented on owned plots. As soil conservation is usually a long-term investment, the farmer (i.e. the person who rented-in the land) may not derive benefit from his/her investment in the short term. The negative relationship between plot ownership and fertiliser use may be because the farmers who own land tend to be more commercialised and thus also use more purchased inputs. Plot size was found to have a positive relationship with application of fertiliser. Area of farmland is considered as a measure of wealth in rural parts of Ethiopia, thus households with more land can afford the use of commercialised inputs such as fertiliser.

Distance from plot to the homestead was also negatively related to the application of fertiliser and certified seed. This is plausible because if the plot is far from the homestead it will receive less attention from the farmer. The perception of

Table 3: Multivariate probit simulation results for households' technology adoption decisions.

Variables	Fertiliser		Manure		Improved seed		Soil conservation	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Household characteristics								
Age of the head of household	-0.090	0.114	0.003	0.090	-0.102	0.091	0.117	0.089
Age^2	0.001	0.001	-0.000	0.001	0.001	0.001	-0.001	0.001
Educational level	0.250*	0.129	0.028	0.117	0.062	0.109	0.196*	0.114
Experience	-0.026	0.029	-0.003	0.028	0.005	0.025	0.015	0.030
Socioeconomic characteristics								
Off/non-farm activity	0.349	0.390	-0.414	0.399	-0.129	0.295	-1.806***	0.445
Family size	-0.150*	0.087	0.087	0.076	-0.070	0.072	-0.148**	0.071
Livestock owned (TLU)	-0.023	0.019	0.081**	0.030	0.007	0.020	0.016	0.018
Area of cultivated land	-0.021	0.163	-0.115	0.192	-0.109	0.148	-0.086	0.154
Institutional characteristics								
Extension contact	0.203	0.240	0.826***	0.226	-0.141	0.194	-0.308	0.226
Distance from home to market	0.056	0.092	-0.035	0.083	-0.126*	0.071	-0.051	0.071
Membership of cooperatives	1.511**	0.744	-0.740	0.452	0.671	0.491	0.523	0.389
Social responsibility	-0.369	0.291	-0.332	0.293	-0.238	0.263	-0.327	0.269
Credit utilisation	0.080	0.319	0.055	0.323	0.299	0.285	-0.301	0.296
Plot characteristics								
Plot size	1.390*	0.740	0.938	0.696	0.548	0.608	0.217	0.628
Soil fertility	0.121	0.375	0.107	0.382	0.631	0.303**	-0.323	0.346
Slop of the plot	0.228	0.398	-1.080***	0.401	0.165	0.325	-0.445	0.390
Plot ownership	0.249	0.362	0.176	0.326	-0.538	0.294*	1.393**	0.628
Plot-home distance	-0.332**	0.158	-0.111	0.185	-0.356	0.148**	-0.205	0.176
_cons	1.667	3.002	4.392**	2.658	1.906	2.328	-0.028	2.363

Wald chi square (72) = 125.00; Log likelihood = -254.44248; Prob > chi square = 0.0001
***, ** and * significant at 1%, 5% and 10% probability level, respectively
Source: own calculations

farmers regarding the fertility status of the plot was significantly related to certified seed. Meanwhile, perception about the slop of the plot was negatively related to manure. This can be justified as if the plot becomes sloppy farmers do not apply manure due to the fear that it will be washed out and affect the neighbours' plots and the environment.

Education was found to have positive relationships with application of fertiliser and adoption of soil conservation practices. This result showed that higher educational status increases the awareness of farmer about the benefits of applying fertiliser and conserving the natural resource. Family size was related to fertiliser application negatively while it was related to soil conservation positively. The positive sign is plausible since conservation practices are often more labour intensive. The negative relationship might be due to the fact that larger family size would increase expenditure for home consumption, creating financial constraints to buying other commercial inputs such as fertiliser.

Livestock ownership was found to have a positive relationship with manure application. Owing to the fact that animal manure is bulky and less transportable it is more supply driven than demand driven. As such, households with more animals will also have more manure and will in turn be more likely to use animal manure in their farms (Priscilla *et al.,* 2014). Off/non-farm activities have a negative relationship with manure application. This can be justified as application of manure is labour intensive and if farmers are engaged in off/non-farm activities they will not have labour for this activity.

Among the institutional characteristics, cooperative membership was found to have a positive relationship with application of fertiliser, and extension contact has a positive relationship with manure application. Distance from home to market was found to have a negative relationship with improved seed. This is reasonable, because market distance contributes to higher transport and transaction costs, so that the use of purchased inputs is less likely in remote areas. Better access to markets enables farmers to obtain market information and other important inputs they may need. When farmers are far from the market, the transaction cost for acquiring inputs will be high and this will, in turn, reduce the relative advantage of adopting new technologies.

Conclusion and recommendations

The need for applying modern agricultural inputs in Ethiopian agriculture is not debatable as the possibility of expanding cultivable land is almost exhausted. Nevertheless, the agricultural sector in the county is well known for its being traditional and use of backward technologies. Therefore, research and adoption of technologies are crucial in increasing agricultural productivity and lowering the poverty levels as the fate of the sector, in terms of increasing its contribution to the overall growth of the economy and securing food self-sufficiency, depends on the development and application of appropriate technologies. Hence, there is a need to minimise constraints that hinder farmers from adopting modern inputs.

