Studies in Agricultural Economics

Volume 122, Number 1

Contents

Manuscripts should be prepared in English and sent via e-mail to the Editor-in-Chief at info@studies.hu.

The cost of printing this issue is supported by the Hungarian Academy of Sciences.

H-1093 Budapest, Zsil utca 3–5.
www.studies.hu
ISSN 1418 2106 (printed)
ISSN 2063 0476 (electronic)
Established 1962

Foreword

I assume none of us has predicted such a start for 2020. Due to the coronavirus outbreak, our everyday life has changed to a great extent and we are now forced to be more on-line and home-office based. This situation has also posed many challenges to our journal which we have successfully met, at least up to now. Despite the global situation, the great news is that Studies in Agricultural Economics was successful in its application for Scopus listing and from 2020, it gets a Scimago Q value! I would hereby like to thank our previous Editor-in-Chief, Andrew Fieldsend, for all his work and efforts towards this process and also many thanks for our Editorial Board for making this happen! This is a great moment in the life of our journal as it now becomes officially recognised by the international scientific community. The challenge now is to keep and even increase this quality, in order to get better rankings and scores inside the Scopus system.

We have seven papers in this first issue, five full papers and two short communications. The first paper, written by Ahmadzai, analyses how off-farm income is linked to on-farm diversification in Afghanistan. Results suggest that a third of farmers do not diversify, while the majority of those that do, grow only two or three crops. Moreover, it turns out that while landholding size, farm characteristics and assets, and proximity to markets significantly increase the extent of diversification, a significantly lower degree of diversification is found for households with higher non-farm income. Identification through instrumental variables confirms endogeneity in off-farm income, revealing that unobserved factors such as risk-aversion behaviour and relative efficiency may drive household decisions to diversify into both non-farm activity and crop mixing.

The second paper, written by Besuspariene and Niskanen, analyses the factors affecting fertiliser use on Lithuanian family farms. Working with FADN data between 2003-2017, results suggest that the significant factors affecting fertiliser use on family farms in Lithuania differ significantly from other EU countries. Therefore, there is no unique methodology or unique set of financial instruments for fertiliser tax modelling among EU countries, and this should be taken into account in future studies. The authors also noticed that investment in land, the extent to which farm output consists of wheat, rye and field vegetables, the use of harvesters and finally, land quality should also be taken account in future fertiliser tax modelling.

The third paper, written by Koner and Laha, analyses the economics of zero budget natural farming (ZBNF) in West Bengal, India. Empirical evidence presented in the paper is based on the performance of this alternative model of farming in respect of three important parameters, namely cost of cultivation, yield and income. Evidence reveals that the sample farmers have experienced a reduction in per hectare production cost and per hectare yield for their crops in the post-conversion period. More importantly, farmers adopting the ZBNF were able to enhance their income, compared to their chemical counterparts. However, results also indicate that the long term sustainability of this model of farming is contingent upon the interplay of agro-climatic conditions and various other socio-economic factors.

The fourth paper, written by Czine, Szakaly and Balogh, assesses consumer preferences for margarine among Hungarian and foreign university students, studying in Hungary, by using the discrete choice experiment. Results suggest that an increase in fat and salt content results in reduced consumer utility and willingness to pay for margarine products. Sunflower oil content, however, was not found to play a significant role in consumer choices. When comparing the two groups, we found that international students tended to be more health conscious than their Hungarian counterparts.

The fifth paper in this issue, written by Kovacs and Szucs, also focused on Hungary and explored efficiency reserves in Hungarian milk production. Their results, based on FADN data, show that the average technical efficiency of the Hungarian dairy sector in 2008-2017 was 77.6%, meaning that output could be increased by 22.4% without changing the level of input (efficiency reserve). Large and small farms are found to be more efficient than medium sized farms, while large farms keeping more than 501 dairy cows were found to be more efficient than the other two size categories. Farms located in Northern Hungary had less efficiency reserves that the farms operating in the Great Hungarian Plain, Central Hungary or in the Transdanubian Region (27.6%). All this suggests high reserves for potential efficiency growth.

The first short communication, written by Kavoosi-Kalashami and Motamed, analysed the productivity of sericulture in Northern Iran in 2007-2016 by using total factor productivity and the Malmquist index. Results show that only Talesh and Rudsar counties achieved productivity growth during the period analysed. Moreover, three counties of Astana-Ashrafieh, Lahijan and Masal & Shandermann experienced negative changes in efficiency and technology, which resulted in a significant negative change in TFP. Among the studied counties, only Sowme'ehSara County had year-to-year increase in productivity over the period 2007 to 2016, while counties of Roodsar and the Sowme'ehSara had the highest and lowest fluctuations of year-to-year TFP. Overall, findings show that with the exception of the years 2011, 2014 and 2016, the major changes in TFP all occurred due to technology change.

The second short communication, written by Shalbuzov, Fikretzade and Huseyn, analysed the international competitiveness of Azerbaijani fruit and vegetable products by calculating domestic resource cost ratios, using the data for 2015–16 as representing base years. Out of the 10 products analysed, almost all were found to have high competitive potential, especially on the Russian and European markets. According to the authors, in order to maintain competitiveness in the arable sector, Azerbaijan will need to achieve dynamic improvements in productivity and run a wise agricultural policy.

On the whole, I think we are now on the right track and we will continue working hard on making Studies in Agricultural Economics an internationally recognised journal writing decent analysis on issues related to and important for Europe and Central Asia.

Attila JÁMBOR
Budapest, April 2020

Hayatullah AHMADZAI*

How is Off-farm Income Linked to On-farm Diversification? Evidence from Afghanistan

The analysis in this paper estimates micro-economic drivers of diversity in crop production in Afghanistan with particular emphasis on the implications of household access to non-farm income. Descriptive analysis shows that a third of farmers do not diversify, while the majority of those that do, grow only two or three crops. Econometric analysis reveals that while landholding size, farm characteristics and assets, and proximity to markets significantly increase diversification, a significantly lower degree of diversification is found for households with higher non-farm income. This is consistent with the hypothesis that allocation of farm labour away from non-farm activities decreases diversity due to negative labour effects, perhaps because the opportunity cost of farm labour is higher than rural wages. Identification through instrumental variables confirms endogeneity in off-farm income, revealing that unobserved factors such as risk-aversion behaviour and relative efficiency may drive household decisions to diversify into both non-farm activity and crop mixing.

Keywords: Off-farm Income, Diversification, Crop Production, Cragg's Type Double Hurdle Models, Afghanistan

JEL classifications: Q12, Q18

* External Research Fellow, Centre for Research in Economic Development and International Trade (CREDIT), School of Economics, University of Nottingham, Nottingham, UK NG7 2RD. E-mail: hayatullah.ahmadzai1@nottingham.ac.uk

Received: 2 February 2020, Revised: 13 March 2020, Accepted: 15 March 2020.

Introduction

In the farming business it is crucial to understand the decision-making environment and behaviour of farm households, particularly subsistence smallholders that are often exposed to various types of risk and uncertainties. Understanding decisions such as the allocation of limited resources among a diverse production portfolio requires empirical evidence. Traditionally, Crop Diversification (CD) is regarded as a management strategy, particularly in the context of subsistence farming, where farmers choose the appropriate crop mix to reduce production risks and sustain their livelihoods and income. Previous studies have established the economic value of CD as an alternative strategy that farmers utilise to enhance productivity and even improve and sustain their incomes (Joshi *et al*., 2007; Kurosaki, 2003; Weinberger and Lumpkin, 2007). To respond effectively to changing market demand and altering consumption patterns, both farmers and agriculture policy makers require a solid empirical understanding of the production decision-making environment, farmers' socio-economic characteristics and the behaviours that drive decisions regarding crop diversification. This paper aims to explore farm households' decisions with regard to the magnitude of crop diversification at the farm level in Afghanistan. It analyses the extent of diversity in crop production, and the empirical relationship between CD and household socio-economic, demographic, farm, and farmer characteristics with a key focus on household off-farm income.

Heterogeneity in farmer crop portfolios under a given set of socio-economic circumstances is an important empirical discussion. Even in the presence of high-return alternatives both on- and off-farm, a large number of farm households still engage in producing low yield food commodities (mainly staple food grains), and crop portfolio choices vary greatly among similar households (Stoeffler, 2016). Hence, farmer's knowledge, technical know-how, and production management practices have critical implications for their income and costs. This implies that without additional costs, there is a great potential for farm households to improve their productivity and income simply by adding high value crops to their production agenda. In addition, markets for particular commodities are imperfect and often fail to facilitate the efficient trade of farm produce, forcing farmers to adjust their production decisions to compensate for losses due to the presence of such market risks. These decisions often involve opting for crop or enterprise diversification to a lesser or greater extent.

Since emerging out of conflict and the establishment of a market-led economy in 2001, Afghanistan's agricultural economy has undergone a drastic policy change, which has created opportunities but also posed risks and uncertainties. The primary emphasis of Afghanistan's National Development Framework (ANDF) 2009 is to increase productivity so as to attain food self-sufficiency and increase farm incomes at national, regional, and household levels. With increased international aid being pledged, Afghanistan's economy grew at a steady rate of 9.4% during 2003-2012 with a significant contribution (about 25%) coming from the agriculture sector (World Bank, 2014). Economic growth has been accompanied by changes in agriculture production and consumption patterns, whilst other economic sectors (e.g. services and manufacturing industries) have been revitalised. With the revitalisation of other sectors and improved levels of education, farm households may have had the opportunity to diversify into off-farm activities. This highlights the importance of understanding the household decisions about labour and resource allocation between on- and off-farm activities.

Current studies on production efficiency find evidence of a positive relationship between crop diversification and production efficiency in Afghanistan (Ahmadzai, 2017; Tavva *et al*., 2017). Broader research also confirms that CD significantly improves farm level efficiency in other countries with a similar socioeconomic context (Coelli and Fleming, 2004; Ogundari, 2013; Rahman, 2009). However, Afghanistan's agriculture sector is still highly dominated by production of staple food grains (mainly wheat), leaving production systems highly undiversified. In addition, the decrease in farm income among rice/wheat producers in Afghanistan due to declining productivity has triggered a change toward farm diversification, especially a shift in production from staple food crops to higher value commodities (Oushy, 2010). Empirical evidence suggests that grain-based production systems may not continue to contribute as significantly in countries with a policy focus on raising incomes and production of high value market crops, generating employment opportunities, and alleviating poverty (Joshi *et al*., 2007). This therefore calls for a transformation in agriculture systems to diversify towards high value crops such as vegetables and fruits.

Concept and Measures of Crop Diversification

There are two common and complementary approaches to crop diversification in agriculture, namely horizontal and vertical diversification. Horizontal diversification as a primary approach to crop diversification, takes place through crop intensification by adding new crops to existing production line or cropping systems. Vertical diversification involves value-added activities such as processing, branding, packaging, and other post-harvest activities to enhance the marketability of farm product. In the context of this study, diversification is defined as a shift in production portfolio away from mono-cropping to adopting a multiple cropping system.

The most common method to measure the extent of crop diversification is the calculation of a vector of income/revenue shares related to different income sources. While this approach puts diversification and income changes directly into the relationship, a relevant part of information related to different aspects of diversification is neglected such as the actual number of crops grown (Asfaw *et al*., 2018; Barrett and Reardon, 2000). The diversity methods that measure crop or species richness are usually used in the ecological research to capture spatial biodiversity of crops and the richness of genetic resources. Count measures provide a general level of overall diversity on a farm, but do not account for whether the farm is growing high value cash crops or staple crops and the percentage of resources allocated among different crops (Turner, 2014).

Given the objective of this study, Composite Entropy Index (CEI) was selected as a primary measure for crop diversification. In addition to revenue shares of individual crops, CEI gives due weighting to the total number of crops grown by the farm household. This is important as the revenue share captures the relative importance of crops based on their economic value which may largely vary depending on the type of crops (i.e. the value of the index will be higher for households that grow high value crops). Thus, the CEI index is sensitive to the changes in the number of crops and their respective revenues. While the CEI index possesses all the desirable properties of Entropy and Modified Entropy Indices, it is adjusted by the number of crops. The CEI can be calculated as:

$$D_i = -\left[\sum_{n=1}^{N} P_n \log_N P_n\right]\left[1 - \frac{1}{N}\right] = \\ = \sum_{n=1}^{N} \frac{\ln P_n}{\ln N}\left[P_n - \frac{P_n}{N}\right] , \quad (1)$$

Where D_i represents CEI, P_n is the share of revenue from the n^{th} crop (for n = 1, 2, …, N) grown by the i^{th} farmer, and is the number of total crops grown in a given year. The computed value of the index increases with level of diversification ranging from 0 implying no diversification (i.e. mono-cropping) to 1 implying the highest level of CD.

Theoretical Framework and the Agriculture Household Model

Farm household decisions pertaining to crop choices and the extent of diversification can be best understood in the context of the standard farm household model initially developed by Singh *et al*. (1986) which assumes farm households are both consumers and producers of agricultural goods operating under a number of constraints. Previous studies adopted this approach to explore the decision of farm households with regard to the intensity of farm or crop diversification (Hitayezu *et al*., 2016; Cavatassi *et al*., 2012; Benin *et al*., 2004; Van Dusen and Taylor, 2005).

Proceeding according to the household model, we may consider an agricultural household that maximises utility over a set of consumption goods produced on the farm (C_f), a set of purchased non-farm commodities (X_{nf}), and leisure (l). The expected utility gained from various combinations and levels of consumption goods directly depends on the vector of preferences of the household, denoted by Φ^{hh}, shaped by household socio-economic, cultural, and other exogenous factors. This maximisation problem can be written as:

$$\max_{C_f, C_{nf}, L, X, A} \quad U(C_f, C_{nf}, l \mid \Phi^{hh}), \quad (2)$$

Subject to the constraints facing the household:

$$p_f(Q_f - C_f) - C(Q_f \mid \Phi^f) + Y_{nf} = \\ = p_{nf}C_{nf} + w(L_f + L_{nf}) , \quad (3)$$

$$Q_f = f(\alpha, L, X_f \mid A, \Phi^f), \quad (4)$$

$$T = (L_f + L_{nf}), \quad (5)$$

$$Y_{nf} = y(L_{nf} \mid \Phi^{nf}), \quad (6)$$

The utility is constrained by the general budget constraint (Equation 3) such that the maximum expenditures of time

$w(L_f+L_{nf})$ and money $p_{nf}+C_{nf}$ cannot exceed the total income of a farm household in a given decision-making period. Total household income is composed of farm income $p_f(Q_f-C_f)$ net of production costs $C(Q_f \mid \Phi^f)$, and off-farm income denoted by Y_{nf} that includes remittances, stocks carried over, and other transfers which are exogenous to the crop choices. The amount of agriculture produce consumed by the household (C_f) or sold Q_f-C_f are chosen from the crop(s) output Q_f (for crop $j=1,2,3,\ldots J$ that household chooses) which is constrained by the production technology embedded here in the cost function $C(Q_f \mid \Phi^f)$ where Φ^f is a vector collecting exogenous farm characteristics. Household decisions about the number of crops and the quantity is constrained by the fixed technology constraint (Equation 4) such that the quantity of goods produced on the farm Q_f is a function of purchased inputs (X_f), Labour (L^f), a given area of land (A) which is allocated to different crops (here denoted by α or the set of share of land allocated between J crops such that $\Sigma_{j=1}^{J}\alpha = 1$, and exogenous characteristics of the farm Φ^f. According to Benin *et al*. (2004), each set of area shares implies a level or combination of crop outputs, hence the objective function in Equation (1) can be re-expressed as:

$$\max_{h} \quad V(C_f, C_{nf}, l \mid \Phi^{hh}), \tag{7}$$

Where $h = ((\alpha_1, \alpha_2, \alpha_3, \ldots \alpha_n) \geq 0, C_f, C_{nf}, X, and\ L))$. The allocation of labour is constrained by the household total labour time (Equation 4) which is denoted by (T) available for off-and on-farm activities (denoted by L^f and L^{nf}) and leisure (l).

Assuming that households maximise utility and markets for farm goods function perfectly, then production decisions by farm households can be made separately from the consumption decisions. Thus, the level of crop diversification is driven by net returns which are determined by market wage, input and output prices (w, p_x, and p_f), and farm physical characteristics (Φ^f). However, production and consumption decisions cannot be separated under imperfect market conditions, then the household optimal choice $h^* = (\alpha^*, L^*, C_f^*, C_{nf}^*, X^*)$ can be expressed as a reduced form function of land holding size, income, and household, farm, and market characteristics. It therefore follows that:

$$h^* = h^*\left[\alpha^*(A, Y_{nf}, \Phi^{hh}, \Phi^f, \Phi^m)\right], \tag{8}$$

Assuming that households do not explicitly value crop diversification (i.e. it is not reflected explicitly in the utility function itself) and that it is the outcome of choices made in a constrained optimisation problem rather than an explicit choice (Benin *et al*., 2004; Van Dusen and Taylor, 2005), then crop diversification (D), can be expressed as a derived demand function given by:

$$D = D\left[\alpha^*(A, L, Y_{nf}, \Phi^{hh}, \Phi^f, \Phi^{nf}, \Phi^m)\right], \tag{9}$$

Where D represents diversification measured by composite entropy index of crop diversity at the household level. Equation (9) indicate that crop diversification is a function of the initial endowments of labour (L), land (A), exogenous non-farm income (Y_{nf}), farm household characteristics (Φ^{hh}), farm characteristics (Φ^f), and market conditions (Φ^m).

Estimation Strategy

Identification

In the context of subsistence small-scale agricultural systems, farming often fails to provide a sufficient livelihood. Though it may remain a household's primary source of income, such households often seek alternative means of income by participating in off-farm activities. This results in the reallocation of production resources among on- and off-farm. This is consistent with the narrative that allocation of farm labour away to off-farm activities decrease diversity due to negative labour effects, particularly when the opportunity cost of household labour is higher than off-farm wages under imperfect markets implying non-separability between households' farm profits and off-farm earnings as argued by Chavas *et al*. (2005). Conversely, off-farm income may have a positive impact on crop diversity due to the overall income effects enabling households to purchase sufficient production inputs required for different crops.

Meanwhile, there might be a third category of unobserved factors affecting both CD as well as diversification towards off-farm activities leading to the endogeneity problem. Subsistence farmers are typically risk-averse and may tend to diversify into both crop diversification and off-farm activities. Given that earning additional off-farm income might also be used as a diversification strategy by some households to spread risk outside the farming sector, one would expect the parameter estimate of off-farm income to be biased upwards if endogeneity is not accounted for. Other examples of these unobserved factors could be the entrepreneurial ability and relative efficiency that can influence both decisions. In addition, the presence of measurement error attributed to the recall of the extent of non-farm income by the household (Zereyesus *et al*., 2017) may cause the coefficient of off-farm income to be biased towards zero.

The cross-section household level data used in this study do not allow to control for unobserved household fixed effects, so instrumental variable (IV) techniques are employed. Two instruments are used to control for the endogeneity bias in off-farm income. Firstly, the share of aggregate off-farm income in the total income for all households in a given district. Controlling directly for the household's family labour and regional fixed effects by including household size and agroecological dummies in the analysis, the only pathway for the instrument to influence household decisions is through the household non-farm income activities. It is important to note that data in the sample comes from 349 districts (with 50 farm households on average) and 34 provinces.

According to Diiro and Sam (2015), this instrument captures the status of local non-farm labour market; higher share of non-farm income signifies a high prevalence of non-farm employment opportunities at a district level which, in turn, translates into greater potential for households to diversify into off-farm activities. Kilic *et al*. (2009) use share of non-farm employment within a district as an instrument for off-farm income, noting that, because the instrument is constructed at the district level, when regional fixed effects are controlled for it is unlikely for the instrument to have a direct effect on the farming decisions of households. Smale *et al*. (2016) studied the relationship between off-farm work and farm output and used share of total non-farm earnings (business and salary) in total income by location as an instrument for off-farm income. Gebregziabher *et al*. (2012) used unemployment rate at the district level to control for potential endogeneity in off-farm income. Similarly, in examining the relationship between participation in non-agricultural labour activities and farm production decisions, Stampini and Davis (2009) used a dummy variable for the existence of off-farm employment opportunities in the commune.

Secondly, we use district level lagged values of off-farm income from year 2011/12 to instrument for off-farm income. Data on lagged off-farm income comes from the same survey conducted by CSO previously referred to as the National Risk & Vulnerability Assessment (NRVA). Off-farm income from the past is expected to positively affect farmer's current non-farm activities. Diiro and Sam (2015) uses off-farm income from previous years as an instrument to control for endogeneity in off-farm income suggesting that income from previous years represents an important form of financial endowment that assists farm households to invest in productive farm assets. One might argue the generation of income is a dynamic process and that transitory values of past income will influence current farming decisions. However, we use district level aggregate lagged income (not household level) as an instrument to capture the overall non-farm employment status. There is also evidence that smallholders are less likely to leave cash money on the table to transfer them from one season to another (Duflo *et al*., 2008).

Econometric Specification

As not every farm household will diversify or choose to diversify, a censoring issue underlies the empirical model. Although theoretically the dependent variable (CEI) is censored on both sides because it is bounded by 0 and 1, however, there are no computed values for CEI that are 1. Since the dependent variable is censored at 0 for 33% of the sample (i.e. non-diversifiers), conventional regression methods (i.e. OLS) fail to account for the qualitative difference between zero observations and continuous observations. Zero values of the CEI may occur for various reasons. Even though farmers may be potential diversifiers, they may not diversify due to constraints such as soil type, climate or farm size. Households may choose to remain non-diversifiers if production of certain crops offer a comparative advantage in market or production of a particular staple food crop is required for food security. In these cases, zero observations represent a corner solution which is an optimal choice by the farmers not to diversify. Therefore, the zero observations are important to be accounted for.

We employ Cragg's double hurdle model which is an alternative variant of the Tobit model to deal with the zero censorship. Cragg's double hurdle model is more flexible than the restrictive Tobit model which allows to estimate diversification as an outcome of the two-stage decision process (i.e. the first step decision to diversify is governed by a Probit model and the second step decision on the extent of diversification is modelled by a truncated regression). The endogeneity problem in the off-farm income is accounted for by employing the instrumental variables through Control Function (CF) approach. The CF approach entails that the endogenous variable is regressed over the instrumental variables (IV's) in the reduced form estimation and subsequently generalised residuals from the reduced form estimation are estimated and used as an independent variable in the structural model along with the endogenous variable (Petrin and Train, 2010; Wooldridge, 2015). Endogeneity is detected if the generalised residual is statistically significant in the structural regression. The CF approach is more efficient for binary outcome endogenous variables which other instrumental variable techniques (such as 2SLS, GMM, IVProbit) do not estimate efficiently. CF can also be more efficient even for weak instruments (Tadesse and Bahiigwa, 2015; Wooldridge, 2007). The reduced form is given by:

$$I_i = \alpha_i + \gamma\pi_i + \beta X_i + \varepsilon_i\,, \tag{10}$$

The reduced form model is estimated by regressing the endogenous off-farm income I_i over a number of controls X_i and instrumental variables. Following Wooldridge (2015), the generalized residuals $\widehat{gr_i}$ after the reduced form regression are obtained and included in the structural model estimated by the Cragg's double hurdle model (Cragg, 1971) specified as:

$$y_{1i}^* = \alpha_i + \delta\widehat{gr_i} + \theta I_i + \beta X_i + v_i\,, \tag{11}$$

Decision to diversify

$$y_{2i}^* = \alpha_i + \delta\widehat{gr_i} + \theta I_i + \beta X_i + \varepsilon_i\,, \tag{12}$$

Extent of diversity

$$y_1 = \begin{Bmatrix} 1\ if\ y_1^* > 0 \\ 0\ if\ y_1^* \leq 0 \end{Bmatrix} and$$

$$y_2 = \begin{Bmatrix} y_2^*\ if\ y_2 > 0\ and\ y_{1i}^* > 0 \\ 0\ if\ otherwise \end{Bmatrix}$$

Where y_{1i}^* is the binary latent variable describing household's decision to diversify, y_{2i}^* is the latent variable describing household's decision on the level of diversification, and y_1 and y_2 are their observed counterparts, respectively. $\widehat{gr_i}$ represents the genialized residual from the reduced form question, I_i represents the endogenous off-farm income variable, and X_i is a vector of control variables explaining level of diversification, and v_i and ε_i are the error terms.

Data, Summary Statistics, and Description of Variables

This study uses data from the Afghanistan Living Condition Survey (ALCS) conducted by the Central Statistics Organisation (CSO) in 2013/14. Geographically, the survey covered all 34 provinces of the country. In total 35 strata were identified, 34 for the provinces of Afghanistan and one for the nomadic (Kuchi) population. Households were selected on the basis of a two-stage cluster design within each stratum. In the first stage Enumeration Areas (EAs) were selected as Primary Sampling Units (PSU's) with probability proportional to Enumeration Area (EA) size. Subsequently, in the second stage ten households in each cluster were selected as the Ultimate Sampling Unit (USU). The data are representative at national and provincial level that covered about 157,262 persons within 20,786 households across the country. The survey was based on continuous data collection during a cycle of 12 months capturing important seasonal variations in a range of indicators including agriculture. Using a structured questionnaire, data were collected on a number of indictors including agriculture production, household labour, assets, education, and other household level indicators.

Initial descriptive analysis of the data showed that roughly 50% (about 9,642) households reported some engagement in agriculture. However, after accounting for missing values on key variables, the total number of usable observations reduced to 8,853 households. Furthermore, the sample of agricultural households was further investigated to examine if the household who only grow a single crop on a very small amount of land (i.e. backyard gardens) are systematically different from those who operate a relatively larger amount of land and grow major crops such as wheat, rice, cotton etc. Based on the t-test, the mean difference was found to be significant between these two categories, indicating that farmers who only produce garden crops may not be regular full-time farmers but may grow garden crops while undertaking off-farm activities as their main occupation. These farmers were therefore excluded from the sample, reducing the sample from 8,853 to 8,613 households.

Descriptive statistics show that there are a total of 22 different crops grown throughout a typical agricultural year. However, food grains such as wheat, maize, barley, and rice are the major crops. On average, wheat accounts for about 49.5% of the total value of revenue, followed by maize (12%), rice (11.42%), potato (5.5%) and onion (5.17%). High value crops such as fruits and vegetables occupy a smaller share of the total revenues. For illustration purposes, two different measures of crop diversification CEI and Transformed Herfindahl index (THI) were constructed (Figure 1). About 33% (equivalent to 2,830 out of 8,613) of the households grow one crop, 48% of the farmers grow two crops, 16.5% grow three crops, and about 3.5% grow four or more, with a sample average of 1.92 crops.

Table 1 provides summary statistics for the variables used in the analysis. Average CEI and THI for the overall sample were calculated to be 29.5% and 28.3% with standard deviation of 0.23, respectively, whereas mean CEI and THI among diversifiers are 0.44% and 42%. The computed value of the CEI for 33% of the households is zero, indicating that they did not diversify (i.e. growing only one crop), whereas for 52% of farms, the value of CEI is between 0.1 and 0.50, and for the remaining 15%, CEI falls between 0.50 and 0.82. The distribution of the THI is quite similar to that of CEI.

Descriptive statistics show that there are a total of 22 different crops grown throughout a typical agricultural year. However, food grains such as wheat, maize, barley, and rice are the major crops. On average, wheat accounts for about 49.5% of the total value of revenue, followed by maize (12%), rice (11.42%), potato (5.5%) and onion (5.17%). High value crops such as fruits and vegetables occupy a smaller share of the total revenues. For illustration purposes, two different measures of crop diversification CEI and Transformed Herfindahl index (THI) were constructed (Figure 1). About 33% (equivalent to 2,830 out of 8,613) of the households grow one crop, 48% of the farmers grow two crops, 16.5% grow three crops, and about 3.5% grow four or more, with a sample average of 1.92 crops.

Table 1 provides summary statistics for the variables used in the analysis. Average CEI and THI for the overall sample were calculated to be 29.5% and 28.3% with standard deviation of 0.23, respectively, whereas mean CEI and THI among diversifiers are 0.44% and 42%. The computed value of the CEI for 33% of the households is zero, indicating that they did not diversify (i.e. growing only one crop), whereas for 52% of farms, the value of CEI is between 0.1 and 0.50, and for the remaining 15%, CEI falls between 0.50 and 0.82. The distribution of the THI is quite similar to that of CEI.

A considerable proportion (roughly 62%) of the sample households are engaged in off-farm activities, with a sample mean of 55K AFN of off-farm earnings per household. For households who actually have access to non-farm activities, noff-farm income is highly variable and ranges from a minimum of 10K to a max of 480K AFN. Some farm households clearly have significant opportunities to transfer and spread risks to off-farm activities.

Heterogeneity with respect to regional conditions may also largely affect the level of crop diversity. Rainfall throughout the year, yields, farm size, market infrastructure and conditions, and even cultural aspects may vary greatly

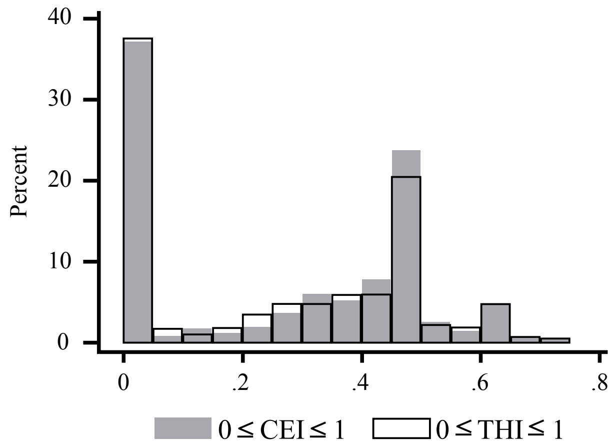

Figure 1: Distribution of Farms with respect to CEI & THI.
Source: own composition based on ALCS (2013-14) data

Table 1: Summary statistics for variables used in the analysis.

Variable	Mean	SD	Min	Max
Dependent Variable				
Composite Entropy Index (0≤CEI≤1)	0.295	0.233	0.000	0.830
Transformed Herfindahl Index (0≤THI≤1)	0.283	0.232	0.000	0.830
Explanatory Variables				
Off-farm Income (in 10,000 AFN)	5.519	11.05	0.000	480.0
Total Land (Ha)	1.564	4.227	0.020	211.2
Transport Equipment (1=access, 0=otherwise)	0.450	0.498	0.000	1.000
Communication Equipment (1=access, 0=otherwise)	0.798	0.402	0.000	1.000
Cattle Ownership (N)	1.477	1.943	0.000	31.00
Oxen & Yaks (N)	0.248	0.635	0.000	9.000
Tractor & Thresher (N)	0.052	0.231	0.000	4.000
Land Quality (1= irrigated agriculture, 0=irrigated & rainfed)	0.437	0.496	0.000	1.000
Landscape (1=open plain, 0=hills & valleys)	0.753	0.431	0.000	1.000
Sufficient Irrigation Water (1=access, 0=otherwise)	0.448	0.497	0.000	1.000
Household Size (persons)	8.124	3.474	1.000	36.00
Head Edu: No Formal Schooling (0=yes)	0.769	0.422	0.000	1.000
Head Edu: Primary & Lower sec (1=yes)	0.116	0.320	0.000	1.000
Head Edu: Upper Secondary (2=yes)	0.079	0.270	0.000	1.000
Head Edu: Teacher College (3=yes)	0.023	0.150	0.000	1.000
Head Edu: Uni & Postgrad (4=yes)	0.013	0.115	0.000	1.000
Household Head Sex (0=F, 1=M)	0.995	0.067	0.000	1.000
Household Head Age (Years)	44.11	13.90	13.000	98.00
Extension Services (1=access, 0=otherwise)	0.184	0.387	0.000	1.000
Distance to Nearest Road (km)	2.513	8.876	0.000	100.0
Distance to Market (0=Not reachable)	0.044	0.204	0.000	1.000
Distance to Market (1=Less than 1h)	0.548	0.498	0.000	1.000
Distance to Market (2=More than 1h)	0.408	0.492	0.000	1.000
AEZ 1: (1=North Eastern Mountains-NEM)	0.023	0.151	0.000	1.000
AEZ 2 (2=Central Mountains-CM)	0.166	0.372	0.000	1.000
AEZ 3: (1=Helmand Farah Lowlands-HFL)	0.040	0.197	0.000	1.000
AEZ 4: (1=Southern Mountains and Foothills-SMF)	0.198	0.399	0.000	1.000
AEZ 5: (5=Helmand Valley & Sistan Basins-HVSB)	0.105	0.306	0.000	1.000
AEZ 6: (6=Turkistan Plains-TP)	0.068	0.252	0.000	1.000
AEZ 7: (7=Northern Mountains & Foothills-NMF)	0.183	0.387	0.000	1.000
AEZ 8: (8=Eastern Mountains & Foothills-EMF)	0.216	0.412	0.000	1.000
Instruments				
IV1-Share of off-farm income in total Income within District	0.519	0.294	0.000	1.000
IV2-Lag District Level off-farm income 2011/12 (10K AFN)	507.6	568.1	11.975	9,090
N	8,613			

Source: own composition based on ALCS (2013-14) data

by regions that may result in different levels of the extent of crop diversification. Based on the early work by Humlum (1959) revived by Dupree (1973), Afghanistan was divided into 11 geographical zones. However, a study by Maletta and Favre (2003) concluded that not all the 11 zones have agricultural significance (i.e. some zones were classified as deserts). Based on ecological properties of land and climate, and some supplementary criteria about accessibility and prevailing agricultural activities, Maletta and Favre (2003) adopted the 8 Agro-ecological Zones (AEZ) scheme which were constructed in the form of whole districts aggregations.

Empirical Results and Discussion

Based on Equations (11) and (12), the estimated average partial effects (APE) from the Cragg's double hurdle model are reported in columns 3 and 4 of Table 2, along with the results from the reduced form model (Equation 10) in column 4. For continuous variables, APE measures the change in probability of the observed , given a unit change of the independent variables, for discrete variables a change from 0 to 1, holding all other variables constant.

It is unclear and difficult to distinguish between crop intensification or inter-cropping and crop diversification (although grains such as wheat, maize, barely, and rice occupy the absolute majority of the land which are highly unlikely to be inter-cropped). Thus, the CEI index (based on crop revenue shares and weighted by the number of crops) is likely to better fit our data as compared to the binary variable (to diversify or not), as it may fail to distinguish between intensification and diversification. However, as an additional robustness check to test the econometric specification, we ran instrumental variable Tobit (IVTobit) and instrumental variable Probit (IVProbit) models to test the possibility that the decisions to diversify and on the extent of diversification are perhaps made simultaneously. Estimated results from both models (presented in Annex 1) are qualitatively

Table 2: Estimations of diversification decisions using Cragg's type double hurdle model.

VARIABLES	Reduced form		Hurdle 1		Hurdle 2	
			Decision to diversify		Extent of diversification	
Generalised residual	-	-	-0.028***	(0.002)	-0.009***	(0.001)
Off-farm income (10K)	-	-	-0.002***	(0.000)	-0.001***	(0.000)
total land (ha)	-0.062**	(0.027)	0.022***	(0.002)	0.002***	(0.000)
transport equip (1=access)	0.926***	(0.251)	0.043***	(0.011)	0.019***	(0.004)
Communication equip (1=access)	0.394	(0.298)	0.031**	(0.013)	0.018***	(0.005)
Ownership of cattle (N)	-0.144**	(0.060)	0.005*	(0.003)	0.003***	(0.001)
Ownership of oxen (N)	-0.685***	(0.191)	0.042***	(0.009)	0.017***	(0.003)
Ownership of tractor (N)	0.522	(0.503)	0.132***	(0.027)	0.030***	(0.008)
Land quality (1=good)	-0.288	(0.341)	0.100***	(0.015)	0.036***	(0.005)
Landscape (1=open plain)	0.806***	(0.268)	0.145***	(0.011)	0.045***	(0.004)
Access to irrigation (1=access)	0.469**	(0.235)	0.045***	(0.010)	0.020***	(0.004)
HH size (persons)	0.589***	(0.035)	0.025***	(0.002)	0.009***	(0.001)
Head edu. (1=primary & sec)	1.378***	(0.351)	0.081***	(0.015)	0.026***	(0.006)
Head edu (2=upper sec)	3.572***	(0.420)	0.168***	(0.016)	0.055***	(0.008)
Head edu. (3=teacher college)	2.103***	(0.737)	0.092***	(0.031)	0.025**	(0.012)
Head edu. (4=uni & grad)	6.757***	(0.954)	0.195***	(0.031)	0.078***	(0.018)
HH head sex (1=male)	-0.049	(1.620)	0.104	(0.075)	0.044*	(0.023)
HH head age (years)	0.002	(0.008)	0.001	(0.000)	0.000	(0.000)
Extension service (1=access)	-1.123***	(0.295)	-0.018	(0.013)	-0.013***	(0.005)
Distance to road (km)	-0.022*	(0.013)	0.000	(0.001)	0.001*	(0.000)
Distance to market (1=< 1h)	0.262	(0.564)	0.030	(0.025)	0.020**	(0.009)
Distance to market (2=>1h)	-0.448	(0.553)	0.022	(0.024)	0.006	(0.008)
AEZ 1 (CM)	-0.922	(0.769)	0.124***	(0.036)	0.013	(0.011)
AEZ 2 (HFL)	1.011	(0.929)	-0.033	(0.043)	-0.028**	(0.013)
AEZ 3 (SMF)	1.273	(0.787)	0.304***	(0.036)	0.068***	(0.012)
AEZ 4 (HVSB)	-0.842	(0.881)	-0.153***	(0.041)	-0.040***	(0.012)
AEZ 5 (TP)	-0.562	(0.869)	-0.077*	(0.041)	-0.056***	(0.012)
AEZ 6 (NMF)	-0.804	(0.775)	0.132***	(0.037)	0.031***	(0.011)
AEZ 7 (EMF)	-1.096	(0.779)	0.261***	(0.036)	0.110***	(0.012)
IV1	10.612***	(0.485)	-	-	-	-
IV2	0.001***	(0.000)	-	-	-	-
Constant	-5.833***	1.881	-	-	-	-
R-squared	0.179					
Pseudo R-square			0.113			
Observations	8,613		8,613		8,613	

Standard errors are in parenthesis. Significance is indicated by *** p<0.01, ** p<0.05, * p<0.1.
Source: own composition based on ALCS (2013-14) data

and quantitatively similar to those of our main results, we therefore stick to the estimations from the preferred Cragg's type hurdle model because IVTobit is restrictive (in the sense that both decisions are governed by the same process) and IVProbit fails to distinguish between crop diversification and intensification.

The reduced-form model (Equation 11) was estimated using OLS and presented as the reduced form stage estimates in Table 2. All instrumental variables had the expected significant impact on the endogenous variables. They satisfy the orthogonality conditions, implying that IVs are directly and significantly correlated with the endogenous variables but affect dependent variables in the structural models only through the inclusion of the computed generalised residuals from the reduced form. It is plausible to believe that any leftover endogeneity after using the CF approach will be uncorrelated with the other covariates in the structural model (Ricker-Gilbert *et al*., 2011).

Endogeneity in off-farm income was investigated by applying the Wald test of exogeneity. The calculated test statistic is 142.49 and rejects the null hypothesis of no endogeneity in off-farm income at 1% significance level conditional on the validity of instruments. The Amemiya-Lee-Newey overidentification test estimator was used to test the null hypothesis that the instruments are jointly valid, and that the excluded instruments are correctly excluded from the estimated equation. The result of Amemiya-Lee-Newey[1] is insignificant, thus establishing the validity of the instruments. Variance Inflation Factor (VIF) was used to test for multicollinearity, the mean value of VIF was less than 10 (2.85) rejecting the possibility of potential multicollinearity in the data.

[1] Additionally, a set of minimum distance version weak-instrument-robust tests including Anderson-Rubin (AR), Conditional Likelihood Ratio (CLR), the Lagrange Multiplier (LM), overidentification (J), and a combination of the LM and *J* over identification (K-J) suggested by Finlay and Magnusson (2009) were also carried out. The confidence intervals for the off-farm income coefficient produced by the weak-instrument tests were not wider than the non-robust Wald confidence intervals, indicating that instruments are strong and that point estimates are robust to weak instrument bias.

Estimated average partial effects illustrate negative and significant impact of household non-farm income on the decision to diversify and the extent of crop diversification. Holding other variables constant, an increase of 10,000 Afghani in off-farm income (equivalent to almost 20% of the sample mean for off-farm income) decreases the likelihood to diversify by 0.2 percent points and decreases the extent of diversification by 0.1 percent points. This is consistent with the hypothesis that allocation of farm labour away to off-farm activities decreases diversity, possibly due to negative labour effects, or perhaps because the opportunity cost of farm labour is higher than off-farm rural wages, probably due to market imperfections. Our findings of negative impact of off-farm income are consistent with the conclusions of earlier studies including Weiss and Briglauer (2000), and Mishra *et al*. (2004) but are in contrast with Cavatassi *et al*. (2012).

Holding all variables at their mean, an increase in land (i.e. total land cultivated by farm household) by one hectare increases the chances of crop diversification by 2.2 percentage points and extent of diversification by 0.2 percent points. The positive effect of land size indicates that households with a relatively larger land size have the flexibility to allocate land among a variety of crops and therefore diversify. These findings are consistent with those of Hitayezu *et al*. (2016) for South Africa, and McNamara and Weiss (2005) for Austria. However, Pope and Prescott (1980) found a positive and quadratic relationship between farm size and diversity arguing that there is a trade-off between scale economies and risk reduction. That is, if there are large-scale economies in an enterprise, then one might expect larger farms to be more specialised.

Farm households living in communities with better access to roads maintain higher crop diversity. Improved access implies better access to market information on demand and prices and lower transaction costs due to better market infrastructure, transport and storage facilities. Moreover, high-value horticultural crops such as vegetables and fruits are perishable and require sustained supply chain in order for the households to sell them in local markets. Rao *et al*. (2008) finds a significant and positive impact of road density on diversification towards high value horticultural crops in India. Turner (2014) indicated that Mozambican farmers lacking access to transport infrastructure do not allocate land to marketable cash crops. Ownership of transport equipment by the households and access to communication equipment (i.e. television, mobile phone, and radio) were also found to have a significant and positive influence on the extent of crop diversity. This further supports the argument that these communication equipment provide better access to market information and ownership of transport equipment introduces efficiency to the cost function through low-cost means of transport.

Households with greater number of livestock (cattle and oxen) maintain higher level of crop diversity. Our findings agree with Benin *et al*. (2004) and Cavatassi *et al*. (2012) that pointed out that owners of oxen tend to plant greater number of crops perhaps due the mechanical power provided by the oxen. Similarly, ownership of cattle herds increases the amount of manure produced at the farm that enhances soil fertility through adding organic materials to the soil. Farm households that own tractors maintain higher degree of diversity enable households to utilise lands more efficiently and increases production efficiency through availability of cheaper and timely traction power.

Agricultural extension services appear to have a significant negative impact on the extent of crop diversification. This is perhaps due to the policy emphasis on achieving self-sufficiency in producing staple grain food crops. While grain, particularly wheat, is the major source of nutrition, Afghanistan still imports a substantial quantity of wheat flour so there is an aim to produce more grains domestically. Mesfin *et al*. (2011) arrives at a similar conclusion arguing that the negative impact of extension services is associated with the extension system favouring specialisation at macro level and overlooks the role of crop diversification in risk minimisation.

There appears to be a significant and positive relationship between land type and CD. Farmers operating on irrigated agriculture alone are significantly more diversified than their counterparts who operate a combination of irrigated and rain-fed land. In addition, farms with stable access to sufficient irrigation water (in irrigated lands) throughout the year appear to be more diversified. Afghanistan is a dry country and farmers often don't have access to sufficient irrigation water during the year. As a result, farmers are restricted to grow limited number of crops, particularly since many vegetables require greater amount of irrigation. Mesfin *et al*. (2011) confirms that irrigation intensity has a positive effect on crop diversity by enabling farmers to grow vegetables along other grains.

Farmers operating in the plains or on flat lands diversify more in comparison to farmers with land in valleys and hills. Altitude and slope of land effects physical conditions of farming which translates into the household decisions on the number and type of crops they choose to grow. Cavatassi *et al*. (2012) indicated that variability in slope of the farmland leads to greater variability in diversity. Our results are in contrast of those of Van Dusen and Taylor (2005) who found that Mexican farms located in areas with steep slope are more diversified.

We controlled for eight agroecological regions: Eastern Mountains and Foothills (EMF), Southern Mountain and Foothills (SMF), and Central Mountains (CM) were the most favourable for crop diversification compared to the reference zone (NEM). Among other heterogeneous unobserved effects such as climatic, physical conditions, and cultural conditions, the level to off-farm employment/income, access to farmland, market development infrastructure and market conditions, and road density are expected to greatly vary from region to region. Figure 2 illustrates spatial variation in crop diversification at the district level across the country.

Highly diversified areas are indicated by darker shades (CEI=0.36-0.67), and the least diversified districts with lighter shades (CEI= 0-0.17), whereas the grey areas represent areas with no data. These areas are either areas with no agricultural significance (i.e. deserts and mountains) or could not be covered by the survey. In addition, these areas may represent the households that were surveyed but did not report any involvement in agriculture activities (i.e. households that did not report crop production).

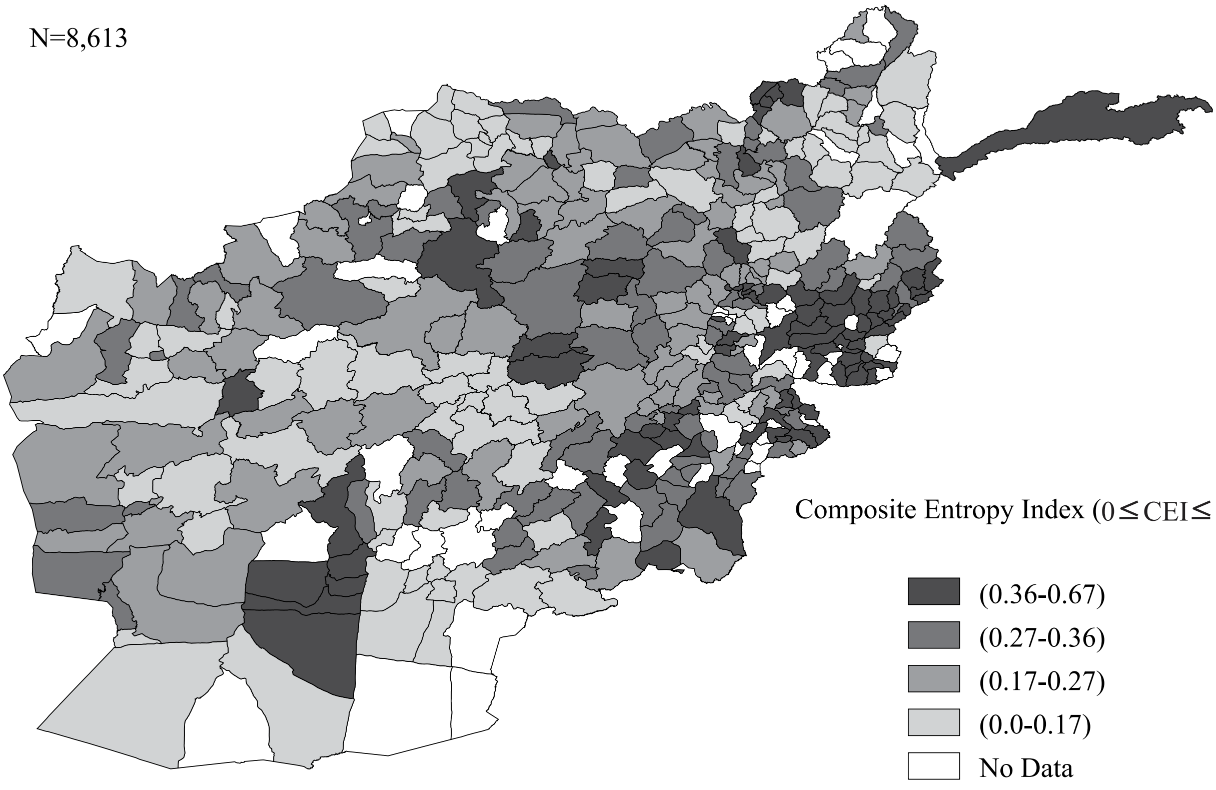

Figure 2: Map of CD at District Level.
Source: own composition based on ALCS (2013-14) data

Robustness Checks

Cultivation of opium poppy is an important aspect of farming in the context of Afghanistan that may generate systematic differences in household characteristics and their management strategies (e.g. crop diversification) across the regions, especially since opium poppy cultivation is relatively more common in some zones or provinces than others. Using information from Afghanistan's Ministry of Counter Narcotics (MCN) on major poppy producing areas, we divided our analytical sample into two sub-samples based on the intensity of poppy cultivation at the provincial level: 1) Households in main opium producing provinces were assigned in one category, and 2) Households in other provinces that were opium free according to the MCN report published in 2013 were assigned to another category. Subsequently, we ran our analysis for each category separately, aiming to investigate the extent to which crop diversification and other household socioeconomic characteristics can differ between opium infected and opium free areas/provinces.

Our results from the two sub-samples suggest no dramatic qualitative differences in the estimates among the two sub-groups, although there are some quantitative differences in the estimated parameters. Off-farm income is consistently significant and negatively associated with the level of crop diversification in all models. The major disparity in the estimated parameters among two groups is that crop diversification is lower in major poppy producing agroecological zones (AEZ) such as Helmand Valley and Sistan Basin (HVSB), Heart-Farah Low Lands (HFL), and Central Mountains (CM), perhaps farm households specialize in opium production in these areas due to the extra income from poppy cultivation.

Proximity to or remoteness from urban centres is another critical aspect in the context of this study, a factor that may alter the crop diversification strategies adopted by farmers. While the narrative central to the analysis presented in this paper pursues the theory that marketisation increases crop diversification, a concern may arise that market orientation may actually motivate farmers to engage in production of specialised crops, since marketisation may offer competitive advantages for certain agricultural commodities. Conversely, subsistence farmers in remote areas may engage in crop diversification, so as to be able to meet their dietary requirement from their own production, given that their access to markets is limited. In the meantime, consistent with the narrative of marketisation-diversification assumed by this paper, if closeness to urbanisation or marketisation truly increases crop diversification, then it could be the case that farm households close to urban centres are probably diversifying way more than those located in remote areas with less access to markets, giving rise to potentially significant differences across households. In both the "marketisation-specialisation" and "marketisation-diversification" scenarios, it was important to carry out a robustness check to ensure that our main results were not driven by this spatial aspect of farming.

We therefore ran a further robustness check and split our analytical sample into two sub-groups: farm households situated within 1 our 2 hours from or to the main urban centres were assigned to one group and farms located in remote areas (e.g. households not located within 1 or 2 hours from the main urban centres) were assigned to another. Overall, our analysis revealed no substantial qualitative dissimilarities for the estimated coefficients across the two sub-samples. The magnitude or size of estimated coefficients varied slightly between the two sub-samples, but in general the results were similar to those of our main results. Off-farm income was consistently significant and negatively associated with the extent of crop diversification in all models. Our main results are contingent upon distance to roads, time taken to reach the market, and ownership of communication and transport equipment by the households which are sufficient to capture any variations associated with urbanisation or marketisation.

Conclusions

In this paper, we investigated the status and determinants of the extent of diversity in crop production in Afghanistan, taking a particular interest in the impact of off-farm income. The computed value of the diversity index measured by composite entropy index establishes the presence of a relatively low level of crop diversity in Afghanistan which greatly varies across the agroecological regions. With the estimated mean CEI of 0.29 (where zero is no diversification), a third of farmers do not diversify, and the majority of those that do, grow only two or three crops.

The results of the Cragg's type models revealed lower level of diversity in crop production for households with higher off-farm income. This is consistent with the hypothesis that allocation of farm labour away to non-farm activities decreases diversity due to negative labour effects, mainly because the opportunity cost of household labour is higher than off-farm wages, this possibly being the case under imperfect market conditions. Identification through instrumental variable techniques reveals an even greater impact of non-farm income on crop diversity suggesting that unobserved factors such as risk-aversion behaviour or the relative efficiency of farmers may drive a household's decision towards diversification of both non-farm activities and crop diversification.

Other factors that significantly determine the intensity of crop diversity include household characteristics, farm characteristics, transaction costs (proxied for by distance to market, nearest road, ownership of transport and communication equipment), ownership of livestock units and tractors, receipt of extension services, and regional factors. Among these factors, land, household ownership of transport and communication equipment, proximity to markets, ownership of cattle, oxen, and tractors, household size and household head education appear to have a positive significant impact on crop diversity. On the contrary, the distance of farm households from roads and their degree of access to extension services were found to be negatively associated with the level of diversity in crop production. Surprisingly, low diversity was found for households with access to extension services; we infer that this might be due the emphasis of agricultural policies on the production of staple crops that are vitally important for food security.

This research is intended to contribute to the understanding of smallholder decision-making in relation to crop portfolio diversification and factors affecting it. It has particularly important implications for household's decisions about allocation of resources such as land and labour among on- and off-farm activities, especially since engagement in non-farm activities reduces crop diversity. In general, smallholder resource-poor farmers are cautiously risk-averse and try to spread risk over a diverse profile of both on-and off-fam activities, particularly if the farming business experiences high volatility. Policies associated with increasing opportunities for off-farm income do not contribute to crop diversification; therefore, if crop diversification is the objective, policies must focus on farmers. Farmers that receive advice from extension agents appear to diversify less, perhaps due the emphasis of government on producing staple food crops to improve food security; thus, it is may be viable to revisit the extension services programmes to encourage crop diversification as a potential strategy for risk mitigation and income sustainability. Policies that incentivise farmers' access to regional and international markets through better forward and backward linkages can augment the diversification process. Public investment in rural infrastructure development such as roads, transportation facilities, market infrastructure, and other means to reduce transaction costs is an equally important aspect to stabilise the supply chain and thereby ensure relatively low level of crop diversity.

Acknowledgement

The author would like to thank Professor Oliver Morrissey and Professor Simon Appleton for their guidance, support, and detailed feedback. The author is also grateful to Dr. Alastair Bailey (University of Kent) and Dr. Markus Eberhardt (University of Nottingham) for their review and constructive comments on an earlier version of this paper.

References

Ahmadzai, H. (2017): Crop Diversification and Technical Efficiency in Afghanistan: Stochastic Frontier Analysis. School of Economics, University of Nottingham, CREDIT Research Paper 17/04.

Asfaw, S., Pallante, G. and Palma, A. (2018): Diversification Strategies and Adaptation Deficit: Evidence from Rural Communities in Niger. World Development, **101,** 219–234. https://doi.org/10.1016/j.worlddev.2017.09.004

Barrett, C.B., Bezuneh, M., Clay, D.C. and Reardon, T. (2005): Heterogeneous Constraints, Incentives and Income Diversification Strategies in Rural Africa. Quarterly Journal of International Agriculture, **44,** 37–60.

Barrett, C.B. and Reardon, T. (2000): Asset, activity, and income diversification among African agriculturalists: Some practical issues. Dept. of Agricultural, Resource and Managerial Economics, Cornell University, Ithaca, NY, USA.

Benin, S., Smale, M., Pender, J., Gebremedhin, B. and Ehui, S. (2004): The economic determinants of cereal crop diversity on farms in the Ethiopian highlands. Agricultural Economics, **31** (2-3), 197–208. https://doi.org/10.1016/j.agecon.2004.09.007

Cavatassi, R., Lipper, L. and Winters, P. (2012): Sowing the seeds of social relations: social capital and agricultural diversity in Hararghe Ethiopia. Environment and Development Economics, **17** (5), 547–578. https://doi.org/10.1017/S1355770X12000356

Chavas, J.-P., Petrie, R. and Roth, M. (2005): Farm Household Production Efficiency: Evidence from The Gambia. American Journal of Agricultural Economics, **87** (1), 160–179. https://doi.org/10.1111/j.0002-9092.2005.00709.x

Coelli, T. and Fleming, E. (2004): Diversification economies and specialisation efficiencies in a mixed food and coffee smallholder farming system in Papua New Guinea. Agricultural Economics, **31** (2-3), 229–239. https://doi.org/10.1016/j.agecon.2004.09.010

Diiro, G.M. and Sam, A.G. (2015): Agricultural technology adoption and Nonfarm earnings in Uganda: a Semiparametric analysis. The Journal of Developing Areas, **49** (2), 145–162.

Duflo, E., Kremer, M. and Robinson, J. (2008): How High Are Rates of Return to Fertilizer? Evidence from Field Experiments in Kenya. American Economic Review, **98** (2), 482–488. https://doi.org/10.1257/aer.98.2.482

Dupree, L. (1973): Afghanistan, Oxford Pakistan paperbacks. Oxford University Press, United Kingdom.

Ellis, F. (1998): Household strategies and rural livelihood diversification. Journal of Development Studies, **35** (1), 1–38. https://doi.org/10.1080/00220389808422553

Finlay, K. and Magnusson, L.M. (2009): Implementing weak-instrument robust tests for a general class of instrumental-variables models. The Stata Journal, **9** (3), 398–421. https://doi.org/10.1177/1536867X0900900304

Gebregziabher, K., Mathijs, E., Maertens, M., Deckers, J., Bauer, H. and Gebrehiwot, K. (2012): Is Non-Farm Income Relaxing Farm Investment Liquidity Constraints for Marginal Farms? An Instrumental Variable Approach. International Journal of Economics and Finance Studies, **4** (1), 123–132.

Greene, W.H. (2012): Econometric analysis, 7th eds. Prentice Hall, Boston, USA.

Hitayezu, P., Zegeye, E.W. and Ortmann, G.F. (2016): Farm-level crop diversification in the Midlands region of Kwazulu-Natal, South Africa: patterns, microeconomic drivers, and policy implications. Agroecology and Sustainable Food Systems, **40** (6), 553–582. https://doi.org/10.1080/21683565.2016.1156595

Joshi, P.K., Gulati, A. and Cummings, R.W. (2007): Agricultural Diversification in South Asia: Beyond Food Security. New Delhi: Academic Foundation 47–82, India.

Kilic, T., Carletto, C., Miluka, J. and Savastano, S. (2009): Rural nonfarm income and its impact on agriculture: evidence from Albania. Agricultural Economics, **40** (2), 139–160. https://doi.org/10.1111/j.1574-0862.2009.00366.x

Kurosaki, T. (2003): Specialization and Diversification in Agricultural Transformation: The Case of West Punjab, 1903-92. American Journal of Agricultural Economics, **85** (2), 372–386. https://doi.org/10.1111/1467-8276.00126

Maletta, H. and Favre, R. (2003): Agroecological zones. Food and Agriculture Organization of the United Nations, Rome, Italy.

McNamara, K. and Weiss, C. (2005): Farm Household Income and On- and Off-Farm Diversification. Journnal of Agricultural and Applied Economics, **37** (1), 37–48. https://doi.org/10.1017/S1074070800007082

Mesfin, W., Fufa, B. and Haji, J. (2011): Pattern, trend and determinants of crop diversification: empirical evidence from smallholders in eastern Ethiopia. Journal of Economics and Sustainable Development, **2** (8), 78–89.

Minot, N., Epprecht, M., Anh, T.T.T. and Trung, L.Q. (2006): Income Diversification and Poverty in the Northern Uplands of Vietnam. IFPRI (International Food Policy Research Institute), Washington, DC, USA.

Mishra, A.K., El-Osta, H.S. and Sandretto, C.L. (2004): Factors affecting farm enterprise diversification. Agricultural Finance Review, **64** (2), 151–166. https://doi.org/10.1108/00214660480001160

Mishra, A.K. and Goodwin, B.K. (1997): Farm income variability and the supply of off-farm labor. American Journal of Agricultural Economics, **79** (3), 880–887. https://doi.org/10.2307/1244429

Newey, W.K. (1987): Efficient estimation of limited dependent variable models with endogenous explanatory variables. Journal of Econometrics, **36** (3), 231–250. https://doi.org/10.1016/0304-4076(87)90001-7

Ogundari, K. (2013): Crop diversification and technical efficiency in food crop production: A study of peasant farmers in Nigeria. International Journal of Social Economics, **40** (3), 267–287. https://doi.org/10.1108/03068291311291536

Oushy, H. (2010): Farm Resource Management in Afghanistan– Training Course. United States Agency for International Development (USAID), New Mexico State University (NMSU), Afghanistan Water, Agriculture, and Technology Transfer (AWATT) project. Retrieved from: https://aces.nmsu.edu/pubs/docs/ (Accessed in December 2019).

Petrin, A. and Train, K. (2010): A control Function Approach to Endogeneity in Consumer Choice Models. Journal of Marketing Research, **47** (1), 3–13.

Pope, R.D. and Prescott, R. (1980): Diversification in Relation to Farm Size and Other Socioeconomic Characteristics. American Journal of Agricultural Economics, **62** (3), 554–559. 10.2307/1240214

Ragasa, C. and Mazunda, J. (2018): The impact of agricultural extension services in the context of a heavily subsidized input system: The case of Malawi. World Development, **105,** 25–47. https://doi.org/10.1016/j.worlddev.2017.12.004

Ricker-Gilbert, J., Jayne, T.S. and Chirwa, E. (2011): Subsidies and Crowding Out: A Double-Hurdle Model of Fertilizer Demand in Malawi. American Journal of Agricultural Economics, **93** (1), 26–42. https://doi.org/10.1093/ajae/aaq122

Rahman, S. (2009): Whether crop diversification is a desired strategy for agricultural growth in Bangladesh? Food Policy, **34** (4), 340–349. https://doi.org/10.1016/j.foodpol.2009.02.004

Rao, P.P., Joshi, P.K., Kumar, S. and Ganguley, K. (2008): Agriculture Diversification in Andhra Pradesh, India: Patterns, Determinants and Implications (No. 2). ICRISAT and IFPRI, New Delhi, India.

Reardon, T., Berdegué, J. and Escobar, G. (2001): Rural nonfarm employment and incomes in Latin America: overview and policy implications. World Development, **29** (3), 395–409. https://doi.org/10.1016/S0305-750X(00)00112-1

Smale, M., Kusunose, Y., Mathenge, M.K. and Alia, D. (2016): Destination or Distraction? Querying the Linkage Between Off-Farm Work and Food Crop Investments in Kenya. Journal of African Economies, **25** (3), 388–417. https://doi.org/10.1093/jae/ejv032

Stampini, M. and Davis, B. (2009): Does nonagricultural labor relax farmers' credit constraints? Evidence from longitudinal data for Vietnam. Agricultural Economics, **40** (2), 177–188. https://doi.org/10.1111/j.1574-0862.2009.00368.x

Stoeffler, Q. (2016): Crop portfolio choices in Burkina Faso. The Journal of Developing Areas, **50** (3), 261–285. https://doi.org/10.1353/jda.2016.0103

Tadesse, G. and Bahiigwa, G. (2015): Mobile Phones and Farmers' Marketing Decisions in Ethiopia. World Development, 68, 296–307. https://doi.org/10.1016/j.worlddev.2014.12.010

Tavva, S., Aw-Hassan, A., Rizvi, J. and Saharawat, Y.S. (2017): Technical efficiency of wheat farmers and options for minimizing yield gaps in Afghanistan. Outlook on Agriculture, **46** (1), 13–19. https://doi.org/10.1177/0030727016689632

Turner, E.C. (2014): Determinants of crop diversification among Mozambican smallholders: Evidence from household panel data. M.S. Thesis, Michigan State University, USA.

Van Dusen, M.E. and Taylor, J.E. (2005): Missing markets and crop diversity: evidence from Mexico. Environment and Development Economics, **10** (4), 513–531. https://doi.org/10.1017/S1355770X05002317

Weinberger, K. and Lumpkin, T.A. (2007): Diversification into Horticulture and Poverty Reduction: A Research Agenda. World Development, **35** (8), 1464–1480. https://doi.org/10.1016/j.worlddev.2007.05.002

Weiss, C.R. and Briglauer, W. (2000): Determinants and dynamics of farm diversification. FE Workingpaper/Universität Kiel, Department of Food Economics and Consumption Studies, Kiel, Germany.

Wooldridge, J.M. (2015): Control function methods in applied econometrics. Journal of Human Resources, **50** (2), 420–445. https://doi.org/10.3368/jhr.50.2.420

World Bank (2014): Agricultural sector review: revitalizing agriculture for economic growth, job creation, and food security. Washington, DC, USA.

Zereyesus, Y.A., Embaye, W.T., Tsiboe, F. and Amanor-Boadu, V. (2017): Implications of Non-Farm Work to Vulnerability to Food Poverty-Recent Evidence from Northern Ghana. World Development, **91,** 113–124. https://doi.org/10.1016/j.worlddev.2016.10.015

Appendix

ANNEX I. IVTobit and IVProbit estimations for joint crop diversification decisions

Table 3: Unconditional Marginal Effects from the IVTobit and IVProbit models.

Variable	1st Stage		IVTobit		IVProbit	
	Coefficient	SE	ME	SE	ME	SE
Off-farm Income (in 10K AFN)	-	-	-0.015***	0.001	-0.070***	0.009
Total Land (ha)	-0.062**	0.027	0.003***	0.001	0.052***	0.015
Transport Equip. (1=access)	0.926***	0.251	0.031***	0.007	0.102***	0.031
Communication Equip (1=yes)	0.394	0.298	0.026***	0.008	0.071**	0.034
Cattle Ownership (N)	-0.144**	0.060	0.004**	0.002	0.012	0.008
Oxen & Yaks (N)	-0.685***	0.191	0.024***	0.005	0.099***	0.025
Tractor & Thresher (N)	0.522	0.503	0.051***	0.013	0.311***	0.082
Land Quality (1=good)	-0.288	0.341	0.050***	0.009	0.226***	0.042
Landscape (1=open plain)	0.806***	0.268	0.064***	0.007	0.344***	0.035
Irrigation Water (1=access)	0.469**	0.235	0.029***	0.006	0.106***	0.029
Household Size (persons)	0.589***	0.035	0.014***	0.001	0.060***	0.010
Head Edu (1=primary & sec)	1.378***	0.351	0.041***	0.01	0.194***	0.047
Head Edu (2=upper sec)	3.572***	0.420	0.088***	0.013	0.435***	0.058
Head Edu (3=teacher college)	2.103***	0.737	0.042**	0.021	0.222***	0.083
Head Edu (4=uni & grad)	6.757***	0.954	0.128***	0.031	0.523***	0.145
Head Sex (1=male)	-0.049	1.620	0.080**	0.04	0.232	0.176
Head Age (years)	0.002	0.008	0.0002	0.00	0.001	0.001
Extension Services (1=access)	-1.123***	0.295	-0.017**	0.008	-0.043	0.035
Distance to Road (km)	-0.022*	0.013	-0.005***	0.001	0.001	0.002
Distance to Market (1=< 1h)	0.262	0.564	0.030**	0.015	0.069	0.057
Distance to Market (2=>1h)	-0.448	0.553	0.016	0.015	0.051	0.055
AEZ 2 (CM)	-0.922	0.769	0.041**	0.00	0.267***	0.087
AEZ 3 (HFL)	1.011	0.929	-0.023	0.023	-0.069	0.147
AEZ 4 (SMF)	1.273	0.787	0.130***	0.02	0.732***	0.094
AEZ 5 (HVSB)	-0.842	0.881	-0.049**	0.022	-0.328***	0.108
AEZ 6 (TP)	-0.562	0.869	-0.059***	0.021	-0.162	0.101
AEZ 7 (NMF)	-0.804	0.775	0.065***	0.02	0.284***	0.088
AEZ 8 (EMF)	-1.096	0.779	0.162***	0.02	0.604***	0.096
IV1- Share of Off-farm Income in Total Income within District	10.612***	0.485	-	-	-	-
IV2-Lag District Level OFY	0.001***	0.000	-	-	-	-
Constant	-5.833***	1.881	-	-	-	-
Log-Likelihood	-32,065.16		-35,949.00		-36,900.66	
Wald Test of exogeneity (chi2, p-value)	-	-	142.25***	0.000	96.22***	0.000
Amemiya-Lee-Newey statistic (chi2, p-value)	-	-	0.500	0.479	0.548	0.459
Left censored observations(N)	-	-	2,830			
Uncensored observations (N)	8,613		5,782			
N			8,613		8,613	

Notes: Marginal Effects for factor levels is the discrete change from the base level significance levels indicated by * p<0.10, ** p<0.05, *** p<0.010.

Source: Own composition based on ALCS (2013-14) data

Erika BESUSPARIENĖ* and Vesa A. NISKANEN**

The Assessment of Factors Affecting Fertiliser Use on Family Farms in Lithuania

Fertiliser use is an ambigious issue in agricultural economics with different arguments commonly given for and against it. The aim of this paper is to find the most important factors affecting fertiliser use in Lithuania, serving as a basis for our fertiliser tax modelling of Lithuanian family farms. Raw data from Lithuanian farms was collected from the Lithuanian Farm Accountancy Data Network (FADN) covering the years 2003–2017, and data from other selected countries was also found in the FADN database, although in this case, different years (2004–2016) were available. Results suggest the significant factors affecting fertiliser use on family farms in Lithuania differ significantly from other EU countries. Hence, our empirical results confirm that there is no unique methodology or unique set of financial instruments for fertiliser tax modelling among EU countries, and this should be taken into account in future studies. We also noticed that investment in land, the extent to which farm output consists of wheat, rye and field vegetables, the use of harvesters and finally, land quality should also be taken account in future fertiliser tax modelling.

Keywords: agricultural and tax policy, family farms, environmental tax, fertiliser tax, Lithuania

JEL classifications: Q15, Q18, H23

* Vytautas Magnus University, K. Donelaičio g. 58, 44248 Kaunas, Lithuania. Corresponding author: erika.besuspariene@vdu.lt

** University of Helsinki, P.O. Box 4, (Yliopistonkatu 3), 00014 Helsinki, Finland.

Received: 29 November 2019, Revised: 27 February 2020, Accepted: 2 March 2020.

Introduction

According to the guidelines of the European Commission for the new CAP post-2020, EU countries are required to respect the environment and climate change. Eurostat data for the period 2006–2015 shows that the consumption of nitrogen fertiliser in Lithuanian agriculture, unfortunately, increased by approximately 36 percent. Family farms in scientific literature are described as one of the main agriculture business forms where agricultural production links to family labour, capital, and control (Kostov *et al*., 2019). In Lithuania, the consumption of fertilisers on family farms is at the average level among EU countries. However, despite the increase in damage, the use of fertilisers is still not taxed. This may lead to the uncontrolled use of fertilisers on family farms in Lithuania.

The new CAP gives more freedom for EU countries in respect of an innovation focus on the environment and climate change, revising the green architecture (Jongeneel, 2018). Various research (Pearce and Koundouri, 2003; Savci, 2012; Mottershead *et al*., 2018) confirmed that the use of fertiliser causes environmental problems. Fertiliser has negative effects on people, on biodiversity, and on climate change.