This study has analysed the adoption of different technologies among maize farmers using plot-, household-, institutional- and infrastructural-level data collected from the Central Rift Valley of Ethiopia. Owing to the fact that farmers are more likely to adopt a mix of technologies than a single strategy, the study used the MVP model. The technologies considered for this study were improved seed and fertiliser from input-intensive technologies, and manure and soil conservation practices from natural resource management technologies. The results of the multivariate correlation coefficient indicated that there are positive relationships between improved seed and fertiliser and between improved seed and soil conservation. There were also negative relationships between adoption of manure and fertiliser and between manure and improved seed. The estimation results indicated that the variables affecting farmers' decisions to adopt a technology differ between technologies. Educational level of the household, family size, off/non activities, livestock ownership, and distance to the market, plot ownership, slop of the plot and other variables also play significant roles, partly with differing signs across technologies.

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Annex 1: Conversion factors used to estimate tropical livestock unit (TLU) equivalents.

Type of animal	TLU
Calf	0.25
Donkey (young)	0.35
Weaned calf	0.34
Camel	1.25
Heifer	0.75
Sheep and goat (adult)	0.13
Cow and ox	1.00
Sheep and goat (young)	0.06
Horse	1.10
Chicken	0.013
Donkey (adult)	0.70

Source: Storck *et al.* (1991)

Annex 2: Simple probit models showing relationships between technologies.

	Fertiliser	Manure	Improved seed	Soil conservation
Fertiliser		-0.462*** (0.087)	0.561*** (0.095)	-0.016 (0.118)
Manure	-0.277*** (0.065)		0.162** (0.086)	0.020 (0.084)
Improved seed	0.424*** (0.087)	0.204* (0.107)		0.223*** (0.086)
Soil conservation	-0.003* (0.068)	0.016 (0.092)	0.194** (0.075)	

Marginal effects are shown with standard errors in parentheses.
N=148; ***, **, * significant at 1%, 5%, and 10% level, respectively.

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Economic valuation of improved management of Dechatu drainage basin in Dire Dawa Administration, Ethiopia

This paper assesses households' awareness of the causes of drainage basin degradation and measures their willingness to pay for improved drainage basin management. Cross-sectional data were collected from 398 randomly-selected households. The spike and bivariate probit models were applied to determine the mean willingness to pay and factors affecting households' willingness to pay, respectively. Agricultural expansion, population pressure, changes in weather conditions and climate change were identified as the main causes of degradation of the Dechatu drainage basin in Dire Dawa Administration, Ethiopia. The study also identified appropriate mechanisms and bases of charging a drainage basin management fee from the sampled respondents. The mean willingness to pay from the spike model was computed to be ETB 111 per annum for five years whereas the mean willingness to pay from the open-ended elicitation method was computed to be ETB 78 per year. The higher mean willingness to pay from the spike model might be due to anchoring effect from the dichotomous choice format. The result suggests that any drainage basin management system needs to consider the monthly income, location, sex, initial bids, occupation, marital status and educational level of the affected households.

Keywords: contingent valuation method, improved drainage basin management, willingness to pay

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Introduction

A drainage basin, also called a catchment or watershed, is an area of land whose surface water runoff is channelled through a common outlet (Sheng, 1990; Swallow *et al.,* 2002; Postel and Thompson, 2005; Wani *et al.,* 2008). A drainage basin can occupy a few hectares or it may cover a very large area (NIEA, 2008). People and livestock are integral parts of a drainage basin or watershed; their activities affect the productive status of the basin and vice versa. The drainage basin plays a crucial role in determining food, social and economic security, and provides life support services to people (Wani *et al*., 2008). It is the main source of fresh water and clean air (Atisa, 2009). However, as demonstrated by MEA (2005), many natural resources, including drainage basins, are being degraded or used unsustainably.

Drainage basin degradation is defined as the loss of health and productive potential of land and water over time caused by a flow of inferior quality, quantity and timing of water (Sheng, 1990; Aglanu, 2014). Reduced economic opportunities and increased social problems are the effects of degradation (Sheng, 1990), and it is a serious threat to the survival of millions of people (Kapta, 2004). Drainage basin management is therefore very important for achieving environmental, social and economic goals (Wani *et al*., 2008). It involves protecting and rehabilitating the basin in a way that increases production, generating both short-term and long-term benefits for the people living there (Nick and Woldehanna, 2012) and/or downstream. Effective drainage basin management requires an integrated and coordinated planning system (NIEA, 2008). However, because of their quasi-public good and externality features, the benefits of drainage basin management are rarely quantified (Georgiou *et al*., 1997). In other words, it is very difficult to exclude an individual from using the drainage basin services. Besides, the effect on the economic profit and utility of the users of these services does not necessarily enter the decision calculus of the supplier of the services.

In Ethiopia no attempt has been made to estimate the economic value of improved drainage basin management using environmental valuation techniques. The free distribution and underestimation of the value of drainage basins enhances the complexity of the degraded resource management decision. This study therefore tries to fill this gap and provides useful information on the value of improved management of the Dechatu drainage basin for management agencies, researchers and the communities that are affected by the degradation of the drainage basin.

Methodology

Study area and sampling techniques

The study was conducted in Dire Dawa Administration which is located in eastern Ethiopia between 9°27' N and 9°49' N latitude and 41°38' E and 41°19' E longitude. It is characterised by two broad agro-ecological zones mainly based on altitude, moisture and physiography (DDAEPA, 2011). A map of Dire Dawa Administration showing *kebeles*[1] is shown in DDAEPA (2011) and one of the Dechatu drainage basin is available in Alemu (2015). There are three groups of streams or tributaries flowing into the Dechatu drainage basin:

- Kersa – Legaodamirga – Harela – Jellobelina – Genet menafesha – Dechatu;
- Dengego – Harela – Jellobelina – Ijaanani – Dechatu;
- Awale – Bishanbahe – Biyoawale – Adada – Legabira – Dechatu.