The use of fertiliser is still the main source of agricultural land pollution. Therefore, to decrease the damage caused by fertilisers to the environment (soil, water, air), an EU Member State has to seek the "minimum requirements for the use of fertilisers and plant protection products, animal welfare" (Jongeneel, 2018). Each EU country must use political instruments to control the use of fertiliser: one such political instrument is tax. According to the experience of different countries, fertiliser tax is a useful tool to seek minimum requirements on the use of fertilisers in the EU (Rougoor *et al*., 2001; Pearce and Koundouri, 2003; Söderholm and Christiernsson, 2008; Vojtech, 2010). Fertiliser tax is the main policy tool for controlling fertiliser consumption (Mergos and Stoforos, 1997).

Moreover, one needs to take into account that fertiliser is necessary to grow more agriculture production. "Fertilisers help feed almost 50 per cent of the global population" (Euractiv, 2018). While the use of fertiliser ensures quantity in agricultural production, unfortunately, it does not ensure the quality and safety of agricultural production. These agricultural practices have negative implications for "the environment and human health" in all processes (use of fertiliser, harvest production, irrigation etc.) of growing agriculture production (Udeigwe *et al*., 2015).

On the one hand, this ensures the quantity of agricultural production and leads to more income for family farms, especially if one considers the growing global population. On the other hand, the quantity of food required by a growing population may lead to the increased use of fertilisers. Therefore, the fertiliser tax may not only reduce the excessive use of fertilisers but may also draw attention to new farming methods. However, determining what level of fertiliser tax is appropriate remains an important challenge. If the fertiliser tax were high enough, there would be a positive influence on reducing the use of the fertiliser. However, there would be less production and less income achieved by family farms. The guidelines of the new CAP post-2020 indicate that the income problems of family farms are still important (Jongeneel, 2018).

Unfortunately, Lithuania is not on the path of ecological tax reform. At the same time, not enough research has been done on the possible effect of a fertiliser tax in Lithuania. Lithuania is one of the EU countries where the environmental tax revenue is among the lowest in the EU (Čiulevičienė and Kożuch, 2015), which leads to the following two issues: first, the use of the fertiliser is not controlled enough in Lithuania; second, there is no tax revenue collected for the compensation of negative externalities caused by the use of fertilisers.

Therefore, this paper analyses how various factors influence the use of fertilisers and why these factors must be taken into account in the fertiliser tax modelling. The aim of our research is to identify the significant factors in the use of fertilisers of family farms in Lithuania and compare these factors with other selected countries.

The importance of fertiliser tax

In order to disclose the need of fertiliser tax as a fiscal policy instrument to control negative externalities, this part includes a discussion of significance, advantages and disadvantages of fertiliser tax, as well the review of studies on the fertiliser tax applied in various countries.

The significance of fertiliser tax includes motivation as an effective tax policy instrument, which is a relatively new environmental tax in Europe, started to be used in the last two decades (Söderholm and Christiernsson, 2008). Fertiliser tax is one of the most important environmental taxes. According to Heady *et al*. (2000), environmental taxes must reduce damage to the environment by increasing the costs of harmful actions and this requires the taxpayers to take into account their negative behaviour towards the environment and pay for the damage.

However, fertiliser tax can reduce the income of many agri-food stakeholders. Von Blottnitz (2006) shows that a decrease in the use of fertilisers would have a negative influence on family farms, producers of the fertiliser, and also for the consumer. It would reduce the income of family farms, reduce the sales of producers of fertiliser, and change consumer's expenditure, with affects international trade. Therefore, these factors must be taken into account when setting a fertiliser tax.

Francis (1992) and Uri (1998) admit that fertiliser tax has advantages compared with other policy instruments for controlling fertiliser use. According to Francis (1992) and Chowdhury and Lacewell (1996), fertiliser tax has many disadvantages as the tax does not determine the impact on producing, consuming and farming communities. The main advantages and disadvantages of fertiliser tax are presented in Table 1.

As evident from Table 1, a fertiliser tax can be a useful policy instrument for solving environmental problems and changing farming practices. According to Francis (1992) and Uri (1998), the cost of fertiliser tax collection is low. Therefore, from the economic point of view, introducing a fertiliser tax is an easy task. Unfortunately, a fertiliser tax may have numerous disadvantages. Chowdhury and Lacewell (1996) admit that family farms may change their behaviour and may avoid paying tax. Similarly, Francis (1992) as well as Chowdhury and Lacewell (1996) confirm that a universal fertiliser tax is not focused on local family farm problems.

Scandinavian countries are distinguished as leaders in respect of ecological issues – consequently, fertiliser taxes were introduced there at the end of the 20th century (Holm Pedersen, 2007). Therefore, most studies on the impact of fertiliser taxes are found in the cases of Scandinavian countries. However, the research results are controversial. According to Rougoor *et al*. (2001), fertiliser tax had a positive influence in decreasing the use of fertilisers in Austria and Sweden. Unfortunately, results in Finland were less pronounced. Pearce and Koundouri (2003) show that fertiliser tax has slightly reduced fertiliser use in Norway and Sweden and it is complicated to assess the tax effect of other policy instruments. Vojtech (2010) admits that fertiliser tax is inexpensive to administer, though unfortunately, it might be less effective as a pollution tax. There are still doubts about how much a fertiliser tax can be effective in reducing fertiliser use. However, fertiliser taxation is now back into discussions in the EU due to climate change effects (Karatay and Meyer-Aurich, 2018). This is confirmed by the research results that non-CO_2 greenhouse gases emissions reduce due to decrease in the use of fertilisers (Mottershead *et al*., 2018).

Empirical analysis of factors related to fertiliser use

The demand for fertilisers introduces the need to limit fertiliser use in the world (Mergos and Stoforos, 1997). Regulating the use of fertilisers is important because not all fertilisers are used efficiently: some of them evaporate into the air or enter into watercourses. To develop a fertiliser tax, it is important to evaluate which objects are affected by the use of fertiliser during the operations of the family farm. Family farms take a large part of the land for the production of food or other products (Wunderlich, 1997) and the use of fertiliser is related to the use of land. The results of various studies reveal that the amount of fertiliser use depends on the characteristics of the land, plants and agricultural machinery. According to the research by Savci (2012), we can see that plants may use up to 50 per cent of fertilisers, while up to 25 per cent remains in the soil. That means that the other 25 per cent of the fertiliser has a negative impact on the environment.

Table 1: Advantages and disadvantages of fertiliser tax.

Advantages	Disadvantages
• Low-cost setting and tax collection • The revenues raised by the fertiliser tax could be used for environmental benefits • Efficiency in controlling the use of fertiliser • Relatively lower cost of production • Promotion of organic farming • Prevention of pollution • Adoption of alternative production practice	• High tax may aggravate the environmental problem • Possibly increased surface erosion • A global tax on the fertiliser might not properly address local problems • The strong opposition of family farms and fertiliser producers • The primary focus of the global fertiliser tax is on how much fertiliser is used rather than when, where, and how it is used • It may increase the shadow market

Source: own composition based on Francis (1992), Chowdhury and Lacewell (1996) and Uri (1998)

Research results show that increased use of machinery also increased the consumption of fertilisers – as in the case of China from 1978 to 1996 (Felloni *et al*., 2001). The negative impact on the environment depends on the type of the used machine. The fertiliser might be lost in the machines. Nowadays, the situation may change. Rehman *et al*. (2017) admit that modern technology, new machines, and computer monitoring systems could ensure that farming is "less wasteful in the use of fuel, fertiliser or seed". According to Zhang *et al*. (2013), modern technologies "can have a large impact on emission reduction" in all fertiliser production and use chains. Research by Felloni *et al*. (2001) points out that tractors and fertilisers might be more important factors together than by studying them separately.

As mentioned earlier, 25 per cent of fertiliser reacts with the soil (Savci, 2012), but also the quantity of fertiliser absorbed in soil depends on soil productivity. The Law of the Republic of Lithuania on the Establishment of the Database of Land Performance Assessment and the Data Update 2008–2011 and the Approval of Rules for the Assessment of Land Performance (2008) provides the basis of the calculation of a soil productivity index. This index includes the correction coefficients of soil acidity (pH), phosphorus, calibration, soil stoniness, a variation of coating (colour), and climatic conditions. Therefore, soil productivity determines how much fertiliser the soil could absorb. Fertiliser is used to restore soil productivity: if soil productivity is good enough, the soil and plants do not absorb minerals. According to Končius (2007), phosphorus transformation of fertilisers depends on soil productivity; plants have a low level of phosphorus absorption or unabsorbed phosphorus. This causes the excess of the fertiliser which enters into the air and water.

The use of fertilisers determines the volume of production, which ensures income for a family farm. Results of various research confirm that a decrease in the use of fertiliser leads to a decrease in farm's income. Consequently, the profit of family farms depends on the quantity of fertiliser used (Mengel *et al*., 2006). However, there is also research indicating that contrary results can be achieved by the promotion of fertiliser with subsidies with a view to reducing poverty and promoting crop production. Fertiliser subsidies are inefficient to increase family farm's income (Ricker-Gilbert and Jayne, 2012). However, it needs to be taken into account that about 90 per cent of the world population lives on low incomes in small family farms (Lipton, 2005, cit. Birner and Resnick, 2010). Therefore, the use of fertiliser ensures that the family farm's income is sufficient, and also ensures food for the wider population. Ladha *et al*. (2005) say that 50 per cent of the population relies on nitrogen fertilisers used in food production. About 60 per cent of nitrogen fertiliser is used worldwide for three main products: rice, wheat and maize.

There also exist some differences in the use of the fertiliser which depend on family farms' size and their resources. The research reveals that family farms' size can affect sustainable farming. Sustainable agriculture is described as a way to avoid the use of fertiliser, herbicides, pesticides, and feed additives (Singh and Jajpura, 2016). Family farms stand out as sources of funding, this has an effect on farm size and the potential to grow into a large farm. Large family farms have better access to markets and information, and the capital often uses external financing (Kozlovskaja, 2012) and for these reasons can be more productive. However, scientists do not accept the stereotype that small family farms are unproductive as they have fewer assets and investments. The research discloses that small family farms are more productive in total output than large farms and are able to make more profit (Rosset, 2000; Altieri, 2009). Small family farms use fewer resources but use them more intensively (Altieri, 2009). Small family farms are more sustainable and better at conserving biodiversity and natural resources (Rosset, 2000).

Altieri (2009) admits that some scientists discuss that small family farms are able to produce much food for rural society "in the midst of climate change and burgeoning energy costs". Rosset (2000) says that the advantages of small family farms extend into the ecological field, and small family farms can be more "effective stewards of natural resources and the soil". Following the research by Altieri (2009) and Rosset (2000), it can be assumed that small family farms use less fertiliser, because small family farms better protect biodiversity and other natural resources, and tend to choose more sustainable farming methods or ecological farming.

The results of the literature review show the key factors that determine fertiliser use (see Figure 1).

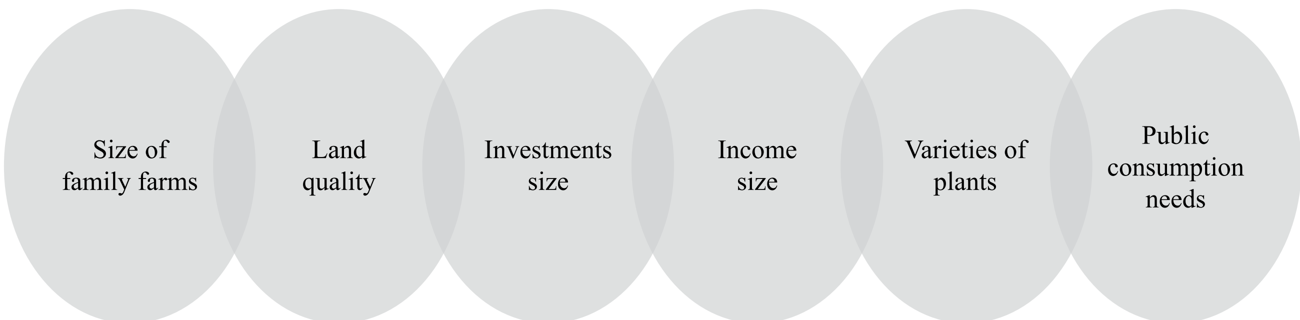

Figure 1: Factors related to the use of fertiliser.
Source: own composition

Methodology and data

The aim of the research is to identify the most significant factors affecting Lithuanian family farm fertiliser use and compare these results with the other selected countries. Our future research raises the question of whether these factors could be used for the design of the fertiliser tax. Taking into account the general regulation of the EU, it is important to evaluate whether the same criteria exist in Lithuania and other EU family farms.

By summarising the theoretical aspects and the previous results of the scientific research concerning the factors related to the fertiliser use, we followed seven steps (Figure 2). Empirical calculations were performed by using the IBM SPSS Statistics 20 software.

The first step for our research was data collection. We used the data of Lithuanian family farms for the years 2003–2017, obtained from the national FADN database. In Step 1 and Step 4, we created groups of family farms, according to their economic size. We regrouped the family farms into micro (>€8,000), small (€8,000–€25,000), medium (€25,000–€100,000), and large (<€100,000) farms as suggested by Vitunskienė (2014).

In Step 2, we studied the relationships between our possible factors in a correlation matrix. In Step 3, we compared our empirical results with the factors found in the literature review. In Step 4, the other selected countries were compared with the Lithuanian results. In the context of climate change, it is important to consider the cases of different countries with the results of Lithuania. We chose three countries which used at least as much fertiliser per hectare as Lithuania and also three countries which used the most fertiliser, according to the FADN database in 2016 (Figure 3).

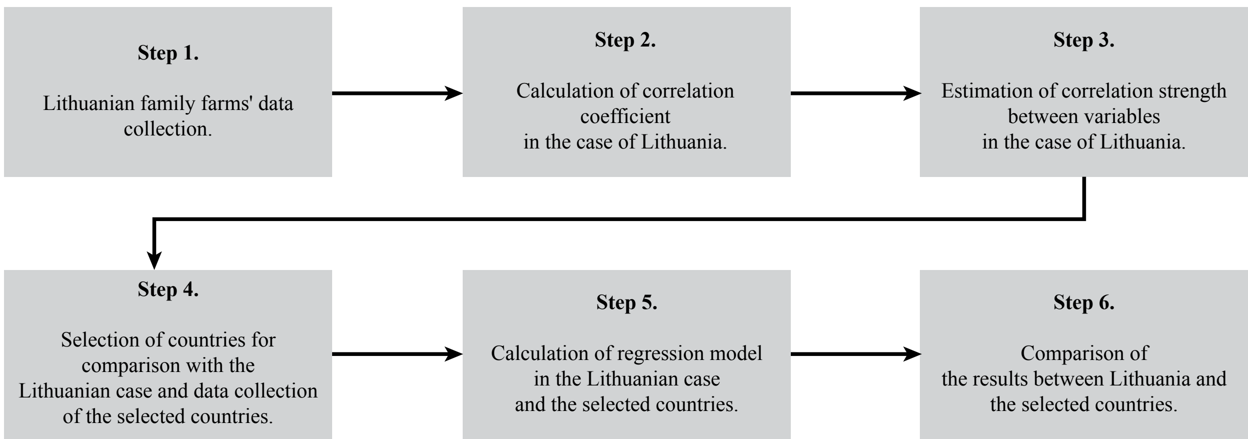

Figure 2: Steps of the methodology of our research.

Source: own composition

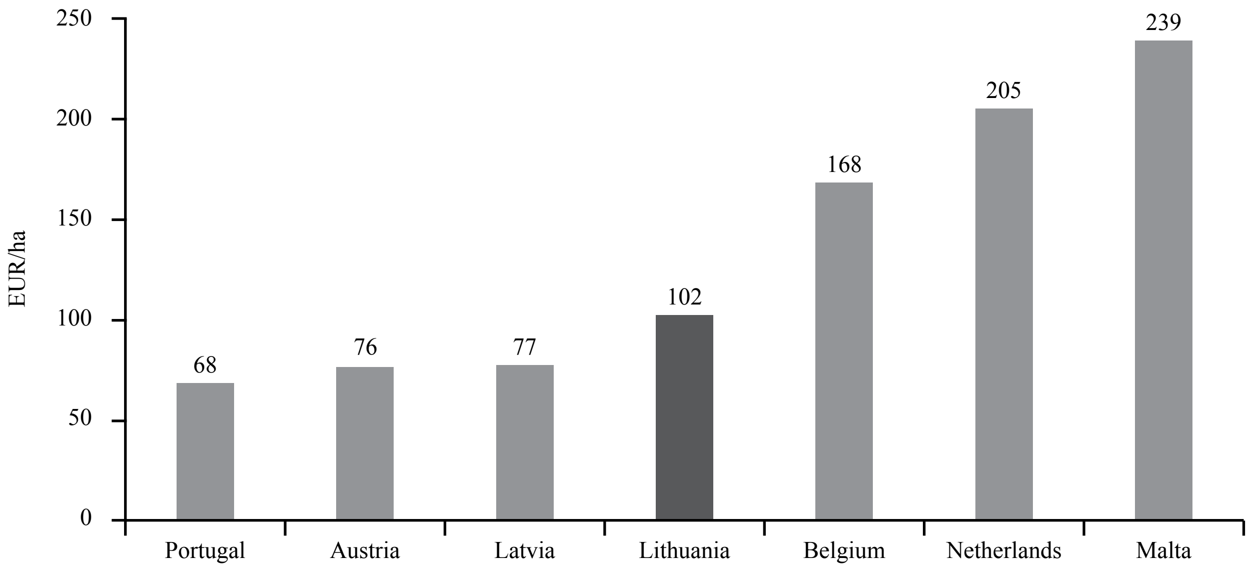

Figure 3: The use of the fertiliser in Lithuania and other selected countries (EUR/ha).

Note that Portugal, Austria, and Latvia use less, whereas Belgium, Netherlands, and Malta use more fertiliser than Lithuanian farmers.

Source: own composition

In Step 5, we were looking for the most suitable regression model to determine the factors that predict the use of fertilisers in Lithuanian family farms and those of other selected countries. We applied the ordinary linear regression model. Our goodness of fit criteria were the level of marginal significance (p-value), the coefficient of determination (R-square) and multicollinearity coefficient (VIF).

The majority of researchers agree that VIF greater than 10 clearly indicates multicollinearity problems (García *et al*., 2015; Akinwande *et al*., 2015). Unfortunately, no precise limit value for multicollinearity is available. García *et al*. (2015) suggested that VIF> 4 may lead to multicollinearity, and this is the classical point of view. Other researchers suggest that the model needs to be reviewed when the VIF is over 5 (Akinwande *et al*., 2015) or 6 (Huang *et al*., 2008). In our regression models, we used the classic rule that VIF has to be between 1 and 6. The regression model is considered to be reliable if its p-value is less than 0.05. When constructing our best regression model, we applied the stepwise method.

In Step 6, we drew the conclusions and comparisons. Our objective was to examine whether the significant factors for the use of the fertiliser were similar among these countries. This aspect is important for further research when setting fertiliser tax in Lithuania.

Results

According to the literature review, we calculated the correlation coefficients between fertiliser use and various investments, financial results of family farms, plants' output, and other factors in Lithuania. Some scientists admit that the use of fertiliser might be important for family farms' investment in assets. According to the literature, the most important investments were made in agricultural machinery and land. According to the data on family farms of Lithuania in 2003–2017, the correlation coefficients indicate that there are moderate positive relationship between land (0.6301) and harvesters (0.5447). The situation can be interpreted that the increase in crop field will increase the use of fertiliser. Fertilisers will ensure production quantities that require harvesters to harvest crops. A low negative correlation exists with the investment in tractors (-0.335). As observable from Figure 3, there is a relationship in some cases, though quite low.

Figure 4 confirms the ideas of Felloni *et al*. (2001), Zhang *et al*. (2013) and Rehman *et al*. (2017) that, today, modern technology in agriculture ensures less waste in the use of fertiliser. Moreover, Figure 4 shows that if family farms' investments in tractors increase, then the use of mineral fertiliser decreases, which confirms again that the higher the number of modern tractors, the more effective is the use of mineral fertiliser.

Family farms play an important role in the food market. Therefore, growing plant varieties disclose the needs for food consumption. We calculated the correlation between fertiliser use and the outputs of various crops. Results showed that the most important crops in Lithuania were wheat (correlation coefficient 0.9504), rape (correlation coefficient 0.9341), sugar beet (correlation coefficient 0.7195), field vegetables (correlation coefficient 0.5970), protein (correlation coefficient 0.3760) and triticale (correlation coefficient 0.3252). These crops increased the use of fertilisers. Only a few crops had negative correlations. The family farms which grow oats (correlation coefficient -0.4518), grain mix (correlation coefficient -0.4911), and other crops (correlation coefficient -0.5426) used less fertiliser.

General subsidies (correlation coefficient -0.3193) ensure less fertilisation in Lithuania. When evaluating the different types of subsidies, results show that subsidies to livestock (correlation coefficient-0.4520) have a negative correlation. This is understandable as fertilisers are not used in animal husbandry. Subsidies to less-favoured areas of farming (correlation coefficient -0.6167) and organic farming (correlation coefficient -0.5997) also ensure a lower amount of fertiliser use. Unfortunately, sugar subsidy (correlation coefficient 0.4755) increased the use of fertilisers.

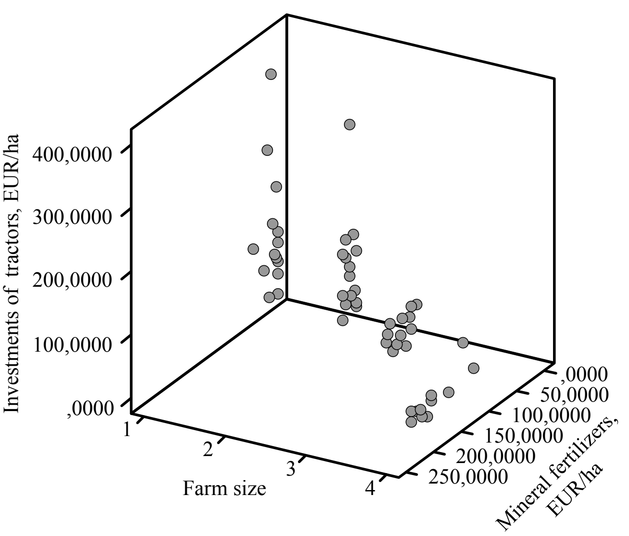

Figure 4: Relationship between the use of fertiliser, investment in tractors and family farm size in Lithuania.

Source: own composition

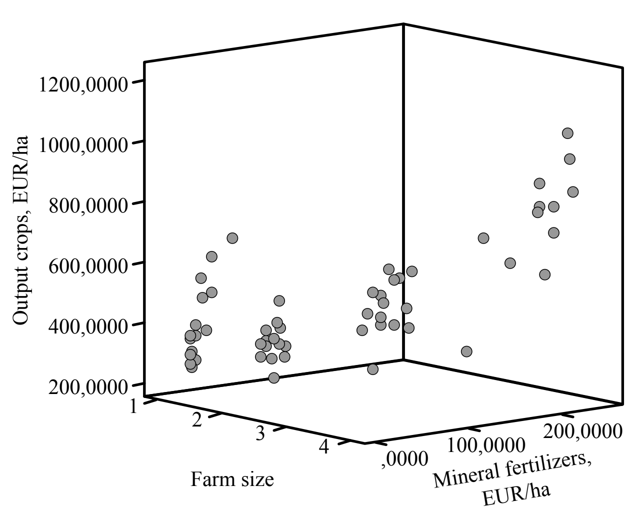

Figure 5: Relationship between the use of fertiliser, crop outputs and family farm size in Lithuania.

Source: own composition

In line with our assumption, micro and small family farms are able to be more productive than medium and large family farms, as previously confirmed by Rosset (2000) and Altieri (2009) (Figure 5).

Micro family farms are more productive than small family farms in Lithuania. What is more, in some cases, micro family farms are able to produce a higher yield of crops than medium family farms and use less fertiliser for production (Figure 5). While small family farms are not as productive as large family farms, they are still able to get the same output from crop production as medium family farms. This confirms the idea of Rosset (2000) and Altieri (2009) that micro and small family farms are more sustainable and use less fertiliser. Consequently, the correlation coefficient between fertiliser use and economic farm size is high (0.9403). This leads to the willingness of medium and large farms to produce larger quantities of crops and ensure financial results.

A high positive correlation exists between the use of fertiliser use and land quality (0.7699) in Lithuania. The relationship shows that if land quality increases, the use of fertiliser increases too, implying existing pollution problems. If soil productivity is good enough, but family farms use more mineral fertilisers for the plants, then the soil does not absorb these minerals and they pollute air, water and land.

On the whole, the results confirm the importance of similar factors related to the use of the fertilisers previously highlighted by the literature review. The variables which have an impact on the use of fertiliser on family farms in Lithuania can be classified into four groups: investments, crop varieties, financial results, and other factors. These factors (Figure 6) are important in fertiliser tax modelling. Therefore, we formed an ordinary least squares regression model using selected variables in Lithuania and the cases of the selected countries (see Table 2) to check the extent to which these factors are significant.

The best regression model was found for the Austrian case (R-squared is 0.951, standard error of the estimate is 7.777) and the Latvian case (R-squared is 0.974, standard error of the estimate is 8.714). The regression model is good enough in the case of Lithuania, yet VIF was left to 6, which, according to some researchers, can signal certain multicollinearity problems. The same situation with the regression model exists in the Portugal and Austrian case. However, the R-square is high enough in Belgium (1.000), the Netherlands (0.974) and Portugal (0.965), which indicates the reliability of the variables. The lowest R-squared is in the Malta regression model (0.812). Moreover, in the case of Malta's regression models, the standard error of the estimate ranged

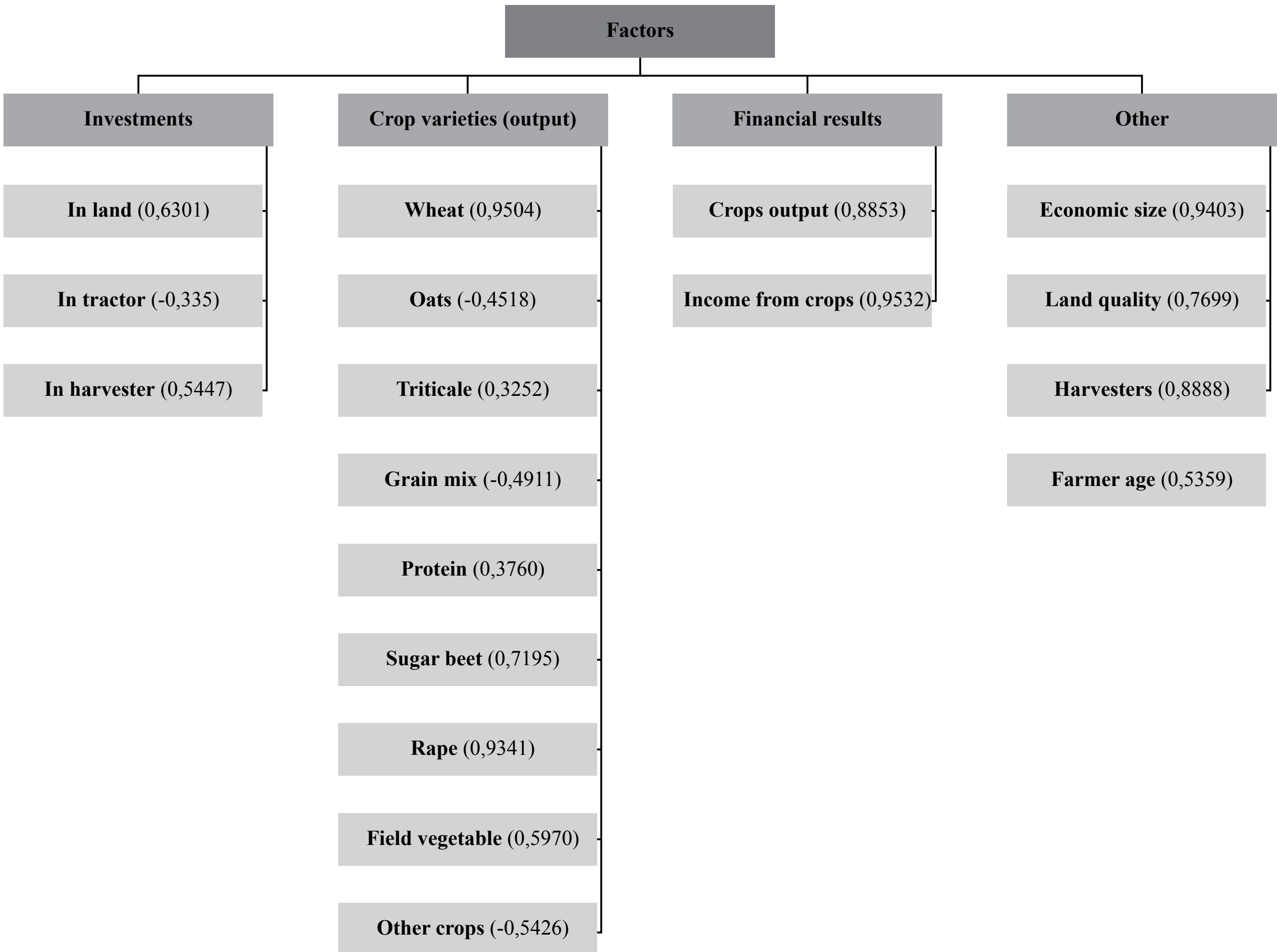

Figure 6: Correlation between fertilisers use and different factors at family farms in Lithuania.

Source: own composition

Table 2: Factors influencing fertiliser use.

Country	Model	Coefficient	p-value	R-squared	VIF	Std. Error
Lithuania	Constant	-136.014	0.003	0.958		13.097
	Wheat output	0.257	0.000		5.246	
	Harvesters	0.139	0.044		6.004	
	Rye output	-0.973	0.320		1.116	
	Land quality	3.625	0.003		3.587	
	Investments in land	0.305	0.003		2.299	
	Field vegetables output	0.479	0.019		1.899	
Latvia	Constant	16.914	0.001	0.974		8.714
	Oil-seed crops output	0.664	0.000		4.775	
	Subsidies dairying	0.871	0.000		1.376	
	Vegetables and flowers output	0.204	0.000		1.563	
	Potatoes output	-0.561	0.000		2.068	
	Other subsidies	0.270	0.001		1.662	
	Fruit output	-0.640	0.004		1.557	
	Other live stock subsidies	0.263	0.023		2.521	
Portugal	Constant	31.879	0.004	0.965		14.648
	Machinery and building current costs	1.742	0.000		6.073	
	Oil-seed crops output	0.981	0.000		2.756	
	Forage crops output	-0.495	0.000		4.473	
	Subsidies other cattle	-0.753	0.001		1.457	
	Fruit output	0.148	0.000		3.324	
	Total support for rural development	-0.162	0.007		2.393	
Austria	Constant	35.216	0.013	0.951		7.777
	Total output	0.039	0.000		5.514	
	Total support for rural development	-0.164	0.000		2.737	
	Wine and grapes output	-0.084	0.002		5.815	
Belgium	Constant	50.096	0.000	1.000		16.071
	Buildings	0.025	0.000		1.283	
	Olives and olive oil	-20.0269	0.001		1.392	
	Other crop output	0.128	0.001		1.550	
	Forage crops	0.183	0.320		1.099	
Netherlands	Constant	26.548	0.037	0.974		12.719
	Economic size	0.330	0.000		4.441	
	Land, permanent crops and quotas	0.002	0.000		1.517	
	Wine and grapes output	177.923	0.003		1.171	
	Farm Net Income	-0.019	0.004		3.317	
	Oil-seed crops output	5.305	0.011		1.390	
Malta	Constant	186.915	0.001	0.812		62.755
	Total output crops and crop production	0.040	0.000		1.549	
	Total OGA output	-0.136	0.000		1.172	
	Gross Investment	0.016	0.000		2.303	
	Buildings	-0.001	0.002		3.005	
	LFA subsidies	-0.533	0.024		1.215	

Source: own composition

from 20 to 90 in different regression models, also indicating potential multicollinearity problems.

The results of the regression models confirm that the use of fertiliser is strongly related to cultivated plants. As we can see from Table 2, the results of the regression models in the Lithuanian case identify similar factors as the correlation coefficients. However, there were some differences. The regression model showed that the quality of land, harvesters, investment in land and various crops (wheat, rye and field vegetables) are still important. However, other factors with strong regression coefficients (investment in tractors and harvesters, economic size, farmer age, and other) did not fit into the regression model in the Lithuanian case.

The regression models were very different in all selected countries analysed. The relationship between the use of the fertiliser and agricultural machinery only existed in Lithuania and Portugal. 1 euro investment in agricultural machinery increased the fertiliser use by 1.742 in Portugal and by 0.139 in Lithuania. In the Lithuanian case, the regression model showed that 1 euro of investment in land increased the use of fertiliser by 0.381. In the case of Malta, the regression model showed that 1 euro of investment in land increases the use of fertiliser by 0.016. This showed that investment is a more influential factor related to the use of fertiliser more in Lithuania than in Malta. No other selected country exhibits a relationship between the use of fertiliser and agricultural machinery or investment.

The results showed that subsidies were not important for fertiliser use for Lithuania. This was confirmed both by the correlation coefficient and the regression model. The comparison of other countries' regression models with the Lithuanian regression model shows that subsidies have a relationship with the use of fertiliser in Latvia, Portugal, Austria, and Malta. 1 euro subsidy on dairy increase the use of fertiliser by 0.871, on other livestock by 0.263, and on other issues by 0.270 in Latvia. As we see, the subsidies are not properly distributed as subsidies promote unsustainable agriculture practices in Latvia. A different situation exists in Portugal, Austria, and Malta as subsidies decrease the use of fertiliser.

The literature review showed that the use of fertiliser depends on the size of the family farm and in some cases, small family farms tend to be more sustainable. The results of the empirical research confirmed that this factor was important only in the Netherlands. The results of the empirical research did not confirm the theoretical assumptions that the size of the family farm had an influence on fertiliser use.

Conclusions

The aim of this research was to ascertain the significant factors affecting fertiliser use by family farms in Lithuania with a view to the possible introduction of a fertiliser tax. The comparison of the regression models between countries and Lithuania shows that the models are very different. Differences can be caused by regions, cultures, policies, farming practices and others issues. Therefore, to regulate the use of fertilisers by setting a fertiliser tax, it is necessary to take into account country-specific features. The factors influencing the use of fertiliser on family farms in Lithuania are investment in land, land quality, and the planting of crops such as wheat, oats, sugar beet, and field vegetables. Identical factors were not found for other selected countries. Likewise, not all factors analysed in the literature review were validated in countries' regression models.

The main limitation of the research is that FADN data for the different types of fertilisers (nitrogen, phosphorus and potassium) were started to be collected in 2014. In our research, we did not take into account different types of fertilisers. The results of various empirical research reveal that taxation can affect the use of fertilisers differently and tax base is built on different types of fertiliser use (Uri, 1998; Gazzani, 2017). Therefore, this needs to be evaluated and re-analysed in future research. However, there are also controversies whether it is appropriate to set a fertiliser tax base separately for each type of fertiliser. It is easy to manipulate by types of fertilisers based on their costs.

The empirical research revealed that Lithuanian micro and small family farms used less fertilisers and were more productive in some cases than large family farms. However, the regression model did not confirm this. The results might have been influenced by the problem of expanding farm sizes in the EU. Also, micro family farms which use simplified accounting entries were not included in the FADN database of Lithuania. As a result, we are not sure to what extent micro family farms are sustainable.