From each of these three groups, one representative *kebele* was selected to obtain a sample of respondents from the rural *kebeles*. Harela, Jellobelina and Biyoawale *kebeles* were selected to represent the drainage basin. Three urban *kebeles* (05, 06 and 09 *kebeles*) were also selected to rep-

[1] *Kebele* is an administrative hierarchy in Ethiopia. The country is a federal state of regions where every region is structured into zones and zones are divided into districts. Every district is again divided into *kebeles*.

resent the drainage basin in the urban area. Given the total number of households of the study area, 398 sample households were selected. The sample allocation to urban and rural areas was based on the probability proportional to size sampling technique. Accordingly, 282 and 116 households from urban and rural areas, respectively were included in the sample. A similar approach was used to determine the sample size from each *kebele*.

Types and methods of data collection

Primary data on the willingness to pay (WTP) of sample households were collected through face-to-face interviews in the period June-November 2014. A structured questionnaire was developed and pre-tested to evaluate its effectiveness and identify the 'initial bids', i.e. the amounts of money the respondents would be willing to pay per month towards the improved management of the drainage basin. The initial bids (ETB 30, 70, 100, 140 and 180[2]) were identified using focus group discussion involving 60 key informants (farmers plus urban dwellers). The chosen bids were randomly assigned to the respondents such that each bid is allocated to an equivalent sub-sample. Also, secondary data were collected from the Ethiopian Central Statistical Agency and the Dire Dawa Administration Bureau of Agriculture. The contingent valuation (CV) scenario was presented to the respondents using the dichotomous choice referendum format. The double-bounded dichotomous choice format is useful to make clear bounds on unobservable true WTP, and it sharpens the true WTP and efficiency gain (Haab and McConnell, 2002; Tietenberg, 2003).

Methods of data analysis

The survey data were analysed using descriptive statistics and econometric models. In the CV survey the respondents may be offered a considerable number of zero responses (Johnson and Whitehead, 2000). These zero responses may be genuine or protest zeros. Hence, to treat these two zero responses, an appropriate framework of analysis should be adopted (Strazzera *et al*., 2003). Non-participation can have a substantial impact on the results of contingent valuation method (CVM) studies. If it is inadequately accounted for in the estimation process, an important difference in the final WTP estimates results (Haab 1999; Dziegielewska and Mendelsohn, 2007). A genuine zero value reflects the true value that the public good has for the respondent. The problem is with protest zero responses (Jorgensen and Syme, 2000). In the traditional CVM analysis, protest responses have tended to be excluded from the sample data set. However, this creates a problem if protest responses encourage a selectivity bias (Calia and Strazzera, 2001). Although there is no general consensus in the CVM literature on the most appropriate way of dealing with this problem of non-participation, a solution that has gained increasing popularity is the spike model.

The spike model was proposed by Kriström (1997) and it explicitly allows for the possibility that some of the respondents are indifferent to the good being valued, i.e. this model assigns a non-zero probability to zero WTP responses. Following Kriström (1997), the simple spike model was used in the study to allow a better handling of the zero responses that are common when using the dichotomous choice referendum format. A respondent was asked whether or not he/she is willing to contribute to the improved management of the drainage basin. The WTP for a change in environmental quality (such as improved management of drainage basin) $q^0 \rightarrow q^1$ (q belongs to R^1) can be expressed as:

$$V(y-WTP, q^1)=V(y, q^0) \tag{1}$$

where $V(y, q)$ is an individual's indirect utility function and y is income. If there is a continuum of individuals who associate different values to the improved management of the drainage basin, the probability that an individual's WTP does not exceed an amount A is given by:

$$Pr(WTP \leq A)=F_{wtp}(A) \tag{2}$$

where F_{wtp} is a right continuous non-decreasing function. As a result, the expected WTP can then be expressed as:

$$E(WTP) = \int_0^{\infty} 1 - F_{wtp}(A)dA - \int_{-\infty}^{0} 1 - F_{wtp}(A)dA \tag{3}$$

To be able to estimate $F_{wtp}(A)$ when binary valuation questions are used, different values of A were allocated to each sub-sample. The spike model assumes that the distribution function of WTP has the following form:

$$F_{wtp}(A) = \begin{cases} 0 \; if \; A < 0 \\ P \; if \; A = 0 \\ G_{wtp} \; if \; A > 0 \end{cases} \tag{4}$$

where P belongs to (0, 1) and $G_{wtp}(A)$ is a continuous and increasing function such that $G_{wtp}(0)=P$ and lim $A \rightarrow \infty \, G_{wtp}(A)=1$. This creates a jump-discontinuity or a spike at zero.

In this study, after the CVM scenario was presented to the respondents, two valuation questions were offered for the spike model. These valuation questions were (a) whether the respondent is willing to participate in the market for improved drainage basin management; and (b) whether the respondent is willing to contribute the initial bid per month.

For each respondent, *i,* an indicator of S_i was defined to determine whether the respondent is 'in-the-market' or not.

$$S_i = \begin{cases} 1 \; if \; WTP > 0 \\ 0 \; if \; WTP \leq 0 \end{cases} \tag{5}$$

The respondent is 'in-the-market' if the additional amount that he/she is asked to contribute towards the improved management of the drainage basin is lower than his/her WTP. A linear non-linear model was used to identify the effect of respondents' socio-economic characteristics on their WTP for improved management of the drainage basin. The model is specified as:

$$S_i = \gamma_0 + \gamma_1 V_{1,j} + \gamma_2 V_{2,j} + \ldots + \gamma_k V_{k,j} + \varepsilon_{S_{i,j}} \tag{6}$$

where $V_{S_i} = \{V_1, V_2, \ldots, V_k\}$ is also a vector of explanatory vari-

[2] EUR 1 = ETB 25.56 during the study period

ables not necessarily distinct from X_{T_i} below; γ is an unknown parameter of the model. After the respondents decision to participate in the hypothetical market ($S_i = 1\,(yes)$ the latent variable T_i was used to indicate the respondent's WTP for the initial bids A. That is:

$$T_i = \begin{cases} 1 \; if \; WTP > A \; and \\ 0 \; otherwise \end{cases} \tag{7}$$

This latent variable T_i is specified as:

$$T_i = \alpha + \beta A_i + \gamma_1 X_{1,i} + \gamma_2 X_{2,i} + \ldots + \gamma_M X_{M,i} + \varepsilon_{T_i,i} \tag{8}$$

where $X_{T_i} = \{X_1, X_2, \ldots, X_M\}$ is a vector of explanatory variables, A_i is the initial bids offered to the respondent in order to enjoy an improvement in the environmental quality $q^0 \rightarrow q^1$; in this study, the improved management of drainage basin. And α, β and γ are unknown parameters of the model. The disturbance terms are assumed to have a bivariate normal distribution with a correlation parameter ρ. That is, $(\varepsilon_{S_i}, \varepsilon_{T_i}) \sim BVN(0, 0, 1, 1, \rho)$. Therefore, with the introduction of these decision rules, the spike model becomes a bivariate specification with sample selection:

$$\begin{Bmatrix} S_i = 0 \; if \; S^* \leq= 0 \\ S_i = 1 \; if \; S^* > 0 \rightarrow \begin{Bmatrix} T = 1 \; if \; T^* > 0 \\ T = 0 \; if \; T^* \leq 0 \end{Bmatrix} \end{Bmatrix} \tag{9}$$

The log likelihood for the sample is then given by:

$$L = \prod_{S_i = 0} P(S^* \leq 0) \prod_{S_i = 1} \Big[\prod_{T_i = 1} P(S^* > 0, T^* > A) \prod_{T_i = 0} P(S^* > 0, T^* \leq A \Big] \tag{10}$$

which implicitly contains the joint probability of S^* and T^* and the marginal probability of S^*

Results

Socio-economic characteristics of sample households

The results show that 8.29 per cent of the sample respondents were protest zero. The entire sample, including the protest bidders, was included in the analysis to avoid the problem of sample selection bias. The descriptive analysis indicates that 85.7 per cent were male and 14.3 per cent were female respondents. Among these respondents 85.1 per cent were married. The remaining 3.5 per cent, 9.1 per cent and 2.3 per cent of the respondents were widow/ers, single and divorced, respectively. The age of the respondents ranged from 18 to 77 years with an average of about 42 years. The mean difference in age between the willing and not willing respondents was not significant (Table 1).

On average, households were composed of about 5.2 persons which was greater than the national average of 4.7 persons reported in FDREPCC (2008). This is due to the fact that polygamy is a custom in the study area. When more people are living in the drainage basin this can have an effect on the management of the basin. The educational status of the sampled respondents ranges from illiterate to 12+3 years of schooling, with an average of about 6 years. The mean difference in educational level between the two groups was statistically significant at the 5 per cent level.

On average the cultivated land area of the sampled households amounted to 0.13 ha, indicating that the average farm size of the study area is lower than the national average of 0.8 ha (CSA, 1995). This might be due to the fact that 70.9 per cent of the respondents were from urban areas. It shows that it is very difficult to produce sufficient agricultural output in the area. The mean difference of cultivated land for the willing and not willing groups was statistically significant at the 5 per cent level. Moreover, the result indicates that the total monthly income of sample households was ETB 666,290 per month. On average the income of the surveyed households was estimated at ETB 1674 per month (Table 1). Taking the average family size of 5.2 the average per capita income was ETB 322 per month. Higher monthly income was recorded because of smuggled products and cash crops production. The mean difference of monthly income for the willing and not willing respondents was statistically insignificant.

Households' perception on water availability and quality

About 84 per cent of the respondents were connected to the water distributer. On the other hand, the remaining 16 per cent fetched water from rivers and deep wells. The average water consumption of the sampled respondents was 1.51 m^3 per month. The majority of the respondents (54.8 per cent) stated that water is available to them for 8 hours per day. About 3 per cent of the respondents reported that water is constantly available (Table 2). This result indicates that availability water is a problem. However the majority of the respondents (73.6 per cent) reported that there is no problem with the quality of water (Table 2), and that they are using it directly from the pipeline. The remaining respondents reported that there is a problem with water quality. The overall result shows that there is no serious problem in terms of the quality of the available water.

Table 1: Socio-economic characteristics of the respondents by group of households (n = 398).

Variable	Willing households		Not willing households		Total sample		t-value
	Mean	SD	Mean	SD	Mean	SD	
Average age of the respondents (years)	41.8	11.5	41.5	13.3	41.7	11.8	0.86
Educational attainment (years of schooling)	6.6	5.0	5.0	4.9	6.4	5.0	2.40**
Family size (persons)	5.3	1.6	4.7	1.2	5.2	1.6	2.64***
Cultivated land area (ha)	0.15	0.31	0.04	0.13	0.13	0.29	2.53**
Monthly income of respondents (ETB)	1,676	1,664	1,012	906	1,674	995	0.09

*** and ** indicate statistically significant at 1% and 5% probability level, respectively
Source: own survey data

Table 2: Respondents' assessments of the availability of water and its quality (n = 398).