Future studies might also consider the relationship between fertiliser tax rate and possible fertiliser reduction levels. Some studies disclose that a fertiliser tax rate between 10 per cent and 15 per cent may reduce the use of fertiliser by 5 percent (Gazzani, 2017). Further research could design a fertiliser tax rate and disclose influence on the productivity and financial results of the family farms' agricultural production based on our regression models in Lithuania and in other countries analysed.

References

Akinwande, M.O., Dikko, H.G. and Samson, A. (2015): Variance inflation factor: as a condition for the inclusion of suppressor variable(s) in regression analysis. Open Journal of Statistics, **5** (7), 754–767. https://doi.org/10.4236/ojs.2015.57075

Altieri, M.A. (2009): Agroecology, small farms, and food sovereignty. Monthly Review, **61** (3), 102–113.

Birner, R. and Resnick, D. (2010): The political economy of policies for smallholder agriculture. World Development, **38** (10), 1442–1452. https://doi.org/10.1016/j.worlddev.2010.06.001

Chen, C.F. and Chen, F.S. (2010): Experience quality, perceived value, satisfaction and behavioral intentions for heritage tourists. Tourism Management, **31** (1), 29–35. https://doi.org/10.1016/j.tourman.2009.02.008

Chowdhury, M.E. and Lacewell, R.D. (1996): Implications of alternative policies on nitrate contamination of groundwater. Journal of Agricultural and Resource Economics, **21** (1), 82–95. https://www.jstor.org/stable/40986899

Čiulevičienė, V. and Kożuch, A.J. (2015): Effects of the environmental tax reforms. Management Theory and Studies for Rural Business and Infrastructure Development, **37** (4), 480–489. http://doi.org/10.15544/mts.2015.40

Euractiv (2018): The future of fertilisers in Europe. Retrieved from https://en.euractiv.eu/wp-content/uploads/sites/2/special-report/EURACTIV-Event-Report-The-future-of-fertilisers-in-Europe.pdf (Accessed in September 2019)

Felloni, F., Wahl, T., Wandschneider, P. and Gilbert, J. (2001): Infrastructure and agricultural production: cross-country evidence and implications for China. TW-2001-103. Washington State University: Pullman, USA.

Francis, D.D. (1992): Control mechanisms to reduce fertiliser nitrogen movement into groundwater. Journal of Soil and Water Conservation, **47** (6), 444–448.

García, C.B., García, J., López Martín, M.M. and Salmerón, R. (2015): Collinearity: Revisiting the variance inflation factor in ridge regression. Journal of Applied Statistics, **42** (3), 648–661. https://doi.org/10.1080/02664763.2014.980789

Gazzani, F. (2017): Economic and Environmental Evaluation of Nitrogen Fertiliser Taxation: A Review. International Journal of Environment, Agriculture and Biotechnology, **2** (4), 1829–1834. http://doi.org/10.22161/ijeab/2.4.47

Heady, C.J., Markandya, A., Blyth, W., Collingwood, J. and Taylor, P.G. (2000): Study on the relationship between environmental/energy taxation and employment creation. Study prepared for the European Commission Directorate General XI. Retrieved from http://ec.europa.eu/environment/enveco/taxation/pdf/entaxemp.pdf. (Accessed in July 2019)

Holm Pedersen, L. (2007): Ideas are transformed as they transfer: a comparative study of eco-taxation in Scandinavia. Journal of European Public Policy, **14** (1), 59–77. https://doi.org/10.1080/13501760601071653

Huang, D., Guan, P., Guo, J., Wang, P. and Zhou, B. (2008): Investigating the effects of climate variations on bacillary dysentery incidence in northeast China using ridge regression and hierarchical cluster analysis. BMC Infectious Diseases, **8** (130), 1–9. https://doi.org/10.1186/1471-2334-8-130

Jongeneel, R.A. (2018): Research for AGRI Committee - The CAP support beyond 2020. Assessing the future structure of direct payments and the rural development interventions in the light of the EU agricultural and environmental challenges Policy. European Union, 2018. Retrieved from http://www.europarl.europa.eu/RegData/etudes/STUD/2018/629174/IPOL_STU(2018)629174_EN.pdf. (Accessed in August 2019)

Karatay, Y.N. and Meyer-Aurich, A. (2018): A model approach for yield-zone-specific cost estimation of greenhouse gas mitigation by nitrogen fertiliser reduction. Sustainability, **10** (3), 710–728. https://doi.org/10.3390/su10030710

Končius, D. (2007): The Effect of Periodical Liming and Fertilization on the Forms of Phosphates and on the Changes in its Fractional Composition in the Soil. Zemdirbyste/Agriculture, **94** (1), 74–88.

Kostov, P., Davidova, S. and Bailey, A. (2019): Comparative efficiency of family and corporate farms: does family labour matter?. Journal of Agricultural Economics, **70** (1), 101–115. https://doi.org/10.1111/1477-9552.12280

Kozlovskaja, A. (2012): Agricultural small and large producers financing impact on innovations and activity results. Management Theory and Studies for Rural Business and Infrastructure Development, **32** (3), 69–80.

Ladha, J.K., Pathak, H., Krupnik, T.J., Six, J. and van Kessel, C. (2005): Efficiency of fertiliser nitrogen in cereal production: retrospects and prospects. Advances in Agronomy, **87,** 85–156. https://doi.org/10.1016/S0065-2113(05)87003-8

Mengel, K., Hütsch, B. and Kane, Y. (2006): Nitrogen fertiliser application rates on cereal crops according to available mineral and organic soil nitrogen. European Journal of Agronomy, **24** (4), 343–348. https://doi.org/10.1016/j.eja.2005.12.001

Mergos, G.J. and Stoforos, C.E. (1997): Fertiliser demand in Greece. Agricultural Economics, **16** (3), 227–235. https://doi.org/10.1016/S0169-5150(97)00013-3

Mottershead D., Hart K., Maréchal A., Meredith S., Lorant A., Bas-Defossez F., Baldock, D., Bureau, J.C. and Matthews, A. (2018). Research for AGRI Committee - Towards the CAP post 2020 - Appraisal of the EC Communication on 'The Future of Food and Farming' of 29 November 2017. Brussels, Belgium. Retrieved from: http://www.europarl.europa.eu/RegData/etudes/STUD/2018/617476/IPOL_STU(2018)617476_EN.pdf (Accessed in June 2019)

Pearce, D. and Koundouri, P. (2003): Fertiliser and pesticide taxes for controlling non-point agricultural pollution. Agricultural and Rural Development Department, World Bank Group, Washington DC, USA.

Rehman, A., Jingdong, L., Khatoon, R., Hussain, I. and Iqbal, M.S. (2017): Modern agricultural technology adoption its importance, role and usage for the improvement of agriculture. Life Science Journal, **14** (2), 70–74. https://doi.org/10.7537/marslsj140217.10

Ricker-Gilbert, J. and Jayne, T.S. (2012): Do fertiliser subsidies boost staple crop production and reduce poverty across the distribution of smallholders in Africa? Quantile regression results from Malawi. In Selected paper prepared for presentation at the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguaçu, Brazil (pp. 18–24). https://doi.org/10.22004/ag.econ.126742

Rosset, P. (2000): The multiple functions and benefits of small farm agriculture in the context of global trade negotiations. Development, **43** (2), 77–82. https://doi.org/10.1057/palgrave.development.1110149

Rougoor, C.W., Van Zeijts, H., Hofreither, M.F. and Bäckman, S. (2001): Experiences with fertiliser taxes in Europe. Journal of Environmental Planning and Management, **44** (6), 877–887. https://doi.org/10.1080/09640560120087615

Savci, S. (2012): An agricultural pollutant: chemical fertiliser. International Journal of Environmental Science and Development, **3** (1), 77–80. https://doi.org/10.7763/IJESD.2012.V3.191

Singh, B. and Jajpura, L. (2016): Sustainable agriculture: a key to the healthy food and better environment, economic prosperity for farmers and a step towards sustainable development. International Journal of Current Microbiology and Applied Sciences, **5** (1), 148–156. http://doi.org/10.20546/ijcmas.2016.501.012

Söderholm, P. and Christiernsson, A. (2008): Policy effectiveness and acceptance in the taxation of environmentally damaging chemical compounds. Environmental Science and Policy, **11** (3), 240–252. https://doi.org/10.1016/j.envsci.2007.10.003

Udeigwe, T.K., Teboh, J.M., Eze, P.N., Stietiya, M.H., Kumar, V., Hendrix, J. and Kandakji, T. (2015): Implications of leading crop production practices on environmental quality and human health. Journal of Environmental Management, **151,** 267–279. https://doi.org/10.1016/j.jenvman.2014.11.024

Uri, N.D. (1998): Environmental considerations in the fertiliser use decision. Environmental Geology, **34** (2-3), 103–110. https://doi.org/10.1007/s002540050260

Vitunskienė, V. (2014): The role of CAP payments in supporting farms income in Lithuania and the European Union as a whole. Science and Studies of Accounting and Finance: Problems and Perspectives, **9** (1), 281–289. https://doi.org/10.15544/ssaf.2014.31

Vojtech, V. (2010): Policy measures addressing agri-environmental issues. OECD Food, Agriculture and Fisheries Papers. No. 24. OECD, Paris, France.

Von Blottnitz, H., Rabl, A., Boiadjiev, D., Taylor, T. and Arnold, S. (2006): Damage costs of nitrogen fertiliser in Europe and their internalization. Journal of Environmental Planning and Management, **49** (3), 413–433. https://doi.org/10.1080/09640560600601587

Wunderlich, G. (1997): Land Taxes in Agriculture: Preferential Rate and Assessment Effects. American Journal of Economics and Sociology, **56** (2), 215–228.

Zhang, W.F., Dou, Z.X., He, P., Ju, X.T.,Powlson, D., Chadwick, D. and Chen, X.P. (2013): New technologies reduce greenhouse gas emissions from nitrogenous fertiliser in China. Proceedings of the National Academy of Sciences, **110** (21), 8375–8380. https://doi.org/10.1073/pnas.1210447110

Nilojyoti KONER* and Arindam LAHA*

Economics of Zero Budget Natural Farming in Purulia District of West Bengal: Is It Economically Viable?

In the light of the growing concerns about the sustainability of the current input-intensive agriculture system, the need for an alternative farming system has arisen. Among the various alternative farming models practised across the world, Zero Budget Natural Farming (ZBNF) has recently come into the spotlight. This paper envisages the economic viability of ZBNF in a local setting. In the empirical survey, the study considers one cluster of farmers practicing ZBNF in Purulia district of West Bengal, India. Empirical evidence presented in this paper is based on the performance of this alternative model of farming in respect of three important parameters, namely cost of cultivation, yield and income. Evidence reveals that the natural farmers have experienced a reduction in per hectare production cost and per hectare yield for their crops in the post-conversion period. More importantly, farmers adopting the ZBNF model (i.e. treatment group) in Purulia were able to enhance their income, compared to their chemical counterparts (i.e. control group). Moreover, an in–depth analysis of performance has been carried out, thereby identifying the factors influencing the long-term sustainability of ZBNF. Results indicate that the long term sustainability of this model of farming is contingent upon the interplay of agro-climatic conditions and various other socio-economic factors.

Keywords: Sustainable Agriculture, Zero Budget Natural Farming, Chemical Farming, Cluster, India

JEL classifications: Q15, Q18

* The University of Burdwan, West Bengal 713104, India. Corresponding author: konernilojyoti@gmail.com.

Received: 13 December 2019, Revised: 27 February 2020, Accepted: 2 March 2020.

Introduction

Agriculture has been the backbone of the Indian economy for centuries. More than half of the country's population at present depends on agriculture and allied services for their livelihoods (Tripathi *et al*, 2018). Over the last few decades there has been a major transformation in the Indian agricultural sector. With the introduction of 'Green Revolution' technologies, agriculture in India has transitioned from subsistence to commercial farming. However, in spite of the success, the input intensive 'Green Revolution' in recent decades has often masked significant externalities, affecting natural resources and human health, as well as agriculture itself. Besides, there is also the added impact of neo-liberal economic reforms. Policy measures such as the reduction or withdrawal of input subsidies, privatisation and marketisation of economic activities have adversely affected the Indian peasants' community (Goswami *et al*., 2017). Moreover, the twin effects of the 'Green Revolution' and the neo-liberalisation of the Indian economy have led to a deep agrarian crisis. The smallholders[1] have become its worst victim. The prevailing agriculture system in India is characterised by high production costs, high interest rates for credit, volatile market prices for crops, and rising costs for fossil fuel-based inputs and private seeds. As a result, Indian farmers (especially the smallholders) increasingly find themselves in a perpetual cycle of debt. More than a quarter of a million farmers have committed suicide in India in the last two decades (Parvathamma, 2016).

In the light of these growing concerns about the sustainability of the current input intensive agriculture system, the need for an alternative farming system has arisen. Various forms of alternative low-input farming practices have emerged in different corners across the world, promising reduced input costs and higher yields for farmers, chemical-free food for consumers and improved soil fertility. In the Indian context, implementation of the National Mission for Sustainable Agriculture (NMSA)[2] signifies a policy reversal away from the 'biologically centred green revolution'. In addition, various initiatives such as Paramparagat Krishi Vikash Yojana (PKVY), Rashtriya Krishi Vikash Yojana (RKVY), Mission Organic Value Chain Development for North Eastern Region (MOVCDNER), Participatory Guarantee System (PGS), and National Programme for Organic Production (NPOP), Network Project on Organic Farming (NPOF) have been undertaken by the government of India in order to promote Organic Farming[3]. Interestingly, the PKVY scheme in its revised guidelines has also included various other organic farming models like Natural Farming, Vedic Farming, Cow Farming, Homa Farming and Zero Budget Natural Farming (GOI, 2019). Among these alternative organic models, ZBNF has recently come into the spotlight. In the Economic Survey, 2018-19, and successively in the budget 2019, the finance minister of India has announced that the government will promote ZBNF with the aim of reducing the cost of cultivation and thereby 'doubling farmers' income'[4] (Bhosle, 2019; GOI, 2019). ZBNF promises to end a reliance on loans and to drastically cut production costs, thereby ending the debt cycle for desperate farmers.

In this context, this study seeks to assess the economic viability of ZBNF. Apart from the introductory section, the

[1] The smallholders (include small and marginal farmers) account for more than 85percent of the total farmers in India (GOI, 2019).

[2] The principal objective of the NMSA is to make agriculture more productive, sustainable, remunerative and climate resilient by promoting location specific integrated farming systems and to conserve natural resources through appropriate soil and moisture conservation measures.

[3] "Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on the ecological processes, biodiversity and cycles adapted to local conditions rather than use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationship and a good quality of life for all involved" (IFOAM, 2019).

[4] The government of India has set a target to double farmer's income by 2022. It has three pillars: one is increasing the total output from agriculture by increasing productivity, the second is to ensure cost effectiveness thorough efficient uses of resources, and the third is to ensure remunerative prices for the farmers (Nirmal, 2019). ZBNF is considered to be an important strategy aimed at achieving cost reductions and thereby 'doubling farmers' income'.

OPEN ACCESS PEER REVIEWED

study has been organised as follows. First, we shall briefly present the concept of ZBNF, its key principles and the current status of ZBNF in India. Next, we shall provide a brief review of relevant past studies in this field. After that, we shall provide the objectives of the study, and it is followed by the database and methodology used in the study. Subsequently, we shall provide a detailed analysis and discussions about the main findings of the study. Lastly, conclusions and policy implications will appear.

Zero Budget Natural Farming (ZBNF)

As per the Economic Survey 2018-19, the word 'budget' refers to credit and expenses, thus the phrase 'Zero Budget[5]' means without using any credit, and without spending any money on purchased inputs. 'Natural farming' means farming with nature and without chemicals (GOI, 2019). Therefore, ZBNF aims to sustain agricultural production with eco-friendly processes in tune with nature in order to produce agricultural produce free of synthetic chemicals by eliminating the use of synthetic chemical inputs and promoting good agronomic practices.

ZBNF originated in Maharashtra in the early 2000s, pioneered by Mr. Subhash Palekar, an agriculturalist, through his on-farm experiments. Later this alternative method of farming is known as Zero Budget Spiritual Farming. Four integral aspects of ZBNF (or four wheels of ZBNF) are identified as (Palekar, 2005; 2006):

- Jivamirta (a soil inoculant): acts as a catalytic agent that enlivens the soil, increasing microbial activity and organic matter. It also helps in preventing fungal and bacterial growth and in increasing earthworm activity.
- Bijamirta (a seed treatment): protects seedlings from seed borne diseases.
- Acchadana (mulching): enhances decomposition and humus formation through activity of the soil biota activated.
- Whapasa (soil aeration/moisture): It is the condition in which there are both air and water molecules present in the soil.

In addition, there is a number of pest management measures such as Neemastra, Agnistra and Brahmstra, which are homemade preparations used for insect and pest control (Palekar, 2005). The ZBNF program is being implemented through a cluster approach under the PKVY and RKVY schemes. Currently a total of 1431 clusters have been set up under both these schemes and so far 163,034 farmers are practicing ZBNF across the country. Among the Indian States, Andhra Pradesh, Himachal Pradesh, Karnataka are progressively practicing ZBNF (GOI, 2019). In fact, the government of Andhra Pradesh is aiming to cover all the 6 million farmers and 8 million hectares in the state under the initiative of Climate Resilient Zero Budget Natural Farming (CRZBNF)[6] by 2027 (APZBNF, 2019). For this purpose, the government of Andhra Pradesh has been in mission mode since 2015-16 and already has covered 83,744 hectares (10 percent of the total area) till 2017-18 (Reddy *et al*., 2019).

Interestingly, Economic Survey 2018-19 describes ZBNF as one of the models of organic farming. However, Subhash Palekar's model of ZBNF is to some extent different to organic farming (ZBSF, 2019). Nevertheless, following Economic Survey 2018-19, in this study we have defined ZBNF as a model of organic farming. The ZBNF practice carried out by the farmers in our study region is a modified version of the ZBNF practices, as originally recommended by Mr. Palekar. However, it is more flexible in using bio-fertilisers and pesticides as compared to the practices recommended by Mr. Palekar.

Review of Literature

In the existing literature, there are very few studies in India that assessed the feasibility of ZBNF, and most of them are based on Andhra Pradesh. For instance, Khadse *et al*. (2017) conducted a survey of 97 farmer households practicing ZBNF in Andhra Pradesh. The results of the survey revealed that 91 percent of the households experienced a decrease in production cost; more than 78 percent of the households witnessed an increase in yield and income has increased for more than 85 percent of the households. In a separate study, a crop cutting experiment (for five major crops i.e. Paddy, Groundnut, Black Gram, Chilly and Maize) was conducted by the government of Andhra Pradesh across ZBNF and non-ZBNF in respect of three important parameters: yield, production cost and income (cited in Mishra, 2018). The results showed that all the crops grown under natural practices had higher yields compared to those produced by means of non-ZBNF practices. The results also indicated that the farmers have experienced a reduction in cost for all crops after converting into ZBNF and more importantly, farmers were able to increase their income by growing crops through natural farming practices. Tripathi *et al*. (2018) made an attempt to map the possible economic, social and environmental impacts of a ZBNF programme led by the government of Andhra Pradesh with respect to specific targets under each Sustainable Development Goal (SDG). Using the data of a crop cutting experiment conducted in all 13 districts of the state, the authors have found that ZBNF could help Andhra Pradesh and India make significant progress towards almost a quarter of the 169 SDG targets. In this context, Naresh *et al* (2018) argued that ZBNF can offer effective options towards the eradication of poverty and hunger while improving the environmental performance of agriculture, but that this requires transformative, simultaneous interventions along the whole food chain, from production to consumption. However, there remains doubt over the efficacy of ZBNF in improving agricultural production and enhancing farmers' income (Vegesna, 2019). In this context, Reddy *et al*. (2019) in their study found that cost of cultivation is lower by 3 to 41 percent for CRZBNF crops in comparison to the Non-CRZBNF crops in Andhra Pradesh. However, the yields rates are found to be

[5] 'Zero budget' does not literally mean that costs are 'zero', but rather implies that the need for external financing is zero, and that any costs incurred can be offset by a diversified source of income which comes via farm diversification rather than dependence on a single monoculture (APZBNF, 2019).

[6] It is a modified version of the ZBNF practices recommended by Mr. Subhash Palekar (Reddy *et al*, 2019).

lower for the same crops to an extent ranging from 6-20 percent even if after the third year of transition to CRZBNF. More importantly, the study has failed to observe any substantial increase in net return even after three years of adoption. The net returns are found to be lower for CRZBNF plots during the first and second years after conversion, a fact which can be explained by the substantial decline in yields immediately after the conversion. Therefore, a number of farmers have suffered huge losses and as a consequence, they have decided to go back to chemical farming. As a consequence, cases of dis-adoption of CRZBNF practices have been rising spreading widely all over the state. In addition, there are questions over its applicability across soil types and agro-climatic zones as it has not been tested on a wider scale (Vegesna, 2019).

In this context, a few pertinent questions may arise: Is Zero Budget Natural Farming economically viable? Can adoption of ZBNF lead to a lower cost of cultivation and higher income for farmer households? Can this alternative form of agriculture be applied on a large scale across different soil types and agro-climatic zones? This study seeks to address these questions.

Methods and data

The study is mainly based on primary survey evidences. Under the scheme of PKVY, around 10,000 clusters (out of which 120 in West Bengal) have so far been formed all over India. In the empirical survey, this study considers one cluster of farmers practicing ZBNF in the Purulia district of West Bengal, India. A multi-stage sampling technique is used for the selection of district and cluster. In the first stage, Purulia district is purposively selected for the present study as it accounts for the highest number of clusters (i.e. 22 clusters out of total of 120) among the districts of West Bengal[7]. In the second stage, Hura block is purposively selected as it has the maximum number of operational clusters in the Purulia district.

In the next stage, 'Dungrigora Harambaba Gaota' cluster of Khairipihira village is purposively chosen as it has been found to practise the ZBNF model of organic farming. For the empirical survey, 25 farmer households practising ZBNF are randomly selected from the cluster. Similarly, an equal number of non-ZBNF (or chemical) farmer households who are not part of cluster but reside within the same village (i.e. Khairipihira) are also randomly selected. Thus, the study comprises a total sample size of 50 farmer households. For the purpose of collecting primary data, a face-to-face interview with the sample farmers was carried out during the agricultural production year 2015-16 (December-June). A structured questionnaire was used and designed in such a way that data for specific crops and farming activities could be collected.

Impact Assessment Methodology

In order to assess the impact of ZBNF in ensuring economic viability of the farmer households the study employs

Table 1: Calculation of DID estimator.

y_{it}	t=0 (before adoption of ZBNF)	t=1 (after adoption of ZBNF)	Difference
i=1 (say ZBNF)	y_{10}	y_{11}	$y_{11}-y_{10}$
i=0 (say non-ZBNF)	y_{00}	y_{01}	$y_{01}-y_{00}$
Change	$y_{10}-y_{00}$	$y_{11}-y_{01}$	DID = $(y_{11}-y_{01})-(y_{10}-y_{00})$

Source: own composition

'Quasi-experiments with constructed controls' design. The design basically involves comparing the attainment of specified research goals among individual households practicing ZBNF to that of households engaged in non-ZBNF (or chemical) farming practices within the study region. Among the different types of quasi-experimental designs that can be used to assess development impacts, we have used a 'differences-in-differences' (DID) method. The method basically involves five steps. In the first step, relevant performance indicators (i.e. yield, total production costs and total income) are selected. The next step involves the selection of time period. In our study, an assessment on the impact of ZBNF between 2014 (the year before the converting into ZBNF system) and 2015 (the year of shifting into ZBNF system) is estimated. The third step deals with collection of data pertaining to agricultural production, cost of cultivation, selling prices, income from agriculture and other demographic characteristics such as number of members in the family, size of land holdings etc. The data were collected for one crop (i.e. paddy), as it was the only major crop grown by the sample farmers. The next step deals with construction of control group. In this step equal numbers of representative households who are engaged in non-ZBNF practices but reside within the study area (i.e. comparable to the farmer households practicing ZBNF) are selected as control groups. The final step deals with the estimation of impact with the help of DID estimators. The basic objective of this step is to estimate whether by converting into ZBNF the farmer households are more likely to reduce the cost of cultivation and enhance yield and income than comparable control groups (i.e. households not engaged in ZBNF) in the study region and this objective is reflected by the estimators. DID estimators are numerically calculated by using a table (table 1), where the lower right cell itself represents the estimator.

Methodology of Cost Calculation

In order to work out the economics of ZBNF vis-à-vis non-ZBNF the cost of production of the cultivated crop (i.e. rice) has been computed using A_2+F_L method of cost estimation[8]. It includes several cost components which are

[7] On the basis of number of clusters as a proportion of 1 lakh hectare of sown area of the districts of West Bengal, Purulia district (10.03) is chosen as the best performing district in comparison to the state average (4.10) in this relative indicator.

[8] It is one of the most popular methods used in the estimation of production costs in agriculture. The National Commission on Farmers headed by MS Swaminathan opted for this method to compute Minimum Support Price (MSP), a form of market intervention by the Government of India to insure agricultural producers against any sharp fall in farm price. However, the method was not finally chosen (Suresh, 2018). As per the budget 2018, MSP on kharif crops at 1.5 times of their costs was based on the A2+FL costs (FE Bureau, 2018).

calculated following standard cost calculation methodology (CSO, 2008; CACP, 2012; Miglani, 2016) as below:

Cost A_1 (INR[9]/ha) = cost of hired human labour, value of bullock labour, hired machinery charges, cost of seeds, cost of fertilisers, cost of pesticides, irrigation charges, interest on working capital, land revenue and taxes, depreciation on farm implements and machinery, miscellaneous expenses.

Cost A_2 (INR/ha) = cost A_1+ rent paid on leased in land.

Cost F_L (INR/ha) = imputed value of unpaid family labour

Total Cost (TC) = cost $A_2 + F_L$

Methodology of Income Calculation

The total income for each of the farmer households under study is calculated as follows:

$TI = (Y \times P) + S - TC$

where,
TI = Total Income, INR/ha
Y = Yield, kg/ha
P = Price, INR/Qt
S = Subsidy, INR/ha
TC = Total Cost of production, INR/ha

Yield for the reference crop (i.e. paddy) is calculated by dividing total quantity of production (kg) by the cultivated area (ha) for each farmer households. Here, data on price represents farm-gate price, the price at which individual farmer sells his agricultural produce (in this case paddy) directly from the farm. In order to eliminate the possible response bias on data relating to yield, cost and price, a few specific measures were taken, such as addressing certain questions two or three times for each household, and cross-verifying the response collected from one sample farmer against the responses of other farmers. For instance, in order to validate the data on price, the responses collected from each sample farmer were matched with the responses of other fellow farmers and also with the data collected from the local intermediaries dealing in paddy.

Data collected on yield suggests lower yield for ZBNF crops compared to crops grown under chemical farming. Regarding price, we have failed to notice any price premium for the crop grown under natural farming. Instead, evidence shows that the chemical farmer received higher prices for their cultivated crop as compared to the chemical farmers. Regarding cost of cultivation evidences indicate lower cost for natural farmers compared to the chemical farmers (Table A.1)

[9] The Indian rupee (INR) is the official currency of India. As per the average exchange rate published by the Reserve Bank of India (RBI) $1 US= 61.14 INR or €1=72.52 INR in 2014-15.

Results and Discussion

In order to assess the economic viability of Zero Budget Natural Farming, the study has conducted an empirical analysis on three important parameters: cost of cultivation, yield and income. First of all, we have tried to examine whether the adoption of ZBNF can lead to a reduction in cost of cultivation for the farmers in the study region. In order to proceed with this analysis first we have calculated cost of cultivation per hectare for both ZBNF and non-ZBNF farmers covering a period of both before and after conversion to ZBNF (table A.2). Then difference-in-difference method is applied to measure the impact of shifting into ZBNF on cost of cultivation for the sample farmers.

Considering the chemical farmers as the control group, a change in total production costs per hectare of the farmers practicing ZBNF (i.e. treatment group) is also examined. Change in total production cost per hectare of treatment group (e.g. decrease by INR.587) is compared with that of the control group (e.g. increase by INR.2230) by calculating the difference-in-difference estimator (Table 2). On the whole, it can be seen that, farmers adopting ZBNF practices have experienced a considerable reduction in total production cost, whereas the non-ZBNF farmers have witnessed an increase in production costs in the same period. The relative savings in production cost (the difference-in-difference of the changes in total production cost per hectare) is INR.2817. This is reflected by the negative DID estimator.

Second, we examine whether the adoption of ZBNF can lead to an increase in yield of the crops grown by the farmers in the study region. In order to examine this fact, first we have calculated yield per hectare of the cultivated crop (i.e. paddy) for both ZBNF and non-ZBNF farmers covering a period of both before and after conversion to ZBNF. Then

Table 2: Difference-in-difference estimates of total production costs (INR/ha) before and after conversion into ZBNF.

Farmers	Before adoption of ZBNF (2014)	After adoption of ZBNF (2015)	Change
ZBNF (Treatment)	33,700	33,113	-587
Non-ZBNF (Control)	35,235	37,465	2,230
Difference	-1,535	-4,352	-2,817

Source: own composition based on survey evidence

Table 3: Difference-in-difference estimates of yield (kg/ha) before and after conversion into ZBNF.

Farmers	Before adoption of ZBNF (2014)	After adoption of ZBNF (2015)	Change
ZBNF (Treatment)	2,880	2,700	-180
Non-ZBNF (Control)	3,450	3,600	150
Difference	-570	-900	-330

Source: own composition based on survey evidence the difference-in-difference method is applied to measure the impact of shifting to ZBNF on yield for the sample farmers.

Change in yield per hectare of treatment group (e.g. decrease by 180 kg.) is compared with that of the control group (e.g. increase by 150 kg.) by calculating the difference-in-difference estimator (Table 3). Overall it can be seen that, farmers adopting ZBNF practices have experienced a slight reduction in yield for their crops, whereas the non-ZBNF farmers have witnessed an increase in yield in the same period. The relative loss in yield (the difference-in-difference of the changes in total yield per hectare) is 330 kg. This is reflected by the negative DID estimator.

Third, an empirical investigation is made to understand whether the adoption of ZBNF can lead to an increase in income for the farmer households in the study region. In order to establish this fact, the total income per hectare of both ZBNF and non-ZBNF farmers covering a period of both before and after conversion to ZBNF has first of all been computed (Table A.2). Then the difference-in-difference method has been applied to measure the impact of converting into ZBNF on income for the sample farmer households.

A general trend of increasing total income per hectare is noticeable in the post-conversion period in Purulia. The change in total income per hectare of the treatment group (e.g. increase by INR.3732) is compared with the change in total income of the control group (e.g. increase by INR.2105) by calculating the difference-in-difference estimator (Table 4). The relative gain (the difference-in-difference of the changes in total income per hectare) is INR. 1627. On the whole, it has been seen that change in total income of farmers adopting ZBNF is more prominent in comparison to the income change for chemical farmers in the study region. This is reflected by the positive DID estimator. So it can be said that the farmer's decision to convert into ZBNF resulted in an increase in income vis-à-vis non-ZBNF (or chemical) farmers in Purulia.

The entire study revolves around the performance of the cluster based on ZBNF model in rural West Bengal. Evidence from the primary survey suggests that the cluster is still continuing its natural farming activities, in spite of several challenges in the form of low yield, inaccessible markets, the absence of a price premium etc. In this section, we have tried two identify the factors that might have an impact on the long-term sustainability of this alternative model of farming in practice.

The long term sustainability of this alternative model of farming can be explained by the agro-climatic and socio-economic condition of the study region. Purulia district falls under 'Eastern Plateau and Hill Region' (Zone VII) among the six agro-climatic sub-climatic sub regions of West Bengal (Ghosh, 2019). Due to the adverse agro-climatic conditions characterised by the presence of shallow soil, soil with low water holding capacity, a shortage of rainfall (spread over only three months covering a period from mid-June to mid-September), the farmers of Purulia district predominantly practise rice based mono-cropping. Evidence from the primary survey indicates that due to this unpromising agricultural setting, the farmers of the study region are mainly engaged in a subsistence mode of farming. Evidence also reveals that before shifting into ZBNF, they were already practising a low external input-based form of farming by mainly using their family resources (such as, homemade fertilizers and family labour) and getting almost similar yields[10] like ZBNF for their cultivated crops. But after the conversion into ZBNF, the farmers were able to get agricultural inputs such as bio-fertilisers and pesticides free of charge and also received financial assistance from the government on a regular basis, which, in turn, reduced their cost of cultivation and thereby contributed to increasing their income. As a result, the farmers adopting the ZBNF model in Purulia remain economically viable and are still carrying out natural farming activities. Interestingly, any change in the above specified factors can turn this alternative model of farming into an economically non-viable livelihood strategy. For instance, in a similar study by Koner and Laha (2019) it is found that after shifting from a high input intensive chemical farming to eco-friendly organic farming the farmers in Burdwan have experienced a significant reduction in yield corresponding with no significant reduction in the cost of cultivation or increase in price (i.e. price premium) for their organic crops. As a result, this model proved to be economically non-viable.

Table 4. Difference-in-difference estimates of total income (INR/ha) before and after conversion into ZBNF.

Farmers	Before adoption of ZBNF (2014)	After adoption of ZBNF (2015)	Change
ZBNF (Treatment)	3,740	7,472	3,732
Non-ZBNF (Control)	10,650	12,755	2,105
Difference	-6,910	-5,283	1,627

Source: Own composition based on survey evidence

Conclusions and Policy Implications

In the light of growing concerns about an agrarian crisis in India marked by reduced profitability due to rising cost of inputs and stagnant output prices, the wider adoption of organic agriculture is considered to be a key strategy in effectively addressing these issues. With this in mind, the government of India is trying to promote organic farming by introducing several schemes. Various Organic models like Natural Farming, Vedic Farming, Cow Farming, Homa Farming and Zero Budget Natural Farming is being practiced across India. In this backdrop, the study has selected one cluster formed under the PKVY scheme from rural west Bengal based on the ZBNF model. The main objective of this paper has been to examine the economic viability of this alternative model of farming. For this purpose, the study has evaluated the performance of this model in terms of three important parameters: cost of cultivation, yield and

[10] The yield behaviour of farms during conversion period largely depends upon the agricultural practices followed before conversion. Conversion from a traditional low external input system of cultivation rarely results in lower yields. However, when switching from external input intensive forms of agriculture, the yield may decline significantly, at least in the initial years of conversion, until the natural soil tilth and fertility are sufficiently developed. After that it may stabilize at a comparable, lower or even higher level depending on the efficacy of organic management, quality of organic fertilizers applied, etc. (Das, 2007).

income. Evidence suggests that farmers shifting into ZBNF have experienced a reduction in production costs in the post-conversion period compared to their non-ZBNF counterparts. However, in respect of yield the evidence indicates that farmers practising ZBNF have suffered a loss as a result of their decision to convert into ZBNF, whereas the non-ZBNF farmers in the same regions have experienced an increase in yield for their crops in the same period. Though the magnitude of such loss is not massive, empirical evidence does raise some doubts as to the ability of this alternative model of farming to achieve higher yield for the cultivated crops. However, empirical evidence strongly suggests that ZBNF can play an important role in income generation for the farmers in Purulia.