Daily duration of water availability	Respondents (%)	Quality of the water	Respondents (%)
Constantly available (24 hrs)	3.3	Highly acceptable	73.6
Moderately available (16 hrs)	42.0	Moderately acceptable	21.6
Available (8 hrs)	54.8	Acceptable	4.8

Source: own survey data

Table 3: Respondents' assessments of the causes of Dechatu drainage basin degradation and of the appropriateness of possible protection measures (n = 398).

Causes of degradation	Respondents agreeing (%)	Possible protection measures	Respondents agreeing (%)
Expansion of agriculture	39.9	Government regulation	23.6
Population pressure	68.6	Tree planting	47.5
Soil and water degradation	53.3	Soil and water conservation	74.4
Changes in weather conditions	7.5	Training of users	37.7
Climate change	13.1	Other sources of income for the communities	17.1

Source: own survey data

Causes and protection measures of drainage basin degradation

The data show that 90.8 per cent of the respondents were aware of the causes of Dechatu drainage basin degradation. They believe these causes are expansion of agriculture, population pressure, soil and water degradation, changes in weather conditions and climate change. Specifically, 39.9 per cent of the respondents believe that expansion of agriculture is the cause. In the case of soil and water degradations 53.3 per cent of the respondents responded 'yes' (Table 3). The result of the study is consistent with the findings of EPA (2012). Solutions were also elicited from the aware respondents for the possible improvement of Dechatu drainage basin. A majority of the respondents suggested that strong government regulation, soil and water conservation, tree planting and training users were the most appropriate protection measures (Table 3).

Assessment of institutional arrangements

Mechanisms proposed to the respondents for collecting the fee to pay for improved management of the drainage basin were: (1) a trust fund (2) a surcharge to be added to water bills (3) recover the cost through income tax. About 18.3 per cent of the sampled respondents were willing to contribute to a trust fund, a further 31.7 per cent believed that a surcharge should be added to water bill while the remaining 11.3 per cent opted for recovery through income tax as the appropriate mechanism to collect the fee. This suggests that the majority of the respondents were prepared to contribute financially to solving the water supply problems. However, 38.7 per cent of the respondents selected none of the above mechanisms.

The sample respondents were also consulted on their preferred basis for charging the fee for improved drainage basin management. The options were: (1) volume of water used (2) income (3) number of persons in the households (4) a fixed rate. The result shows that 38.7 per cent of the respondents selected none of the above bases for charging the fee. About 25.4 per cent selected the first basis, and 19.3 and 10.1 per cent of them selected the second and third bases respectively. The remaining respondents chose the fixed rate as the basis for charging the fee.

Table 4: Households' responses to the offered bids from the double bounded elicitation method (n = 398).

Value of bid (ETB)			Share of sampled households (%)			
Initial	Second higher	Second lower	yes-yes	yes-no	no-yes	no-no
30	60	15	11.8	6.3	0.2	1.8
70	140	35	4.3	8.8	2.8	4.3
100	200	50	2.5	8.0	3.3	5.8
140	280	70	1.8	3.5	7.3	7.0
180	360	90	1.3	2.8	7.0	9.5

Source: own survey data

Table 5: Parameter estimates of the spike model for the improved management of the Dechatu drainage basin (n = 398).

	Coefficient	Std. error	z	P>z
Initial bid	0.01728	0.001249	13.83	0.000
Constant	1.76828	0.138737	12.75	0.000
A	0.14576	0.017274	8.44	0.000
WTP	111.477	6.142573	18.15	0.000

Wald chi square(1)=191.21; Log likelihood=-343.47; Prob>chi square=0.000
A: 1/(1+exp(_b[s:_cons]))
WTP: 1/(_b[eq1:initialbid])*log(1+exp(_b[s:_cons]))
Source: model output

Households' WTP for improved management of the drainage basin

About 85 per cent of the sampled households were willing to pay for improved drainage basin management. The descriptive statistics of households' responses from the double bounded dichotomous choice format shows that 51 per cent of the respondents were willing to accept the initial bids. The remaining respondents rejected the initial bids. The average of the initial bids assigned to the respondents was ETB 104. From discrete responses of WTP, the study found that 21.6 per cent of the respondents accepted both the first and second bids. Besides, 29.4 per cent of the respondents responded 'yes-no', whereas the remaining respondents responded 'no-yes' and 'no-no' to the offered bids (Table 4).

The mean WTP for improved management of drainage basin was ETB 111 per year per household for a five year period (Table 5). The result shows that the mean WTP calculated from the spike model was significantly greater (at the 1 per cent level) than the mean value from the open-ended response. This implies that an open-ended elicitation method

Table 6: Factors affecting the sample households' maximum WTP for the improved management of the drainage basin according to the bivariate probit model (n = 398).