The study provide insights on the challenges of this alternative method of cultivation, and factors leading to the success of ZBNF, that may be useful to the policy makers. Evidence suggests that the long term sustainability of this model is contingent upon the interplay of agro-climatic conditions and various socio-economic factors (such as the economic conditions of the farmers, past agricultural practices, yield and cost of cultivation, subsidy from the government and the presence of a market premium for agricultural produce). In the design of an appropriate policy on ZBNF, appropriate selection of crops and targeting of farmer households (small farmers' community practising a low external input-based farming) need to be accorded priority in accordance with the agro-climatic condition of that particular region. Besides, government measures are required in linking farmers practising ZBNF with the market, implementing a price support mechanism, and the provision of other forms of assistance (disbursement of a subsidy element, technical assistance with both the operation of and certification procedure for natural farming, and supplying fertilisers and pesticides) to ensure a smoother transition into ZBNF.

References

APZBNF (2019): Zero budget natural farming. Retrieved from http://apzbnf.in/faq/ (Accessed in November 2019).

Bhosle, J. (2019): Budget 2019: Zero Budget farming has few takers in the state where it originated. The Economic Times. Retrieved from https://m.economictimes.com/news/economy/agriculture/budget-2019-zero-budget-farming-has-few-takers-in-the-state-where-it-originated/articleshow/70089472.cms (Accessed in February 2020).

CACP (2012): Price policy for kharif crops the marketing season 2012-13. New Delhi: Ministry of Agriculture, Government of India.

CSO (2008): Manual on Cost of Cultivation Surveys. Central Statistical Organisation, Directorate of Economics and Statistics, Government of India. Retrieved from http://mospi.nic.in/sites/default/files/publication_reports/manual_cost_cultivation_surveys_23july08_0.pdf (Accessed in September 2019).

Das, K. (2007): Towards a Smoother Transition to Organic Farming. Economic and Political Weekly, 2243-2245. Retrieved from https://www.jstor.org/stable/4419703 (Accessed in November 2019).

Das, V. (2019): How Seriously Should We Take Sitharaman's Idea of Zero Budget Farming? The Wire. Retrieved from https://thewire.in/agriculture/union-budget-zero-budget-farming-agriculture (Accessed in November 2019).

FE Bureau (2018): Budget 2018 promise: MSP- Govt. to adopt A2+FL formula, know what this means. Financial Express. Retrieved from https://www.financialexpress.com/budget/budget-2018-promise-msp-govt-to-adopt-a2fl-formula-know-what-this-means/1060478/ (Accessed in November 2019).

Ghosh, S. (2019): Doubling Farmers' Income by 2022: Issues and Strategies for West Bengal. Department of Economic Analysis and Research, NABARD. Retrieved from https://www.nabard.org/auth/writereaddata/tender/2803195936Doubling_Final%20Report_West%20Bengal.pdf (Accessed in October 2019).

GOI (2019): Agriculture and Food Management. Economic Survey Report 2018-19, Department of Economic Affairs, Ministry of Finance, Government of India, Retrieved from https://www.thehinducentre.com/resources/article28283454.ece/binary/Economic%20Survey%20Volume%20II%20Complete%20PDF.pdf (Accessed in September 2019).

Goswami, B., Bezbaruah, M.P. and Mandal (2017): Indian Agriculture After the Green Revolution: Changes and Challenges. Routledge.

IFOAM (2019): What is Organic Agriculture? International Federation for Organic Agriculture Movement. Retrieved from https://www.ifoam.bio/en/our-library/organic-basics#What%20is%20OA. (Accessed in October 2019).

Khadse, A., Rosset, P.M., Morales, H. and Ferguson, B.G. (2018): Taking agroecology to scale: The zero budget natural farming peasant movement in Karnataka, India. The Journal of Peasant Studies, **45** (1), 192–219. http://dx.doi.org/10.1080/03066150.2016.1276450

Khadse, A. and Rosset, P.M. (2019): Zero Budget Natural Farming in India–from inception to institutionalization. Agroecology and Sustainable Food Systems, **43** (7-8), 1–24. https://doi.org/10.1080/21683565.2019.1608349

Koner, N. and Laha, A. (2019): Agricultural Sustainability through Solidarity Groups in Organic Farming: Implications on Sustainable Development Goals. SSE Knowledge Hub for SDGs, United Nations Inter-Agency Task Force on Social and Solidarity Economy (UNTFSSE). Retrieved from http://unsse.org/wp-content/uploads/2019/06/222_Koner_Agricultural-Sustainability-through-Solidarity-Groups_En.pdf (Accessed in October 2019).

Miglani, V. (2016): Economics of contract farming: A case of white onion and chip-grade potato cultivation in selected Districts of Maharashtra (Doctoral dissertation, Gokhale Institute of Politics and Economics (GIPE), Pune, India. Retrieved from https://dspace.gipe.ac.in/xmlui/bitstream/handle/10973/40205/MV-Chapter-08.pdf?sequence=9&isAllowed=y (Accessed in September 2019).

Mishra S. (2018): Zero Budget Natural Farming: Are This and Similar Practices The Answers. Nabakrushna Choudhury Centre for Development Studies, Bhubaneswar. Retrieved from http://ncds.nic.in/sites/default/files/WorkingandOccasionalPapers/WP70NCDS.pdf (Accessed in August 2019).

Naresh, R.K., Vivek, M.K., Kumar, S., Chowdhary, U., Kumar, Y., Mahajan, N.C. and Tomar, S.S. (2018): Zero budget natural farming viable for small farmers to empower food and nutritional security and improve soil health: A review. Journal of Pharmacognosy and Phytochemistry, **7** (2), 1104–1118.

Nene, Y.L. (2017): A critical discussion on the methods currently recommended to support organic crop farming in India. Asian Agri-History, **21** (4), 265–283.

Nirmal, R. (2019): We're on track to doubling farmers' income: Ashok Dalwai. Business Line. Retrieved from https://www.thehindubusinessline.com/economy/agri-business/were-on-track-

to-doubling-farmers-income-ashok-dalwai/article29565133.ece (Accessed in October 2019).
Palekar, S. (2005): The Philosophy of Spiritual Farming I (2nd Ed.). Amravati: Zero Budget Natural Farming Research Development and Extension Movement, 2nd Ed. Amaravati, Maharashtra.
Palekar, S. (2006): The Philosophy of Spiritual Farming II (2nd Ed.) Amravati: Zero Budget Natural Farming Research Development and Extension Movement, 2nd Ed. Amaravati, Maharashtra.
Parvathamma, G.L. (2016): Farmers Suicide and Response of the Government in India-An Analysis. IOSR Journal of Economics and Finance, **7** (3), 1–6.
Reddy, B., Reddy, V. and Mandala, S. (2019): Potential and Constraints of Zero Budgeted Natural Farming (ZBNF): A Study of Andhra Pradesh. Indian Journal of Agricultural Economics **74** (3), 321–332. Retrieved from https://www.researchgate.net/profile/Srinivasa_Mandala3/publication/337102276_Potential_and_Constraints_of_Zero_Budgeted_Natural_Farming_ZBNF_A_Study_of_Andhra_Pradesh/links/5e0d986da6fdcc28374ff75f/Potential-and-Constraints-of-Zero-Budgeted-Natural-Farming-ZBNF-A-Study-of-Andhra-Pradesh.pdf (Accessed in November, 2019).
Suresh, P. (2018): Explainer: How is MSP calculated in India. CNBCTV18. Retrieved from https://www.cnbctv18.com/agriculture/how-msp-is-calculated-in-india-254871.html (Accessed in November 2019).
Tripathi, S., Shahidi, T., Nagbhushan, S. and Gupta N. (2018): Zero Budget Natural Farming for the Sustainable Development Goals. Council on Energy, Environment and Water. Andhra Pradesh, India. Retrieved from https://www.ceew.in/sites/default/files/CEEW_ZBNF_Issue_Brief_2nd_Edition_19Sep18.pdf (Accessed in November 2019).
Vegesna, P (2019): Despite environmental benefits, experts doubt over the efficacy of zero budget natural farming, call for nation-wide scientific studies. Firstpost. Retrieved from https://www.firstpost.com/india/despite-environmental-benefits-experts-doubt-efficacy-of-zero-budget-natural-farming-call-for-nation-wide-scientific-studies-6956321.html, (Accessed in November 2019).
ZBSF (2019): Zbsf vs. Organic Faming. Retrieved from http://www.palekarzerobudgetspiritualfarming.org/organic.aspx (Accessed in November 2019).

Appendix

Table A.1. Descriptive statistics on Yield, Price, Cost, Revenue and Income under both farming system.

	ZBNF		Non-ZBNF	
	2014	**2015**	**2014**	**2015**
Average Yield (kg/ha)	2,880	2,700	3,450	3,600
Average Price (INR/Qt)	1,300	1,350	1,330	1,400
Average Total Revenue (Yield × Price) (INR/ha)	37,440	36,450	45,885	50,400
Average Subsidy (INR/ha)	–	4,135	–	–
Average Total Cost (INR/ha)	33,700	33,113	35,235	37,465
Average Total Income (INR/ha)	3,740	7,472	10,650	12,755

Source: Own composition based on survey evidence

Table A.2. Total income and cost of cultivation of farmers in Purulia district

Farmers	ZBNF in Purulia			
	Before conversion		After conversion	
	ZBNF	**Non-ZBNF**	**ZBNF**	**Non-ZBNF**
Cost Items				
Hired human labour wage	–	20,663	–	21,880
Value of bullock labour	4,725	–	4,782	–
Hired machinery charges	–	7,125	–	7,500
Cost of seed	1,350	1,568	1,020	1,688
Cost of fertilizers	808	1,895	0	2,034
Cost of pesticides	280	1,735	0	1,910
Irrigation charges	170	220	208	275
Interest on working capital				
Land revenue				
Depreciation on farm implements	95	116	110	163
Miscellaneous Expenses	142	375	158	450
Cost A_1	**7,570**	**33,697**	**6,278**	**35,900**
Rent paid on leased in lands	830	1,138	830	1,138
Cost A_2	**8,400**	**34,835**	**7,108**	**37,038**
Family Labour (F_L)	25,300	400	26,005	427
Total Cost (A_2+F_L) (INR/ha)	**33,700**	**35,235**	**33113**	**37,465**
Total Revenue (TR) (INR/ha)	37,440	45,885	36,450	50,400
Total Income (TR- Cost A_2+F_L) (INR/ha)	6,150	10,650	3,337	12,755
Total Income (INR/ha) **(incl. subsidy)**	**6,150**	**10,650**	**7,472**	**12,755**

Source: Own composition based on survey evidence

Peter CZINE*, Zoltan SZAKALY and Peter BALOGH***

A Review of Purchasing Preferences for Margarine among Hungarian and International Students

This paper assesses consumer preferences for margarine among Hungarian and foreign university students (studying in Hungary) by using the discrete choice experiment. The questionnaire-based survey was preceded by a focus group interview which, supplemented with knowledge gained from literature, established product attributes involved in the examination (such as price, fat, salt and sunflower oil content). Results suggest that the increase in fat and salt content result in reduced consumer utility and willingness to pay for margarine products. Sunflower oil content, however, was not found to play a significant role in consumer choices. When comparing the two groups, we found that international students tended to be more health conscious than their Hungarian counterparts.

Keywords: consumer preferences, margarine consumption, discrete choice experiment

JEL classifications: I12, M31

*University of Debrecen, Faculty of Economics and Business, Institute of Statistics and Methodology. Böszörményi út 138, 4032-Debrecen, Hungary. Corresponding author: czine.peter@econ.unideb.hu

**University of Debrecen, Faculty of Economics and Business, Institute of Marketing and Trade.

Received: 5 January 2020, Revised: 26 February 2020, Accepted: 28 February 2020.

Introduction

The examination of consumer preferences has proved to be one of the most popular topics in economics literature recently. There are a number of studies on what priorities characterise groups of different individuals in relation to certain products/services. The majority of them attempt to draw a distinction between consumer layers based on particular factors, these being primarily cultural, social, personal and other characteristics (Bhatt and Bhatt, 2015).

We are witnessing an ever-increasing emphasis being placed on health awareness in developed societies, primarily induced by the spread of civilisation diseases (cardiovascular diseases, obesity etc.). A major field in this research deals with nutrition, focusing on defining the quantity and composition of nutrient intake necessary for groups of individuals with different characteristics. This area especially considers what kind of macro and micro elements are essential to be consumed for health preservation and also what components of food intake should be reduced or avoided completely (Hamilton *et al.*, 2000; Ares and Gámbaro, 2007; Barreiro-Hurlé *et al.*, 2010; Bowen *et al.*, 2018; Loebnitz and Grunert, 2018).

Based on food research to date, the health effects of margarine can be considered quite a divisive issue. Compared to butter, its primary substitute, it contains considerably larger amounts of unsaturated fatty acids and less saturated fatty acids. However, several studies have found that this beneficial effect was not in direct proportion to the reduced risk of developing cardiovascular diseases (Ramsden *et al.*, 2016; Ajmal *et al.*, 2018; Trautwein *et al.*, 2018; *Górska-Warsewicz et al., 2019;* Kouli *et al.*, 2019). Salt content must also be mentioned as a further significant product attribute which is also known to contribute to the development of cardiovascular diseases (Mozaffarian *et al.*, 2014; Farquhar *et al.*, 2015; Shin *et al.*, 2018; Frieden and Jaffe, 2018; Jayedi *et al.*, 2019).

There are two main trends in preference assessment procedures in the literature. Revealed methods draw conclusions from the daily choices of consumers, while in the course of stated methods, hypothetical situations are analysed, making it possible to analyse decision situations involving alternatives currently not available on the market. By using the additional information gained from the latter method, companies are able to make more effective decisions as to whether certain products/services are to be launched onto the market or not, and in addition, their innovation strategies can be more successful (Georgescu, 2007; Aizaki *et al.*, 2014; Birkner *et al.*, 2017; Hanley and Czajkowski, 2019; Mendelsohn, 2019).

The discrete choice experiment belongs to the category of stated preference assessment procedures. The procedure is based on random utility theory, according to which individuals have preference for the alternative with the highest utility level for them as compared to other options. Another feature is the discrete choice situation, which means that only one option will be selected from among the elements of the decision set presented. Finally, we should mention the characteristics of the demand theory developed by Lancester (1966), assuming that the utility of products/services derive from the level of certain characteristics they contain. In most cases the completion of the experiment is preceded by focus group interviews in order to allow researchers to identify the attributes consumers deem to be the most important regarding the product/service in question, while the choices are made during the questionnaire-based survey. In the evaluation of results, focus is shifted to the choice between different models, all of which have their own advantages and disadvantages (Kjaer, 2005; Louviere *et al.*, 2010; Vossler *et al.*, 2012; Hensher *et al.*, 2015; Hess–Palma, 2019a).

In light of the factors mentioned above, the examination of consumer preferences concerning margarine, with the application of the discrete choice experiment, is likely to result in providing several novel pieces of information. The present study seeks to find out whether there is a difference in health awareness and stated preferences concerning the product in question between the Hungarian and the foreign students studying in Hungary.

Methodology

The research was conducted at the Faculty of Economics and Business of the University of Debrecen with a sample of Hungarian and international students. In compliance with the methodology of the discrete choice experiment, this was preceded by a qualitative procedure (focus group interviews with two groups of Hungarian and two groups of international students with eight participants by each group in September 2019). We chose students in higher education as a target group since they had been found to have extremely disparate divergent behaviour in terms of health awareness in several studies (Yahia *et al.*, 2008; Al-Rethaiaa *et al.*, 2010; Abraham *et al.*, 2018; Kyrkou *et al.*, 2018; Sogari *et al.*, 2018; Alkazemi, 2019; Powell *et al.*, 2019). By supplementing the results of the focus group interviews with knowledge gained from the literature, we defined the product attributes to be examined in the research. It is worth mentioning that it was obvious in the very beginning (even in the qualitative phase) that the two groups differed considerably in terms of their habits as consumers. The selected product attributes included the price (for 450-500 gram packs, in HUF and in € in the questionnaires for international students); fat and salt content (in percentage); and sunflower oil content (Table 1). In order to determine their realistic level, we examined the product supply of several supermarkets. Since we had expected linear effects, "design" coding was used while carrying out the analyses. The questionnaire-based survey was conducted in October and November 2019.

The compilation of alternatives and decision situations was carried out by using Ngene 1.2 software. The D-efficient experimental design, a fractional factorial layout was chosen, which reduces the number of decision situations in a way that the results obtained should remain statistically the most effective. Eight decision situations were generated by the program, all of which contained three product alternatives (Table 2).

Data from the discrete choice experiment were processed with the application of the Apollo 0.0.6 plug-in of the R software (Hess–Palma, 2019b). The selected model specification was a multinomial logit model (MNL) created by McFadden (1973).

The model is based on the random utility theory which means that the person choose the alternative with the highest value of utility from the elements of a decision set. In this case, we can separate the utility to a systematic (observable) and a random (non-observable) part (Equation 1).

$$U_{n,i} = \Sigma_{k=1}^{K} \beta_k X_{n,i,k} + \varepsilon_{n,i}, \tag{1}$$

where n is the person, i is the alternative, k is the attribute and $\mathcal{E}$ the non-observable part of the utility. The probability of choice (person n choose alternative *i*), according to the multinomial logit model came from Equation 2.

$$Prob_{n,i} = \frac{\exp^{\Sigma_{k=1}^{K} \beta_k X_{n,i,k}}}{\Sigma_{i=1}^{I} \exp^{\Sigma_{k=1}^{K} \beta_k X_{n,i,k}}}, \tag{2}$$

According to the model, the utility of individuals is expressed in Equation 3.

$$V_{n,i} = ASC + \beta_1 X_{Price} + \beta_2 X_{Middle\ f.} + \beta_3 X_{High\ f.} + \\ + \beta_4 X_{Middle\ s.} + \beta_5 X_{High\ s.} + \beta_6 X_{Sunflower\ oil\ cont.} , \tag{3}$$

where $V_{n,i}$ represents the systematic part of the utility of the *n*-th person in terms of the *i*-th alternative, while *ASC* stands for the alternative specific constant value, *f.* refers to fat content, *s*. to salt content and *cont*. to *sunflower oil* content.

Results

The questionnaire had three parts. The first part consisted of questions related to purchasing, consumption and health awareness. The second part contained the decision situations of the discrete choice experiment itself. In the final part, socio-demographic information was surveyed. Descriptive statistics of the sample are demonstrated in Table 3.

Table 3 clearly shows that the Hungarian sample was dominated by females, while the international one by male respondents. As to permanent residence, more than half of the Hungarian respondents live in towns and in small or medium sized towns, while in the case of the international sample, big cities dominate. Differences in the highest level of education are also observable, which is due to the fact that the international sample included more respondents already with a college degree. In terms of income, a considerable proportion of respondents in the Hungarian sample have a monthly net income above 1100 € per capita, while in the international sample, the rate of respondents with income less than 500 € was found to be relatively high.

Table 1: Attributes, their levels and coding in the discrete choice experiment.

Attribute	Attribute level	Encoding
Price	1.1 € 1.4 € 1.7 €	Continuous variable
Fat content	<31% 31-50% 50%<	1 2 3
Salt content	<0.51% 0.51-0.8% 0.8%<	1 2 3
Sunflower oil content	Contain Does not contain	1 0

Source: own composition

Table 2: An example of a decision situation.

	Alternative 1	Alternative 2	Alternative 3
Price (€)	1.4 €	1.1 €	1.7 €
Fat content (%)	50%<	<31%	<31%
Salt content (%)	<0.51%	0.51-0.8%	0.51-0.8%
Sunflower oil content	Contain	Contain	Does not contain
Is Your choice (X):			

Source: own composition

Results of the first part of the questionnaire (questions regarding purchase and consumption) are shown in Table 4

Table 4 shows that compared to Hungarian students, considerably fewer international students purchase and consume margarine. This difference has already become obvious during the focus group interviews. Furthermore, results indicate that considering price paid, in the international sample, more students purchase margarine for less than 1 € than in the Hungarian sample. Looking at the place of purchase, we can conclude that Hungarians mostly prefer discount stores, whereas international students favour super- and hypermarkets. Finally, it should be mentioned that the majority of Hungarian students rarely deviate from the brand they usually buy, while a high proportion of international students do not seem to care about brands.

Table 3: Demographic data of the respondents.

Variable	Hungarian sample (N=150)	International sample (N=134)
Gender (%)		
Male	34.7	52.3
Female	65.3	44.0
Did not respond		3.7
Age (mean)	20.6	22.2
Residence (%)		
Township	19.0	2.2
Small town	25.2	6.7
Medium city	11.6	28.4
Big city	44.2	61.9
Did not respond		0.8
Highest level of education (%)		
Graduation	86.4	23.9
Graduation and further qualification	13.6	74.6
Did not respond		1.5
Monthly net income (per capita) (%) (€)		
<500	21.2	32.1
500-800	35.7	34.3
800-1100	21.9	16.4
1100<	21.2	14.2
Did not respond		3.0
Marital status (%)		
Single	80.1	87.3
Life partner / Married	19.9	12.7

Source: own composition

Respondents also had to identify the most preferred brands in both samples. 63% of Hungarian respondents gave an answer to this open-ended question. Their preferences were as follows: Rama 52%, Delma 22%, Flora 12%, Vénusz and Bords eve (both 7%). In the international sample, only 13% of respondents named brands, presumably because of lower levels of brand loyalty. 83% of those naming a brand chose Rama margarine.

Table 4: Respondents' purchase and consumption habits.

Question	Hungarian sample	International sample
Frequency of purchase (%)		
Less frequently than monthly	27	22
1-2 times a month	37	22
1-2 times a week	6	7
3-4 times a week	2	3
Daily	0	2
Do not consume margarine	17	34
Do not know	11	10
Frequency of consumption (%)		
Less frequently than monthly	7	18
1-2 times a month	23	11
1-2 times a week	17	17
3-4 times a week	22	9
Daily	7	3
Several times a day	1	1
Do not consume margarine	19	37
Do not know	4	4
Price paid (%) (€)		
Under 1 €	3	8
Between 1 and 1.3 €	24	19
Between 1.3 and 1.6 €	26	17
Between 1.6 and 1.9 €	11	7
Above 1.9 €	2	4
Do not consume margarine	19	30
Do not know	15	15
Place of purchase (%)		
Variety store	6	2
Retail partnership	10	3
Discount store	31	15
Supermarket	19	20
Hypermarket	15	20
Do not consume	19	40
Brand loyalty (%)		
Do not care about brand	20	27
I often deviate from the brand I usually buy	11	12
I rarely deviate from the brand I usually buy	37	16
Always choose the same brand	13	7
Do not consume	19	38

Source: own composition

Table 5: Results of the Mann-Whitney test according the sample type**.**

Question	Median / Mean rank				Z-value	Effect-size
	Hungarian sample		International sample			
Health awareness	4	134.82	4	151.10	-1.718	0.1020
Calorie	3	129.64	3	156.89	-2.843**	0.1687
Distribution of nutrient content	2.5	121.45	4	166.06	-4.655**	0.2762
Glycemic index	2	122.67	3	164.70	-4.404**	0.2613
Vitamin and mineral content	4	124.58	5	162.56	-3.994**	0.2370
Sodium content	2	123.25	3	164.05	-4.301**	0.2552
Fat content	3	131.06	4	155.30	-2.533**	0.1503
Knowledge about differences between saturated and unsaturated fatty acids	3	141.62	3	143.48	-0.193	0.0115
Vegetable oils	3	123.86	4	163.37	-4.125**	0.2448
Effects of Omega 6 fatty acids	4	138.56	4	146.91	-0.872	0.0518
Think the margarines healthy	3	147.41	3	137.00	-1.092	0.0650

Note: **Significant at 5% level.
Source: own composition

As a next step, respondents were asked to assess the importance of 11 statements relating to health awareness on a six-point scale. Our aim was to find out whether there were apparent discrepancies between the two groups (Hungarian and international students), and if so, which answers to the statements were different. For the assessment, the Mann-Whitney test was applied, results of which are shown in Table 5.

Results clearly indicate that there are significant differences in 7 factors (checking the calorie content and the distribution of nutrient content in foods, avoiding products with high glycemic index, sodium content and fat content; the importance of consuming vitamins, minerals and vegetable oils) between the two groups. With regard to all these factors, it is the international students that had a higher mean score suggesting that their behaviour can be considered more health conscious than that of the Hungarian students in the sample.

Next, our aim was to find out whether there were apparent discrepancies between gender, residence, highest level of education, income and marital status levels.

Based on the results of Table 6, it can be concluded that there is significant difference in one factor (fat content) between the gender types. We can see that female students had a higher mean score in Hungarian sample and male students had a higher mean score in international sample.

On the basis of the results of Table 7, we can see that there are significant differences in two factors (health awareness, vitamin and mineral content) between the residence types in the Hungarian sample. The students who live in medium or big cities had a higher mean score according to the two factors.

Table 8 shows no significant differences between the highest level education types according the factors.

It is also observable that there is significant difference in one factor (effects of Omega 6 fatty acids) between the income level types in the Hungarian sample (Table 9). We observed that higher income level students had a higher mean score in this factor.

Table 10 suggests that there are significant differences in three factors (Vitamin and mineral content, Effects of Omega 6 fatty acids, Think that margarines are healthy) which reflect marital status type. According to our results, the students with a life partner or who were married had a higher mean score according vitamin and mineral content in the Hungarian sample and students with life partner or who were married had a higher mean score in relation to the effects of Omega 6 fatty acids and thinking that margarines are healthy in the international sample.

Table 6: Results of the Mann-Whitney test according to gender.

Question	Mean rank				Z-value		Effect-size	
	Male		Female		H	I	H	I
	H	I	H	I				
Health awareness	68.43	70.44	76.96	58.54	-1.197	-1.849	0.099	0.163
Calorie	68.90	70.08	76.71	58.97	-1.083	-1.713	0.088	0.151
Distribution of nutrient content	71.29	69.54	75.44	59.61	-0.576	-1.533	0.048	0.135
Glycemic index	70.56	65.70	75.83	64.17	-0.736	-0.237	0.061	0.021
Vitamin and mineral content	68.62	66.89	76.86	62.76	-1.148	-0.646	0.095	0.057
Sodium content	69.97	67.47	76.14	62.07	-0.864	-0.847	0.071	0.075
Fat content	61.33	72.38	80.73	56.25	-2.694**	-2.487**	0.222	0.219
Knowledge about differences between saturated and unsaturated fatty acids	68.93	66.42	76.69	63.31	-1.070	-0.478	0.088	0.042
Vegetable oils	66.17	65.44	78.16	64.47	-1.659	-0.150	0.137	0.013
Effects of Omega 6 fatty acids	72.37	67.09	74.86	62.52	-0.346	-0.704	0.029	0.062
Think the margarines healthy	68.41	69.79	76.97	59.32	-1.191	-1.619	0.098	0.143

Note: **Significant at 5% level.
Source: own composition

Table 7: Results of the Mann-Whitney test according to residence.

Question	Mean rank				Z-value		Effect-size	
	Township or Small town		Medium or Big city		H	I	H	I
	H	I	H	I				
Health awareness	65.98	72.29	80.36	66.48	-2.106**	-0.512	0.174	0.044
Calorie	68.12	65.54	78.66	67.14	-1.527	-0.140	0.126	0.012
Distribution of nutrient content	70.69	74.00	76.62	66.31	-0.860	-0.672	0.071	0.058
Glycemic index	69.68	57.08	77.42	67.98	-1.127	-0.956	0.093	0.083
Vitamin and mineral content	66.38	62.42	80.04	67.45	-1.985**	-0.447	0.164	0.039
Sodium content	69.97	58.17	77.2	67.88	-1.056	-0.860	0.087	0.075
Fat content	71.55	68.54	75.95	66.85	-0.638	-0.148	0.053	0.013
Knowledge about differences between saturated and unsaturated fatty acids	70.15	53.29	77.05	68.36	-0.993	-1.311	0.082	0.114
Vegetable oils	69.25	56.08	77.76	68.08	-1.228	-1.052	0.101	0.091
Effects of Omega 6 fatty acids	68.09	64.42	78.68	67.26	-1.534	-0.247	0.127	0.021
Think the margarines healthy	73.72	76.79	74.23	66.03	-0.074	-0.943	0.006	0.082

Note: **Significant at 5% level.
Source: own composition

Table 8: Results of the Mann-Whitney test according to highest level of education**.**

Question	Mean rank				Z-value		Effect-size	
	Graduation		Graduation and further qualification		H	I	H	I
	H	I	H	I				
Health awareness	75.43	65.14	64.95	66.94	-1.059	-0.237	0.087	0.021
Calorie	71.62	64.45	89.13	67.16	-1.749	-0.355	0.144	0.031
Distribution of nutrient content	72.52	63.66	83.38	67.41	-1.086	-0.492	0.090	0.043
Glycemic index	71.75	61.77	88.30	68.02	-1.665	-0.824	0.137	0.072
Vitamin and mineral content	75.39	64.44	65.20	67.16	-1.022	-0.363	0.084	0.032
Sodium content	71.59	66.83	89.28	66.40	-1.783	-0.058	0.147	0.005
Fat content	73.19	68.11	79.15	65.99	-0.596	-0.279	0.049	0.024
Knowledge about differences between saturated and unsaturated fatty acids	73.46	66.27	77.45	66.58	-0.396	-0.040	0.033	0.003
Vegetable oils	72.11	69.06	86.03	65.68	-1.386	-0.445	0.114	0.039
Effects of Omega 6 fatty acids	72.51	65.25	83.45	66.90	-1.093	-0.216	0.090	0.019
Think the margarines healthy	73.90	68.34	74.65	65.91	-0.075	-0.320	0.006	0.028

Source: own composition

Table 9: Results of the Mann-Whitney test according to monthly net income (per capita).

Question	Mean rank				Z-value		Effect-size	
	< 800 €		800 € <		H	I	H	I
	H	I	H	I				
Health awareness	64.17	69.21	75.38	57.44	-1.696	-1.701	0.145	0.149
Calorie	65.41	63.78	73.75	69.23	-1.245	-0.782	0.106	0.069
Distribution of nutrient content	66.05	66.38	72.90	63.59	-1.025	-0.401	0.088	0.035
Glycemic index	64.39	65.28	75.09	65.99	-1.609	-0.102	0.137	0.009
Vitamin and mineral content	65.61	64.93	73.48	66.74	-1.182	-0.265	0.101	0.023
Sodium content	68.00	65.11	70.32	66.35	-0.350	-0.181	0.031	0.016
Fat content	67.96	63.92	70.37	68.94	-0.361	-0.719	0.031	0.063
Knowledge about differences between saturated and unsaturated fatty acids	64.67	66.76	74.72	62.77	-1.492	-0.570	0.127	0.050
Vegetable oils	66.24	67.26	72.64	61.67	-0.953	-0.804	0.081	0.070
Effects of Omega 6 fatty acids	63.17	67.68	76.7	60.77	-2.021**	-0.988	0.173	0.087
Think the margarines healthy	68.18	64.67	70.08	67.3	-0.286	-0.379	0.024	0.033

Note: **Significant at 5% level.
Source: own composition

Table 10: Results of the Mann-Whitney test according to marital status**.**

Question	Mean rank				Z-value		Effect-size	
	Single		Life partner / Married		H	I	H	I
	H	I	H	I				
Health awareness	72.42	64.76	80.15	80.07	-0.918	-1.498	0.076	0.130
Calorie	73.35	65.85	76.52	71.57	-0.371	-0.555	0.031	0.048
Distribution of nutrient content	72.75	64.81	78.87	79.70	-0.719	-1.446	0.059	0.126
Glycemic index	72.86	65.03	78.45	77.97	-0.661	-1.261	0.055	0.110
Vitamin and mineral content	70.06	65.93	89.37	70.97	-2.278**	-0.497	0.188	0.043
Sodium content	72.88	66.19	78.38	68.93	-0.653	-0.270	0.054	0.024
Fat content	71.00	64.93	85.72	78.77	-1.732	-1.344	0.143	0.117
Knowledge about differences between saturated and unsaturated fatty acids	75.56	64.74	67.93	80.27	-0.889	-1.503	0.073	0.131
Vegetable oils	74.43	65.34	72.33	75.53	-0.245	-0.993	0.020	0.086
Effects of Omega 6 fatty acids	73.87	64.08	74.50	85.40	-0.074	-2.066**	0.006	0.180
Think the margarines healthy	74.05	64.16	73.80	84.77	-0.030	-2.007**	0.002	0.175

Note: **Significant at 5% level.
Source: own composition

Estimations based on the Multinomial logit model (MNL) for the total sample (involving Hungarian and international students) and for two groups are demonstrated in Table 11–13.

From the estimates of the total sample, it can be concluded that price, fat and salt content represent significant factors affecting consumer choices. All of these attributes have a negative connotation, meaning that any increase in them simultaneously results in the reduction of consumer utility. It must also be stressed that sunflower oil content is not considered a significant factor in consumers making a decision.

Table 11: Results of Total sample model estimation.

	Estimate	Standard error	t-test
ASC_alternative2	0.1952	0.0514	3.80
ASC_alternative3	-0.2408	0.0574	-4.19
Price	-0.6174	0.0003	-5.56
Medium fat content	-0.2286	0.0930	-2.46
High fat content	-0.6872	0.0654	-10.51
Medium salt content	-0.2149	0.0684	-3.14
High salt content	-0.4086	0.0691	-5.92
Sunflower oil content	-0.0076	0.0515	-0.15
Observations		2272	
R^2		0.0627	
$AdjR^2$		0.0595	
LL		-2,339.525	
AIC		4,695.05	
BIC		4,740.88	

Note: ASC_alternative1, Low fat content, Low salt content and the Does not contain sunflower oil variables represent the basis levels in estimates.
Source: own composition

Table 12: Results of the Hungarian sample model estimation.

	Estimate	Standard error	t-test
ASC_alternative2	0.1011	0.0714	1.42
ASC_alternative3	-0.2274	0.0778	-2.92
Price	-0.6424	0.0005	-4.20
Medium fat content	-0.1028	0.1276	-0.81
High fat content	-0.7132	0.0912	-7.82
Medium salt content	-0.1447	0.0929	-1.56
High salt content	-0.4195	0.0970	-4.32
Sunflower oil content	-0.0647	0.0703	-0.92
Observations		1 200	
R^2		0.0658	
$AdjR^2$		0.0597	
LL		-1,231.59	
AIC		2,479.18	
BIC		2,519.90	

Note: ASC_alternative1, Low fat content, Low salt content and the Does not contain sunflower oil variables represent the basis levels in estimates.
Source: own composition

Table 13: Results of International sample model estimation.

	Estimate	Standard error	t-test
ASC_alternative2	0.2977	0.0743	4.01
ASC_alternative3	-0.2571	0.0854	-3.01
Price	-0.6008	0.1623	-3.70
Medium fat content	-0.3843	0.1367	-2.81
High fat content	-0.6646	0.0942	-7.05
Medium salt content	-0.3025	0.1014	-2.98
High salt content	-0.4049	0.0987	-4.10
Sunflower oil content	0.0610	0.0763	0.80
Observations		1,072	
R^2		0.0647	
$AdjR^2$		0.0579	
LL		-1,101.523	
AIC		2,219.05	
BIC		2,258.86	

Note: ASC_alternative1, Low fat content, Low salt content and the Does not contain sunflower oil variables represent the basis levels in estimates.
Source: own composition

Table 14: Results of WTP estimation.

Attribute	WTP of Total sample (€)	WTP of Hungarian sample (€)	WTP of International sample (€)
Medium fat content	-0.37	-0.16	-0.64
High fat content	-1.11	-1.11	-1.11
Medium salt content	-0.35	-0.23	-0.5
High salt content	-0.66	-0.65	-0.67

Source: own composition

Findings from the Hungarian sample also suggest that an increase in price, fat and salt content reduces consumer utility (the effect of medium fat and salt content cannot be considered significant), while sunflower oil content does not influence it.

Results from the international sample shows similar trends to the ones observed with the total and the Hungarian sample. Regarding fat and salt content, the presence of health awareness is also noticeable since their increase reduces consumer utility at the same time. However, it should be noted that in contrast to the Hungarian sample, all levels of fat and salt content produced significant effects. Finally, it should also be mentioned that sunflower oil content was not found to be significant in this sample, either.

The table below (Table 14) demonstrates the results of WTP (Willingness to pay) estimation for the total sample (involving both Hungarian and international students) and for the two groups.

Based on WTP estimation, we can state that in both the Hungarian and the international samples, the increase in fat and salt content resulted in the decrease in their willingness to pay. Regarding the former attribute, compared to the low-fat (below 31%) margarine, representing a base level, Hungarians would be willing to pay approximately 0.16 € less for medium fat content and 1.11 € less for margarine with high-fat content, while the international students would be willing to pay approximately 0.64 € less for medium fat margarine and 1.11 € less for margarine with high-fat content. Taking the latter attribute into consideration, when it is compared to margarine with low (0.51%) salt content, Hungarians would be willing to pay about 0.23 € less for medium and 0.65 € less for high salt content, whereas the data in the case of international students is as follows: about 0.5 € less for margarine with medium and 0.67 € for high salt content.

Conclusions

Our research focused on the examination of consumer preferences regarding margarine. A survey was carried out among university students (Hungarian and international students studying in Hungary) in order to find out whether they indeed represent a disparate layer as had been previously demonstrated by several authors. Furthermore, we intended to establish what differences could be detected between the preferences of the members of the test groups with respect to the product selected.

Based on our results, we came to similar conclusions to the majority of the literature. Significant differences emerged even in consumer habits among the groups studied, which are primarily manifested by the fact that a relatively large proportion of international students do not consume margarine. In terms of health awareness, several differences were identified as well, which led to the conclusion that international students in the sample behaved in a more heath conscious way than Hungarian students. Based on the estimations of the multinomial logit models, it was revealed that the increase in fat and salt content reduced consumer utility and willingness to pay, and also that sunflower oil content did not represent a significant factor in making a purchase decision.

It should be noted that the applied multinomial logit model has two considerably significant limitations, one of which is the estimation of homogeneous preferences for every single respondent, and the other one is the assumption of the independence of irrelevant alternatives. Moreover, its explanatory power () can also be considered rather low, which is a conclusion that may give direction to future research with the possibilities of applying further, more complex models.

References

Abraham, S., Noriega, B.R. and Shin, J.Y. (2018): College students eating habits and knowledge of nutritional requirements. Journal of Nutrition and Human Health, **2** (1), 13–17.

Aizaki, H., Nakatani, T. and Sato, K. (2014): Stated Preference Methods Using R. CRC Press, Boca Raton.

Ajmal, M., Nadeem, M., Batool, M. and Khan, I.T. (2018): Review: Probable Ingredients for Trans Free Margarine with Omega-3 Fatty Acids. Pakistan Journal of Scientific and Industrial Research Series B: Biological Sciences, **61** (3), 182–186.

Al-Rethaiaa, A., Fahmy, A.A. and Al-Shwaiyat, N.M. (2010): Obesity and eating habits among college students in Saudi Arabia: a cross sectional study. Nutrition Journal, **9** (39), 1–10.

Alkazemi, D. (2019): Gender differences in weight status, dietary habits, and health attitudes among college students in Kuwait: A cross-sectional study. Nutrition and Health, **25** (2), 75–84. https://doi.org/10.1177/0260106018817410

Ares, G. and Gámbaro, A. (2007): Influence of gender, age and motives underlying food choice on perceived healthiness and willingness to try functional foods. Appetite, **49** (1), 148–158. https://doi.org/10.1016/j.appet.2007.01.006

Barreiro-Hurlé, J., Gracia, A. and de-Magistris, T. (2010): Does nutrition information on food products lead to healthier food choices? Food Policy, **35** (3), 221–229. https://doi.org/10.1016/j.foodpol.2009.12.006

Bhalerao, A. and Pandey, R.K. (2017): Consumer Behaviour: A literature review. International Journal of Engineering Technology Science and Research, **4** (8), 1095–1103.

Bhatt, S. and Bhatt, A. (2015): Consumer Behaviour Towards Packaged Food in Rural Areas: An Empirical Study in Ahmedabad District, Gujarat. The IUP Journal of Marketing Management, **14** (1), 7–20.

Birkner, Z., Máhr, T. and Berkes-Rodek, N. (2017): Changes in Responsibilities and Tasks of Universities in Regional Innovation Ecosystems. Nase Gospodarstvo / Our Economy, **63** (2), 15–21.

Bowen, K.J., Sulivan, V.K., Kris-Etherton, P.M. and Petersen, K.M. (2018): Nutrition and Cardiovascular Disease – an Update. Current Atherosclerosis Reports, **20** (8), 1–11. https://doi.org/10.1007/s11883-018-0704-3

Farquhar, W.B., Edwards, D.G., Jurkovitz, C.T. and Weintraub, W.S. (2015): Dietary Sodium and Health: More Than Just Blood Pressure. Journal of the American College of Cardiology, **65** (10), 1042–1050. https://doi.org/10.1016/j.jacc.2014.12.039

Frieden, T.R. and Jaffe, M.G. (2018): Saving 100 million lives by improving global treatment of hypertension and reducing cardiovascular disease risk factors. Journal of Clinical Hypertension, **20** (2), 208–211. https://doi.org/10.1111/jch.13195

Georgescu, I. (2007): Fuzzy choice functions. Springer Berlin Heidelberg, New York.

Górska-Warsewicz, H., Rejman, K., Laskowski, W. and Czeczotko, M. (2019): Butter, Margarine, Vegetable Oils, and Olive Oil in the Average Polish Diet. Nutrients, **11** (12), 1–15. https://doi.org/10.3390/nu11122935

Hamilton, J., Knox, B., Hill, D. and Parr, H. (2000): Reduced fat products: Consumer perceptions and preferences. British Food Journal, **102** (7), 494–506. https://doi.org/10.1108/00070700010336454

Hanley, N. and Czajkowski, M. (2019): The Role of Stated Preference Valuation Methods in Understanding Choices and Informing Policy. Review of Environmental Economics and Policy, **13** (2), 248–266. https://doi.org/10.1093/reep/rez005

Hensher, D.A., Rose, J.M. and Greene, W.H. (2015): Applied Choice Analysis. Cambridge University Press, Cambridge, United Kingdom.

Hess, S. and Palma, D. (2019a): Apollo: a flexible, powerful and customisable freeware package for choice model estimation and application. Journal of Choice Modelling, **32**, 100170, https://doi.org/10.1016/j.jocm.2019.100170

Hess, S – Palma, D. (2019b): Apollo version 0.0.6, user manual. www.ApolloChoiceModelling.com (Accessed in September 2019)

Jayedi, A., Ghomashi, F., Zargar, M.S. and Shab-Bidar, S. (2019): Dietary sodium, sodium-to-potassium ratio, and risk of stroke: A systematic review and nonlinear dose-response meta-analysis. Clinical Nutrition, **38** (3), 1092–1100. https://doi.org/10.1016/j.clnu.2018.05.017

Kjaer, T. (2005): A review of the discrete choice experiment – with emphasis on its application in health care. University of Southern Denmark, Health Economics Papers, 2005:1, 143p.

Kouli, G., Panagiotakos, D.M., Kyrou, I., Magriplis, E., Georgousopoulou, E.N., Chrysohoou, C., Tsigos, C., Tousoulis, D. and Pitsavos, C. (2019): Olive oil consumption and 10-year (2002-2012) cardiovascular disease incidence: the ATTICA study. European Journal of Nutrition, **58** (1), 131–138. https://doi.org/10.1007/s00394-017-1577-x

Kyrkou, C., Tsakoumaki, F., Fotiou, M., Dimitropoulou, A., Symeonidou, M., Menexes, G., Biliaderis, C.G. and Michaelidou, A. (2018): Changing Trends in Nutritional Behavior among University Students in Greece, between 2006 and 2016. Nutrients, **10** (1), 64. https://doi.org/10.3390/nu10010064

Lancaster, K.J. (1966): A New Approach to Consumer Theory. Journal of Political Economy, **74** (2), 132–157.

Lin, X., Featherman, M., Brooks, S.L. and Hajli, N. (2018): Exploring Gender Differences in Online Consumer Purchase Decision Making: An Online Product Presentation Perspective. Information Systems Frontiers, **21** (5), 1187–1201. https://doi.org/10.1007/s10796-018-9831-1

Loebnitz, N. and Grunert, K.G. (2018): Impact of self-health awareness and perceived product benefits on purchase intentions for hedonic and utilitarian foods with nutrition claims. Food Quality and Preference, **64**, 221–231. https://doi.org/10.1016/j.foodqual.2017.09.005

Louviere, J.J., Flynn, T.N. and Carson, R.T. (2010): Discrete Choice Experiments Are Not Conjoint Analysis. Journal of Choice Modelling, **3** (3), 57–72. https://doi.org/10.1016/S1755-5345(13)70014-9

McFadden, D. (1973): Conditional logit analysis of qualitative choice behaviour, 105–142. In: Frontier in Econometrics. Academic Press, New York, USA.

Mendelsohn, R. (2019): An Examination of Recent Revealed Preference Valuation Methods and Results. Review of Environmental Economics and Policy, **13** (2), 267–282. https://doi.org/10.1093/reep/rez003

Mozaffairan, D., Fahimi, S., Singh, G. M., Micha, R., Khatibzadeh, S., Engell, R. E., Lim, S., Danaei, G., Ezzati, M. and Powles, J. (2014): Global Sodium Consumption and Death from Cardiovascular Causes. New England Journal of Medicine, **371** (7), 624–634. https://doi.org/10.1056/NEJMoa1304127

Powell, P.K., Durham, J. and Lawler, S. (2019): Food Choices of Young Adults in the United States of America: A Scoping Review. Advances in Nutrition **10** (3), 479–488. https://doi.org/10.1093/advances/nmy116

Ramsden, C.E., Zamora, D., Majchrzak-Hong, S., Faurot, K.R., Broste, S.K., Frantz, R.P., Davis, J.M., Ringel, A., Suchindran, C.M. and Hibbeln, J.R. (2016): Re-evaluation of the traditional diet-heart hypothesis: analysis of recovered data from Minnesota Coronary Experiment (1968-73). BMJ, **353**, i1246. https://doi.org/10.1136/bmj.i1246

Shin, C., Keller, C., An, K. and Sim, J. (2018): Cardiovascular Disease in Korean Americans: A Systematic Review. Journal of Cardiovascular Nursing, **33** (1), 82–93. https://doi.org/10.1097/JCN.0000000000000417

Sogari, G., Velez-Argumedo, C., Gómez, M.I. and More, C. (2018): College Students and Eating Habits: A Study Using An Ecological Model for Healthy Behaviour. Nutrients, **10** (12), 1823. https://doi.org/10.3390/nu10121823

Trautwein, E.A., Koppenol, W.P., de Jong, A., Hiemstra, H., Vermeer, M.A., Noakes, M. and Luscombe-Marsh, N.D. (2018): Plant sterols lower LDL-cholesterol and triglycerides in dyslipidemic individuals with or at risk of developing type 2 diabetes; a randomized, double-blind, placebo-controlled study. Nutrition and Diabetes, **8** (1), 1–13. https://doi.org/10.1038/s41387-018-0039-8

Vossler, C.A., Doyon, M. and Rondeau, D. (2012): Truth in Consequentiality: Theory and Field Evidence on Discrete Choice Experiments. American Economic Journal, **4** (4), 145–171. https://doi.org/ 10.1257/mic.4.4.145

Yahia, N., Achkar, A., Abdallah, A. and Rizk, S. (2008): Eating habits and obesity among Lebanese university students. Nutrition Journal, **7** (32), 1–6. https://doi.org/10.1186/1475-2891-7-32

Krisztián KOVÁCS* and István SZŰCS*

Exploring efficiency reserves in Hungarian milk production

This paper aims to explore the efficiency of Hungarian dairy farms. Based on FADN data representing more than 950 dairy farms in Hungary, our sample contains more than 6800 data points which we analysed by applying different Data Envelopment Analysis models. Results suggest that the average technical efficiency of the Hungarian dairy sector during the examined 10 years was 77.6%, meaning that output could be increased by 22.4% without changing the level of input (efficiency reserve). Large and small farms are more efficient (79.2%) than medium sized farms (59.2%). Moreover, large farms keeping more than 501 dairy cows were found to be more efficient (92.5%) than the other two size categories (77.9% and 65%, respectively). Farms located in Northern Hungary had less efficiency reserves (23.6%) that the farms operating in the Great Hungarian Plain, Central Hungary (34.8%) or in the Transdanubian Region (27.6%). All this suggests high reserves for potential efficiency growth.

Keywords: DEA, dairy farms, efficiency, Hungary, milk sector

JEL classifications: Q12, Q13

* University of Debrecen, Faculty of Economics and Business, Institute of Applied Economic Sciences. Böszörményi út 138, 4032-Debrecen, Hungary. Corresponding author: kovacs.krisztian@econ.unideb.hu

Received: 2 October 2019, Revised: 16 December 2019, Accepted: 7 January 2020.

Introduction

Milk and milk products play an important role in human nutrition; thus milk production is an important issue in the global food supply chain, particularly in developing countries. Milk is one of the most valuable human staple foods of high nutritional value. Although many nutrients and vitamins are found in vegetables and can be produced synthetically as well, this type of animal protein is essential for a balanced diet.

Consequently, in terms of global nutrition supply, it is essential to increase milk production efficiency in the future to meet the enormous dairy product demand of explosive global population growth. From an economics as well as a social perspective, increasing the efficiency level of milk production is a highly important issue for most countries of the world. Production efficiency should be a priority area for both European Union and Hungarian dairy farms to ensure that a single dairy farm can also produce milk competitively and efficiently for the national and global markets in an economically, socially and ecologically sustainable way.

Oligopolistic Hungarian dairy processors exhibit price setting behaviour directed towards the milk producers, who have to follow a price-taking behaviour in the market because of their low level of market concentration. If milk producers want to increase their profitability, the only way of doing so is to increase their efficiency level.

The aim of this paper is to explore the efficiency of Hungarian milk production. More concretely, we would like to answer the following research questions:

1. What differences are observable in the overall technical efficiency of Hungarian dairy farms between 2008 and 2017?
2. What differences can be observed in the technical efficiency of Hungarian small, medium and large scale dairy farms?
3. What differences exist in the three main Hungarian regions' technical efficiency indicators for milk production?

Global cow milk production has shown a continuously rising trend in the last three decades. According to Fasostat (2019) data, global cow milk production has increased by more than 50 percent between 1983 (450 million tonnes) to 2017 (678 million tonnes). The biggest cow milk producer in terms of quantity in the world is Europe (32.69%), followed by Asia (30.18%) and the American continent (27.21%). Hungary produced 1.967 million tonnes of milk in 2017, which was around 0.29 % of the global and 0.89% of the European production (Faostat, 2019). Regarding countries, the biggest cow milk producer in the world was the European Union in 2017 with 164.5 million tonnes of production, giving around 24.27% of global production alone (Table 1).

As to trade, global cow milk exports – measured as milk equivalent – totalled 126.6 million tonnes in 2017, out of which 59.51% came from the European Union (75.34 million tonnes), while 14.74% (18.66 million tonnes) came from New Zealand. Inside the EU, the biggest milk exporter country was Germany (16.21 million tonnes), followed by the Netherlands (11.81 million tonnes). On the import side, 125.25 million tonnes of cow milk were imported all around the globe in 2017, most of which went to the European Union (45%) and China (11%).

In the case of Hungary, milk production has been continuously increasing since 2009, and it has now reached 1.924 million tonnes per year (HCSO, 2019). Production in terms

Table 1: The TOP 5 cow milk producers in 2017.

Country	Cow milk production (tonnes)	Share (%)
European Union	164,472	24.27
United States of America	97 762	14.43
India	83,634	12.34
Brazil	33,312	4.92
China	30,772	4.54
Total	677,671	100.00

Source:own calculations based on Faostat (2019) data

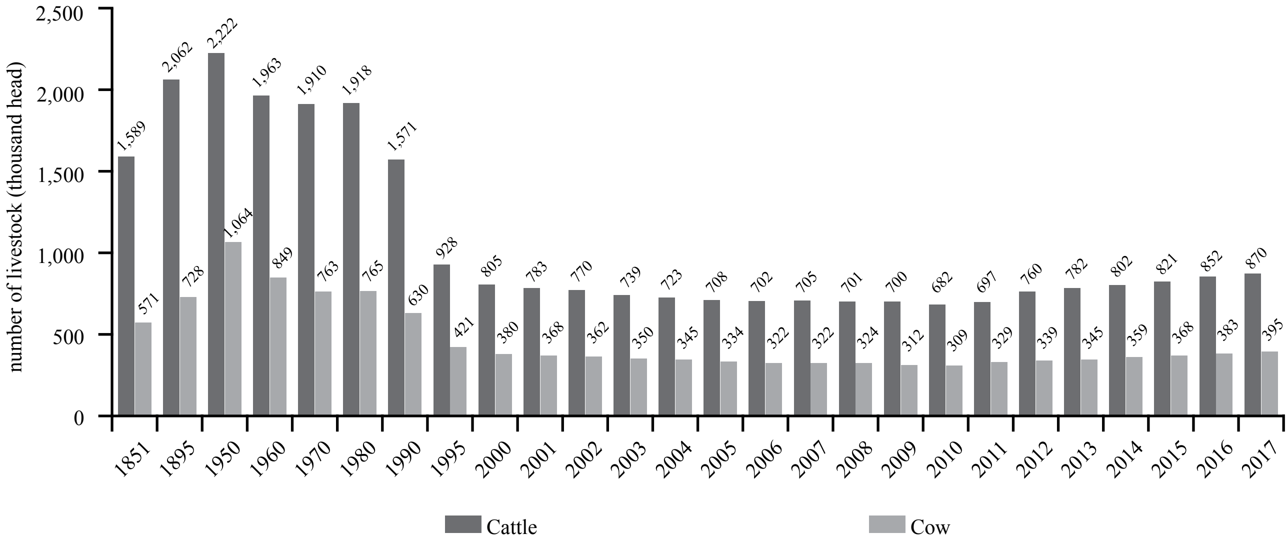

Figure 1: Hungarian cattle and cow livestock numbers from 1851 to 2017.

Source: own composition based on HCSO (2019) data

Table 2: Regional share of Hungarian cattle and cow livestocks.

Region	Cattle			of which: cow	Livestock per 100 hectares
	Corpo-rations	Indi-vidual farms	in total	in total	
Budapest	7.0	0.7	7.7	2.5	16
Pest Region	42.4	29.5	71.9	26.8	21
Central Hungary	**49.3**	**30.2**	**79.5**	**29.3**	**20**
Central Transdanubia	72.4	35.9	108.3	51.3	18
Western Transdanubia	79.1	36.9	116.0	50.6	20
Southern Transdanubia	68.0	41.7	109.6	51.9	14
Transdanubia	**219.5**	**114.4**	**333.9**	**153.9**	**17**
Northern Hungary	45.8	36.0	81.8	42.9	14
Northern Great Plain	116.9	93.4	210.3	94.6	18
Southern Great Plain	84.3	95.0	179.3	82.2	15
Great Plain and Northern Hungary	**247.0**	**224.4**	**471.4**	**219.6**	**16**
Total	**515.8**	**369.0**	**884.8**	**402.8**	**17**

Source: own calculations based on HCSO (2019) data

of quantity was the highest in 1988 when Hungarian annual milk production was 2.95 million tonnes, coinciding with a record number of dairy cows (2.5 million). Cattle numbers have significantly decreased since 1990 - in 2017, Hungary had 630,000 cattle and 395,000 cows (Figure 1).

Table 2 summarises Hungarian cattle and cow livestock numbers in a regional breakdown. The Great Plain represents 44.02% of the total cattle livestock and 43.89% of the cow livestock, followed by Northern Hungary (9.26% and 10.65%) and the Transdanubia region (37.74% and 38.21%), respectively. Average cattle density in Hungary is 17 dairy cows/100 ha (HCSO, 2019).

Figure 2 shows basic efficiency indicators of Hungarian milk production. The number of dairy cows has been dramatically decreasing until 2010, but annual milk production seems to have stagnated around 1.8 million tonnes, implying an increasing yield per dairy cow indicator. Yield growth of milk production per dairy cow is clearly observable from 5000 litres/head to 8000 litres/head on average from 1990 to 2017.

Measuring the productive efficiency of the dairy sector is important to both the practical experts and the policymakers. *"If economic planning is to concern itself with practical industries, it is important to know how far a given industry can be expected to increase its output by simply increasing its efficiency, without absorbing further resources."* (Farrell, 1957) Thus, measuring the technical performance can be important for the sector not only with the purpose of increasing the dairy cows' yield performance, but also for increasing the efficiency of other resources, as well as for raising incomes at individual dairy farms. The question of considerable substance is how we can measure dairy farms' performance, using not only one output and one input, but also several parameters, which best represent dairy farm management practices.

In the scientific literature, a number of different papers can be found analysing a country's technical efficiency with different methods. Based on the excellent work of Bravo-Ureta *et al*. (2007), Table 3 summarises the most important papers written until 2005. A recent review on available articles in the topic was provided by Galluzzo (2019).

Method and data

Measuring efficiency is a widely used concept in economics. Economic (or overall) efficiency is expressed as a combination of technical and allocative (or price) efficiencies. Technical efficiency is the ability of the farmer to obtain maximal output from a given set of inputs, while allocative efficiency measures the ability of the farmer to use inputs in optimal proportions, given their input prices and technology (Coelli *et al*., 2005). Various methods exist in economics to measure efficiency, out of which probably the most well-known is Data Envelopment Analysis (DEA).

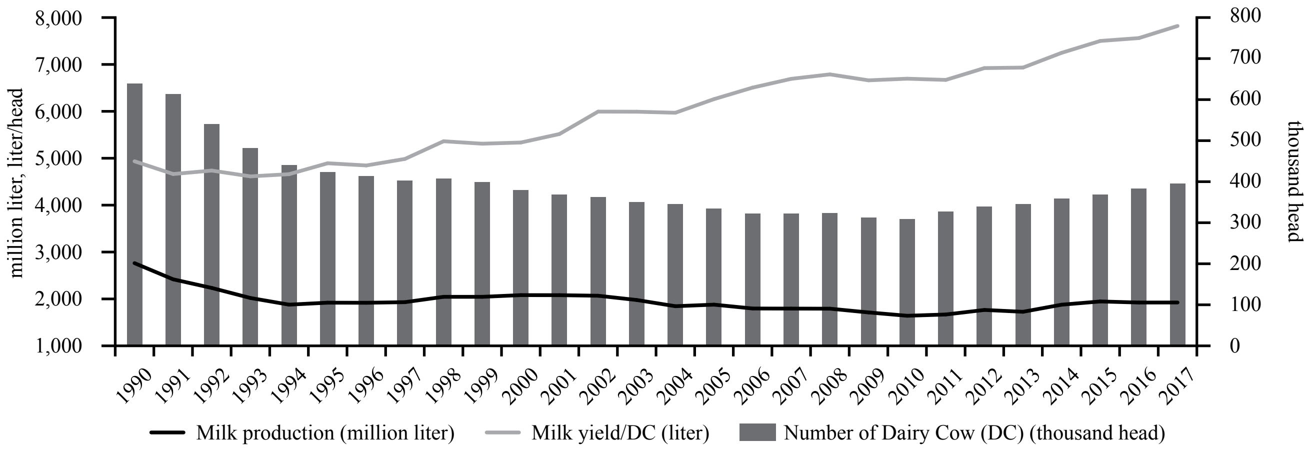

Figure 2: Hungarian milk production and its efficiency.

Source: own calculations based on HCSO (2019) data

Table 3: Most important articles measuring efficiencies in the dairy sector, 1990-2005.

Author	Year	Country	Sector	Sample	Average technical efficiency
		I. Non-parametric (DEA)			
FRASER	1999	Australia	Milk	50	88.5
ASMILD	2003	The Netherlands	Milk	1,808	80.5
LATRUFFE	2004	The Netherlands	Milk and Grain	222	64.0
LATRUFFE	2005	The Netherlands	Milk and Grain	199	69.8
REINHARD	2000	The Netherlands	Milk and Grain	1,535	79.7
CLOUTIER	1993	Canada	Milk	187	89.8
WEERSINK	1990	Canada	Milk	105	91.8
PIESSE	1996	Slovenia	Milk	272	93.0
JAFORULLAH	1999	New-Zealand	Milk	264	89.0
TAUER	1993	USA	Milk	395	78.3
TAUER	1998	USA	Milk and Beef	630	91.8
THOMAS	1994	USA	Milk	125	89.2
		II. Parametric methods: Deterministic frontier (DF)			
KARAGIANNIS	2002	United Kingdom	Milk	2,147	77.6
MAIETTA	2000	Italy	Milk	533	55.0
HALLAM	1996	Portugal	Milk	340	62.5
ALVAREZ	1999	Spain	Milk	410	72.0
ALVAREZ	2004	Spain	Milk	196	70.0
OREA	2004	Spain	Milk	445	65.9
PIESSE	1996	Slovenia	Milk	272	57.5
TURK	1995	Slovenia	Milk	272	77.1
AHMAD	1996	USA	Milk	1,072	76.5
BRAVO-URETA	1986	USA	Milk	222	82.2
BRAVO-URETA	1990	USA	Milk	404	63.3
POE	1992	USA	Milk	675	74.8
TAUER	1987	USA	Milk	432	69.3
		Stochastic frontier (SFA)			
BATTESE	1988	Australia	Milk	336	70.7
DAWSON	1987	United Kingdom	Milk	434	85.3
DAWSON	1988	United Kingdom	Milk	406	81.0
DAWSON	1990	United Kingdom	Milk	306	86.9
DAWSON	1991	United Kingdom	Milk	306	86.0
BAILEY	1989	Equator	Milk	68	78.1
BRÜMMER	2002	Germany, Poland, The Netherlands	Milk	300	86.9
CUESTA	2000	Spain	Milk	410	82.7
AHMAD	1996	USA	Milk	1,072	81.0
BRAVO-URETA	1990	USA	Milk	404	83.9
BRAVO-URETA	1991	USA	Milk	511	83.0

Source: own composition based on Bravo-Ureta *et al*. (2007)

Farell (1957) distinguishes input and output orientated measures depending on which factor we assume altering. In the input orientated measure, the input quantities change without changing the output quantities. The assumed objective is to reduce the input quantities as much as possible, without changing the output quantities. The other measure of efficiency referred to by both Farell (1957) and Coelli *et al.* (2005) is the output orientated measure. Here the question is by how much output quantities can be proportionally expanded without altering the input quantities. If technology is characterised by constant returns to scale, the two orientations produce the same technical efficiency score. Differences, however, appear under changing returns to scale.

Figure 3 presents technical efficiencies from an output orientation, considering a firm with two outputs (q_1 and q_2) and a single input (x_1). Keeping input quantity fixed, ZZ' represents the production possibility curve and point B represents an efficient, while point A an inefficient firm. The distance AB measure shows the technical inefficiency, hence the output orientated technical efficiency is the ratio of 0A and 0B, which shows the percentage by which outputs could be increased without requiring extra input.

The input and the output orientated models estimate the same frontier and identify the same set of firms as being efficient. The difference is the efficiency measures associated with the inefficient firms that may differ between the two methods (Coelli *et al.*, 2005). In practice, the efficient isoquant is not known, hence researchers have to estimate it from the sample data using different kinds of analyses. These will be introduced in the following section.

The DEA framework was introduced by Farrell (1957) and popularised by Charnes *et al.* (1978). It is a non-parametric mathematical programming approach to frontier estimation. The first models were the input orientated CRS models, solving the following linear programming problem for each firm to obtain the efficiency score:

$$\max_{u,v} (u'y_i / v'x_i), \quad \text{constrains: } u'y_j / v'x_j \leq 1, \quad j = 1, 2, \ldots, N, \quad u,v \geq 0 \tag{1}$$

assuming K inputs and M outputs for each N firms. For the i-th firms the column vectors are represented by x_i and y_i,

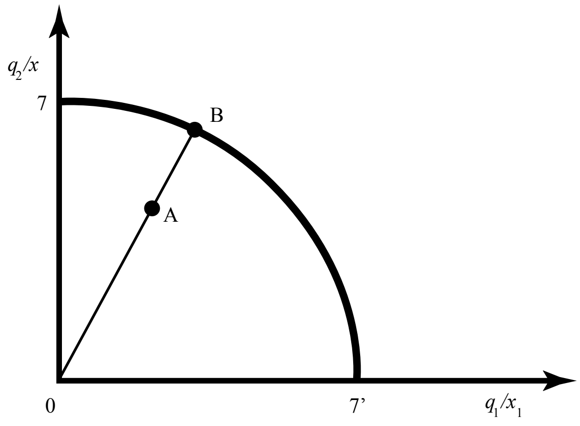

Figure 3: Technical efficiency from an output orientation.

respectively. X indicate the K*M input matrix and Y shows the M*N output matrix for all N firms. To measure efficiency we want to obtain the measure of the ratio of all outputs over all inputs, like $u'y_i / v'x_i$, where u represents the M*1 vector of output weights and v represents the K*1 vector of input weights. The obtained efficiency score will be less than or equal to one. As this model has an infinite number of solutions, Charnes *et al.* (1978) added one more constrain ($v'x_i = 1$) and reformulated the objective function a bit, thereby creating the multiplier form of DEA. Using the duality linear programming method from the multiplier formula, we get the envelopment form as follows:

$$\text{xmin}_{\theta\lambda}\, \theta, \quad \text{constrains: } -y_j + Y\lambda \geq 0, \quad \theta x_i - X\lambda \geq 0, \quad \lambda \geq 0, \tag{2}$$

where λ represents the vector of peer weights. θ is a scalar and its value is the efficiency score for the i-th firm, where the value of 1 indicates the frontier and hence a technically efficient firm (which does not exist in practice). This linear programming problem must be solved N times, once for each firm in the sample. Hence, each firm has its own θ efficiency score (Coelli *et al.*, 2005). The points of the fully efficient firms determine the fully efficient frontier line.

Equation 2 takes the *i-th* firm and then seeks to radially contract the input vector, x_i, as much as possible, while still remaining within the feasible input set. The inner boundary of this set is a piece-wise linear isoquant (see Equation 1), determined by the observed data points which are the firms in the sample. The radial contraction of the input vector, x_i, produces a projected point, ($Y\lambda$, $X\lambda$), on the surface of this method. This projected point is a linear combination of these observed data points. The constraints in Equation 2 ensure that this projected point cannot lie outside the feasible set (Coelli *et al.*, 2005).

The constant returns to scale assumption is acceptable if the firms in the sample are operating at an optimal scale, but in practise, firms with imperfect competition do not behave like that. Banker *et al.* (1984) suggested a model which deals with a variable returns to scale (VRS) situation. This model is quite similar to the CRS model except by adding a convexity constraint ($N1'\lambda = 1$) to the model, accounting for the variable returns to scale.

The approach by Banker *et al.* (1984) and Coelli and Perelman (1996) presents an output oriented model, where firms have fixed quantity of resources (capital, labour, livestock and land) and want to produce output (milk and calf) as much as possible. This model is very similar to the input orientated model. The formula of an output orientated VRS model is the following:

$$\max_{\phi\lambda} \phi, \quad \text{constrains: } -\phi y_j + Y\lambda \geq 0, \quad x_i - X\lambda \geq 0, \quad N1'\lambda = 1, \quad \lambda \geq 0, \tag{3}$$

where N1 is an N*1 vector of ones, $1 \leq \phi < \infty$ and $\phi-1$ is the proportional increase in output that could be achieved by the i-th firm, with input quantities held constant. $1/\phi$ determine the technical efficiency score, which lies between zero and one. The DEA VRS formula envelopes the data points more tightly and provides higher or equal efficiency scores than the CRS model. The difference between the VRS and CRS technical efficiency scores is the scale inefficiency.

In this paper, we use the European Farm Accountancy Data Network (FADN) database, containing, inter alia, Hungarian dairy farm level data from 2008 to 2017. We use two output variables in our output orientated DEA model - the first is *cow's milk and milk products* (values expressed in euro in the database under the following code: SE216), while the second is the *beef and veal variable* (values expressed in euro in the database under the following code: SE220). For the farms model (Kovacs, 2014), the five input variables were as follows:

1. *Total fixed assets:* It includes land associated to agricultural activity and the buildings and is expressed in euro. These assets remain constant all the times, or at least for a prolonged time to serve the population of economic activity and they do not or just slightly wear out during production. This is shown under the following code in the FADN database: SE441.
2. *Total current assets:* The current assets comprise stocks and other rotating equipment and expressed in euro. This variable is basically the value of breeding animals which wear during production, or stocks wholly destroyed, or else pass through the target assets, so their continuous replacement is essential. The following code is associated in the FADN database: SE465.
3. *Labour input:* It contains the total number of working hours under the code SE011.
4. *Major cost items:* Most important cost categories pertain here and these items are also expressed in euro. This category includes livestock feed and energy costs as well as the value of the plant and lubricants as well. Direct costs also pertain here, containing veterinary expenses, but including a variety of tests or storage costs that can be directly charged to the sector. These are listed under the following codes in the FADN database: SE310 + SE330 + SE345.
5. *Dairy cows:* This category includes cows expressed in European Livestock Units (LSU) which are held primarily for milk production. This can be found under the following code in the FADN database: SE085.

The database contains 6818 data points, which includes data from about 974 dairy farms in Hungary. Efficiency indicators of dairy farms were analysed between 2008 and 2017. We presumed an output orientation DEA model, estimating to what extent production (outputs) can be proportionally increased (maximised) without changing the input quantities used (Kovacs, 2014).

Based on farms' standard production values, three categories can be created:

1. small farms (annual SPV between 4 000€ and 25 000€);
2. medium farms (annual SPV between 25 000€ and 500 000€) and
3. large farms (annual SPV more than 500 000€).

Among the examined 974 farms, 24% was large, 61% was medium and 15% was considered small.

As to livestock sizes, categories are as follows:

1. small farms (less than 50 dairy cows)
2. medium farms (between 51 and 500 cows)
3. large farms (more than 501 cows)

Large farms represents 8%, medium farms 41% and small farms 51% out of the total 974 dairy farms in this regard.

In terms of geographical regions, the majority of the farms (59%) were located in the Great Hungarian Plain and Central Hungary (574 farms). 30% of the farms in the sample (294 farms) was located in the Transdanubian Region and only 11% were located in Northern Hungary (106 farms).

The efficiency of Hungarian milk production

Before presenting results of our model runs, Table 4-7 contain the descriptive statistics of our variables used.

It becomes evident from our model runs that the effectiveness of the Hungarian dairy farms is 77.60% on average (Table 7). This means that effective backup solution (reserves) lies in an average of 22.40% of the Hungarian milk producing farms. In other words, Hungarian milk producers can still have an opportunity to increase their efficiency by 22.40% simply by using their inputs more effectively.

According to Table 8, the most efficient years were 2011 and 2013, reflecting the record low levels of cattle livestock as evident from Figure 1. The biggest technical efficiency reserves was observable in 2009, where Hungarian dairy farms could have increased their output by 28.7% without using more inputs for milk production. Table 8 also reflects declining efficiency scores after 2013.