Explanatory variable	eq1: WTP participate		eq2: WTP initial bid	
	coefficient	**P>z**	**coefficient**	**P>z**
Location	1.43	0.000***	1.68	0.000***
Age	0.01	0.441	0.001	0.917
Sex	0.43	0.05**	0.25	0.26
Maritalstatus	-	-	-	-
Single (1)(base)	-	-	-	-
Married (2)	0.39	0.20	-0.09	0.748
Widow/er (3)	0.24	0.659	0.36	0.527
Divorced (4)	-0.45	0.39	-0.98	0.068*
Occupation	-	-	-	-
Unemployed (1) (base)	-	-	-	-
Self-employed (2)	0.28	0.297	0.49	0.05**
Governmentemployee (3)	-0.15	0.627	0.27	0.39
Privatesectoremployee (4)	-0.24	0.836	-5.11	1.00
Education	0.11	0.000***	0.07	0.006***
Familysize	0.10	0.19	-0.03	0.58
Totalincome	0.0002*	0.142	0.0003	0.000***
Waterconsumption	0.22	0.149	0.25	0.021**
Bid	-0.01	0.006***	-0.02	0.000***
_cons	-1.65	0.009	-0.51	0.37

Wald chi square (22) = 251.04; Log likelihood = -293.87; Prob > chi2 = 0.000
***, ** and * indicate statistically significant at 1%, 5% and 10% probability level, respectively
Source: model output

has the advantage of avoiding the anchoring effect. This result is consistent with other studies (Amponin *et al*., 2007; Alem, 2012). Using the spike model, the mean WTP of the urban and rural residents was computed to be ETB 97 and ETB 143 respectively. This indicates that households in the rural areas were more willing to pay than urban households. This might be due to the fact that the livelihoods of the urban residents are less dependent on the drainage basin than those of the rural households.

Households' willingness to pay derived from open-ended questions

The mean WTP of the respondents was ETB 78 per household per year for five years. The total WTP of the 398 sample respondents was estimated to be ETB 30,861 per year with a minimum of ETB 0 and maximum ETB 360 per household. Just over 30 per cent of respondents were willing to pay a monthly fee towards the improved management of the drainage basin in the range ETB 41-80, but thereafter the 'yes' response of the respondents decreased as the offered bids increased (Figure 1).

Different reasons were elicited from the willing households on their maximum WTP for the improved management of the drainage basin. Because of inadequate income, about 46.5 per cent of the respondents reported that they could not afford more than what they stated. On the other hand, 31.4 and 7.3 per cent respectively of the respondents stated "I think it is worth that amount" and "others should pay" as their reasons for the maximum WTP. About 46 per cent of the respondents stated "I could not afford more" as their reason for their maximum WTP. However, about 15 per cent of the sample respondents were not willing to pay for the improved management of the drainage basin, and provided a zero response. About 45 per cent of the not willing households responded with a genuine zero bid. Whereas, the remaining respondents stated protest zero[3].

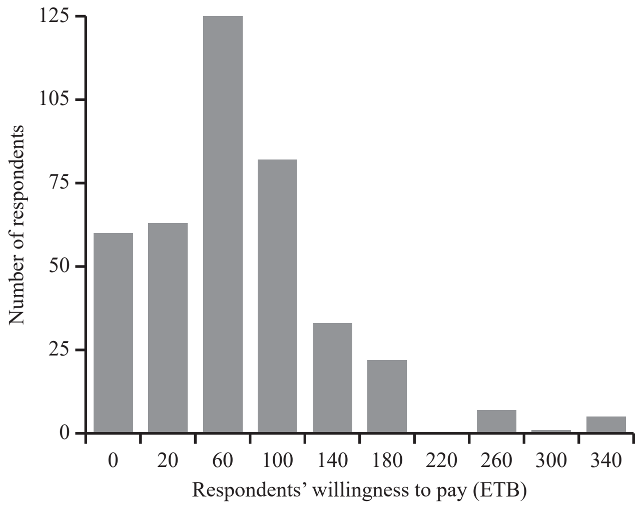

Figure 1: The sample households' maximum WTP for the improved management of the drainage basin, mid-points values of each group, i.e. 20 represents the range 1-40 (n = 398).

Determinants of households' willingness to pay

The bivariate probit model was used to identify the determinants of households' WTP for improved drainage basin management. The monthly income of the respondents (*Totalincome*) is positively and significantly related to the households' WTP to the offered bids (Table 6), indicating that respondents with higher monthly incomes were either more likely to be willing to pay, or simply have a greater ability to pay, than those with lower incomes. Amponin *et al.*

[3] The criteria for selecting protest zero was based on the discussion on NOAA panel guide in Arrow *et al*. (1993).

(2007) and Alem (2012) also found a significant association between households' income and WTP.

The education level of the respondents (*Education*) was positively and statistically significantly related to WTP. One reason for this might be that literate individuals know more about the significance of resources and are more concerned about environmental degradation (and hence drainage basin management) than are illiterate ones. On the other hand, it might be that education enables respondents to make independent decisions and paves the way to have greater access to job opportunities. This result is in agreement with the findings of other studies (Tegegne, 1999; Carlsson, *et al.* 2004).

The coefficient of sex (*Sex*) had a positive sign which was statistically significant at the 5 per cent level. This indicates that male respondents were more willing to contribute to improved management of the drainage basin than their female counterparts. This might be that male respondents have the power to make decisions on the expenditure of the family. Or, due to the high involvement of women in home production activities, they might face a money shortage that restricted them from contributing to drainage basin management.

Households that are located in the urban area (*Location*) were expected to have high WTP because they were thought to have more income than those in rural areas. However, our result shows that rural households were more willing to pay for improved management of the drainage basin than urban residents. This is because the livelihoods of the rural residents are more dependent on the drainage basin than urban residents. Divorced respondents were less likely to be willing to pay for improved management of the drainage basin than single respondents. The coefficient of this variable was negative and statistically significant at the 10 per cent level.

The result also shows that self-employed respondents were more willing to pay than the unemployed for the improvement of the drainage basin. The coefficient of this variable was statistically significant at the 5 per cent level. The coefficient of starting bids (*Bid*) had a negative sign and was statistically significant at the 1 per cent level in the first and second equations. This indicates that as the starting bid price increases, the probability of household's WTP reduces. This may indicate the existence of income scarcity or cash poverty. Besides, the result shows that demand for improved management of the drainage basin decreases as the starting bids increase. This is consistent with the findings of various authors (Whittington *et al*., 1990; Carlsson *et al*., 2004; Amponin *et al*., 2007; Alem, 2012).

Aggregate WTP for improved management of the drainage basin

An important issue related to the measurement of welfare using WTP is aggregation of benefit. According to Mitchell and Carson (1989), there are important issues to be considered in estimating a valid aggregation of the benefits of the environmental resource. However this could be affected by population choice bias, sampling frame bias, non-response bias and sample selection bias. In this study, the sample respondents were selected using a random sampling method. Besides, a face-to-face interview method was used to collect the data. To avoid sample selection bias, protest zero responses were included in the analysis. Hence, none of the above CVM biases was expected in this study. Mean WTP was used as a measure of aggregate value of improved management of drainage basin since the good dealt with is not a pure public good. The aggregate WTP was calculated by multiplying the mean WTP by the total number of households in the population (Table 7). Therefore, the aggregate benefit for improved management of the drainage basin of the total population of the study area was computed to be ETB 5,869,235 per year.

Table 7: Annual aggregate WTP of all households in the Dechatu drainage basin as calculated using the spike model and the open-ended elicitation method.

Location	Total households	Total WTP	
		spike model	open-ended elicitation method
Rural	22,091	3,150,618	2,103,505
Urban	53,602	5,206,362	3,766,613
Rural + urban	75,693	8,438,256	5,869,235

Source: survey data

Discussion

The CVM was used to elicit households' WTP for improved management of the Dechatu drainage basin in Dire Dawa Administration. The respondents believe that the drainage basin has been degraded because of agricultural expansion, population pressure, soil and water degradation, changes in weather conditions and climate change. Therefore, the government should introduce new practices such as environmental rehabilitation, family planning and resettlement. Besides, the residents should carry out soil and water conservation and tree planting to rehabilitate the degraded drainage basin.

The preferred mechanism for collecting the money from households for improved management of the drainage basin differed from household to household. Any management body should collect the money for this purpose using different mechanisms because using one mechanism may underestimate or overestimate the value of the resource. In addition, the basis of charging the fee should also differ from individual to individual.

The annual WTP value of households from the double bounded dichotomous choice format was greater than the annual total WTP from the open-ended format. We conclude that the double bounded dichotomous choice is affected by the anchoring effect. Thus, when designing a new management policy, decision makers and researchers should give more attention to solving the problem of the anchoring effect from the double bounded dichotomous choice format. Furthermore, the WTP value from rural households was higher than from their urban counterparts. It is therefore very important to elicit the value of drainage basin management from households whose livelihoods are more dependent on the drainage basin. However, this should not be considered as an end for improved drainage basin management. The value can be used in future cost-benefit analyses for policy formulation, especially as regards improved drainage basin management, and can be considered as the societal benefits of improved drainage basin management. Our findings can also be used to compare the cost of the improved drainage basin management plan, for example to the aggregate WTP of the households which is ETB 5,869,235 per year. If the aggregate WTP is lower than the proposed cost of the management plan, effort is required from the management agency or government to solve the social acceptability problem.

The households' WTP is affected by the socio-economic characteristics of the different households. This result leads us to conclude that an understanding of the socio-economic characteristics that significantly affect households' WTP is a necessary and first step to achieving improved drainage basin management.

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Workshop report

Policy Guidelines for Agricultural Research

Budapest, 10 November 2015

This workshop was organised jointly by the Hungarian Ministry of Agriculture (FM) and the Research Institute of Agricultural Economics, Budapest (AKI) with the assistance of the Hungarian Chamber of Agriculture (NAK). Its objective was to initiate a dialogue between the representatives of national agricultural research organisations, establishing guidelines for the areas considered to be of strategic importance by the actors. The participants were mainly the leaders and delegates of universities, research institutes, administration and organisations representing farmers. The event was the first of a series of activities, the outcome of which will be an active agri-innovation network that supports the matching of needs and potentials.

The conference was opened by Dr. Feldman Zsolt, Deputy State Secretary for Agriculture. In his welcome speech he pointed out that, just as in the European Union (EU), the performance of agricultural research in Hungary is measurable and interpretable mainly through its effects of innovation (i.e. by the level of its contribution to farming standards). The FM recognises the importance of the establishment of a national agri-innovation network, and the identification of practical demands, innovative ideas and operators. For this purpose a new Agri-Innovation Department (AID) has been set up within the Ministry.

In the first presentation of the plenary session Dr. Juhász Anikó, Director General of AKI, recalled that applicants from Central and Eastern European (CEE) and Visegrad Group (V4) countries had only limited success in applying for funding from the EU's Seventh Framework Programme for Research and Technological Development (FP7). She drew participants' attention to the areas of *Horizon 2020*, the EU's current research and innovation programme, that should be taken into account and described the factors that are prerequisites for a successful application. Then, Kránitz Lívia, Head of the AID, described the potential of the European Innovation Partnership 'Agricultural Productivity and Sustainability' (EIP-AGRI). This involves a new form of cooperation aimed at bridging the gap between research and practice. The resources for establishing cooperation for innovation and implementation of joint projects are being provided by the Hungarian Rural Development Programme 2014-2020.