Table 9 shows our results by farm size. Efficiency of large farms was the highest with 79.2% technical efficiency, followed by 71.2% of technical efficiency for small farms and 59.2% technical efficiency of medium farms. This means that small farms are found to be more efficient than medium ones and the difference between the efficiency of small and large farms is not remarkable. On average, Hungarian dairy farms can increase their efficiency by 30%.

As to results by livestock sizes, the highest efficiency number belongs again to large farms (92.5%), which means that they are close to their possible production frontier curve line; their efficiency reserve is 7.5%. Efficiency of medium farms was 77.9%, while that of small farms was 65% (Table 10). It should be noted that medium size farms based on livestock sizes were found to be more efficient than on a simple farm size basis.

Last but not least, the technical efficiency by the three geographic regions was calculated. As evident from Table 11, the most efficient region was the Northern Hungarian Region, with a technical efficiency of 76.4%. It should be

Table 4: Sample descriptive statistics by year.

Year	Cows' milk & milk products production (EUR)	Beef and veal production (EUR)	Total fixed assets (EUR)	Total current assets (EUR)	Labour input (hour)	Major direct cost (EUR)	Number of dairy cows (head)	Total number of farms (pieces)
2008	373,823	60,575	650,211	399,047	26,513	321,832	175	92
2009	281,889	45,010	562,776	331,901	19,415	240,213	142	110
2010	319,018	54,140	647,938	369,104	23,018	300,767	154	95
2011	402,807	80,091	867,799	534,022	29,873	389,513	177	90
2012	438,706	67,286	1,017,289	572,164	32,849	456,017	187	94
2013	483,666	67,620	1,094,249	587,617	33,378	481,023	200	87
2014	494,489	69,909	985,012	519,910	32,843	368,906	193	93
2015	412,914	58,714	924,484	483,252	30,495	347,278	194	109
2016	390,542	64,160	913,995	492,201	29,803	343,227	198	100
2017	476,826	63,947	883,324	498,396	28,099	421,946	191	104
Average	**405,457**	**62,681**	**849,944**	**475,702**	**28,463**	**364,212**	**181**	**97**
Standard Deviation	**1,012,899**	**139,091**	**2,066,493**	**1,163,696**	**68,579**	**894,611**	**368**	**8**
Minimum	100	49	2,119	1,710	270	552	2	87
Maximum	11,034,750	1,643,210	23,553,110	13,789,835	743,486	11,034,030	3,492	110

Source: own calculations based on FADN (2019) data

Table 5: Sample descriptive statistics by farm size.

Farm size category	Cows' milk & milk products production (EUR)	Beef and veal production (EUR)	Total fixed assets (EUR)	Total current assets (EUR)	Labour input (hour)	Major direct cost (EUR)	Number of dairy cows (head)	Total number of farms (pieces)
Large	945,194	135,374	1,784,327	1,019,456	71,546	862,764	407	229
Medium	189,051	36,320	426,814	218,417	16,727	170,284	103	599
Small	137,577	24,491	276,178	171,455	12,366	127,854	70	146

Source: own calculations based on FADN (2019) data

Table 6: Sample descriptive statistics by livestock size.

Livestock's size category	Cows' milk & milk products production (EUR)	Beef and veal production (EUR)	Total fixed assets (EUR)	Total current assets (EUR)	Labour input (hour)	Major direct cost (EUR)	Number of dairy cows (head)	Total number of farms (pieces)
Large	2,453,505	371,909	4,382,150	2,585,674	180,516	2,209,447	1,015	79
Medium	365,455	58,027	754,328	407,913	30,839	334,115	190	397
Small	23,147	7,989	120,568	47,897	3,540	23,466	19	498

Source: own calculations based on FADN (2019) data

Table 7: Sample descriptive statistics by region.

Region	Cows' milk & milk products production (EUR)	Beef and veal production (EUR)	Total fixed assets (EUR)	Total current assets (EUR)	Labour input (hour)	Major direct cost (EUR)	Number of dairy cows (head)	Total number of farms (pieces)
Great Hungarian Plain and Central Hungary	312,884	55,591	606,434	331,060	25,927	290,119	155	574
Transdanubia	453,031	62,466	954,236	536,351	33,976	412,761	201	294
Northern Hungary	338,652	56,744	686,329	376,273	30,980	277,204	156	106

Source: own calculations based on FADN (2019) data

Table 8: Technical efficiency numbers in the Hungarian dairy sector by year.

Year	No. of firms	crsTE	vrsTE	Scale	Efficiency reserves
2008	92	0.746	0.785	0.949	0.215
2009	110	0.627	0.713	0.891	0.287
2010	95	0.668	0.731	0.919	0.269
2011	90	0.744	0.822	0.909	0.178
2012	94	0.742	0.779	0.954	0.221
2013	87	0.875	0.841	0.940	0.159
2014	93	0.752	0.817	0.920	0.183
2015	109	0.677	0.746	0.913	0.254
2016	100	0.696	0.747	0.931	0.253
2017	104	0.683	0.776	0.888	0.224
Total	**974**	**Average**	**0.776**	**Average**	**0.224**

Source: own calculations based on FADN (2019) data

Table 9: Technical efficiency numbers in the Hungarian dairy sector by farm size.

Size category	Number of firms	crsTE	vrsTE	Scale
Large	229	0.776	0.792	0.981
Medium	599	0.564	0.592	0.955
Small	146	0.631	0.717	0.894
Total	**974**	**Average**	**0.700**	

Source: own calculations based on FADN (2019) data

Table 10: Technical efficiency numbers in the Hungarian dairy sector by livestock size.

Livestock's size category	No. of firms	crsTE	vrsTE	Scale
Large	79	0.879	0.925	0.951
Medium	397	0.705	0.779	0.908
Small	498	0.579	0.650	0.897
Total	**974**	**Average**	**0.785**	

Source: own calculations based on FADN (2019) data

Table 11: Technical efficiency numbers in the Hungarian dairy sector by region.

Region	No. of firms	crsTE	vrsTE	Scale
Great Hungarian Plain and Central Hungary	574	0.589	0.652	0.912
Transdanubia	294	0.669	0.724	0.927
Northern Hungary	106	0.709	0.764	0.934
Total:	**974**	**Average:**	**0.713**	

Source: own calculations based on FADN (2019) data

noted that this does not mean that these farms are the best in Hungary, although it is true that these farms used their resources most effectively, when compared with other regions. The dairy farms located at the Great Hungarian Plain and Central Hungarian Region were the least efficient ones compared to the other two regions. They could increase their output with 34.8% without using more resources.

Conclusions

This paper analysed the technical efficiency of Hungarian dairy farms from 2008 to 2017. We have seen some declining trends in efficiency after 2013 with significant differences by farm sizes and regions. On a farm size basis, large farms were found to be the most efficient ones, followed by small farms (simple size basis) and medium farms (livestock size basis). Regionally, farms in the Northern Hungarian Region were found to be the most efficient ones. All this suggests significant efficiency reserves in Hungarian dairy production. Besides the limitations of the methodology, this research can help decision makers to better understand the efficiency of diary farms under different scenarios. We would suggest that the future development of the sector should concentrate on large and medium farms, especially considering their magnitude and results obtained. Future research would be necessary to examine the reasons for the differences found between regions, in terms of livestock sizes and the standard production values of farms. There are many factors that could significantly influence the results obtained, ranging from farm characteristics to environmental and socio-economic factors.

Possible directions for future research might be to estimate allocative efficiency models involving different regions or maybe countries, taking into account that different input and output prices also play an important role when attempting to compare efficiency among the different regions. Unfortunately, the FADN database – when consulted directly – cannot contain information about prices, but indirectly we can calculate it. These analyses need more time and a more complex model so as to be able to estimate the frontiers. To get a better picture of dairy sector efficiency in the future we need to analyse other important fields or sectors (e.g. feeding industry, plan cultivating sectors) which play important role in the dairy sector or instead take the examined country import-export market and use other methods to measure efficiencies like the total factor productivity (TFP) indexes. These methods may be used for analysing other EU countries' or regions' sectors, if proper data is available for analysis. The adaptability of this model is wide so we can analyse different sectors in the agriculture sector and different industrial sectors as well.

References

Banker, R.D., Chames, A. and Cooper, W.W. (1984): Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis. Management Science, **30** (9), 1078–1092. https://doi.org/10.1287/mnsc.30.9.1078

Bauer, P.W., Berger, A.N., Ferrier, G.D. and Humphrey, D.B. (1998): Consistency conditions for regulatory analysis of financial institutions: a comparison of frontier efficiency models. SSRN Electronic Journal, **50** (2), 85–114. https://doi.org/10.1016/S0148-6195(97)00072-6

Bravo-Ureta, B.E., Solís, D., Moreira López, V.H., Maripani, J.F., Thiam, A. and Rivas, T. (2007): Technical efficiency in farming: a meta-regression analysis. Journal of Productivity Analysis, **27** (1), 57–72. https://doi.org/10.1007/s11123-006-0025-3

Charnes, A., Cooper, W.W. and Rhodes, E. (1978): Measuring the efficiency of decision making units. European Journal of Operational Research, **2** (6), 429–444. https://doi.org/10.1016/0377-2217(78)90138-8

Coelli, T., Rao, D.S.P., O'Donell C.J. and Battese, G.E. (2005): An introduction to efficiency and Productivity Analysis, Springer, Germany.

Coelli, T.J. and Perelman, S. (1996): Efficiency Measurement, Multiple-output Technologies and Distance Functions: With Application to European Railways. CREPP Discussion Paper no. 96/05, University of Liege, Liege, France.

EUROSTAT (2019): http://epp.eurostat.ec.europa.eu/portal/page/portal/agriculture/data/database (Accessed in August 2019)

FADN (2019): http://ec.europa.eu/agriculture/rica/database/database_en.cfm (Accessed in August 2019)

FAOSTAT (2019): http://www.fao.org/faostat/en/#data (Accessed in September 2019)

Farrell, M.J. (1957): The measurement of productive efficiency. Journal of the Royal Statistical Society, Series A, 120 (3), 253–281. https://doi.org/10.2307/2343100

Galluzzo, N. (2019): An analysis of technical efficiency in Icelandic dairy and sheep farms. Studies in Agricultural Economics, **121** (3), 144–150. https://doi.org/10.7896/j.1916

HCSO (2019): http://www.ksh.hu/docs/eng/xstadat/xstadat_long/h_omf001c.html?down=111 (Accessed in August 2019)

Kovacs, K. (2014): Dairy farms efficiency analysis before the quota system abolishment. Apstract, **8** (2–3), 147–157.

Short communication

Mohammad KAVOOSI-KALASHAMI* and Mohammad Karim MOTAMED*

Productivity analysis of sericulture in Northern Iran

Increasing productivity is the best and most efficient way for achieving economic growth in the agriculture sector. Guilan province in northern Iran is a leading region in sericulture production in Iran. The production of sericulture has been very volatile and in recent years as a significant proportion of the producers was out of production. This study investigates Total Factor Productivity (TFP) changes and its components in the sericulture system of Guilan province, Northern Iran, during 2007-2016. For this purpose, non-parametric Malmquist index and panel data of 15 counties over 11 years were used. Results show that only Talesh and Rudsar counties achieved productivity growth during the period analysed. Moreover, three counties of Astana-Ashrafieh, Lahijan and Masal & Shandermann experienced negative changes in efficiency and technology, which resulted in a significant negative change in TFP. Among understudy counties, only Sowme'ehSara County had year-to-year increase in productivity over the period 2007 to 2016. Furthermore, the counties of Roodsar and the Sowme'ehSara had the highest and lowest fluctuations of year-to-year TFP, respectively. The average of TFP change for all counties was negative. Overall, findings show that with the exception of the years 2011, 2014 and 2016, the major changes in TFP all occurred due to technology change.

Keywords: Malmquist index, efficiency change, technology change, scale change, distance function

JEL classification: D24

* Department of Agricultural Economics, Faculty of Agricultural Sciences, University of Guilan, Rasht, Iran. Corresponding author: mkavoosi@guilan.ac.ir

Received: 22 January 2020, Revised: 24 February 2020, Accepted: 28 February 2020.

Introduction

Productivity is one of the most important areas of economic research (Bayyurt and Yılmaz, 2012). It is most often defined as the ability of production factors to produce (Latruffe, 2010). OECD (2001) defined productivity as a ratio of a volume measure of output to a volume measure of input use. Also, Pfeiffer (2003) stated productivity as an essential source of growth that encompasses the output gains attributable to technical change. Fabricant (1959) claimed that the broader the coverage of inputs, the better the measure of productivity, defining the best measure of productivity as one that compares output with the combined use of all inputs. As a result, productivity growth in many studies was estimated using a total factor productivity (TFP) approach. Researchers and policy makers alike have recognized the importance of enhancing productivity to increase agricultural output. Economic growth in different sectors is achieved through two strategies. The first approach is to increase production using more inputs, while the other is using new technologies and to utilise production factors more effectively. In most developing countries, including Iran, limited access to inputs and their scarcity in the agriculture sector have made the application of the former strategy impossible. Therefore, policymakers in these countries have used the second strategy of increasing production based on improving productivity. In Iran, the necessity of improving the productivity of the agriculture sector is mentioned in many laws and documents (Note 35 of the Iran's second development plan (1995-2000); Article 5 of the Iran's fourth development plan (2005-2010); Articles 128, 130 and 133 of Iran's fifth development plan (2011-2016)).

Investigation of the agriculture sector situation in developing countries showed that insufficient knowledge of production facilities and resources and low productivity and efficiency of production caused these countries failed to achieve their agricultural development goals (Chizari and Sadeghi, 2001). Productivity increase is the best and most effective way of achieving economic growth and enhancing the ability of Iran's agricultural sector to compete with other sectors. The study of the research centre of Iran's Islamic Consultative Assembly (IICA) showed that TFP growth of the agricultural sector during the implemented development plans after the Iran's revolution (1979) has been declining. During the early years of the first development plan (1991-1993), the second development plan (1995-2000), the third development plan (2000-2005) and the fourth development plan (2005-2010), the average TFP growth in Iran's agriculture sector were equal to 2.87, 0.16, 0.17 and -0.43, respectively. An initial estimate by the research centre of IICA showed that TFP change for Iran's agriculture sector during the fifth development plan (2011-2016) was overall negative (-0.26%). This situation highlights the need to pay more attention to the issue of productivity and evaluate changes in productivity levels in the various activities of Iran's agriculture sector.

Agriculture is a major economic activity in Iran's rural, deprived and remote areas. Planning for improving agricultural productivity is a key to achieving sustainable development in rural areas. Improvement of productivity indices in this sector have a significant role in removing and reducing economic, social and cultural anomalies in deprived areas of Iran. In this regard, awareness of productivity and its growth in different areas and activities can increase the effectiveness of the proposed policies for regional economic growth and welfare. Measurement is an integral part of productivity analysis. The measurement of productivity provides information on how to move from the present situation to the desired goals.

Demand increase for sericulture products, low costs of breeding, low environmental pollution in production process, the possibility of breeding in most parts of Iran (due to the existence of mulberry tree), market capacity and a short period of production operations (45 days) are among the causes that have brought attention to this ancient activity and its revival in Iran. To the best of our knowledge, there are no studies investigating productivity changes in sericulture production in Iran. Guilan province is considered as the main hub of sericulture production in Iran. The present study investigates the TFP changes of sericulture production system in this province during 2007-2016.

The next section provides a review of some pertinent literature. The data and sources, and models used to estimate TFP change are described under section 3 as methodology. Section 4 captures the results and discusses the reported estimations. The final section concludes.

Literature Review

The study of productivity change goes back to the early works of Koopmans (1951) and Solow (1957). The Malmquist Index was first introduced in 1953 to analyse input consumption and then in 1982 was used to calculate TFP change and its components over two time periods (Färe *et al*., 1992). Caves *et al*. (1982) presented the Malmquist productivity index based on the distance function of inputs. Färe *et al*. (1992) combined two idea of Farrell (1957) and Caves *et al*. (1982) and created the Malmquist Productivity Index directly from inputs and outputs using Data Envelopment Analysis (DEA). Measuring and evaluating productivity changes in different economic sectors, especially in the agriculture sector, has a long history.

Kijek *et al*. (2019) showed that convergence occurred in agricultural productivity almost in all EU member states (except Belgium and the United Kingdom). Also, in new EU member states, the process of making up differences in the productivity of agriculture was stronger than in old EU member states. Djokoto and Pomeyie (2018) explored the productivity comparison further through the evaluation of a common production technology used in 74 countries around the world, over the period 2005 to 2014. The findings relating to production function approach revealed conventional agriculture to be more productive than organic agriculture and the productivity of conventional agriculture was shown to be exponentially rising, whereas that of organic is declining, although it has a quadratic growth path. Du and Lin (2017) have constructed a Malmquist energy productivity index based on the Shephard energy distance function to measure total-factor energy productivity change. The model was applied to compare energy productivity growth across the world's 123 economies. The findings showed that on average, the world witnessed a 34.6% growth of energy productivity between 1990 and 2010, which was mainly driven by technological progress. Moreover, developed countries achieved higher growth in energy productivity than the developing countries and the developed countries took the lead in achieving technological progress, while the developing countries performed better in efficiency improvement.

Nowak and Kijek (2016) determined the relationship between total, average and marginal human factor productivity and the level of education of a farm manager in Poland. The study involved the Cobb-Douglas production function method. Results showed that human capital approximated by the level of education had a positive effect on the average and marginal productivity of the analysed farms. Rizov *et al*. (2013) used a structural semi-parametric estimation algorithm directly incorporating the effect of subsidies into a model of unobserved productivity for the Farm Accountancy Data Network (FADN) samples of the EU-15 countries. Results showed that subsidies impact negatively on farm productivity in the period before the decoupling reform was implemented. However, after decoupling, the effect of subsidies on productivity was more nuanced and in several countries it turned to be positive. Singh and Singh (2012) analysed the rate of TFP growth and technical progress of Indian Agriculture between the periods 1971-2004, using Malmquist productivity index and a Data Envelopment Analysis (DEA). It was observed that productivity growth of Indian agriculture was negative, confirming that the entire output growth was generated by input growth. The decomposition of productivity growth into efficiency change and technical progress reveals that the efficiency change is positively contributing towards the growth of productivity, whereas the negative growth of technology restrict the potential productivity growth in Indian agriculture. Furthermore, it was also observed that efficiency change was insignificant, while technical change was Hicks non-neutral in Indian agriculture. Latruffe *et al*. (2011) showed that higher subsidy and labour dependence was significantly associated with higher productivity across Denmark, France, Germany, Ireland, Spain, Netherland and the United Kingdom. Similarly, the authors stated that the Common Agricultural Policy (CAP) regime introducing fully decoupled payments reduced productivity in all countries considered except Denmark. Linh (2009) also applied the Malmquist productivity index method to measure TFP growth in Vietnamese agriculture using a panel data from 60 provinces in Vietnam during the period 1985-2000. This study indicated that most of the early growth in Vietnamese agriculture (1985-1990) was due to TFP growth, in response to incentive reforms. During the period 1990-1995, the growth rate of TFP fell and Vietnam's agricultural growth was mainly caused by drastic investment in capital. In the last period (1995-2000), TFP growth increased again, though the figure for this period was still much lower than in the period 1985-1990. Overall, the TFP growth rate for the whole period was estimated to be 1.96 percent, contributing to 38% of Vietnam's agricultural growth.

In Iran, the first attempts to measure and evaluate productivity changes in the agriculture sector using non-parametric approaches has begun from the 1990s. Heydari (1999) studied TFP in wheat production of Markazi province using the Törnqvist index. Mojaverian (2003) used the Malmquist index to study the TFP change of strategic crops production system (wheat, barley, cotton, rice and sugar beet) in Iran's agriculture sector over the period 1990-1998. Kavoosi-Kalashami and Khaligh-Khiyavi (2017) studied the TFP change of Iran's crop production subsector using Malmquist approach between 1990 and 2008. For the first time in Iran, this study analysed the TFP changes of 23 major crops during 18 crop years. Results showed that sugar beet production had the highest and rainfed barley and chickpea production had the lowest productivity growth in the studied period. In Iran, few studies have examined productivity in the livestock sub-sector and its related activities. ZandiBaghcheban-Maryam *et al*. (2009) studied the TFP of 36 goat herds in Kurdistan Province using the Törnqvist-Thiel index. Daneshvar-Ameri and Akhondan (2013) investigated the effect of technology change on growth of shrimp production in Bushehr province. The data used were from 48 shrimp farms during the years 2000-2003. Dashti *et al*. (2015) used the Törnqvist-Thiel index for calculating TFP of red meat production in Iran during 1992-2012, while Abedi-Parijani *et al*. (2017) investigated TFP of 240 sericulturists in Mazandaran Province using Cobb-Douglas production function.

Methodology

This study applies the nonparametric Malmquist method based on a panel data of 16 counties in Guilan Province, Northern Iran, during the time period 2007-2016. The TFP estimated by the Malmquist index does not need observed prices and allow the decomposition of TFP growth into efficiency change and technical change (Linh, 2009). Färe *et al*. (1994) showed that the Malmquist productivity index could be calculated without any price data. In their approach, the output distance function is defined as (Färe *et al*, 1992):

$$D(i,o) = \min\{\delta : (o/\delta) \in P(i)\}, \tag{1}$$

The output distance function $D(i,o)$ will take a value larger than zero and less than or equal to one if the output vector o is an element of the feasible production set. If o is located on the boundary of the feasible production set, the output distance function will take a value of unity.

The output-oriented Malmquist TFP index measures the TFP change between two periods by calculating the distance functions of each data point to the relevant technology. Following Färe *et al*. (1994), the Malmquist (output-oriented) TFP change index between period s (the base period) and period e under constant return to scale (CRS) is defined as:

$$M_s^e(o_s, i_s, o_e, i_e) = \sqrt{\left[\frac{D_e^s(o_e, i_e)}{D_s^s(o_s, i_s)}\right] \times \left[\frac{D_e^e(o_e, i_e)}{D_s^e(o_s, i_s)}\right]}, \tag{2}$$

In which, D_e^s, D_e^e, D_s^s and D_s^e are distance functions under CRS. Also, o and i are the output and input vectors. The TFP change index in (2) is actually the geometric mean of two TFP change measure. The first is relative to period s, and the second is relative to period e. On the whole, a Malmquist index greater than unity indicates a TFP increase from s to e, while a Malmquist index less than unity indicates a TFP decrease.

Equation (2) can be arranged to show that the TFP change index is equivalent to the product of a technical efficiency change index and an index of technology change:

$$M_s^e(o_s, i_s, o_e, i_e) = \frac{D_e^e(o_e, i_e)}{D_s^s(o_s, i_s)} \times \sqrt{\left[\frac{D_e^s(o_e, i_e)}{D_e^e(o_e, i_e)}\right] \times \left[\frac{D_s^s(o_s, i_s)}{D_s^e(o_s, i_s)}\right]}, \tag{3}$$

In the above equation, the first part shows technical efficiency change index between time periods s and e (EC_s^e) and the second part indicates technology change index between time periods s and e (TC_s^e):

$$EC_s^e = \frac{D_e^e(o_e, i_e)}{D_s^s(o_s, i_s)}, \tag{4}$$

$$TC_s^e = \sqrt{\left[\frac{D_e^s(o_e, i_e)}{D_e^e(o_e, i_e)}\right] \times \left[\frac{D_s^s(o_s, i_s)}{D_s^e(o_s, i_s)}\right]}, \tag{5}$$

The efficiency change index (EC_s^e) can be further decomposed into pure efficiency change or efficiency change between time periods s and e under variable return to scale (PEC_s^e) and scale efficiency change in the same time period (SEC_s^e).

$$PEC_s^e = \frac{D_{e\_VRS}^e(o_e, i_e)}{D_{s\ VRS}^s(o_s, i_s)}, \tag{6}$$

$$SEC_s^e = \frac{D_e^e(o_e, i_e) / D_{e\_VRS}^e(o_e, i_e)}{D_s^s(o_s, i_s) / D_{s\_VRS}^e(o_s, i_s)}, \tag{7}$$

The distance functions are estimated by a Linear Programming (LP) problem under constant return to scale (CRS). For example for $\hat{D}_s^e(o_s, i_s)$ we have:

$$\begin{aligned} &\left[\hat{D}_s^e(o_s, i_s)\right]^{-1} = Max_{\theta,\lambda}\hat{\theta} \\ &\text{Subject to:} \\ &-\theta o_{is} + O_e\lambda \geq 0, \\ &i_{is} + X_e\lambda \geq 0 \\ &\lambda \geq 0 \end{aligned} \tag{8}$$

For the distance functions under Variable Return to Scale (VRS), the convexity constraint added to the above LP problem.

Panel data used related to 15 counties of Guilan province include Astana-Ashrafieh, Amlash, Bandar-Anzali, Talesh, Rasht, Rezvanshahr, Roodbar, Roodsar, Siahkal, Shaft, Sowme'ehSara, Fouman, Lahijan, Langrood and Masal&Shanderman during 2007-2016. Inputs for each county include mulberry garden size (hectare), number of distributed mulberry sapling, number of sericulturists and number of distributed silkworm cocoons eggs (basket). Production of silk cocoon (kg) considered as an output in productivity analysis. The requested data set was obtained from Iran's Sericulture Development Centre (ISDC).

Results

As evident from Table 1, the results of the Malmquist index shows that only Talesh and Roodsar counties (13.33% of total counties) experienced productivity growth during the study period and TFP decreased in all other counties. In Talesh and Roodsar counties, efficiency and technology growth contributed to TFP, and the share of technology growth in TFP growth of these two counties were 85% and 75%, respectively. The three counties of Astana-Ashrafieh, Lahijan and Masal & Shanderman had a negative change in efficiency and technology that led to a significant negative change in TFP. Negative technology change has a major role to play and its share of negative TFP change for these three counties were 99.4%, 99.7% and 65.1%, respectively. In the three counties of Amlash, Bandar-Anzali and Rasht, all the negative change in TFP was due to the negative change in silk cocoon production technology. During the study period, the counties of Rezvanshahr, Roodbar, Siahkal, Shaft, Sowme'ehSara, Fouman and Langrood had poor efficiency growth (less than 1%) in the silk cocoon production system, but a negative change in technology led to a negative change in TFP for all these counties. The average efficiency growth in these seven counties was 0.39%, but the average negative change in technology was -28.76%. Decomposing the values of the efficiency changes into two components of efficiency pure change and scale change showed that in 78% of the counties experiencing efficiency growth (Talesh, Rezvanshahr, Roodbar, Siahkal, Shaft, Fouman and Langrood) was solely due to the scale change of the production system.

Only in the Roodsar and Sowme'ehSara counties (22% of the studied counties), the efficiency growth was driven by a positive efficiency pure change, so that in Roodsar county, 100% of efficiency growth was due to the growth of this component. The negative contribution of the scale change component (-0.3%) in the Sowme'ehSara county reduced the positive effect of the pure efficiency change component on efficiency (from 1.2% to 0.9%) of the sericulture production system.

Astana-Ashrafieh, Lahijan and Masal&Shanderman counties also had negative efficiency changes. The negative efficiency change in the counties of Lahijan and Masal&Shanderman was all caused by a negative scale change. The shares of pure efficiency and scale changes in negative efficiency change of Astana-Ashrafieh County were 67% and 33%, respectively. In the three counties of Amlash, Bandar-Anzali and Rasht, there were no changes in the components of pure efficiency and scale.

As observable in Table 2, descriptive statistics of year-to-year TFP change of silk cocoon production in Guilan province indicated that only the median of year-to-year TFP change for Sowme'ehSara County was positive. Roodsar and Sowme'ehSara counties had the highest and lowest fluctuations of year-to-year TFP, respectively. Among the studied counties, only Astana-Ashrafieh had negative median in year-to-year pure efficiency change. The counties of Siahkal, Sowme'ehSara and Fouman had a negative median in year-to-year scale efficiency change over the period analysed.

During 2007-2016, the average value of TFP change for all studied counties was negative, indicating that if an increase in the amount of silk cocoon production in Guilan province occurred, it was entirely caused by increase in inputs consumption (Table 3). The share of efficiency and technology in the average TFP change during this period was 2.9% and 97.1%, respectively, indicating a decline in production technology of this product.

The highest year-to-year TFP growth can be seen in 2011-2012, while the lowest TFP change belonged to 2009-2010. With the exception of 2011, 2014, and 2016, the major year-to-year TFP changes in the silk cocoon production system of Guilan province occurred due to technology change. It was only in 2013-2014 when the simultaneous growth of effi-

Table 1: Average changes in TFP of sericulture in Guilan province, 2007-2016 (%).

County	Efficiency change	Technology change	Pure change in efficiency	Scale change	TFP change
Astana-Ashrafieh	-0.3	-34.7	-0.2	-0.1	-34.9
Amlash	0.0	-11.8	0.0	0.0	-11.8
Bandar-Anzali	0.0	-27.2	0.0	0.0	-27.2
Talesh	0.4	2.3	0.0	0.4	2.7
Rasht	0.0	-40.2	0.0	0.0	-40.2
Rezvanshahr	0.1	-19.8	0.0	0.1	-19.7
Roodbar	0.7	-9.1	0.0	0.7	-8.4
Roodsar	0.2	0.6	0.2	0.0	0.8
Siahkal	0.2	-36.3	0.0	0.2	-36.1
Shaft	0.3	-38.8	0.0	0.3	-38.5
Sowme'ehSara	0.9	-33.1	1.2	-0.3	-32.2
Fouman	0.4	-38.7	0.0	0.4	-38.3
Lahijan	-0.1	-42.2	0.0	-0.1	-42.3
Langrud	0.1	-25.5	0.0	0.1	-25.4
Masal& Shanderman	-14.1	-26.3	0.0	-14.1	-40.4
Max	Sowme'ehSara	Talesh	Sowme'ehSara	Roodbar	Talesh
Min	Masal&Shanderman	Lahijan	Astana-Ashrafieh	Masal&Shanderman	Lahijan
Average	-0.8	-26.7	0.1	-0.9	-27.5

Source: own calculations based on ISDC (2016) data ciency and technology occurred. Efficiency growth caused 66.4% of TFP growth, while the share of scale growth in TFP growth of 2013-2014 was 61%.

2009, 2010 and 2013 were the years when negative changes in technology efficiency occurred. Although low efficiency growth occurred in these years, this was not able to offset the negative impact of technology change on TFP. In 2008, 2010, 2011, 2015 and 2016, there was a negative change in efficiency and technology growth compared to the previous year. With the exception of 2010 and 2016, technology growth offset the negative impact of efficiency and led to the growth of TFP in the silk cocoon production system of the Guilan province.

The efficiency change decomposition showed that except for the years of 2010, 2013 and 2014, the scale change was negative compared to the previous year. Scale growth was associated with pure efficiency growth over the period 2013-2014, while no change in pure efficiency over 2009-2010 and 2012-2013 occurred. Compared to the previous year, pure efficiency change and scale change were in opposite

Table 2: Descriptive statistics of year-to-year TFP change of sericulture in Guilan province, 2007-2016 (%).

County	Descriptive statistics	Efficiency change	Technology change	Pure change in efficiency	Scale change	TFP change
Astana-Ashrafieh	Median	-1.90	-4.60	-0.10	0.00	-2.00
	S.D.	9.09	35.54	7.62	4.94	33.93
Amlash	Median	0.00	-24.00	0.00	0.00	-24.00
	S.D.	3.63	58.40	3.33	0.25	63.73
Bandar-Anzali	Median	0.00	1.40	0.00	0.00	-1.10
	S.D.	6.21	35.82	5.19	2.43	35.52
Talesh	Median	2.40	-3.20	0.00	2.40	-8.70
	S.D.	11.70	189.70	0.00	11.7	217.46
Rasht	Median	0.00	-4.60	0.00	0.00	-1.00
	S.D.	9.37	37.33	9.12	1.47	34.38
Rezvanshahr	Median	-0.50	5.30	0.00	0.00	-3.90
	S.D.	11.14	31.93	6.72	6.36	34.87
Roodbar	Median	0.00	-6.70	0.00	0.00	-2.70
	S.D.	12.15	336.25	5.08	12.35	307.01
Roodsar	Median	0.00	4.30	0.00	0.00	-7.20
	S.D.	9.17	1,040.96	6.32	6.44	1,190.09
Siahkal	Median	-1.70	-5.80	0.00	-1.70	-5.20
	S.D.	7.95	46.89	0.10	7.99	46.59
Shaft	Median	0.00	4.10	0.00	0.00	-1.60
	S.D.	9.02	34.32	0.00	9.02	34.97
Sowme'ehSara	Median	-0.40	-3.30	0.00	-0.40	2.70
	S.D.	12.06	36.14	8.15	4.63	33.69
Fouman	Median	-0.10	-3.30	0.00	-0.50	-1.30
	S.D.	9.78	35.97	7.95	5.89	35.36
Lahijan	Median	0.00	-7.00	0.00	0.00	-5.70
	S.D.	5.79	35.3	0.00	5.79	34.93
Langrood	Median	0.00	-2.90	0.00	0.00	-2.50
	S.D.	6.86	34.48	0.00	6.86	34.78
Masal&Shanderman	Median	0.00	8.50	0.00	0.00	-6.40
	S.D.	25.81	42.07	1.67	26.2	41.71

Source: own calculations based on ISDC (2016) data

Table 3: Average changes in year-to-year TFP of sericulture in Guilan province, 2007-2016 (%).

Year	Efficiency change	Technology change	Pure change in efficiency	Scale change	TFP change
2007-2008	-2.8	4.0	-1.1	-1.7	1.2
2008-2009	1.4	-27.4	1.9	-0.5	-26.0
2009-2010	3.8	-96.1	0.0	3.8	-92.3
2010-2011	-6.8	6.0	-2.3	-4.5	-0.8
2011-2012	-2.9	107.8	-1.6	-1.3	104.9
2012-2013	0.1	-17.8	0.0	0.1	-17.7
2013-2014	9.7	4.9	3.8	5.9	14.6
2014-2015	-2.8	9.0	-1.2	-1.6	6.2
2015-2016	-6.1	0.1	1.3	-7.4	-6.0
Max	2014	2012	2014	2014	2012
Min	2011	2010	2011	2016	2010
Average	-0.8	-26.7	0.1	-0.9	-27.5

Source: own calculations based on ISDC (2016) data directions for 2009 and 2016, which in the first case of pure efficiency growth, eliminated the negative effect of scale change and caused TFP growth, but in the second case, this did not happen.

Discussion and Conclusions

Productivity plays an effective role in production growth and increasing competitiveness of Guilan province silk cocoon production system. Therefore, improving productivity and technology upgrades should be on the agenda of the ISDC, which has been in charge of the sericulture industry in Iran since 2014. Optimal policies adapted by the government, including the timely determination, announcement, and provision of a reliable cocoon guarantee price as a support tool (such that the sericulturists would be aware of price ranges when they need to purchase silkworm cocoons eggs) could help boost producers' motivation as well as help optimise the sericulturists's decisions as to the amount or volume of silkworm breeding operations they undertake. Optimal combination of inputs and operation volume determination play an important role in improving TFP.

Identifying the agents of sericulture industry so as to assess the status of silkworm breeding, cocoon production and silk production accurately and consistently as well as provide desirable technical-educational services, and in particular organise and facilitate the marketing process of silk products, is an indispensable prerequisite for observing productivity changes. According to the Iran's National Productivity Centre (INPC) stated goal to increase TFP by 4.4% (YadollahzadeTabari and Khoshabi, 2012), it can be concluded that there is a considerable gap between the productivity of sericulture system in Guilan Province and the level considered desirable. The first step is to develop a comprehensive program to improve hard and soft factors of productivity in the silk cocoon production system of Guilan Province.

An important factor in motivating producers to improve the TFP is incentives. Undoubtedly, sericulture producers' investment in technology and efficiency improvement (hard factors of TFP growth), which ultimately leads to TFP growth, needs financial incentives. Implementation of a step-by-step policy to balance domestic prices of silk products with world prices and shift to equilibrium prices, establishing appropriate customs tariffs and regulating the import of cocoon and silk to support domestic production, providing comprehensive training to sericulturists in the form of technical recommendations for the separation of high-quality cocoons from expanding ones (cocoons grading and sorting) and launching a quality assessment system for silk produced from the cocoon of sericulturist in order to justify and proper pricing of their products could be considered as four important policies for Iran's sericulture industry.

The purpose of this study was to monitor the performance of the sericulture section in Guilan Province, Northern Iran in order to make performance comparisons across this province's counties, and finally to assist policymakers to design optimal policies to improve productivity. In particular, productivity growth can be largely attributed to public research and development (R&D) expenditure so that productivity measurement is a first step to establish whether the investments made in sericulture research represent an appropriate use of public funds. Negative TFP change during the study period showed that research of public centres (like public universities and research centres) in sericulture section did not have contributions to productivity growth. Increasing productivity in sericulture has a number of important effects. First, it releases resources that can be used by other sericulturists in different counties, thereby creating economic growth. Second, higher levels of productivity result in lower prices of sericulture products that increase consumers' welfare. Third, productivity growth in sericulture improves the competitive position of the agriculture sector in Guilan Province.

References

Abedi-Parijani, A., Motamed, M.K. and Kavoosi-Kalashami, M. (2017): Investigating total factor productivity and factors affecting it in sericulture of Mazandaran province. Animal Production Research, **5** (1), 89–96.

Bayyurt, N. and Yılmaz, S. (2012): The impacts of governance and education on agricultural efficiency: An international analysis. Procedia-Social and Behavioral Sciences, **58**, 1158–1165. http://dx.doi.org/10.1016/j.sbspro.2012.09.1097

Caves, D.W., Christensen, L.R. and Dievert, W.E. (1982): The economic theory of index number and the measurement of input, output and productivity. Econometrica, **50**, 1393–1414.

Chizari, A. and Sadeghi, A. (2001): Economic impact of drainage system on productivity of Date Production, Case Study of Bushehr Province. Iranian Journal of Agricultural Economics and Development **30**, 76–92. (In Persian)

Daneshvar-Ameri, ZH. and Akhondan, N. (2013): The effect of technology change on growth of shrimp production in Bushehr province. Iranian Journal of Agricultural Economics and Development Research **43** (2), 193–200. (In Persian)

Dashti, GH., JagjoTazekand, E. and Ghahremanzadeh, M. (2015): The Impact of Government Support Policies on total factor productivity changes of meat production in Iran. Animal Science Research, **25** (3), 33–45. (In Persian)

Djokoto, J.G. and Pomeyie, P. (2018): Productivity of organic and conventional agriculture – a common technology analysis. Studies in Agricultural Economics, **120** (3), 150–156. https://doi.org/10.7896/j.1808

Du, K. and Lin, B. (2017): International comparison of total-factor energy productivity growth: A parametric Malmquist index approach. Energy, **118**, 481–488. https://doi.org/10.1016/j.energy.2016.10.052

Fabricant, S. (1959): Basic Facts on Productivity Change. Occasional Paper No. 63, National Bureau of Economic Research, Washington DC., USA.

Färe, R., Grosskopf, S., Lindgren, B. and Roos, P. (1992): Productivity changes in Swedish pharmacies 1980-1989: A non-parametric Malmquist approach. Journal of Productivity Analysis, **3**, 85–101. https://doi.org/10.1007/BF00158770

Färe, R., Grosskopf, S., Norris, M. and Zhang, Z. (1994): Productivity growth, technical progress, and efficiency change in industrialized countries. American Economic Review, **84** (1), 66–83.

Heydari, K.H. (1999): Total factor productivity of wheat production in Markazi Province. Iranian Journal of Agricultural Economics and Development **28**, 137–157. (In Persian)

Kavoosi-Kalashami, M. and Khaligh-Khiyavi, P. (2017): Total factor productivity analysis in Iran's crop subsector. Iranian Journal of Agricultural Economics Research, **8** (2), 157–172. (In Persian)

Kijek, A., Kijek, T., Nowak, A. and Skrzypek, A. (2019): Productivity and its convergence in agriculture in new and old European Union member states. Agricultural Economics-Czech, **65,** 1–9. https://doi.org/10.17221/262/2017-AGRICECON

Koopmans, T.C. (1951): An analysis of production as an efficient combination of activities, In: T.C. Koopmans (ed.), Activity Analysis of Production and Allocation. Cowles Commission for Research in Economics. Monograph No. 13, New York: Wiley.

Latruffe, L. (2010): Competitiveness, Productivity and efficiency in the agricultural and agri-food sectors. OECD Food, Agriculture and Fisheries Papers, No. 30. Paris: OECD publishing.

Latruffe, L., Bravo-Ureta, B.E., Moreira, V.H., Desjeux, Y. and Dupraz, P. (2011): Productivity and Subsidies in European Union Countries: An Analysis for Dairy Farms Using Input Distance Frontiers. Paper prepared for presentation at the EAAE 2011 Congress Change and Uncertainty, Challenges for Agriculture, Food and Natural Resources, August 30 to September 2, 2011, ETH Zurich, Zurich, Switzerland.

Linh, V.H. (2009): Vietnam agricultural productivity: a Malmquist index approach. Vietnam Development Forum, Working Paper No. 0903. Retrieved from: http://www.vdf.org.vn/workingpapers/vdfwp0903 (Accessed in October 2019)

Mojaverian, M. (2003): Estimation of Malmquist Productivity Index for Iran's Strategic Products over the Period of 1991-2000. Iranian Journal of Agricultural Economics, **43-44,** 143–162. (In Persian)

Nowak, A. and Kijek, T. (2016): The effect of human capital on labour productivity of farms in Poland. Studies in Agricultural Economics, **118** (1), 16–21. http://dx.doi.org/10.7896/j.1606

OECD (2001): Measuring Productivity – OECD Manual: Measurement of Aggregate and Industry-level Productivity Growth. OECD, Paris, France.

Pfeiffer, L.M. (2003): Agricultural Productivity Growth in the Andean Community. American Journal of Agricultural Economics, **85** (5), 1335–1341. https://doi.org/10.1111/j.0092-5853.2003.00553.x

Research Centre of Iran's Islamic Consultative Assembly (2014): Report on performance evaluation and agricultural sector goals in development plans. (In Persian)

Rizov, M., Pokrivcak, J. and Ciaian, P. (2013): CAP subsidies and productivity of the EU farms. Journal of Agricultural Economics, **64** (3), 537–557. https://doi.org/10.1111/1477-9552.12030

Singh, P. and Singh, A. (2012): Decomposition of technical change and productivity growth in Indian agriculture using non-parametric Malmquist index. Eurasian Journal of Business and Economics, **5** (9), 187–202.

Solow, R. (1957): Technical change and the aggregate production function. Review of Economics and Statistics, **39**, 312–320.

ZandiBaghcheban-Maryam, M., MoradiShahrBabak, M., MirayiAshtiani, S.R. and Kavoosi-Kalashami, M. (2009): Comparison of total factor productivity of Markhoz goat herds in Kurdistan Province. Animal Science Journal, **83**, 74–82. (In Persian)

Short communication

Namig SHALBUZOV*, Firdovsi FIKRETZADE* and Ramil HUSEYN**

The International Competitiveness of Azerbaijani fruit and vegetable products

Azerbaijan is a highly oil-dependent country that needs to find new avenues for increasing its international competitiveness. Therefore, this paper analyses the competitiveness of various fruit and vegetable products by calculating domestic resource cost ratios, using the data for 2015–16 as representing base years. Out of the 10 products analysed, almost all were found to have high competitive potential, especially on the Russian and European markets. In order to maintain competitiveness in the arable sector, however, Azerbaijan will need to achieve dynamic improvements in productivity and run a wise agricultural policy.

Keywords: Azerbaijan, agriculture, competitiveness, DRC, export

JEL classification: Q12

* Agro Research Center, Baku, Azerbaijan. Corresponding author: n.shalbuzov@mail.ru

** Center for Economic Reforms and Communication, Baku, Azerbaijan

Received: 21 September 2019, Revised: 17 October 2019, Accepted: 20 October 2019.

Introduction

The rapid decline in oil prices has been negatively affecting the Azerbaijani economy, which is highly dependent on oil exports, since the end of 2014. As a result, GDP growth has dropped to 3.1 percent in 2016 and Azerbaijani exports declined to $13.1 billion to 2016 compared to US $30.2 billion in 2014 (SSCRA, 2019). As a consequence, the Azerbaijani government has adopted 12 strategic roadmaps for the development of the non-oil sector to increase the share of non-oil-related goods among its exports (SRPNE, 2016; SRAAPPS, 2016). As a result, non-oil exports increased by 24 percent in 2017 compared to 2016 and amounted to $1.5 billion (SSCRA, 2019), with the majority of this figure coming from agricultural products. In 2017, for instance, 33 percent of Azerbaijan's non-oil exports consisted of fruits and vegetables, the majority of which was tomato exports, worth $151.6 million.

There is a high need to identify potentially competitive sectors in the economy and this article aims to fill the gap in the academic literature by analysing the competitiveness of Azerbaijani fruit and vegetable products over the course of the last 15 years by calculating Domestic Resource Cost (DRC) ratios. This article also aims to make some estimates for 2020 and 2025 under different scenarios.

Methodology

While there is a lack of consensus on how international competitiveness should be measured, in practice the DRC ratio has been widely applied (Tsakok, 1990). The DRC of a commodity compares the opportunity cost of domestic resources used in production of that commodity to the value added it generates at international prices (Masters and Winter-Nelson, 1995).

This concept builds upon the notion of effective production, but extends it through the use of opportunity costs of domestic resources rather than the domestic market price of the resources. The DRC ratio compares the opportunity costs of domestic production to the value added it generates. The criteria of the DRC thus indicates the cost of the production factors (and non-tradeable goods) necessary for the production of the equivalent of one foreign currency unit (Gorton *et al.*, 2006).

The DRC expresses the effective income (the cost) of the non-tradeable production factors (the "domestic resources" of the economy) devoted to the potential net earning of one currency unit of "tradeable resources". The difference between tradeables and non-tradeables is also critical as the exchange rate is concerned. Both numerator and denominator of the DRC are given in the same currency by multiplying the latter by the economic opportunity cost of foreign exchange, or the shadow exchange rate, which expresses the marginally efficient rate at which non-tradable primary factors of production may be transformed into tradable value added. Multiplying the denominator of the DRC by this rate converts the shadow prices of tradable outputs and inputs, expressed in foreign currency, into their opportunity cost at the margin in terms of domestic factors of production. Once this is done, the numerator and denominator of the DRC may be compared to see whether activity *j* is more or less efficient than the activity that, at the margin, is just efficient. If the DRC is less than one, the domestic resource cost per unit of value added is less for activity *j* than for the marginally efficient activity, so the country has a comparative advantage in activity *j*. If the DRC is greater than one, the opposite is true and the country does not have a comparative advantage (Masters and Winter-Nelson, 1995).

In other words, DRC is an indicator of the efficiency with which a country's factors of production (land, labour and capital) are converted into useful output. More precisely,

Table 1: World Bank DRC calculations for Azerbaijani fruits and vegetables in 2000–02.

	Irrigated		Not irrigated	
	Current practice	Ideal practice	Current practice	Ideal practice
Tomato	0.431	0.230	n.a.	n.a.
Hazelnut	1.064	0.702	0.832	n.a.
Pomegranate	0.619	0.174	0.703	0.223
Potato	0.955	0.638	1.009	0.661
Cotton	1.618	1.150	n.a.	n.a.
Cabbage	0.593	0.364	n.a.	n.a.
Grape	0.825	0.475	1.180	0.534
Apple	0.813	0.514	0.854	0.549
Persimmon	n.a.	n.a.	n.a.	n.a.
Cucumber	n.a.	n.a.	n.a.	n.a.

Source: ADPSA (2003)

Table 2: USAID and UNDP DRC calculations for Azerbaijani fruits and vegetables in 2009.

Product	Destination	DRC coefficient (Calculations by USAID)	DRC coefficient (Calculations by IER)
Greenhouse tomatoes	Russia	0.14	0.07
Persimmons	Russia	0.86	0.11
Fresh pomegranate	Russia	0.74	0.29
Apples	Russia	0.32	0.18
Cherries	Russia	0.16	0.63
Greenhouse cucumbers	Russia	0.36	0.06
Potatoes	Russia	0.15	0.11
Hazelnuts	Russia, Europe	0.47 0.56	–
Kiwi	Russia	0.94	–
Feijoa	Russia	0.31	–
Table grapes	Russia	–	0.46
Onions	Russia	–	0.07
Cabbages	Russia	–	0.07
Cotton	International market	–	0.30

Source: USAID (2009), IER under UNDP project, UNDP (2009)

we define the DRC for a given economic activity as the ratio of the economic opportunity cost of the domestic, non-tradeable resources used in the production of output *j* to the value added that is created measured in world market prices, which equal the shadow prices or economic opportunity cost of tradeable goods. An excellent review on the method with mathematical background is given in Masters and Winter-Nelson (1995) and Gorton *et al.* (2006).

Two reports have previously calculated DRC ratios for the Azerbaijani agriculture. The World Bank made DRC calculations in 2003 to reveal the products with comparative advantages (ADPSA, 2003). The calculations were made in two scenarios for current and ideal practices (Table 1).

According to World Bank results, tomato, cabbage and pomegranate had the highest DRC ratios in irrigated areas with 0.431, 0.593 and 0.619 values, respectively, with current practice. In ideal practice, DRC ratios for the same products could be 0.230, 0.364 and 0.174, respectively.

The USAID and UNDP have also made similar calculations for Azerbaijani agriculture (USAID, 2009; UNDP, 2009). Both analyses have been carried out according to the product-source-destination approach which shows whether products from a definite region have comparative advantages in a certain market. Results suggest that apples, cherries, persimmons, fresh pomegranate, pomegranate juice, apple juice, greenhouse tomatoes and cucumbers, tomato paste, early potatoes, hazelnuts, kiwi and feijoa have quite favourable DRCs (less than one). In Table 2, the main products with comparative advantages are observable.

As evident from Table 2, the main export market for Azerbaijani fruits and vegetables products is Russia. Cherries from the Guba-Khachmaz region, greenhouse tomatoes and cucumbers from Absheron and Shamkir and early potatoes from Jalilabad show the highest comparative advantage. Apple, feijoa and kiwi stand on the second place, followed by hazelnuts from Zagatala and Gakh. However, in the case of hazelnuts, there is an additional advantage compared to other products, as along with the Russian market, hazelnuts also have a comparative advantage in the Europe market. Fresh pomegranates from Goychay are also considered to be competitive with a DRC ratio of 0.74.

Market prospects for Azerbaijani fruits and vegetables were found to be positive in both the domestic and foreign markets, yet in case of fresh produce, the sector can fully explore market opportunities if innovation in varieties and quality improvements are taken into account. Investments in storing and packaging may be an attractive strategy to sell the produce later in time or to markets at further distance to

Table 3: DRC calculations for Azerbaijani fruits and vegetables products (2015-2016).

Product	Sowing type	All	Absheron	Ganja-Gazakh	Duzen Shirvan	Daglig Shirvan	Mil-Karabakh	Mugan-Salyan	Quba-Khachmaz	Shaki-Zaqatala	Lankaran-Astara
Potato, fresh	Not irrigated	**0.249**	n.a.	0.254	n.a.	n.a.	n.a.	n.a.	0.218	0.262	0.192
	Irrigated	**0.121**	n.a.	0.113	0.115	n.a.	0.105	0.154	0.500	0.194	0.126
Tomato	Irrigated	**0.059**	0.067	0.116	0.070	n.a.	0.058	0.051	0.033	0.092	0.054
	Green-house	**0.077**	0.076	0.078	0.179	n.a.	0.127	n.a.	n.a.	n.a.	n.a.
Cucumber	Irrigated	**0.042**	0.031	0.071	0.079	n.a.	0.125	0.055	0.022	n.a.	0.060
	Greenhouse	**0.043**	n.a.	0.043	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Grape	Irrigated	**0.058**	n.a.	0.058	n.a.	n.a.	n.a.	n.a.	0.040	n.a.	n.a.
	Not irrigated	**0.128**	n.a.	n.a.	n.a.	0.118	n.a.	n.a.	n.a.	0.117	0.174
Apple	Irrigated	**0.251**	n.a.	0.212	n.a.	n.a.	n.a.	n.a.	0.252	n.a.	n.a.
	Not irrigated	**0.318**	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0.314	n.a.	0.377
Hazelnut	Irrigated	**0.028**	n.a.	0.028	n.a.	n.a.	n.a.	n.a.	0.036	0.016	n.a.
	Not irrigated	**0.037**	n.a.	n.a.	n.a.	0.035	n.a.	n.a.	n.a.	0.071	n.a.
Cabbage	Irrigated	**0.180**	0.077	0.094	n.a.	n.a.	0.109	0.427	0.096	n.a.	0.122
	Not irrigated	**0.106**	n.a.	0.177	n.a.	n.a.	n.a.	n.a.	n.a.	0.203	n.a.
Pome-granate	Irrigated	**0.078**	n.a.	0.195	0.063	0.130	n.a.	n.a.	n.a.	n.a.	0.151
Per-simmon	Irrigated	**0.021**	n.a.	0.012	0.099	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Cotton	Irrigated	**0.370**	n.a.	0.851	0.420	n.a.	0.271	0.405	n.a.	n.a.	n.a.

Source: own calculations based on FDMS data

the producer's production region (USAID, 2009). Moreover, high fragmentation and small scale of the producers, limited access to knowledge and technologies, lack of finance and relatively high rates of interests are among the main problems negatively affecting the competitiveness of local fruit production.

Results and Discussion

Ten agricultural products (tomato, hazelnut, persimmon, apple, pomegranate, grape, potatoes, cotton, cucumber and cabbage) with the highest share in agricultural export of Azerbaijan are chosen for the analysis. In estimating DRC ratios for each commodity, a number of assumptions were made related to the social prices for outputs and tradable inputs, the social costs of non-tradable domestic resources and the choice of production structures.

Social prices for outputs and tradable inputs are measured as border prices (export/import parity prices) and are adjusted to the farm level. Products for which Azerbaijan was a net exporter an average free on board (FOB) export parity price was taken as the unadjusted reference price. The social prices for tradable inputs are based on border prices and data for Azerbaijan were taken from National Statistical Office and State Office of Customs. The adjustment of prices from border to farm were made, where appropriate, of handling charges, transport, storage and maintenance costs. Private input prices and quantities, together with information on yields, were taken from Azerbaijan Farm Data and Monitoring System, providing information on over 4000 agricultural enterprises.

The prices of non-tradable resources were measured in terms of the opportunity costs of land, labour and capital employed in the production. In the case of land, the opportunity costs can be indicated by the social rental value in the second best alternative. But even in this case, there is often a problem in identifying a single second best alternative according to the level of risk, income, demand, price stability over time and other factors. For example, vegetable crops usually are more profitable compared to staple food crops, but still many producers continue to grow food crops because of their higher price and demand stability over time. In this situation, land of identical quality produces a variety of crops. In order to handle this situation, an average of suitable commodity alternatives for deriving shadow land prices was taken. In case of capital, the economic cost of fixed asset has been indicated by the interest rate that could be earned if the amount invested in the asset were invested into the financial market as the second best alternative.

As far as labour is concerned, the wage rate in the second best alternative, mainly in non-agricultural labour opportunities, is taken. As agricultural producers are not professional specialists, alternative occupations are generally unskilled in nature. Therefore, the social value of labour was calculated by weighting to the average wage rates of unskilled workers in non-agricultural occupations in the country excluding the capital of Baku. Table 3 summarises the results of our calculations.

Results suggest that on the country level, potato production is competitive in both irrigated and non-irrigated areas with DRC ratios of 0.121 and 0.249, respectively. In some regions specialised in potato production, DRC ratios were

Table 4: Expected DRC ratios for Azerbaijani fruits and vegetables products for 2020 and 2025 .

Product	2020		2025	
	Effects of price change	Effects of yield change	Effects of price change	Effects of yield change
Tomato	0.166	0.211	0.247	0.276
Hazelnut	0.133	0.246	0.223	0.239
Persimmon	0.124	0.268	0.367	0.406
Potato, fresh	0.142	0.206	0.278	0.295
Grape	0.289	0.355	0.365	0.378
Apple	0.284	0.389	0.427	0.489
Pomegranate	0.257	0.341	0.342	0.407
Cotton	0.371	0.405	0.458	0.473
Cucumber	0.147	0.204	0.242	0.344
Cabbage	0.200	0.217	0.260	0.310

Source: own calculations

even better (Ganja-Gazakh: 0.113, Duzen Shirvan: 0.115), compared to country average.

Our calculations have also revealed that tomato was one of the most competitive products. For irrigated areas, the country's average DRC ratio was 0.059 and for greenhouses, it was 0.077. However, it should be noted that greenhouses have the advantage that tomato production can be run during the whole year. In the case of Guba-Khachmaz region, the DRC for irrigated lands was the lowest, indicating the highest comparative advantage in tomato production.

The same situation can be observed for cucumbers. The country's average DRC ratios for cucumbers were almost equal for both irrigated lands and greenhouses with values of 0.042 and 0.043, respectively. For the Guba-Khachmaz region, DRC in irrigated lands was even less, 0.022. For cotton, which is one of the most important export products of Azerbaijan, the country's average DRC ratio equalled to 0.370. However, in the Mil-Karabakh region (the main area for cotton production), the DRC ratio was even less, 0.271.

As for perennial crops, grapes were also found to be competitive with a DRC ratio of 0.058 for irrigated areas and 0.129 for non-irrigated areas, meaning that non-irrigated grape production was more competitive. In the case of apples, production was again competitive for both irrigated and non-irrigated lands with respective DRC values of 0.251 and 0.318. Hazelnut production was extremely competitive with DRC ratios of 0.028 for irrigated and 0.037 for non-irrigated lands, suggesting it has great export potential. Pomegranate is also very competitive on export markets, although this product needs irrigation at all times. As for persimmon, high competitive potential was also found here with a DRC value of 0.021 – again, irrigation is highly needed here.

As a next step, we have also made some projections based on the same methodology, taking into account possible changes in prices and yields of products. Average prices for 2020 and 2025 were taken from OECD-FAO Agricultural Outlooks (OECD, 2019) and local price collection system for agricultural products (PI, 2019)[1]. Possible changes in yields were calculated according to average yield change in the country based on State Statistical Committee data (SSCRA, 2019). Table 4 summarises the results of the foresight exercise.

As evident from Table 4, all products analysed will remain competitive in 2020 and 2025. The best indicators for 2020 are observed in the case of persimmons, hazelnuts, fresh potato, cucumber and tomato with DRC ratios of 0.124, 0.133, 0.142, 0.147 and 0.166, respectively, taking into account price effects. As to yield changes, these products are still competitive but to a lesser extent. By 2025, hazelnuts, cucumber, tomato, cabbage and fresh potato demonstrate the highest DRC ratios with 0.223, 0.242, 0.247, 0.260 and 0.278, respectively. Taking into account the effects of yield change, these products are less competitive. The rest of the products also show competitive DRC ratios, suggesting that local agricultural production has a future in global markets.

As to the policy side, the Azerbaijani government aims to support agriculture in a number of ways. First of all, farmers get subsidies (200 manats ~ $118) per hectare. However, this rate changes according to species and cultivation techniques and is about to increase. Moreover, the government provides input support (irrigation water, elite seeds, fuel and fertilizers and machinery) to farmers through the state-owned company Agroleasing, which is due to be privatised, and the newly established Agro Insurance Fund will start its activities and support 50% of state insurance payments this year. Agricultural policy also grants tax exemptions for local farmers. Moreover, the Azerbaijani government also aims to encourage agro-processing investments as well as to create agro-based clusters (Agroparks), playing the role of a hub for production, logistics and sales of agricultural products. On the whole, governmental support is expected to increase the competitiveness of Azerbaijan's agricultural products, including fruits and vegetables (Berkum, 2017; Ruijs, 2017).

Conclusions

The article analysed the competitiveness of Azerbaijan's fresh fruits and vegetables products by calculating their DRC indices. Russia and Europe were found to be the main markets and out of the 10 products analysed, almost all of them held important market potential. There is a high need for Azerbaijan to find sectors and products with competitive potential to at least partially offset oil-dependence in exports. Governmental policies aim to increase the competitiveness of local agricultural and food production, including fruits and vegetables. Future research might want to evaluate other sectors and products also with other methods to get a more diversified picture of the competitiveness of Azerbaijan's agriculture.

[1] A price collection system for agricultural products (www.aqrarbazar.az) has been created between January 2014 and April 2015. The database includes daily updated wholesale and retail prices of 46 kinds of fruits and vegetables and their 400 varieties based on a simple product classification system (small, medium and large). The database started working from 1st August 2015, the primary version covered 19 retail and 5 wholesale markets in Baku and in other regions. Organisations under control of the Ministry of Agriculture were responsible for collecting price information.

References

ADPSA (2003): Azerbaijan Republic, The Agency for the Development of Private Sector in Agriculture, agricultural development and crediting project, agricultural policy framework document. Baku, February 2003, 486 p.

Berkum, van S. (2017): Market and competitiveness analysis of the Azerbaijan agricultural sector: an overview. Paper conducted by Wageningen Economic Research and Delphy, the Netherlands. https://www.wecr.wur.nl/sara/docs/Market%20and%20Competitiveness%20analysis%20report.pdf (Accessed in May 2019)

Gorton, M., Davidova, S., Banse, M. and Bailey, A. (2006): The International Competitiveness of Hungarian Agriculture: Past Performance and Future Projections, Post-Communist Economies, **18** (1), 69–84, https://doi.org/10.1080/14631370500505289

Masters, W.A. and Winter-Nelson, A. (1995): Measuring the Comparative Advantage of Agricultural Activities: Domestic Resource Costs and the Social Cost-Benefit Ratio. American Journal of Agricultural Economics, **77** (2), 243 – 250. https://doi.org/10.2307/1243534

OECD/FAO (2019): OECD-FAO Agricultural Outlook 2019-2028, OECD Publishing, Paris, France. https://doi.org/10.1787/agr_outlook-2019-en.

PI (2019): Price Information. www.aqrarbazar.az (Accessed in April 2019)

Ruijs, M. (2017): Master Plan Azerbaijan: Vegetable Sector Assessment. Paper conducted by Wageningen Economic Research and Delphy, The Netherlands. https://www.wecr.wur.nl/sara/docs/Protected%20vegetables%20Sector%20Assessment%20Report.pdf (Accessed in April 2019)

SRAAPPS (2016): Strategic roadmap on agriculture and agricultural products processing sector in the Republic of Azerbaijan. http://www.president.az/articles/22110 (Accessed in May 2019)

SRPNE(2016):Strategic roadmap on perspective of the national economy of the Republic of Azerbaijan. http://president.az/articles/21993 (Accessed in May 2019)

SSCRA (2019): State Statistical Committee of the Republic of Azerbaijan. The Agriculture of Azerbaijan - Statistical yearbook 2019. 644 pages, Baku, Azerbaijan.

Tsakok, I. (1990): Agricultural Price Policy: A Practitioner's Guide to Partial-Equilibrium Analysis. Cornell University Press. Ithaca, USA.

UNDP (2009): Issues related with increasing competitiveness of agricultural sector in the Republic of Azerbaijan. The final report on the research project Institute for Scientific Research On Economic Reforms. 118 pages, Baku, Azerbaijan. Accessed http://ier.az/uploads/ISRER-UNDP_Agriculture-eng.pdf (Accessed in April 2019)

USAID (2009): Private Sector Competitiveness Enhancement Program in Azerbaijan, Domestic Resource Cost Analysis of Azerbaijan Final Report, Baku, Azerbaijan.

Studies in Agricultural Economics

Information for authors

Studies in Agricultural Economics is an international journal publishing original research papers, short communication and book reviews on agricultural economics and related disciplines including agricultural production and competitiveness, food consumption, agri-food supply chain management, markets and marketing, international trade, agri-food policy, agri-environmental issues, rural development and the bioeconomy. The journal's main geographical focus is Europe and Central Asia (ECA).

Audience

Researchers, academics, policy makers and practitioners in agricultural economics and rural development, especially in Europe and Central Asia.

Submission of manuscripts

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

Shorter papers and comments, of up to 1500 words, will also be considered for publication. Such notes might deal with the economic aspects of policy, with the results of small research projects that do not justify a full-length article, or comment on articles previously published.

Manuscripts should be submitted in .doc or compatible format. They should be prepared using A4 format, TNR 12 pt text and 1.5 line spacing and be in single-column format with wide margins. Do not hyphenate words and use **bold** face and *italics* only sparingly, but use subscripts and superscripts where appropriate. Avoid the use of single-sentence paragraphs. Tables should be placed at the end of the manuscript and figures should be submitted as separate files, numbered accordingly. Page and line numbering (restart each page) must be used but no reference should be made to page numbers in the text. You should use the 'spell-check' and 'grammar-check' functions of your wordprocessor, which should be set to *English* English, to avoid unnecessary errors.

Manuscripts will be double-blind reviewed by at least two reviewers and may be returned to the author(s) for revision before acceptance for publication. The Editor-in-Chief will normally consider only one re-submission.

Article structure

Divide your article into clearly defined sections but do not use section or subsection numbers. Each heading should appear on its own separate line. For research papers you are urged to consider using the following structure:

- **Introduction.** State the objectives of the work and provide an adequate background with reference to the international literature, but avoiding a detailed literature survey or a summary of the results.
- **Methodology.** Provide sufficient detail to allow the work to be reproduced. Methods already published should be indicated by a reference: only relevant modifications should be described.
- **Results.** Results should be clear and concise.
- **Discussion.** This should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section should normally be avoided. You should show how your results add to existing knowledge but avoid extensive citations and discussion of published literature.

Where it is not appropriate to use the above framework, you should finish the paper with conclusions.

Essential title page information

- **Title.** Concise and informative. Avoid abbreviations and formulae where possible.
- **Running title.** Please provide an abbreviated title of no more than 60 characters (including spaces) that can be used as a running title on the page header.
- **Author names and affiliations.** Present the authors' affiliation addresses (where the actual work was done) below their names.
- **Corresponding author.** Clearly indicate the corresponding author who will handle correspondence at all stages of refereeing and publication, also post-publication. Please provide a telephone and fax number in addition to the e-mail address and the complete postal address.
- **Present/permanent address.** If an author has moved since the work described in the article was done, or was visiting at the time, a 'Present address' (or 'Permanent address') may be indicated. The address at which the author actually did the work must be retained as the main, affiliation address.

Additional information

- **Abstract.** A single paragraph of 100-250 words should state the purpose of the research, the principal results and major conclusions.
- **Keywords.** Please provide a maximum of six keywords.
- **Abbreviations.** If necessary, define abbreviations that are not standard in this field on the first page of the article.

- **Acknowledgements.** If applicable, collate acknowledgements in a separate section at the end of the article before the references. List here those individuals and/or organisations that provided help, including financial support, during the research.
- **Nomenclature and units.** Follow internationally accepted rules and conventions: use the international system of units (SI) i.e. metre, second, kilogramme etc. or accepted alternatives e.g. day, litre, tonne.
- **Math formulae.** Present simple formulae in the line of normal text where possible. Number consecutively any equations that have to be displayed separately from the text (if referred to explicitly in the text). For simple fractions use the solidus (/) instead of a horizontal line. Powers of e are often more conveniently denoted by exp. Give the meaning of all symbols immediately after the equation in which they are first used. Levels of statistical significance which can be mentioned without further explanation are: *P <0.05, **P <0.01 and ***P <0.001.
- **Footnotes.** Footnotes should be used sparingly. Number them consecutively throughout the article, using superscript Arabic numbers. Indicate each footnote in a table with a superscript lowercase letter.

Tables and figures

- **Tables.** Number tables consecutively in accordance with their appearance in the text. Each table should be accompanied by a title and fully descriptive caption. Column headings should be brief but sufficiently explanatory and standard abbreviations of units of measurement should be included between parentheses. Do not use vertical rules to separate columns. Large tables should be avoided. If many data are to be presented, you should consider dividing them over two or more tables. Reversing columns and rows will often reduce the dimensions of a table.
- **Figures.** Graphs, drawings or photographs should be supplied in digital format in monochrome and be of sufficient contrast. Figures prepared with Excel® software (or compatible format) are preferred. Captions should be included in the main manuscript, not attached to the figure, and should explain all symbols and abbreviations used. The text should include references to all figures. The use of figures from other publications is discouraged but, if used, permission of the author(s) or the copyright owner is necessary.

References

Please ensure that every reference cited in the text is also present in the reference list (and vice versa). Citations may be made directly (or parenthetically). Groups of references should be listed first alphabetically, then chronologically. For example: 'as demonstrated (Allan, 1996a, 1996b, 1999; Allan and Jones, 1995). Kramer *et al.* (2000) have recently shown ...' Citation of a reference as 'in press' implies that the item has been accepted for publication.

In the reference list, references should be arranged first alphabetically and then further sorted chronologically if necessary. They should not be numbered. More than one reference from the same author(s) in the same year must be identified by the letters 'a', 'b', etc. placed after the year of publication. The title of a non-English publication should be followed by the English translation in square brackets. Journal titles should not be abbreviated. Examples:

- **Reference to a journal publication.** Van der Geer, J., Hanraads, J.A.J. and Lupton, R.A. (2000): The art of writing a scientific article. Journal of Science Communication **163**, 51-59.
- **Reference to a book.** Strunk Jr., W. and White, E.B. (1979): The Elements of Style (3rd edition). New York: Macmillan.
- **Reference to a chapter in an edited book.** Mettam, G.R. and Adams, L.B. (1999): How to prepare an electronic version of your article, in Jones, B.S and Smith, R.Z. (eds), Introduction to the Electronic Age. New York: E-Publishing, 281–304.

For Web references, as a minimum, the full URL should be given and the date when the reference was last accessed. Any further information, if known (DOI, author names, dates etc.), should also be given. Web sources should be included in the reference list alphabetically according to the author's surname or organisation's name.

Publication ethics

Studies in Agricultural Economics aims to comply with the standards outlined in the COPE Codes of Conduct for Journal Editors and Publishers. These can be accessed at www.publicationethics.org/resources/code-conduct.

After acceptance

The corresponding author will be provided, at no cost, with a PDF file of the article via e-mail. The PDF file includes a cover sheet with the journal cover image and a disclaimer outlining the terms and conditions of use. *Studies in Agricultural Economics* has no page charges or submission fees.

Complete full-text articles may be published on the AKI website in advance of their publication in a printed issue. These do not yet have volume, issue or page numbers, so cannot be cited in the traditional way. They are therefore given a Digital Object Identifier (DOI), which allows the article to be cited before it appears in printed form.

Studies in Agricultural Economics is accessible online at https://ageconsearch.umn.edu/search?ln=en&cc=1316 and at www.studies.hu. It is listed in the Web of Science Emerging Sources Citation Index, CitEc, Crossref, the Directory of Open Access Journals (www.doaj.org), EconPapers and is included in the Citations in Economics database (http://ideas.repec.org/s/ags/stagec.html). Papers are indexed by Google Scholar.

The printed version of *Studies in Agricultural Economics* is designated by the publisher as the original version of the journal.