Following these presentations, the workshop was introduced and moderated by Dr. Nemes Gusztáv, a researcher from the Hungarian Academy of Sciences. Seven thematic workgroups were set up, covering two major topics:

- Managing challenges caused by the continental climate and its change (covering the reduction of dependence on non-renewable energy sources; exploiting the potential for protein crop production and livestock feeding; Central and Eastern Europe as an east-west/south-north buffer zone for pathogens; and preservation of the quality of natural resources, ecosystem services and biodiversity);
- Adaptation to the challenges of social and economic changes (covering opportunities for promotion of modern management in agriculture; efficiency of the supply chain, increasing the added value, bio-economy; and alternative effects on consumer attitudes).

The participants were asked to address three issues. Firstly, a consensus had to be reached on the relevance of their topic and whether the research field is well defined in the CEE / V4 countries. Here the corresponding most important problems, research questions and directions, and project ideas were collected. Then, the subject-related domestic and international (mainly CEE / V4 countries) associations that could potentially be involved in cooperation for research and enhancement of interests were identified. Finally, the participants could make pledges and commitments for work and tasks to be carried out before the publication of the 2018-2020 work programme of *Horizon 2020*.

Across the seven workgroups, the participants identified 46 relevant problem areas and challenges, while 63 research topics focus areas were defined. The participants in every workgroup identified a fair number of potential partners. Altogether, nearly 110 organisations were named by those present, two-thirds of which are outside Hungary. The commitments to undertaking tasks were also encouraging. The most common contributions to be made were partner mediation, information sharing, the moving of social networks, communication, dissemination, project management, coaching, conducting empirical research and the preparation of professional materials. In conclusion it can be stated that due to the highly successful and active work of the groups a large amount of information was collected that will be valuable for reaching the pursued objective.

The event ended with a panel discussion moderated by Dr. Nemes Gusztáv in which Prof. Dr. Németh Tamás, full member of the Hungarian Academy of Sciences, Dr. Jenes Barnabás, Director General of the Hungarian National Agricultural Research and Innovation Centre, Dr. Fertő Imre, scientific advisor of the Hungarian Academy of Sciences, Papp Gergely, Deputy Director of Hungarian Chamber of Agriculture, Dr. Juhász Anikó and Kránitz Lívia summarised the most pressing problems of Hungarian agricultural research. The participants were encouraged to carry out the responsibilities they assumed courageously, persistently and in close cooperation with each other. Only in this way is there a chance for the region to become more successful in securing funding for its agricultural research project proposals submitted to *Horizon 2020*.

More information about the planned agri-innovation network is available by email from Dr. Juhász Anikó at juhasz.aniko@aki.gov.hu.

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.

SZABÓ Dorottya and JUHÁSZ Anikó

The characteristics of markets from the consumers' and the producers' point of view

Agroeconomic Book, published 2013

Today the role of the short supply chains became more important, this is why we chose to investigate this sales channel in our study. It is remarkable that the share of markets from the Hungarian domestic consumption of daily consumer goods was only 5 per cent in 2012, however, this ratio has stayed constant since 2000. In this research, producer and consumer surveys were mainly conducted by online questionnaires but they were complemented with paper-based ones. The consumers participating in the survey could be divided into clusters, which were clearly separated on the basis of their attitude towards markets, it ranged from market fans to market refusers. Based on our results, people preferring markets were typically urban, economically active, higher educated buyers with family, while those living in villages, with lower level of education and economically inactive preferred markets less. The results also demonstrated that selling on markets rather than in long supply chains provided higher income for the farmers, but it also meant additional costs, mainly due to the additional tasks of marketing, logistics and storing.

BORBÉLYNÉ TAKÁCS Krisztina and DANCS Gyuláné (eds)

Production data for the major Hungarian food products in 2013

Agroeconomic Information, published 2015

The publication presents data, for a wide selection of products, on the production costs and sales income of the food processing industry in 2013 compared to the previous year. Firstly, the price changes for the major food product groups are summarised and, secondly, tabulated data for individual food products are presented. These data show that in 2013 the production costs of meat products generally increased. It is true for all products that the manufacturers aimed to compensate for their growing production costs with some increases in sales prices. For a number of meat industry products the increases in the sales prices did not compensate for the increases in the production costs in 2013, so the profits were lower or remained at the same level. In the poultry, dairy, milling and baking industries, as well as in the production of pasta products, increases – at various scales – can be observed in raw material costs compared to the previous period, and more or less in total production costs. The results usually varied between products and food industry sectors, with the exception of the production of pasta, where the results for all the presented products declined. The profitability of the milling industry improved in 2013, while in the baking industry – as in the previous year – not all the products listed in this publication could realise a profit.

VÁGÓ Szabolcs and VALKÓ Gábor (eds)

Hungarian Food and Agricultural Statistics 2014

Agroeconomic Information, published 2015

The publication provides information on the results achieved in 2014 in agriculture, forestry and food industry. We assured the comparability of time-series in connection with the pocketbooks published in the recent years. Besides the national and branch indicators and data, the principal agricultural data are also given in details by counties. The international data are suitable to demonstrate the main trends. The published data are compiled on the basis of the publications of the Central Statistical Office, EUROSTAT, the Food and Agricultural Organization (FAO) and the Research Institute of Agricultural Economics.

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Studies in Agricultural Economics publishes original research papers, review papers, policy analyses and book reviews on agricultural economics, rural development and related topics including: agricultural production and competitiveness, environmental resource management, agri-food supply chain management, markets and marketing, international trade, econometrics, rural economic geography, rural economy and sociology, and development of information and knowledge based society in rural areas.

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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